Progress Report No. 1

METEOROLOGICAL STUDY OF NATURAL VENTILATION IN THE ATMOSPHERE, BIG ROCK POINT NUCLEAR PLANT, CHARLEVOIX, MICHIGAN

Prepared for

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I PURPOSE

In the Revised Hazards Summary Report of October 14, 1960 Appendix A.2 was entitled "Preliminary Evaluation of Natural Ventilation in the Atmosphere near Charlevoix, Michigan." Most of this section was based on visual observations of weather made four miles from the site at the U. S. Coast Guard Station, Charlevoix. This was the only location within 30 miles of the site where routine observations of wind speed and direction were made and recorded several times per day year after year. These observations along with temperature are made by the U. S. Coast Guard at four-hour intervals on a continuous basis.

Wind speed observations are made without instruments using the Beaufort Scale--a well recognized method of estimating wind. (It relates wind speed to such things as "wind felt on face, leaves rustle," or, "raises dust and loose paper; small branches are moved.") Wind direction observations are made by estimating the position of a wind vane atop a 65 ft flag pole. Air temperature observations were made using a mercury-in-glass thermometer located 15 ft above lake level on the porch of the Coast Guard Station. Although this frequency of observing meteorological variables and the accuracy of estimations is probably adequate for the needs of the Coast Guard, they are inadequate for the evaluation of the climatology of the site of the Big Rock Point Nuclear Plant. Considerably more accurate, more detailed and more frequent observations are needed than those available from the United States Coast Guard.

In order to accurately assess the general air flow and the dilution potential of the air passing the plant site the following information was needed:

(1) average and extreme values of wind speed, wind direction and turbulence,

(2) the variability of these parameters with height to at least 250 ft above ground, (The presence of trees greatly increases the turbulence of the wind in the lower layers; furthermore wind observations should be made to a height equal to or greater than the height of the stack.)

(3) temperature lapse rate measurements (and thus stability) to this same height,

(4) diffusion studies of a tracer material to determine

(a) if stable and relatively non-turbulent W and WSW winds blowing off the lake and passing the site would continue nonturbulent carrying any effluent a significant distance,

(b) if stable, nonturbulent N winds passing the site would become turbulent in passing over the wooded areas to the south thus markedly diluting any effluent.

To obtain this information a 250-ft tower was erected and instrumented within one-half mile of the plant.

II TOWER INSTALLATION

A. Site Selection

In general the turbulence of the wind is much less for wind having an all water trajectory than for an all land trajectory. From a meteorological point of view, air currents moving toward the Harbor Springs-Petoskey area and toward Charlevoix are of greatest interest. Accordingly it was desirable that the tower be located to give maximum accuracy of recording of winds blowing toward these areas. Fortunately the land is very flat in the area of the plant site so there is little if any channeling of winds in any direction, and thus the location of hills did not have to be considered.

The site selected was a pronounced point of land on the plant property, extending into Lake Michigan and at a distance of about 2000 ft to the WNW of the stack. After removal of trees from the point it provided an excellent location for a tower from which winds blowing from WSW and W could be measured without unrepresentative gustiness caused by local surface roughness (nearby trees).

The general location of the plant and the tower relative to Charlevoix, Petoskey and Harbor Springs are shown in Figure 1. The exposed location of the instrumented tower (and complementary instrumented pole) is shown in Figure 2. This location permits obtaining reliable wind observations from off the water for more than 180°--from 240° in azimuth (SW), through N to 75° azimuth (ENE).

With occasional heavy pile-ups of ice in the spring with strong west winds it was unwise to locate the tower fully out on the point with its foundation below the normal high water mark. Accordingly the tower was located 150 ft back from the point, on safe ground, and in addition a 70-ft

pole (65 ft above ground) was erected near the end of the point to obtain the low level winds. Two closer views of the tower and pole may be seen in Figures 3 and 4.

B. Instrumentation

Most, if not all, standard commercial wind speed and direction sensors do not record fluctuating winds very accurately. Most wind vanes resonate with gusts of 40 to 100 ft in wave length indicating wind direction changes as much as two to three times the true value. On the other hand, the full amplitude of wind speed changes is not shown. Wind direction fluctuations are often used as an indicator of the degree of atmospheric diffusion. For instance, with isotropic turbulence if an instrument indicates the wind is fluctuating back and forth through an arc of 20° both horizontally and vertically one would expect the smoke emanating from a chimney would be dispersed through a solid angle of 20°. Now if the true wind is fluctuating through an arc of only 10° the smoke will be dispersed into a cone of solid angle 10°, whose volume is only $1/(2^2) \sim 1/4$ that of the 20° cone. Thus using such a wind vane one would overestimate the dilution by the wind by a factor of $3(= 4-1)$--a very sizable error. To avoid this common error special low inertia wind vanes were fabricated for this study. The maximum overshoot of these vanes for any gust wave length is about 50 percent. Thus the maximum overestimation of dilution with these sensors would be approximately $1(= 1.5^2 - 1)$. It appears that for moderate turbulence the average maximum overshoot is probably less than 10 percent, so the corresponding overestimation of dilution with these sensors would be approximately 20 percent.

Standard 3-cup Electric Speed Indicator Company wind speed sensors were used.

Four sets of wind speed and direction sensors were used, these being located at 32, and 64 ft on the pole; and at 128, and 256 ft on the tower. These instruments have been in continuous operation since October 13, 1960 as indicated in Table 1. They are shown in Figure 5. Gustiness or turbulence measurements were obtained with these same instruments. The wind recorders are seen in Figure 8.

To obtain temperature measurements accurate to within 0.1°C over the range -50° to +50°C, copper-constantan thermocouples and a special Minneapolis-Honeywell potentiometer-type strip chart recorder were used. The thermojunctions at all levels are shielded from solar and terrestrial radiation and have air drawn over them at a rate of about 30 ft per sec by a common exhauster--see Figures 5, 6, 7. Initially temperatures were measured as follows: at 10 ft below the lake surface; at 10 and 50 ft above the lake on the pole; and at 50, 100, 150, 200 and 250 ft on the tower. However, freezing of water in the air duct from the pole to the common exhauster necessitated the discontinuance of the pole temperature observations. The following temperatures are recorded in sequence on the 12-point temperature recorder: water temperature 3 ft below the surface; air temperatures on the tower at 10, 50, 100, 150, 200 and 250 ft above the lake level, as shown in Table 1. This recorder is seen in Figure 9.

To reduce the labor of abstracting the temperature data from the Minneapolis-Honeywell recorder, the latter was equipped with a Giannini-Datex encoder Model K attached to a Monroe recorder that prints out on adding machine paper the position of the Minneapolis-Honeywell recorder pen each time it operates. Since the Giannini-Datex unit divides the chart space -50°C to +50°C into 1000 equal units it prints out the corresponding temperatures to the nearest 0.1°C, where 000 represents -50°C; 500 represents 0.0°C; and 999 represents +49.9°C. This digitalizing system is seen in Figure 9.

A recording rain and snow gage is installed on a post to the west of the Instrument Hut (not visible in any of the photographs). This instrument closes an electric circuit with the receipt of each 0.01 in. of rain. Each impulse is recorded by a second pen on the Minneapolis-Honeywell recorder. Thus the rate of rainfall as well as the total fall is automatically recorded.

III DATA ANALYSIS

Wind speed and wind direction data have been abstracted for all hours of the day, from November 1, 1960 to August 31, 1961. To facilitate the analysis of these means, the data has been placed on IBM punch cards, 24 cards per day. Temperature data for the period March 1 to May 31 has been similarly abstracted and placed on the punch cards. Subsequent data is being similarly handled.

The wind data has been analyzed in several different ways. For maximum information, the frequency of occurrence of winds from the 36 points of the compass (0° to 360°), with corresponding wind speeds, has been obtained from the computer. The data for the 32-ft and 256-ft levels on the tower are given in Tables 3 to 12 of the Appendix, covering the 9-month period, November 1, 1960 to August 31, 1961.

It was found that this division of directions was too fine for the immediate needs, so wind directions have been broken down into five general categories, plus two special cases. These seven wind directions are tabulated in Table 13, and shown on Figure 10. To further facilitate analysis of the data, the 24-hr periods have been broken down into six 4-hr periods, as given in Table 13. Tabular data for these six periods of the day, month by month, for the 32-ft and 256-ft levels on the tower are given in Tables 14 to 23.

Monthly and seasonal summaries of data for winds from the five directions, plus calm, are given in Tables 24 to 27. Corresponding data is plotted on Figures 11 and 12.

Since the number of occurrences and duration of calms (winds less than 4 mph) at the plant site are of some interest, the records from the 32-ft and 256-ft levels have been

so analyzed and the data given in Tables 28 and 29. The 32-ft level was selected for consideration in connection with low level emissions; the 256-ft level was chosen for consideration during routine release from the stack. The frequency of occurrence of calms for various hours of the day for the 32-ft and 256-ft levels of the tower is given in Tables 30 and 31.

The number of occurrences of wind flow toward Charlevoix, along with the persistence of wind direction, is of interest in this study. These data are given in Table 32. The corresponding data for winds blowing toward Harbor Springs-Petoskey is given in Table 33.

IV CLIMATOLOGY

A. General Climatology of the Charlevoix-Petoskey Area

By the Köppen system of climatic classification, the lower peninsular area of Michigan surrounding Charlevoix and Petoskey has a "humid continental climate with cool summers." The continental characteristics include great departures from seasonal temperature means and a summer maximum in rainfall, but due to the proximity of the Great Lakes, these features are modified somewhat, so that the magnitude and persistence of the larger temperature anomalies are reduced, and the annual rainfall maximum is shifted toward fall, when the lake water is relatively warm.

The surface winds blowing across the area are basically westerly, with considerable variability in summer and the transition seasons. Southwesterly winds with a lake trajectory of about 200 miles are especially common in summer, but the mean wind speed is at a maximum of some 20 miles per hour in December-January, falling to 10-15 miles per hour the rest of the year.

Snow cover is important because of rapid radiation from the snow surface and protection of the underlying soil. Lying only 150 miles from the boundary of the Subarctic climatic zone to the north, the Charlevoix-Petoskey area averages 120 days per year of snow cover. This tends to lower winter temperatures and to retard spring warming. The average long period temperature and precipitation values abstracted for Michigan [1] are as follows:

Annual mean monthly temperature range: 20°F (February) to 70°F (July),
Monthly precipitation: 1.5 in. (February) to 3.5 in. (September) with a yearly total of 29 in.

With a high frequency of surface winds coming from Lake Michigan, the lake's annual temperature regime is of interest. According to Church [2][3], the following periods are distinguishable:

(1) Spring warming period, phase 1: A slow warming to about 4°C occurs, this temperature being attained throughout the lake water. The ending of this phase is between May 10 and June 10.

(2) Spring warming period, phase 2: After the formation of a protective thermocline near the surface, a rapid warming to about 20°C takes place. This phase ends in mid-July.

(3) Summer stationary period: A fairly constant temperature is maintained, there being a heat balance at the surface. This continues until late September.

(4) Fall cooling period: As autumn cooling begins and wind-stirring increases, the thermocline is destroyed and the lake becomes isothermal vertically. This period ends in November.

(5) Winter cooling period: Further cooling continues until March, when the cycle begins to repeat itself. Ice forms in winter near the lake shores, to build inward toward the center of the lake.

The Charlevoix-Petoskey area lies in maritime-polar (Pacific) and continental-polar air much of the time. However, it is frequently overrun by continental-arctic air, and is reached by maritime-tropical air in all seasons. This means that there are numerous frontal passages averaging two or three per week when one considers both cold and occluded fronts. Because of these frontal passages and the lake influences, the amount of cloudiness is rather great.

B. Diffusion Climatology of the Charlevoix-Petoskey Area

Diffusion at the Big Rock Point site is largely determined by the shore line location. Mechanical turbulence is related to the roughness of the surface over which the air flows; thermal turbulence is governed by the difference between air and water or soil temperatures. Land and lake breezes will occur locally and will influence the trajectories followed by the air and the associated turbulence and diffusion. Diffusion coefficients which are appropriate for use may therefore be expected to vary seasonally and with wind direction and speed. Some of these various aspects are discussed briefly in subsequent sections.

