

BILLINGS NWS AIRPORT

YELLOWSTONE COUNTY

The Billings airport is located on the rimrocks in Billings, at 45 48 00 N and 108 31 48 W (Site No. 139 on Map II-1). Elevation at the airport is 3,582 feet. The Yellowstone River Valley, which is about 400-500 feet deep, lies immediately south of the airport. Elsewhere in the area the land consists of rolling plains. The Bull Mountains, which rise to about 4,700 feet, are located about 30 miles to the north. The Pryor Mountains, with summits of nearly 9,000 feet, lie about 30 miles to the south. About 50 miles to the southwest are the Beartooth Mountains, which rise to over 12,000 feet.

Although most of the land in the area is privately owned, sections owned by the state and the federal governments are scattered throughout the area. The Crow Indian Reservation lies nearby to the south and southeast.

Electrical power in the area is provided by the Montana Power Company, Montana-Dakota Utilities, and the Yellowstone Valley Electric Cooperative. Many transmission lines cross the area.

Billings is the major communications and commercial center in the region. The Billings airport is an important air transportation center.

Meteorological data have been collected at this site for many years by the National Weather Service. These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in reporting interval, the data set was broken into three sections for analysis: January 1, 1948, through June 25, 1958; June 26, 1958, through December 31, 1964; and January 1, 1965, through December 31, 1978. Data from the most recent period only were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Billings consists of summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 7.6 meters. The site is representative of a large area of south-central Montana.

Average annual wind speed at the airport was 11.4 miles per hour. Average monthly wind speeds ranged from 9.6 miles per hour in July to 13.4 miles per hour in January.

Average annual wind power was 130.0 watts/m². Average monthly wind power varied from 69.0 watts/m² in August to 211.0 watts/m² in January.

Average seasonal wind speeds were 9.9 miles per hour in summer, 11.3 miles per hour in autumn, 11.4 miles per hour in spring, and 13.2 miles per hour in winter. The highest average wind speeds occurred in mid-afternoon in autumn and winter, and in mid to late afternoon in spring and summer. The lowest average wind speeds occurred around midnight in spring and summer, and during late evening in autumn and winter. The diurnal range of average wind speeds was greatest in summer and least in winter.

The most common wind directions were southwest through west-southwest. Winds from the east-southeast through south-southeast were least common. By direction, average wind speeds varied from 7.2 miles per hour for winds from the south-southeast to 14.3 miles per hour for winds from the west-southwest through west-northwest.