Influence of Underlying Surface on Diffusion. Both the roughness of the underlying surface and the wind speed occurring will influence the degree of mechanical turbulence generated. Even relatively flat terrain such as that surrounding the Big Rock Point site will lead to considerable mechanical turbulence. For any given land trajectory the mechanical turbulence may be expected to increase almost linearly with the wind speed. The lake surface, on the other hand, tends to be relatively smooth: the surface roughness represented by waves increases with wind speed, so that mechanical turbulence over the lake may be assumed to increase with wind speed. However, since waves are much smaller surface features than land objects such as trees, buildings, etc., mechanical turbulence over water is expected to be substantially less than that over land for the same wind speed and stability conditions.

To illustrate the influence of underlying surface on diffusion a number of photographs taken during the summer of 1961 are presented. Figures 13 and 14 show the diffusion of a smoke plume over the lake with an isothermal lapse rate. Figure 13 shows considerable lateral diffusion while Figure 14 shows restricted vertical diffusion. Even though the wind speed was about 8 mph, there is little evidence in the photographs of mechanical turbulence. Figure 15 shows the diffusion of a smoke plume over land with an isothermal lapse rate. Note that close to the source, the plume appears to be diffusing rather slowly. As the plume passes over the trees, it begins to break up rapidly. This evident mechanical

turbulence is the more striking when it is pointed out that the wind speed when this picture was taken was about 4 mph.

The irregular nature of the shore line near the Big Rock Point site, at the entrance to Little Traverse Bay, also has a substantial effect on diffusion. Figure 16 shows a fanning plume with an isothermal lapse rate. Close to the source, the plume appears to be diffusing rather slowly. As it passes over the lake-beach interface, it starts to break up because of the mechanical turbulence generated at the shore line.

The degree of thermal turbulence is related to the difference between air temperature and that of the underlying land or water surface. When the latter is substantially warmer than the air, active thermal turbulence is promoted and diffusion is rapid in the associated churning and mixing of the air. Active thermal turbulence may then be expected over the lake with off shore winds (SSW, S, SE, E, NE, and NNE) in the fall and early winter, especially with off shore winds from the sector ENE through NE which tend to be cold. By the same reasoning active thermal turbulence will occur over the warm land during the day with on shore winds (NNE, N, NW, W, SW, and SSW) in the spring and early summer, especially with on shore winds from the sector N through W which are cold in these seasons. On the other hand, when the land or water surface is substantially cooler than the overlying air, surface inversion layers develop in which thermal turbulence is suppressed and vertical mixing and diffusion are slight. No thermal turbulence will therefore occur over the lake with off shore winds in the spring and early summer, the lack being particularly pronounced with off shore winds from the sector S through E which tend to be warm before reaching the lake. Similarly, an absence of thermal turbulence is to be expected over the cool land on clear nights with on shore winds in the fall and early winter, especially with on shore winds from the sector WSW through SW which are warm in these seasons.

Characteristics and Influence of Land and Lake Breezes. In coastal areas local wind systems known as land and sea breezes are frequently observed in the late spring, summer, and early fall. These systems are characterized by light to moderate breezes which blow from water to land on clear,

sunny days; on clear nights there may be a light reverse flow, from land to sea. These features are found only when the prevailing wind system for the larger region is slight. With stronger area winds these local effects appear only as a diurnal variation in the prevailing wind speed or direction or both.

Such local wind systems have been observed on the shore line of the Great Lakes, where they have been called "land and lake breezes" [4]. Some general conclusions about their behavior may be stated as follows:

(1) Identifiable land and lake breezes are most likely to be observed if the general pressure gradient is very weak.

(2) Such breezes occur with strong heating of the land by solar radiation; therefore in middle latitudes they are most pronounced in the summer.

(3) The lake breeze usually commences about two or three hours before noon, reaches its maximum about mid-afternoon and subsides by sunset.

(4) In the absence of strong pressure gradients, onset is gradual. Nothing striking occurs at the shore line although the air temperature usually becomes steady. With a stronger pressure gradient there may be a delayed onset of the lake breeze which occurs as a sort of cold frontal passage, with squally winds and a temperature drop.

(5) The influence of the deflecting force of the earth's rotation, the Coriolis force, is not great and is not usually evident until five or six hours after the onset of the lake breeze. In the northern hemisphere, the Coriolis force leads to a veering of the wind, as from west at noon to northwest later in the afternoon.

(6) The land breeze is lighter and less frequent than the lake breeze. It is

most likely to occur with light and variable winds and clear skies, conditions characteristic of the central portion of an anticyclone.

In terms of the Big Rock Point site, lake breezes are likely to be significant because of their association with inversions. In summer a light easterly wind may carry warm air from the land out over the cold waters of Lake Michigan, so that the air near the water cools to form an inversion layer. As the lake breeze develops, the inversion layer is carried landward and arrives at the plant site. If the lake breeze is perpendicular to the shore line the inversion is rapidly dissipated over the warm land and diffusion improves rapidly as the air moves inland. However, if the conditions are favorable for the Coriolis force to cause a veering of the wind until it moves nearly parallel to the shore line, this dissipation of the inversion does not occur and slow diffusion persists.

A land breeze may occur with a nocturnal radiation inversion over land. Since in spring and early summer the surface waters of Lake Michigan are relatively cool, the nocturnal inversion which originated over land will persist as it moves over the lake, leading to continuing slow diffusion conditions. If the air comprising the inversion layer reaches land again during the night, it will persist until dissipated next morning by solar heating.

REFERENCES

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2. The University of Chicago Miscellaneous Reports No. 4, Phil E. Church, Chicago, Illinois.

3. The University of Chicago Miscellaneous Reports No. 18, Phil E. Church, Chicago, Illinois.

4. Hewson, E. W., G. C. Gill, and H. W. Baynton, "Meteorological Analysis." The University of Michigan Research Institute Report No. 2515-3-P, Ann Arbor, 1959.

A P P E N D I X

TABLE 1

Locations of meteorological sensors, and the time observations started--Big Rock Nuclear Power Plant

Sensor	Height (above lake)	Date observations started
Wind Speed	32, 64 ft (on pole)	32, 64, 256 ft levels started Oct. 13, 1960
	128, 256 ft (on tower)	128 ft level started Nov. 5, 1960
Wind Direction	Same levels as wind speed.	Same dates as wind speed.
Temperature	-3 ft in lake; 10, 50, 100, 150, 200, 250 ft on tower	Feb. 13, 1961.
Rainfall	8 ft	June 19, 1961

TABLE 2

Meteorological tower data being abstracted routinely

Sensor	Levels (ft)	Hourly values of
Wind Speed	32, 64, 128, 256	$\overline{V}$, $(V_{max}-V_{min})$, mph
Wind Direction	32, 64, 128, 256	Mean direction, 0-36
Thermo-junctions	-3, 10, 50, 100, 150, 200, 250	Temperature (°C)
Rain gage	8	Rainfall (inches)

The following legends apply to Tables 3 to 11 inclusive:

* Total of frequencies may not add up to 100 percent because of rounding off.

** Calm - When the average wind speed for an hour is 3 mph or less, the direction is recorded as calm.

TABLE 3

WIND SUMMARY - November, 1960

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
No Data	20.6	--			
Calm**	2.9	--	Calm**	1.4	--
10	1.0	0.0	10	1.1	14.1
20	0.8	14.3	20	1.1	11.1
30	0.9	12.0	30	0.5	12.0
40	0.0	0.0	40	0.2	12.5
50	0.2	10.0	50	0.1	10.0
60	0.6	16.6	60	1.1	17.6
70	0.6	19.8	70	1.8	18.5
80	1.5	18.9	80	0.6	10.0
90 (E)	1.2	14.2	90 (E)	2.9	17.7
100	3.4	14.8	100	1.8	19.0
110	1.5	12.7	110	1.2	14.4
120	0.4	5.7	120	0.2	7.5
130	0.1	4.0	130	0.8	8.7
140	0.4	4.7	140	1.8	10.5
150	1.3	4.5	150	1.6	12.6
160	0.9	7.1	160	2.9	12.3
170	3.4	7.2	170	2.3	14.1
180 (S)	3.6	8.7	180 (S)	2.5	14.4
190	5.8	10.2	190	7.9	18.5
200	7.6	12.6	200	6.9	20.7
210	5.8	14.1	210	7.2	18.8
220	4.7	17.2	220	5.5	20.6
230	2.7	19.7	230	3.3	21.5
240	1.3	18.6	240	3.0	24.1
250	1.6	23.8	250	3.3	22.3
260	2.7	20.7	260	3.8	23.3
270 (W)	2.9	24.6	270 (W)	6.2	23.1
280	1.8	19.7	280	5.0	23.6
290	1.8	19.8	290	2.9	20.5
300	1.2	19.9	300	1.2	22.3
310	0.6	17.0	310	2.3	19.2
320	1.1	15.8	320	3.4	16.2
330	2.3	13.3	330	2.1	14.5
340	1.2	17.3	340	4.1	18.6
350	1.8	21.2	350	4.0	25.9
360 (N)	2.7	26.7	360 (N)	1.1	30.3

NOTE: 153 hours of data from 32 ft level missing.

TABLE 4

WIND SUMMARY - December, 1960

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	0.5	--	Calm**	0.3	--
10	2.4	20.0	10	1.0	16.6
20	1.2	16.4	20	2.5	16.4
30	2.6	15.2	30	2.1	15.4
40	2.1	15.5	40	1.8	15.0
50	1.7	16.3	50	1.6	17.3
60	1.0	15.8	60	1.7	20.2
70	0.6	17.4	70	0.9	13.1
80	1.6	22.0	80	0.5	8.0
90 (E)	0.8	14.6	90 (E)	0.2	11.0
100	0.4	9.6	100	0.1	10.0
110	0.4	8.3	110	0.2	8.5
120	0.2	8.0	120	0.0	0.0
130	0.0	0.0	130	0.5	10.2
140	0.4	5.3	140	0.4	6.0
150	0.5	4.2	150	0.2	7.5
160	0.9	5.4	160	2.6	18.7
170	5.2	9.8	170	4.3	18.1
180 (S)	4.8	10.0	180 (S)	4.3	17.6
190	3.8	11.6	190	5.3	18.6
200	3.2	11.7	200	5.5	19.0
210	9.1	16.0	210	4.4	22.8
220	2.1	19.4	220	2.6	23.7
230	2.6	26.5	230	4.1	29.0
240	2.0	32.2	240	4.9	26.6
250	3.0	30.5	250	3.6	26.4
260	3.2	27.7	260	4.3	22.9
270 (W)	4.0	23.3	270 (W)	5.1	20.3
280	5.9	20.9	280	5.5	19.4
290	6.5	18.8	290	4.9	21.6
300	6.0	20.2	300	2.8	21.6
310	2.0	19.6	310	3.7	18.7
320	3.4	17.9	320	4.0	16.9
330	4.5	16.8	330	2.8	19.7
340	1.6	17.1	340	3.2	20.1
350	4.5	18.4	350	2.9	23.2
360 (N)	3.6	18.8	360 (N)	3.6	21.4

TABLE 5

WIND SUMMARY - January, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	3.5	--	Calm**	2.8	--
10	2.4	16.4	10	1.3	15.4
20	1.6	20.8	20	1.0	5.8
30	1.0	9.6	30	0.8	9.3
40	0.9	8.8	40	0.4	4.0
50	0.5	10.0	50	1.4	12.7
60	0.0	0.0	60	2.4	12.5
70	1.3	12.2	70	5.5	10.9
80	2.1	14.0	80	2.4	9.0
90 (E)	2.8	13.2	90 (E)	1.4	6.7
100	2.8	8.1	100	0.6	6.2
110	3.0	7.1	110	1.6	9.5
120	1.7	5.7	120	0.9	9.1
130	1.3	5.1	130	0.8	7.8
140	0.1	4.0	140	1.0	7.0
150	0.8	4.8	150	1.2	12.6
160	1.8	5.3	160	4.8	14.0
170	5.9	6.9	170	4.0	15.1
180 (S)	6.9	8.2	180 (S)	5.1	17.8
190	3.2	9.4	190	3.8	14.8
200	3.8	11.6	200	3.4	13.8
210	3.2	11.2	210	2.4	18.0
220	0.9	16.7	220	1.2	19.5
230	0.8	19.8	230	2.1	19.9
240	1.2	18.7	240	0.9	18.1
250	0.4	23.6	250	4.0	19.0
260	1.3	18.1	260	6.3	18.6
270 (W)	5.9	16.9	270 (W)	4.5	17.8
280	6.4	16.5	280	5.1	16.7
290	5.2	15.7	290	2.4	19.4
300	3.0	16.5	300	4.1	19.2
310	3.0	16.7	310	4.5	19.2
320	5.6	15.9	320	2.5	16.8
330	3.0	14.4	330	5.7	21.5
340	3.5	20.0	340	4.0	19.2
350	4.4	16.1	350	3.4	13.5
360 (N)	2.8	12.1	360 (N)	1.0	27.1

TABLE 6

WIND SUMMARY - February, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	6.9	--	Calm**	5.5	--
10	2.6	12.2	10	1.0	12.0
20	2.0	10.6	20	1.4	11.3
30	0.2	14.0	30	1.0	7.1
40	0.7	9.4	40	1.7	8.6
50	0.2	5.5	50	3.2	14.3
60	0.7	10.6	60	4.9	15.1
70	3.7	14.2	70	6.5	14.7
80	8.4	13.0	80	7.5	11.3
90 (E)	8.4	11.5	90 (E)	3.4	10.3
100	5.9	8.9	100	1.6	10.6
110	2.5	7.7	110	2.8	11.2
120	2.0	7.2	120	1.9	13.9
130	1.4	5.6	130	2.0	10.0
140	0.5	5.0	140	1.6	10.5
150	1.0	5.2	150	0.4	10.0
160	0.7	6.0	160	0.8	7.1
170	4.0	7.6	170	1.6	10.3
180 (S)	6.6	8.7	180 (S)	2.8	15.4
190	3.5	7.9	190	5.8	15.1
200	5.3	8.3	200	4.4	14.6
210	2.3	12.5	210	2.3	13.3
220	2.2	11.3	220	5.2	14.9
230	2.9	11.4	230	4.4	16.3
240	3.4	11.8	240	3.8	15.7
250	3.1	12.2	250	3.5	17.2
260	2.3	13.7	260	3.1	14.4
270 (W)	2.3	14.5	270 (W)	2.8	19.1
280	1.6	19.8	280	2.2	9.9
290	2.6	16.8	290	1.4	10.8
300	1.1	16.3	300	1.6	10.5
310	1.1	17.6	310	1.4	9.0
320	0.8	16.3	320	1.7	12.0
330	1.1	11.1	330	1.1	13.7
340	0.5	13.0	340	1.9	16.7
350	1.0	13.5	350	2.8	11.4
360 (N)	2.4	12.2	360 (N)	1.8	15.5

TABLE 7

WIND SUMMARY - March, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	2.9	--	Calm**	2.8	--
10	4.9	16.0	10	2.2	13.6
20	3.6	13.3	20	1.7	9.9
30	1.6	13.2	30	1.2	13.8
40	1.3	11.2	40	3.6	14.3
50	1.6	13.0	50	4.3	14.1
60	2.8	14.7	60	5.7	17.7
70	2.2	13.1	70	6.9	16.4
80	9.2	14.8	80	2.9	17.5
90 (E)	6.3	14.7	90 (E)	5.3	12.5
100	8.0	12.9	100	1.8	11.0
110	1.3	8.3	110	0.6	9.4
120	0.4	4.3	120	0.0	0.0
130	0.5	4.7	130	1.3	13.7
140	1.2	5.3	140	2.5	14.1
150	1.2	5.8	150	2.5	17.2
160	1.4	7.0	160	2.8	19.5
170	3.3	7.4	170	3.6	17.6
180 (S)	4.1	8.8	180 (S)	1.8	15.5
190	2.6	9.8	190	3.2	15.7
200	2.4	11.8	200	1.7	17.1
210	2.4	12.0	210	1.3	18.5
220	0.9	15.7	220	1.8	24.8
230	1.3	12.2	230	1.8	21.7
240	1.3	22.0	240	2.1	16.8
250	1.6	17.8	250	1.3	13.5
260	1.6	15.5	260	0.9	15.7
270 (W)	1.0	11.2	270 (W)	1.2	20.8
280	0.9	12.8	280	4.1	17.3
290	3.0	16.2	290	1.7	20.7
300	3.2	17.2	300	3.0	18.5
310	2.1	15.2	310	3.2	20.7
320	4.9	16.5	320	2.6	17.3
330	2.2	13.8	330	4.1	17.9
340	2.5	12.3	340	2.6	15.9
350	3.8	15.7	350	3.6	20.5
360 (N)	2.0	14.6	360 (N)	4.9	15.4

TABLE 8

WIND SUMMARY - April, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	8.4	--	Calm**	2.3	--
10	2.9	9.4	10	3.0	10.7
20	3.6	13.7	20	2.5	11.6
30	1.9	9.6	30	1.6	9.0
40	1.3	10.1	40	1.5	9.3
50	0.8	13.8	50	4.4	17.8
60	2.0	7.2	60	6.1	22.3
70	2.2	14.8	70	4.8	14.4
80	6.5	16.8	80	2.7	13.0
90 (E)	6.5	15.1	90 (E)	2.2	12.0
100	3.1	10.7	100	2.2	10.7
110	2.9	9.2	110	1.1	10.2
120	2.0	7.6	120	0.6	10.4
130	0.4	4.0	130	0.9	16.1
140	0.5	6.5	140	2.3	17.4
150	0.9	5.5	150	1.6	15.4
160	0.6	8.0	160	1.1	16.0
170	1.9	9.2	170	1.8	13.6
180 (S)	2.6	8.1	180 (S)	0.6	10.6
190	1.6	7.2	190	1.3	12.1
200	0.6	7.2	200	1.9	11.9
210	1.3	7.7	210	1.2	12.4
220	0.6	6.0	220	2.6	12.9
230	2.0	9.0	230	4.4	14.0
240	5.4	9.2	240	2.2	11.1
250	4.0	9.6	250	2.7	10.8
260	3.7	9.9	260	2.0	12.4
270 (W)	2.7	8.1	270 (W)	2.0	13.4
280	0.6	6.8	280	2.3	11.9
290	1.8	13.6	290	2.5	11.7
300	1.8	11.1	300	3.6	18.5
310	1.2	12.0	310	6.6	18.7
320	4.3	15.1	320	5.4	15.0
330	5.2	15.5	330	4.1	14.5
340	4.3	12.0	340	6.8	15.2
350	3.0	12.9	350	1.3	11.2
360 (N)	3.0	13.2	360 (N)	3.7	11.5

TABLE 9

WIND SUMMARY - May, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	6.1	--	Calm**	2.4	--
10	3.9	13.1	10	2.9	13.5
20	2.1	8.5	20	1.7	10.9
30	0.8	10.3	30	0.2	10.5
40	0.1	5.0	40	0.9	10.4
50	0.1	4.0	50	1.6	16.1
60	1.0	10.0	60	2.4	13.3
70	1.0	10.3	70	1.8	12.1
80	4.7	10.3	80	1.7	9.6
90 (E)	2.6	8.4	90 (E)	2.4	13.5
100	1.4	8.0	100	0.8	12.5
110	2.6	9.8	110	0.6	15.6
120	1.6	7.1	120	0.8	14.3
130	0.4	4.6	130	1.8	13.5
140	0.4	6.0	140	4.1	16.2
150	1.6	6.4	150	1.8	15.2
160	1.2	7.2	160	1.0	15.6
170	3.4	8.1	170	1.7	12.6
180 (S)	4.8	7.8	180 (S)	1.3	14.4
190	2.5	8.7	190	2.2	14.4
200	2.8	9.4	200	3.4	17.1
210	2.5	12.3	210	4.4	17.4
220	1.4	12.2	220	5.6	21.8
230	5.3	11.1	230	6.0	17.0
240	8.7	13.3	240	5.1	15.4
250	5.7	10.6	250	2.0	12.2
260	2.6	8.4	260	2.5	12.9
270 (W)	1.7	9.3	270 (W)	2.8	14.1
280	2.4	12.1	280	2.6	12.3
290	2.2	12.0	290	4.7	15.8
300	1.8	10.5	300	2.2	16.9
310	2.4	12.9	310	4.9	14.7
320	2.5	13.7	320	4.0	15.3
330	2.9	10.4	330	3.0	16.3
340	4.5	12.2	340	5.5	15.7
350	3.6	10.8	350	1.9	12.8
360 (N)	2.9	9.8	360 (N)	5.2	17.2

TABLE 10

WIND SUMMARY - June, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	8.6	--	Calm**	2.7	--
10	2.3	11.1	10	3.1	13.4
20	0.2	9.0	20	2.0	10.2
30	1.2	7.8	30	0.9	12.7
40	0.4	13.0	40	0.5	5.5
50	0.4	12.0	50	1.1	11.1
60	1.3	8.5	60	0.5	18.7
70	3.7	11.0	70	2.6	16.0
80	7.3	10.4	80	4.5	15.3
90 (E)	3.4	6.8	90 (E)	1.2	12.6
100	1.8	7.0	100	1.9	9.0
110	2.5	5.3	110	1.2	8.5
120	1.1	4.6	120	1.1	9.5
130	0.2	5.0	130	1.6	9.8
140	0.5	4.7	140	1.9	8.7
150	0.6	5.2	150	0.6	9.2
160	0.5	5.5	160	1.2	10.7
170	3.1	7.8	170	2.5	13.0
180 (S)	5.0	7.8	180 (S)	1.8	17.3
190	3.6	9.6	190	3.0	13.2
200	6.5	10.6	200	3.8	16.3
210	4.0	10.0	210	5.0	16.3
220	2.2	13.3	220	6.8	16.4
230	7.9	13.0	230	8.4	16.7
240	8.6	14.5	240	9.3	20.5
250	5.4	13.2	250	6.2	15.7
260	2.7	9.0	260	2.9	14.3
270 (W)	1.8	7.9	270 (W)	2.9	14.7
280	2.2	12.3	280	2.0	15.4
290	1.1	10.3	290	3.4	12.9
300	1.2	12.4	300	2.0	11.8
310	0.8	7.0	310	1.2	12.7
320	0.5	9.5	320	1.1	8.5
330	0.9	14.7	330	1.3	17.4
340	2.5	15.0	340	3.1	19.1
350	1.6	11.6	350	1.4	12.6
360 (N)	1.0	0.0	360 (N)	3.2	15.0

TABLE 11

WIND SUMMARY - July, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**	8.6	--	Calm**	9.0	--
10	2.6	8.9	10	3.2	7.5
20	1.4	7.3	20	0.6	6.0
30	1.4	7.9	30	0.9	8.4
40	0.6	6.8	40	0.9	7.2
50	0.2	5.0	50	0.5	6.2
60	1.3	8.8	60	0.2	9.0
70	2.0	9.8	70	2.1	11.6
80	3.8	10.9	80	3.8	11.2
90 (E)	2.1	6.1	90 (E)	2.0	10.0
100	0.8	6.1	100	1.0	10.2
110	0.6	5.2	110	0.8	5.3
120	0.2	4.0	120	0.6	8.8
130	0.2	4.0	130	1.0	7.1
140	0.5	4.0	140	1.7	7.7
150	0.8	5.3	150	1.3	8.0
160	1.2	4.8	160	1.4	10.5
170	5.9	6.1	170	2.0	12.3
180 (S)	4.8	6.8	180 (S)	3.7	11.0
190	3.0	6.0	190	3.7	15.6
200	3.2	5.7	200	2.5	11.4
210	2.1	9.6	210	3.6	10.0
220	2.0	8.1	220	5.2	10.9
230	5.9	10.6	230	7.1	14.6
240	4.7	11.0	240	6.4	13.1
250	3.4	10.0	250	5.5	12.8
260	5.7	8.7	260	3.0	10.4
270 (W)	3.8	8.0	270 (W)	3.0	9.8
280	1.8	9.0	280	2.5	12.2
290	2.2	9.8	290	4.3	12.1
300	2.1	8.1	300	3.8	10.8
310	1.3	12.4	310	1.7	11.3
320	1.6	9.1	320	2.2	7.4
330	1.2	7.1	330	2.9	9.1
340	1.6	7.9	340	2.2	8.7
350	2.4	7.9	350	3.0	12.0
360 (N)	1.3	9.2	360 (N)	2.0	13.2

TABLE 12

WIND SUMMARY - August, 1961

32 foot level			256 foot level		
Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)	Wind Direction (degrees)	Frequency* of Occurrence (percent)	Avg Speed (mph)
Calm**		--	Calm**	5.8	--
10	12.6	11.4	10	4.2	13.2
20	2.5	9.1	20	2.9	9.3
30	0.8	11.3	30	0.8	1.5
40	0.5	7.2	40	0.2	10.0
50	0.7	9.0	50	0.5	9.5
60	1.7	10.5	60	2.3	9.1
70	2.0	8.5	70	2.0	9.2
80	1.6	9.3	80	2.2	9.9
90 (E)	2.6	6.3	90 (E)	1.7	9.8
100	1.3	6.0	100	1.4	9.2
110	1.3	5.2	110	1.4	8.6
120	1.0	5.0	120	0.8	9.8
130	0.4	4.6	130	1.4	10.4
140	0.2	5.0	140	1.6	8.3
150	0.8	4.5	150	2.2	9.8
160	2.8	5.2	160	2.2	11.8
170	5.3	7.1	170	3.8	11.7
180 (S)	5.6	7.6	180 (S)	5.0	15.2
190	3.5	7.8	190	3.1	14.0
200	3.7	8.5	200	2.9	15.8
210	2.6	13.8	210	2.3	15.3
220	1.3	20.4	220	2.9	16.9
230	3.1	12.6	230	4.7	20.5
240	2.0	14.5	240	4.1	16.7
250	3.1	12.7	250	5.2	13.5
260	2.5	11.2	260	1.7	12.6
270 (W)	1.3	12.3	270 (W)	2.5	10.2
280	3.4	9.2	280	2.3	10.5
290	2.3	7.8	290	2.3	9.0
300	1.0	11.7	300	1.6	10.7
310	1.7	11.1	310	1.4	13.9
320	2.2	9.6	320	2.6	10.3
330	3.5	11.5	330	2.8	15.9
340	5.0	10.5	340	5.0	12.5
350	4.0	11.6	350	4.7	13.1
360 (N)	1.9	6.5	360 (N)	2.6	14.1

TABLE 13

Definitions of terms used in subsequent tables

Wind Direction #	Type of Wind	Azimuth
1	On Shore	280° thru 360° thru 20°
2	Toward Charlevoix	30° thru 50°
3	Off Shore	100° thru 220°
4	Toward Harbor Springs-Petoskey	240° thru 270°
5	Along Shore and Residue	60° thru 90° , 230°
6	Calm, wind less than 4 mph	No direction
7	Variable, wind greater than 4 mph	No direction

Time Period	Includes Hours Ending At			
No. 1	0100	0200	0300	0400
No. 2	0500	0600	0700	0800
No. 3	0900	1000	1100	1200
No. 4	1300	1400	1500	1600
No. 5	1700	1800	1900	2000
No. 6	2100	2200	2300	2400

Temperature	Height Above Ground, ft
No. 1	Water Level
No. 2	10
No. 3	50
No. 4	100
No. 5	150
No. 6	200
No. 7	250

Wind Data	Height Above Ground, ft
No. 1	32
No. 2	64
No. 3	128
No. 4	256

TABLE 14

Wind Summary, November, 1960 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	25.8	17.7	36.7	18.3
	2	0.8	6.0	0.0	0.0
	3	40.8	11.2	42.5	18.8
	4	0.8	27.0	8.3	25.5
	5	0.3	26.8	10.8	13.4
	6	5.0	--	1.7	--
Time Period 2	1	16.7	19.6	25.0	20.4
	2	0.0	0.0	0.0	0.0
	3	44.2	11.8	45.8	16.2
	4	5.8	24.6	14.2	25.5
	5	6.7	13.9	12.5	17.1
	6	5.0	--	2.5	--
Time Period 3	1	11.7	23.6	14.3	22.5
	2	0.0	0.0	0.8	12.0
	3	41.7	11.8	48.7	15.7
	4	12.5	23.1	23.5	24.8
	5	10.8	16.6	11.8	17.5
	6	1.0	--	0.8	--
Time Period 4	1	16.7	17.5	18.3	20.6
	2	3.3	12.0	4.2	10.6
	3	32.5	11.8	40.0	17.9
	4	17.5	23.2	30.0	23.0
	5	10.0	20.8	6.7	25.9
	6	1.0	--	0.8	--
Time Period 5	1	20.0	20.8	35.0	22.9
	2	1.7	17.0	0.8	18.0
	3	35.8	12.0	40.8	17.8
	4	9.2	20.9	13.3	19.1
	5	6.7	17.5	8.3	21.1
	6	5.0	--	1.7	--
Time Period 6	1	25.8	20.9	42.5	21.9
	2	1.7	8.0	0.0	0.0
	3	41.7	12.0	38.3	19.4
	4	6.7	17.4	10.0	20.2
	5	4.2	17.6	9.2	20.4
	6	2.0	--	0.0	--

TABLE 15

Wind Summary, December, 1960 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	46.0	19.8	39.5	21.7
	2	6.5	18.5	4.8	19.0
	3	31.5	12.4	33.1	20.0
	4	11.3	27.6	16.9	22.6
	5	4.8	20.0	2.4	26.3
	6	0.0	0.0	3.2	0.0
Time Period 2	1	47.6	19.9	40.3	20.8
	2	4.0	17.8	4.0	21.0
	3	26.6	11.8	29.0	19.7
	4	14.5	31.5	16.9	36.8
	5	6.5	22.9	6.5	34.8
	6	0.8	0.0	3.2	0.0
Time Period 3	1	40.3	19.0	38.7	20.5
	2	5.7	17.3	2.4	17.3
	3	25.8	10.6	24.2	16.4
	4	20.2	27.6	18.6	25.5
	5	6.5	30.6	12.9	30.7
	6	1.6	0.0	3.2	0.0
Time Period 4	1	41.0	17.2	36.9	17.2
	2	9.0	12.8	4.9	10.2
	3	30.3	14.2	29.5	19.9
	4	10.7	22.4	20.5	21.4
	5	9.0	23.7	8.2	23.8
	6	0.0	0.0	0.0	0.0
Time Period 5	1	36.3	18.4	36.3	19.0
	2	8.1	13.0	6.5	12.8
	3	38.7	12.4	34.7	18.7
	4	10.5	27.4	14.5	27.7
	5	6.5	17.1	8.1	15.9
	6	0.0	0.0	0.0	0.0
Time Period 6	1	41.9	19.0	32.3	20.2
	2	6.5	17.1	11.3	16.6
	3	36.3	12.7	34.7	19.4
	4	7.3	29.2	16.9	26.3
	5	8.1	15.1	4.8	10.7
	6	0.0	0.0	0.0	0.0

TABLE 16

Wind Summary, January 1961, by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	44.4	16.8	40.3	19.1
	2	2.4	11.0	0.8	4.0
	3	50.8	7.9	40.3	15.2
	4	0.0	0.0	7.3	17.4
	5	0.0	0.0	10.5	9.0
	6	2.4	0.0	0.8	0.0
Time Period 2	1	44.4	16.2	37.1	19.2
	2	0.0	0.0	0.0	0.0
	3	39.5	9.0	32.3	17.0
	4	7.3	19.1	14.5	18.0
	5	3.2	15.5	11.3	10.6
	6	5.7	0.0	4.8	0.0
Time Period 3	1	41.9	16.5	31.5	17.8
	2	1.6	15.0	2.4	14.0
	3	33.9	8.3	31.5	14.3
	4	12.9	19.9	19.4	21.3
	5	8.9	13.9	13.7	14.8
	6	0.8	0.0	1.6	0.0
Time Period 4	1	38.7	14.9	32.3	16.0
	2	3.2	7.0	3.2	12.5
	3	23.4	9.8	21.8	13.7
	4	18.6	17.2	25.8	17.4
	5	14.5	13.9	14.5	14.3
	6	1.6	0.0	2.4	0.0
Time Period 5	1	38.7	17.1	29.8	18.6
	2	3.2	8.5	4.8	10.5
	3	28.2	8.1	25.8	12.8
	4	10.5	15.0	18.6	18.6
	5	14.5	13.6	15.3	13.4
	6	4.8	0.0	5.7	0.0
Time Period 6	1	43.6	17.2	40.3	19.5
	2	4.8	9.0	4.0	9.8
	3	40.3	8.0	30.7	15.2
	4	4.0	17.2	8.1	20.7
	5	1.6	17.0	16.1	10.1
	6	5.7	0.0	0.8	0.0

TABLE 17

Wind Summary, February, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	8.7	14.4	14.1	10.9
	2	3.3	7.7	7.6	10.3
	3	43.5	7.8	30.4	13.3
	4	7.6	15.4	15.2	17.7
	5	21.7	10.5	27.2	11.5
	6	15.2	0.0	5.4	0.0
Time Period 2	1	12.0	17.1	10.9	15.1
	2	0.0	0.0	3.3	7.3
	3	58.7	8.5	34.8	14.3
	4	1.1	23.0	12.0	17.2
	5	19.6	12.6	28.3	13.5
	6	8.7	0.0	10.9	0.0
Time Period 3	1	10.9	19.7	7.6	9.4
	2	1.1	6.0	4.4	11.5
	3	34.8	7.8	34.8	13.4
	4	7.6	10.4	12.0	20.5
	5	35.9	14.7	32.6	15.8
	6	9.8	0.0	7.6	0.0
Time Period 4	1	12.0	14.7	12.0	8.4
	2	0.0	0.0	8.7	19.1
	3	27.2	8.3	29.4	10.2
	4	22.8	10.0	10.9	15.6
	5	33.7	15.1	35.9	14.9
	6	4.4	0.0	3.3	0.0
Time Period 5	1	10.9	12.7	13.0	14.3
	2	2.2	5.0	7.6	13.0
	3	35.9	8.9	27.2	14.8
	4	12.0	10.9	13.0	10.5
	5	34.8	10.3	34.8	12.2
	6	4.4	0.0	4.4	0.0
Time Period 6	1	15.2	10.7	21.7	12.1
	2	0.0	0.0	7.6	10.3
	3	43.5	8.3	28.3	14.6
	4	12.0	15.9	10.9	14.8
	5	22.8	10.8	29.4	14.1
	6	6.5	0.0	2.2	0.0

TABLE 18

Wind Summary, March, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	26.6	17.9	25.0	19.0
	2	4.0	12.6	10.5	16.7
	3	38.7	8.9	29.0	21.1
	4	4.0	26.2	5.7	25.3
	5	25.0	14.4	27.4	13.7
	6	1.6	0.0	2.4	0.0
Time Period 2	1	30.7	15.8	32.3	17.5
	2	3.2	11.3	4.8	11.3
	3	36.3	9.9	26.6	16.8
	4	4.8	26.2	3.2	29.0
	5	22.6	15.0	30.7	18.5
	6	2.4	0.0	2.4	0.0
Time Period 3	1	33.9	14.6	33.9	16.8
	2	5.7	8.9	12.9	13.3
	3	32.3	11.6	24.2	14.5
	4	3.2	19.3	3.2	16.5
	5	23.4	14.1	21.8	17.9
	6	1.6	0.0	4.0	0.0
Time Period 4	1	43.6	12.9	40.3	15.4
	2	3.2	11.8	9.7	15.2
	3	20.2	11.9	18.6	14.8
	4	12.1	12.0	10.5	13.0
	5	21.0	16.2	20.2	16.8
	6	0.0	0.0	0.8	0.0
Time Period 5	1	37.4	14.7	40.3	17.7
	2	7.3	13.0	8.1	16.3
	3	19.5	12.1	18.6	17.4
	4	7.3	10.8	8.1	12.5
	5	20.3	13.4	17.7	16.4
	6	8.1	0.0	7.3	0.0
Time Period 6	1	30.7	17.5	36.3	20.4
	2	4.0	18.8	8.1	12.2
	3	34.7	8.0	33.1	16.6
	4	2.4	22.7	2.4	16.3
	5	25.8	13.7	20.2	15.0
	6	2.4	0.0	0.0	0.0

TABLE 19

Wind Summary, April, 1961, by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	26.7	14.1	41.2	14.5
	2	5.8	9.7	9.2	12.7
	3	31.7	7.6	24.4	15.7
	4	4.2	10.4	3.4	13.8
	5	17.5	12.9	18.5	14.4
	6	14.2	0.0	3.4	0.0
Time Period 2	1	26.7	13.3	34.2	16.4
	2	6.7	14.6	6.7	13.5
	3	33.3	8.0	30.0	12.0
	4	9.2	8.1	5.0	10.2
	5	13.3	15.9	20.0	15.6
	6	10.8	0.0	4.2	0.0
Time Period 3	1	36.4	12.8	40.0	15.0
	2	0.9	15.0	5.0	14.7
	3	12.7	10.1	11.7	12.9
	4	23.7	9.8	12.5	10.3
	5	22.9	14.7	27.5	15.5
	6	3.4	0.0	3.3	0.0
Time Period 4	1	41.7	12.3	46.7	14.5
	2	0.8	4.0	5.0	20.7
	3	7.5	8.4	11.7	12.7
	4	32.5	10.1	15.8	11.0
	5	13.3	19.5	20.8	20.3
	6	4.2	0.0	0.0	0.0
Time Period 5	1	34.2	13.1	41.7	15.7
	2	3.3	6.8	5.0	19.6
	3	8.3	9.8	19.2	13.6
	4	23.3	8.5	15.0	10.9
	5	25.8	14.5	15.8	19.2
	6	5.0	0.0	2.5	0.0
Time Period 6	1	27.5	13.8	46.7	13.2
	2	7.5	9.8	13.3	11.6
	3	25.8	8.1	20.0	14.5
	4	3.3	6.0	3.3	27.3
	5	24.2	10.5	16.7	16.1
	6	11.7	0.0	0.0	0.0

TABLE 20

Wind Summary, May, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	29.8	11.9	35.5	14.7
	2	1.6	18.0	3.2	9.3
	3	38.7	7.9	37.1	17.2
	4	7.3	11.7	11.3	16.3
	5	12.1	8.0	12.1	11.9
	6	10.5	0.0	0.8	0.0
Time Period 2	1	26.6	13.3	33.1	15.6
	2	1.6	8.0	0.8	17.0
	3	46.0	8.1	43.6	15.9
	4	7.3	10.4	6.5	19.4
	5	9.7	9.9	14.5	12.3
	6	8.9	0.0	1.6	0.0
Time Period 3	1	33.9	12.2	34.7	16.8
	2	0.8	5.0	3.2	12.3
	3	25.0	10.4	29.0	15.3
	4	25.0	13.1	13.7	15.1
	5	12.9	12.4	16.9	16.1
	6	2.4	0.0	2.4	0.0
Time Period 4	1	36.3	10.6	41.9	14.7
	2	0.8	6.0	3.2	16.8
	3	12.1	12.5	19.4	21.4
	4	33.9	12.3	20.2	13.8
	5	14.5	13.0	15.3	18.5
	6	2.4	0.0	0.0	0.0
Time Period 5	1	29.3	12.3	39.5	16.2
	2	0.8	4.0	4.0	19.6
	3	11.4	10.4	21.0	19.3
	4	36.6	10.1	14.5	13.0
	5	19.5	11.3	14.5	14.4
	6	2.4	0.0	6.5	0.0
Time Period 6	1	33.9	11.1	46.0	15.8
	2	0.8	4.0	2.4	6.7
	3	29.8	7.7	29.0	15.3
	4	4.0	8.2	8.1	9.6
	5	21.0	7.7	12.1	13.1
	6	10.5	0.0	2.4	0.0

TABLE 21

Wind Summary, June, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	10.8	12.8	19.2	12.1
	2	4.2	12.4	5.8	13.3
	3	50.0	7.8	49.2	13.8
	4	1.7	7.0	10.8	11.5
	5	15.8	7.2	13.3	14.6
	6	17.5	0.0	1.7	0.0
Time Period 2	1	8.3	13.7	16.8	12.4
	2	5.0	10.7	3.4	17.0
	3	50.0	8.4	54.6	13.0
	4	6.7	12.6	11.8	18.5
	5	24.2	10.5	12.6	17.4
	6	5.8	0.0	0.8	0.0
Time Period 3	1	17.5	10.8	18.3	14.5
	2	0.8	4.0	2.5	7.0
	3	17.5	8.7	20.8	10.0
	4	32.5	13.3	34.2	17.4
	5	30.0	12.0	22.5	18.1
	6	1.7	0.0	1.7	0.0
Time Period 4	1	16.7	12.3	29.2	15.3
	2	0.8	4.0	0.0	0.0
	3	11.7	11.4	11.7	17.9
	4	41.7	13.5	40.0	20.1
	5	24.2	13.1	15.0	19.7
	6	5.0	0.0	4.2	0.0
Time Period 5	1	16.7	13.0	30.8	15.5
	2	0.0	0.0	0.0	0.0
	3	20.0	10.8	20.0	15.3
	4	22.5	11.7	20.8	17.6
	5	34.2	10.8	25.0	16.9
	6	6.7	0.0	3.3	0.0
Time Period 6	1	18.3	10.8	28.3	15.3
	2	1.7	6.0	2.5	6.0
	3	43.3	8.7	40.0	15.5
	4	6.7	9.5	10.0	14.3
	5	15.0	8.7	15.0	9.6
	6	15.0	0.0	4.2	0.0

TABLE 22

Wind Summary, July, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	13.7	9.7	27.1	11.2
	2	4.0	10.0	0.8	6.0
	3	43.6	6.3	45.9	12.5
	4	5.7	11.4	8.2	11.2
	5	12.9	9.2	13.9	13.2
	6	20.2	0.0	4.1	0.0
Time Period 2	1	15.3	10.2	18.5	12.8
	2	0.8	12.0	0.0	0.0
	3	54.9	6.8	46.0	12.3
	4	4.0	11.6	10.5	10.1
	5	8.9	9.8	16.9	12.2
	6	16.1	0.0	8.1	0.0
Time Period 3	1	21.8	9.9	21.8	13.7
	2	1.6	5.0	0.0	0.0
	3	20.2	6.2	27.4	8.7
	4	23.4	8.1	18.6	10.0
	5	21.8	10.4	20.2	13.6
	6	11.3	0.0	12.1	0.0
Time Period 4	1	36.3	7.5	42.7	8.8
	2	2.4	4.7	0.0	0.0
	3	5.7	10.3	9.7	13.4
	4	28.2	10.5	27.4	15.6
	5	16.1	12.4	13.7	14.7
	6	9.7	0.0	6.5	0.0
Time Period 5	1	17.9	7.9	24.2	10.8
	2	4.1	5.0	8.1	6.9
	3	7.3	6.0	12.1	10.9
	4	30.9	9.7	27.4	12.7
	5	22.0	9.2	16.9	14.1
	6	17.9	0.0	11.3	0.0
Time Period 6	1	15.3	9.4	31.7	10.8
	2	1.6	10.0	4.1	12.0
	3	23.4	5.5	28.5	10.6
	4	15.3	7.6	16.3	9.6
	5	10.5	6.7	8.9	8.3
	6	33.9	0.0	10.6	0.0

TABLE 23

Wind Summary, August, 1961 by Period of Day

		32 foot level		256 foot level	
	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Frequency of Occurrence (percent)	Avg Speed (mph)
Time Period 1	1	17.9	11.1	22.3	11.2
	2	1.8	13.0	1.8	15.0
	3	47.3	7.7	50.0	13.4
	4	3.6	16.5	9.8	16.8
	5	9.8	10.4	11.6	16.8
	6	19.6	0.0	4.5	0.0
Time Period 2	1	20.5	10.4	22.3	11.6
	2	1.8	10.0	0.9	13.0
	3	55.4	8.1	51.8	13.1
	4	0.9	19.0	5.4	13.8
	5	8.4	6.2	14.3	12.1
	6	13.4	0.0	5.4	0.0
Time Period 3	1	33.9	9.5	26.8	12.3
	2	1.8	8.5	0.9	4.0
	3	27.7	8.4	33.0	10.9
	4	8.9	14.6	16.1	14.4
	5	20.5	9.8	16.1	10.7
	6	7.1	0.0	7.1	0.0
Time Period 4	1	57.1	9.4	55.0	10.8
	2	2.7	9.3	1.8	10.5
	3	5.4	12.5	6.3	15.1
	4	23.2	13.2	24.3	15.0
	5	6.3	11.3	9.9	14.7
	6	5.4	0.0	2.7	0.0
Time Period 5	1	42.9	10.8	42.0	13.1
	2	4.5	8.2	3.6	8.8
	3	10.7	9.7	10.7	17.5
	4	15.2	10.5	18.8	12.1
	5	14.3	11.4	16.1	13.6
	6	12.5	0.0	8.0	0.0
Time Period 6	1	28.2	13.1	30.9	15.0
	2	0.9	10.0	1.8	9.5
	3	37.3	7.3	40.0	12.4
	4	2.7	7.0	8.2	9.0
	5	9.1	7.1	11.8	14.7
	6	21.8	0.0	7.3	0.0

TABLE 24

WIND SUMMARY - Fall, 1961

32 foot level			256 foot level		
Wind Direction* (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Wind Direction* (number)	Frequency of Occurrence (percent)	Avg Speed (mph)
For Month of NOVEMBER, 1960					
1	19.4	18.8	1	28.6	21.0
2	1.3	11.6	2	1.0	11.9
3	39.4	11.8	3	42.6	17.5
4	8.8	22.3	4	16.5	23.2
5	6.9	18.2	5	9.9	18.6
6	2.9	--	6	1.4	--
No data	21.3**	--			

* See Table 13 for definition of terms.

** Pen failed on this recorder for 21.3 percent of month.

TABLE 25

WIND SUMMARY - Winter, 1960-1961

32 foot level			256 foot level		
Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)
For Month of DECEMBER, 1960					
1	42.1	18.9	1	37.2	19.9
2	6.6	15.6	2	5.6	15.9
3	31.5	12.4	3	30.8	19.1
4	12.4	27.8	4	17.3	25.9
5	6.9	21.5	5	7.1	24.7
6	0.5	--	6	0.3	--
			No data	1.7	
For Month of JANUARY, 1961					
1	41.9	16.5	1	35.0	18.5
2	2.6	9.4	2	2.6	11.0
3	36.0	8.4	3	30.4	14.8
4	8.9	17.7	4	15.6	18.8
5	7.1	14.0	5	13.6	12.2
6	3.5	--	6	2.8	--
For Month of FEBRUARY, 1961					
1	17.3	14.4	1	17.4	12.7
2	1.2	10.8	2	5.5	12.7
3	38.7	8.5	3	32.1	14.0
4	11.2	12.8	4	12.9	17.2
5	24.7	12.6	5	26.6	13.8
6	6.9	--	6	5.5	--
Summary for WINTER, 1960-1961					
1	33.8	17.2	1	29.8	18.1
2	3.4	14.0	2	4.5	13.9
3	35.6	9.6	3	31.0	16.0
4	10.7	17.1	4	15.3	20.9
5	12.9	14.3	5	15.9	14.9
6	3.6	--	6	3.5	--

TABLE 26

WIND SUMMARY - Spring, 1961

32 foot level			256 foot level		
Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)
For Month of MARCH, 1961					
1	33.7	15.3	1	34.7	17.7
2	4.6	12.6	2	9.0	14.4
3	30.2	10.1	3	25.0	17.0
4	5.6	16.9	4	5.5	17.1
5	23.0	14.4	5	23.0	16.4
6	2.9	--	6	2.8	--
For Month of APRIL, 1961					
1	32.1	13.1	1	41.7	14.8
2	4.2	10.6	2	7.5	14.5
3	19.9	8.3	3	19.4	13.6
4	16.0	9.3	4	9.2	11.9
5	19.4	13.6	5	19.9	16.8
6	8.4	--	6	2.3	--
For Month of MAY, 1961					
1	31.6	11.8	1	38.4	15.6
2	1.1	8.9	2	2.8	13.7
3	27.2	8.8	3	29.8	17.0
4	19.0	11.5	4	12.2	14.3
5	14.9	10.3	5	14.2	14.6
6	6.2	--	6	2.4	--
Summary for SPRING, 1961					
1	32.5	13.5	1	38.4	15.9
2	3.3	11.4	2	6.4	14.4
3	25.8	9.2	3	24.7	16.1
4	13.5	11.4	4	9.0	14.1
5	19.1	13.1	5	19.0	16.1
6	5.8	--	6	2.5	--

TABLE 27

WIND SUMMARY - Summer, 1961

32 foot level			256 foot level		
Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)	Wind Direction (number)	Frequency of Occurrence (percent)	Avg Speed (mph)
For Month of JUNE, 1961					
1	14.7	12.0	1	23.8	14.5
2	2.1	9.7	2	2.4	11.8
3	32.1	8.8	3	32.6	13.9
4	18.6	12.7	4	21.3	17.6
5	23.9	10.8	5	17.2	16.3
6	8.6	--	6	2.7	--
For Month of JULY, 1961					
1	20.0	8.8	1	27.6	11.0
2	2.4	7.3	2	2.2	8.4
3	25.8	6.5	3	28.1	11.5
4	17.9	9.4	4	18.0	12.1
5	15.3	9.8	5	15.1	12.9
6	18.6	-	6	9.0	--
For Month of AUGUST, 1961					
1	30.4	10.4	1	31.2	11.8
2	2.0	9.5	2	1.6	10.2
3	34.7	8.5	3	35.5	14.0
4	9.1	12.4	4	14.1	13.3
5	11.2	9.7	5	12.8	13.7
6	12.6	--	6	5.8	--
Summary for SUMMER, 1961					
1	21.7	10.3	1	27.5	12.3
2	2.2	8.7	2	2.1	10.2
3	30.9	8.1	3	32.1	13.2
4	15.2	11.3	4	17.8	14.6
5	16.8	10.3	5	15.0	14.4
6	13.2	--	6	5.5	--

TABLE 28

Occurrences of calm winds* at 32 ft level

November 1960 to August 1961

Month	% Calm	Length of Period in Hours													Longest Non-Calm Periods, Hr
		1	2	3	4	5	6	7	8	9	10	11	12	13	
Nov	3.6														152 92 91 67
Dec	0.4	1	1												419 247 71
Jan	3.5	5	6	3											138 122 98 80 78 74 65
Feb	6.8	4	6	6	3										203 127 74 64 62
Mar	2.7	5	4	1	1										175 121 113 95 81
Apr	8.2	15	6	2		1			1					1	105 72
May	6.1	13	4		1	1		1	1						210 66 63 63 60
Jun	8.6	18	10	4	3										92 73 70 62
Jly	18.2	23	13	3	7	5	1		1		1				66
Aug	11.8	12	11	3	2	1	2		1				1		100 89 73 71 70
Avg	7.0														

* Calm = wind speed less than 4 mph.

TABLE 29

Occurrences of calm winds* at 256 ft level

November 1960 to August 1961

Month	% Calm	Length of Period in Hours 1	2	3	4	5	6	7	8	9	Longest Non-Calm Periods				
Nov	1.2	3	3								199	180	119	104	Hr
Dec	0.3		1								408	320			
Jan	2.6	4	2	1	2						267	123	79	89	
Feb	4.9	2	4	3		1				1	219	94	81		
Mar	2.7	3	2	3	1						177	128	117	113	110
Apr	2.2	8	1	2							179	153	91	91	78
May	2.3	7		2	1						166	116	106	99	97
Jun	2.6	9	5								204	155	110		
Jly	8.7	15	6	10	2						118	113	72		
Aug	5.9	3	1	4	2	1	1		1		304	147			
Avg	3.3														

* Calm = wind speed less than 4 mph.

TABLE 30

Number of occurrences of calm conditions (less than 4 mph) at 32 ft level for various hours of the day for each month, November 1960 to August 1961 inclusive

	Hour ending (local time)																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Nov	1	2	2	1		1	1	2	2	1							1	2	2	2				
Dec								1	1	1														
Jan	1			2	4	3						1				2	2	2	1	1	3	3		1
Feb	2	4	3	4	2	1	3	3	2	3	2	2		1	1	2	1		2	1	2	1	1	2
Mar	1			1	1	1	1			1	1						1	1	5	3	2	1		1
Apr	4	4	4	5	3	4	4	2	1	1	1	1	2	1	1	1	2	1	2	1	4	5	2	3
May	4	2	4	3	4	4	3		1	1		1	2			1	1		1	1	1	2	5	5
Jun	5	7	4	5	3		2	2	1			1			4	2	2	2	3	1	3	2	4	9
Jly	7	6	6	6	4	5	5	5	3	4	3	4	3	2	4	3	4	4	8	6	9	12	10	11
Aug	6	6	7	5	3	5	4	3	2	2	1	2	1	1	1	3	2	2	3	5	4	7	7	7
Totals	31	31	30	32	24	24	23	18	13	14	8	12	8	5	11	14	16	14	27	21	28	33	29	39
4-hr sums	124				89				47				38				78				129			

TABLE 31

Number of occurrences of calm conditions (less than 4 mph) at 256 ft level for various hours of the day for each month, November 1960 to August 1961 inclusive

	Hour ending (local time)																							
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Nov	1		1			1	1	1	1							1	1	1						
Dec									1	1														
Jan	1				2	2	1	1			1					2	3	2	1	1	1			
Feb	1	1	2	1	2	4	4	3	2	3	2		1		1	1	2	1					1	1
Mar		1	1	1	2	1				2	2	1			1		2	2	2	1	1			
Apr	1	1	1	1	1	3	1	2				1					2		1					
May				1			1	1	1	1	1						1	2	3	2	1		1	1
Jun	1			1	1						1	1	1		1	2		1	1	1	1	1	2	1
Jly	1	1	1	2	2	3	1	4	4	4	3	4	2	3	1	1	3	3	6	2	4	2	5	2
Aug	1	2	2	2	2	1	2	1	1	1	3	3	2			1	1	2	3	3	2	3	3	2
Totals	7	6	8	9	12	15	11	13	10	12	13	10	6	3	4	8	15	14	17	10	10	6	12	7
4-hr sums	30				51				45				21				56				35			

TABLE 32

Number of occurrences of wind at 32 ft blowing toward Charlevoix (030-050°)

November 1960 to August 1961

	Length of Period in Hours																			
Month	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Nov		1		1																	
Dec	1	2		1				1													1
Jan	1	2	3																		
Feb	3																				
Mar	7		1		1																
Apr	3	2	2																		
May	1																				
Jun	3	1	1																		
Jly	2		1																		
Aug	1		1																		

TABLE 33

Number of occurrences of wind at 32 ft blowing toward Harbor Springs-Petoskey (240-270°)

November 1960 to August 1961

	Length of Period in Hours																
Month	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Nov	6	4	2	2				1		1							
Dec	3	2	4	2	2	2		1	1	1							
Jan	3	1		2		1		1	1								
Feb	2	2	3	2	2	2				1							
Mar		2	1		1												1
Apr	4	4	2	1	1	1	1	2			1	1		1			
May	5	6	3	3	3	2	2									1	
Jun	5	3	2	2	1		1	1	2	1	1	1					
Jly	6	7	4	2	1	1	1	3			1						
Aug	3	1	3		2	3											

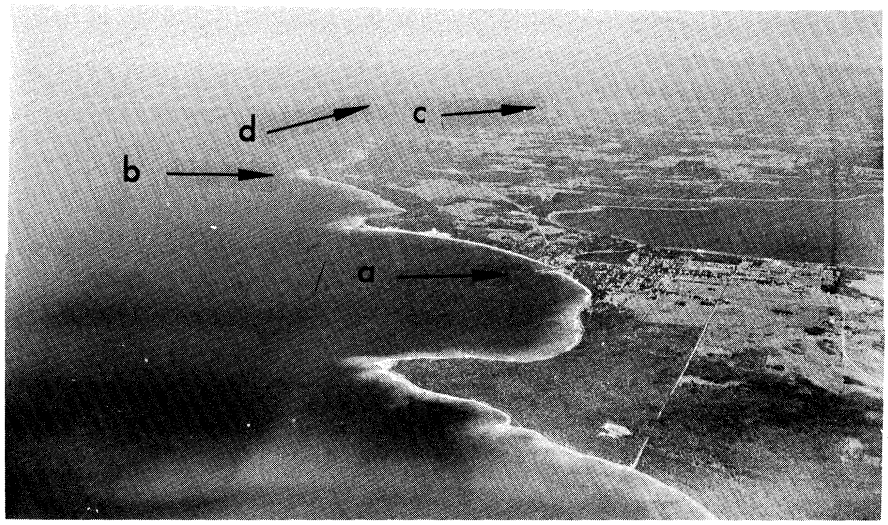


Fig. 1. Little Traverse Bay Area, looking toward the NE—as seen from about 5400 ft above lake level. (a) Charlevoix, (b) Big Rock Point Plant, (c) Petoskey, (d) Harbor Springs.

Fig. 2. Big Rock Point Nuclear Plant Site—looking almost vertically downward from 7400 ft above lake level. (a) Plant, (b) Tower, (c) Pole.

NOTE: (1) generally wooded area about plant; (2) removal of trees along a NE-SW line 250 ft to the SE of tower.

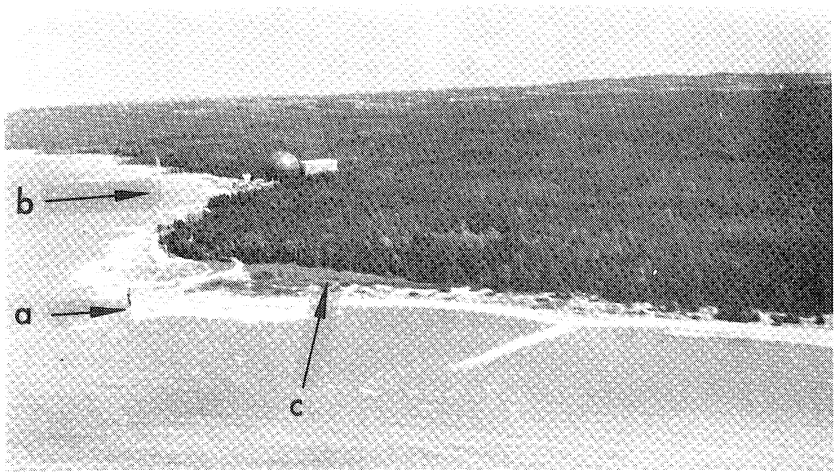


Fig. 3. Big Rock Point Nuclear Plant Site—looking toward the NE; from about 400 ft above lake level. (a) 65 ft pole next waters edge, (b) 250 ft tower, (c) cut back of trees.

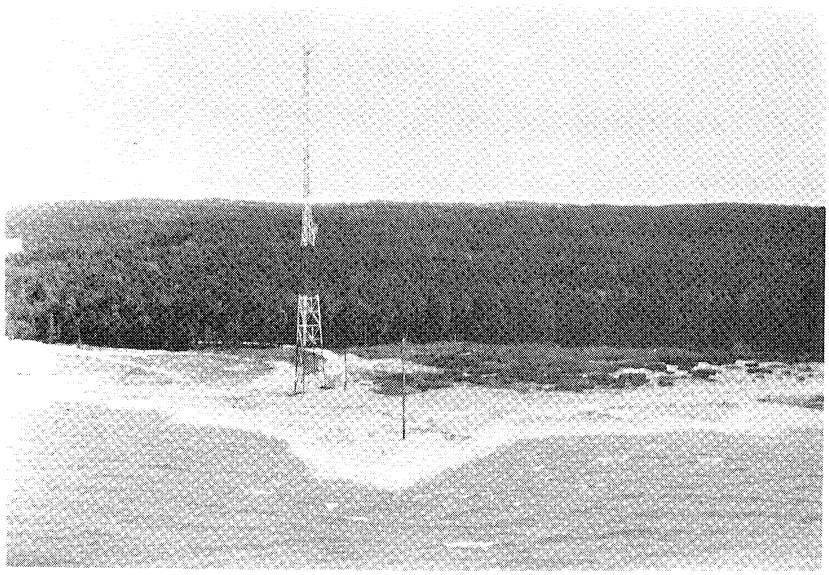
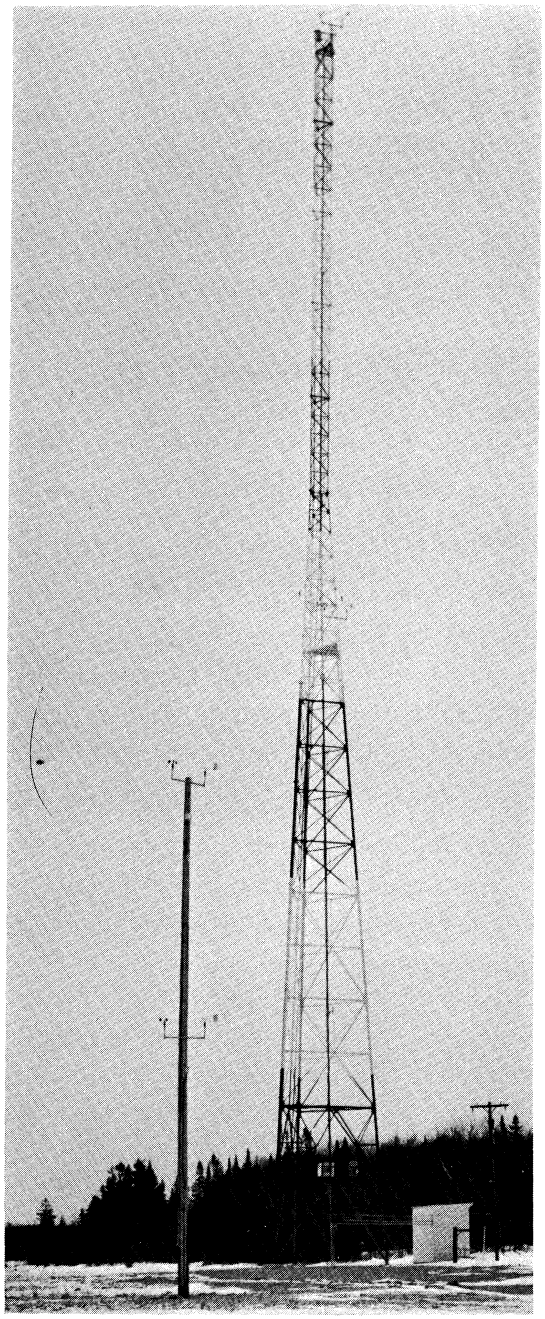
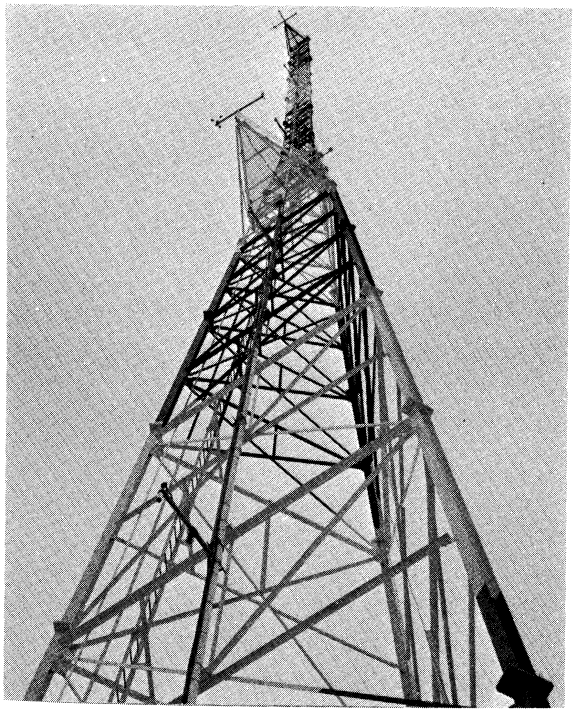


Fig. 4. Meteorological Tower and pole—looking toward SE, from about 150 ft above lake level. Wind instruments on pole at 32 and 64 ft above lake level; on tower at 128 and 256 ft above lake level. Instrument hut to right of tower base.





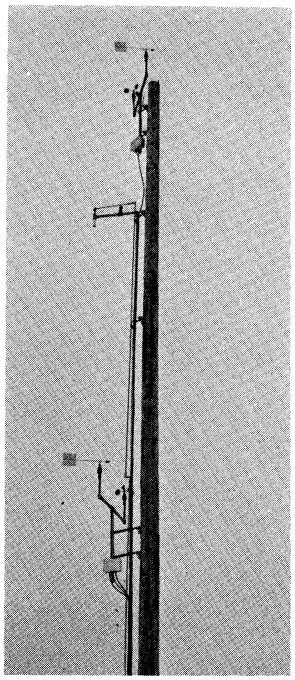


Fig. 5. Meteorological Tower and Pole.

NOTE: Wind vanes and cup anemometers at 32 and 64 ft levels on pole; at 128 and 256 ft levels on tower; artificially ventilated temperature thermojunctions at 50 ft on pole (10 ft level not shown); at 10, 50, 100, 150, 200, and 250 ft levels on tower. All sensors to west side of pole and tower.

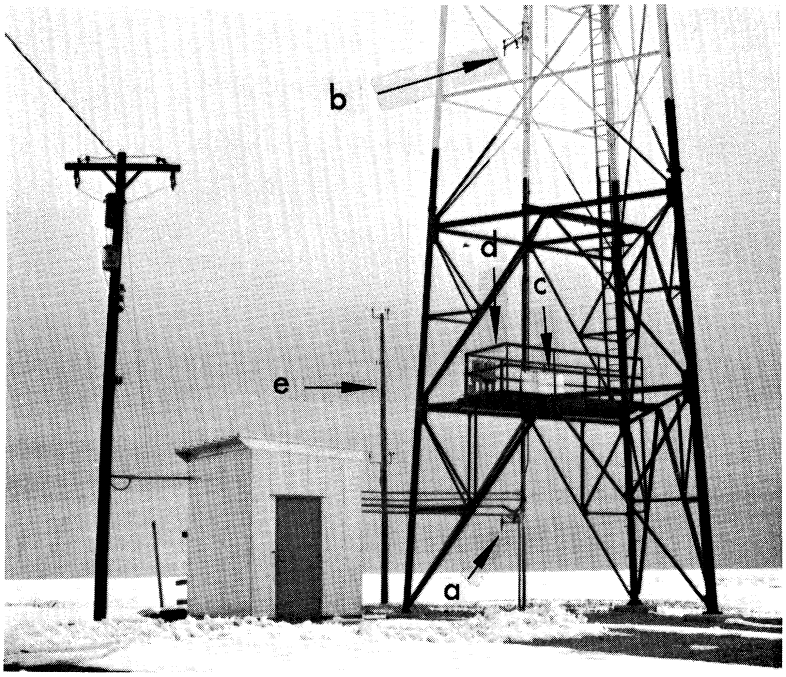


Fig. 6. Base of tower and instrument hut. (a) Ventilated temperature thermojunction 10 ft above lake level, (b) ventilated temperature thermojunction 50 ft above lake level, (c) housing over exhauster that ventilates all thermojunctions, (d) sampler for obtaining background radiation, (e) instrumented pole in background.

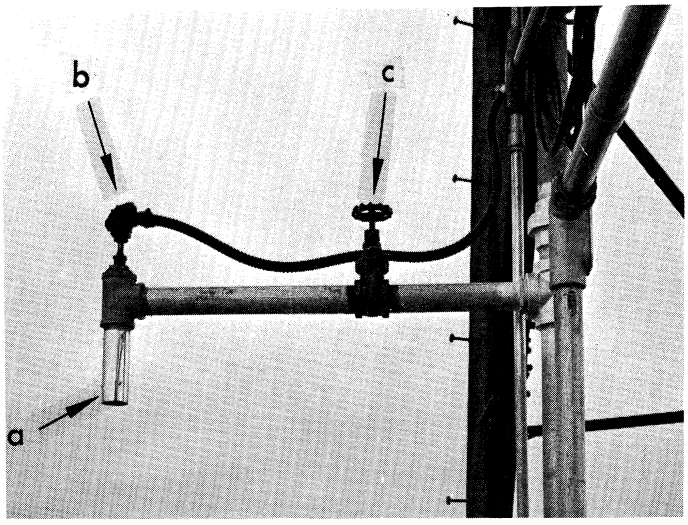


Fig. 7. Close-up of artificially ventilated thermojunction at 50 ft level. (a) Two concentric chromium plated radiation shields through which air is drawn over thermojunction (b), (c) gate valve for regulating ventilation rate.

Fig. 8. Wind speed and wind direction recording panel. Four dual channel Esterline Angus recorders record wind speed and direction at each of four levels, 32, 64, 128, and 256 ft above lake level.

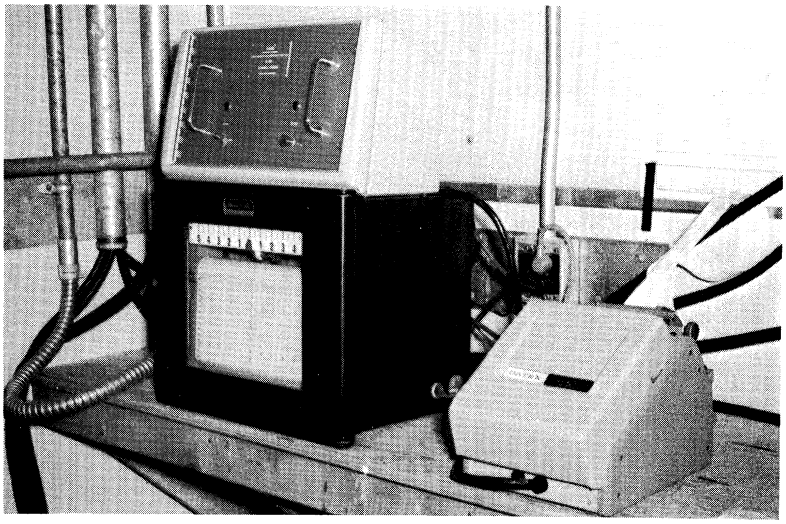


Fig. 9. Temperature-lapse rate recorders. Lower left—Minneapolis-Honeywell 12 point potentiometer recorder; upper left and lower right—Giannini-Datex-Monroe data encoder and print out system.

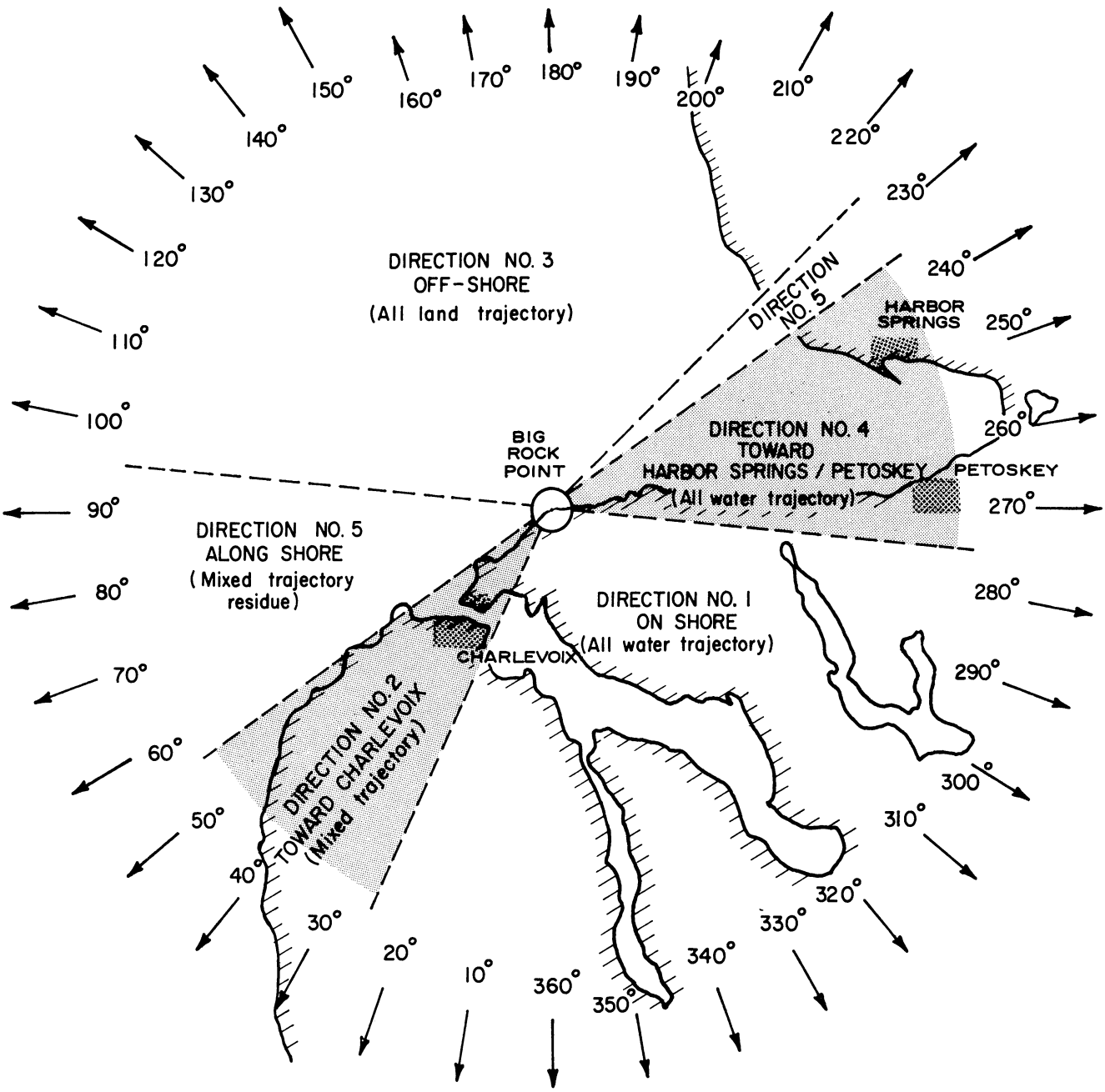


Fig. 10. Wind direction categories of special interest at the Big Rock Point Site.

NOTE: Arrows and numbers around periphery indicate direction from which wind is blowing. (See Table XIII.)

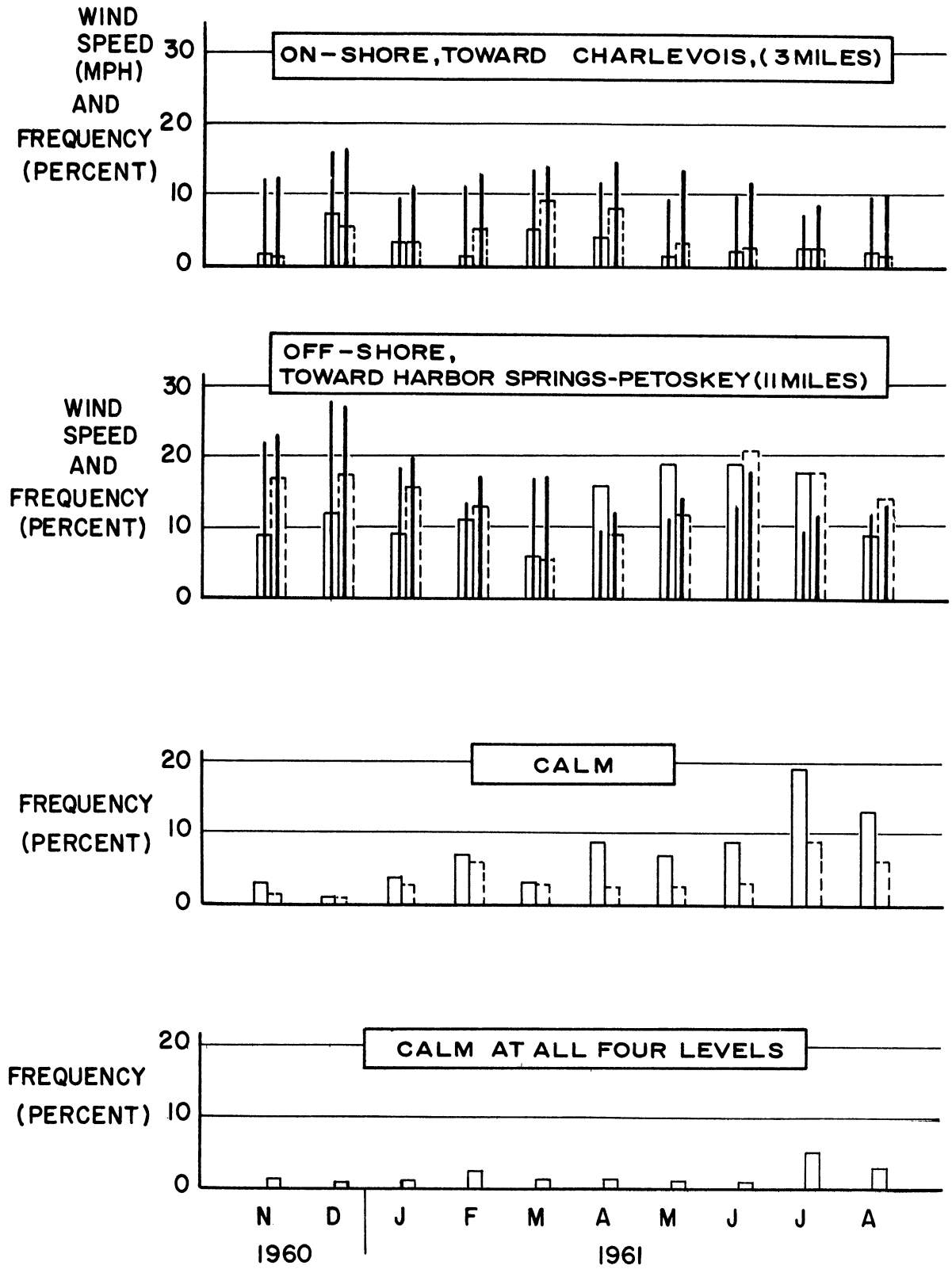


Fig. 11. Percentage frequency of occurrence of wind from specified directions (rectangles) and corresponding wind speed in mph (heavy lines) for various

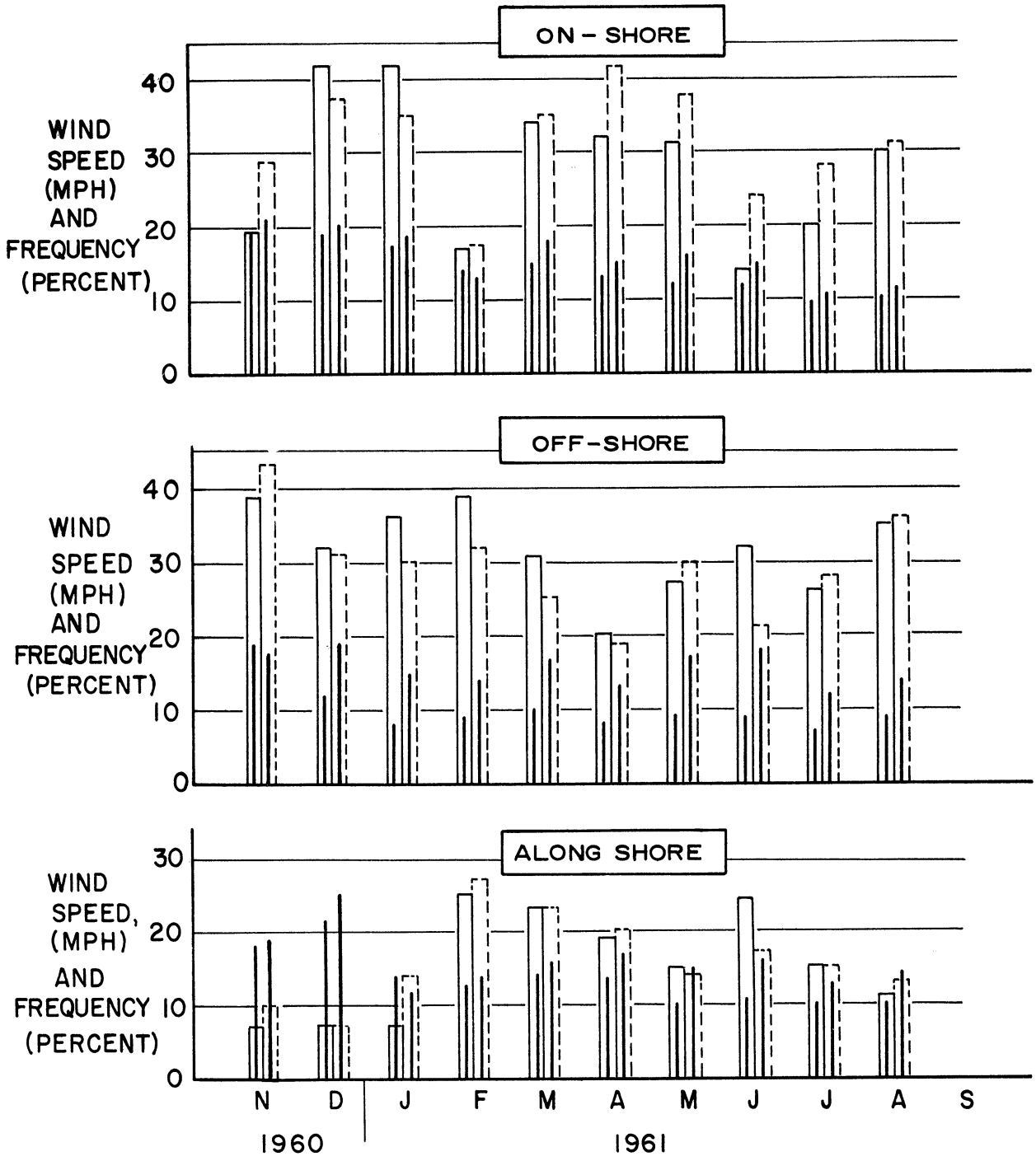


Fig. 12. Percentage frequency of occurrence of wind from specified directions (rectangles) and corresponding wind speed in mph (heavy lines) for various months of year. Data on left of each pair are for 32 ft level on tower; on right are for 256 ft level. (See Fig. 10 for direction categories.)

Fig. 13. Two plumes from tower; lower at 64 ft level, upper at 250 ft level. Note good horizontal diffusion of both plumes, but in different directions.

Time of picture: 0615, July 19, 1961
Altitude of camera: 4000 ft above lake
Air temperature conditions at tower: Isothermal lapse rate
Wind conditions at tower:

	64 ft level	256 ft level
Direction	80°	140°
Speed	4 mph	8 mph
$(V_{max} - V_{min})$	1 mph	2 mph

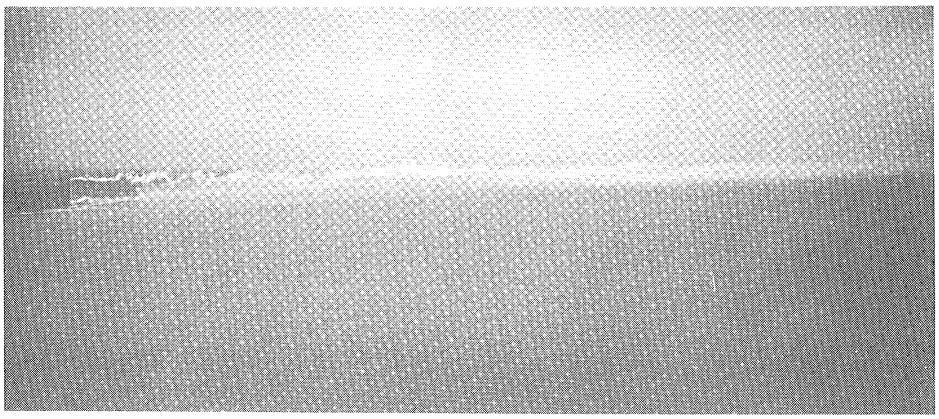


Fig. 14. Side view of fanning plumes over lake, taken at approximately same time as Fig. 13. Picture shows restricted diffusion in vertical direction.

Time of picture: 0620, July 19, 1961
Altitude of camera: 250 ft above lake
Atmospheric and wind conditions: same as in Fig. 13.

Fig. 15. Side view of plume traveling over land. Picture shows little diffusion close to source but a rapid breaking up of the plume as it encounters mechanical turbulence caused by wind traveling over rough land surface.

Time of picture: 1607, July 18, 1961
Altitude of camera: 300 ft above lake
Air temperature conditions: Isothermal lapse rate up to about 300 ft
Wind conditions:

Direction	280°
Speed	4 mph
$(V_{max} - V_{min})$	1 mph

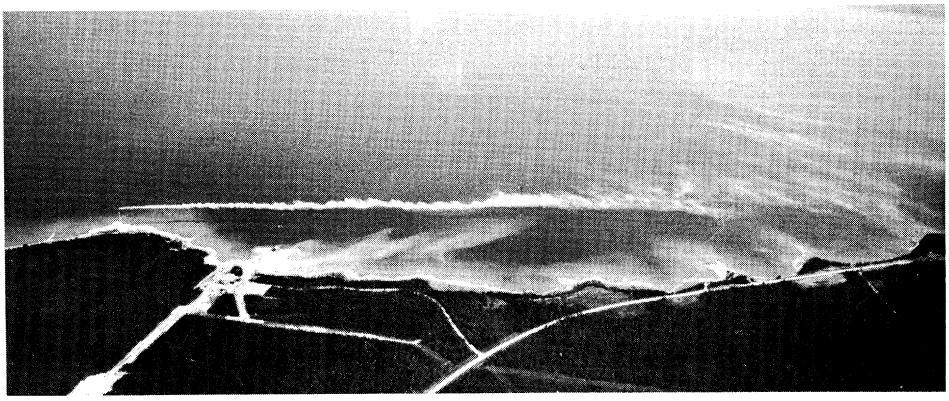


Fig. 16. Fanning plume traveling along shore line east of the Big Rock Point site. Picture shows little diffusion of the plume close to the source but a rapid horizontal diffusion as it encounters wind shear generated at the shore line.

Time of picture: 0915, July 15, 1961
Altitude of camera: 1400 ft above lake
Air temperature conditions: Isothermal lapse rate up to about 300 ft
Wind conditions:

Direction	250°
Speed	8 mph
$(V_{max} - V_{min})$	1-2 mph