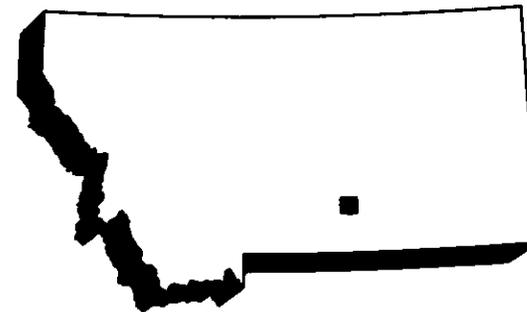


Table IV - 167

Monthly Wind Speed Distribution

YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT

01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	1.7	1.6	1.6	1.2	1.3	1.8	2.0	1.1	1.0	1.2	1.4	1.6	1.5	CALM (<0.5)
1.1- 3.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.5- 1.4
3.4- 5.4	6.6	6.1	7.1	5.8	6.3	7.0	7.2	6.7	6.3	6.2	7.3	6.5	6.6	1.5- 2.4
S 5.6- 7.6	11.2	11.9	15.8	15.6	16.8	18.7	21.1	22.1	18.8	15.3	14.6	10.9	16.1	2.5- 3.4
P 7.8- 9.8	13.9	14.8	18.2	21.6	22.3	25.1	28.7	28.9	24.2	20.0	17.1	13.6	20.7	3.5- 4.4
E 10.1-12.1	11.9	13.2	15.5	17.3	18.0	19.1	18.4	18.8	18.5	16.8	14.8	13.5	16.3	4.5- 5.4
E 12.3-14.3	11.4	12.2	12.6	12.1	12.6	12.3	10.2	11.1	13.0	14.1	13.8	13.5	12.4	5.5- 6.4
D 14.5-16.6	11.3	11.7	10.7	9.9	9.6	7.3	6.5	5.8	9.0	10.9	10.0	11.3	9.5	6.5- 7.4
M 16.8-18.8	13.0	12.0	8.5	8.0	6.6	4.6	3.5	3.1	5.2	8.2	10.3	11.5	7.9	7.5- 8.4
L 19.0-21.0	8.4	7.8	4.9	3.6	3.3	1.9	1.2	1.2	2.2	3.9	5.5	8.2	4.3	8.5- 9.4
I 21.3-23.3	5.7	4.9	2.7	2.1	1.8	1.2	0.6	0.6	1.2	1.8	3.1	5.4	2.6	9.5-10.4
E 23.5-25.5	2.0	1.3	0.9	1.0	0.6	0.5	0.2	0.2	0.3	0.6	0.8	1.9	0.9	10.5-11.4
S 25.7-27.7	1.5	0.8	0.6	0.6	0.2	0.2	0.1	0.1	0.1	0.4	0.7	1.2	0.5	11.5-12.4
/ 28.0-30.0	0.9	0.8	0.6	0.4	0.2	0.3	0.2	0.1	0.2	0.3	0.4	0.5	0.4	12.5-13.4
H 30.2-32.2	0.2	0.4	0.2	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	13.5-14.4
O 32.4-34.4	0.2	0.2	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	14.5-15.4
U 34.7-36.7	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4
R 36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	17.5-18.4
41.4-43.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE														
SPEED (MPH)	13.4	13.0	11.6	11.6	11.0	10.3	9.6	9.8	10.5	11.4	12.1	13.2	11.4	
AVERAGE														
SPEED (M/SEC)	6.0	5.8	5.2	5.2	4.9	4.6	4.3	4.4	4.7	5.1	5.4	5.9	5.1	
AVERAGE														
WIND POWER	211.0	194.0	140.0	134.0	109.0	86.0	70.0	69.0	90.0	120.0	147.0	194.0	130.0	
(WATTS/M**2)														

ANEMOMETER HEIGHT = 25.0 FEET = 7.6 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 168
Percentage Frequency Summary for Wind Speed
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (WINTER)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV	AV
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	SPEED	SPEED
																		(MPH)	(M/SEC)
H	3	1.6	0.2	7.1	10.7	15.6	12.6	13.6	10.5	12.5	7.0	5.1	1.5	1.1	0.7	0.2	0.2	13.0	5.8
	6	1.4	0.0	6.9	9.9	14.8	13.3	12.8	12.3	13.2	7.3	4.3	1.5	1.5	0.6	0.2	0.1	13.1	5.9
O	9	2.2	0.1	6.2	9.8	12.9	13.0	12.1	12.6	13.2	8.3	6.4	1.1	0.6	0.9	0.4	0.2	13.4	6.0
	12	1.6	0.3	5.8	9.3	12.6	12.8	12.6	10.9	10.8	10.5	7.1	1.8	2.4	0.8	0.4	0.4	14.0	6.3
U	15	1.1	0.1	5.9	10.4	12.8	11.3	11.4	11.5	13.7	9.3	6.0	3.0	1.5	0.7	0.5	0.7	14.1	6.3
	18	1.4	0.0	6.0	13.3	15.2	13.1	12.3	10.6	12.0	7.8	4.5	1.8	0.7	0.4	0.3	0.6	13.0	5.8
R	21	2.1	0.0	6.2	14.2	14.9	12.9	12.0	11.6	11.0	7.3	5.3	1.0	0.6	0.6	0.1	0.1	12.6	5.6
	24	1.7	0.0	7.1	13.0	13.6	13.8	12.3	11.1	10.9	7.4	4.2	2.1	1.0	1.1	0.1	0.3	12.9	5.8
ALL HOURS		1.6	0.1	6.4	11.3	14.1	12.9	12.4	11.4	12.2	8.1	5.3	1.7	1.2	0.7	0.3	0.3	13.2	5.9

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 169
Percentage Frequency Summary for Wind Speed
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (SPRING)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV SPEED (MPH)	AV SPEED (M/SEC)
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	AV SPEED (MPH)	AV SPEED (M/SEC)
H	3	2.2	0.1	7.8	16.9	23.2	17.1	11.4	10.1	6.2	2.8	1.5	0.1	0.1	0.4	0.1	0.0	10.7	4.8
	6	1.8	0.1	7.6	16.5	21.4	18.8	13.8	8.6	5.6	3.4	1.5	0.3	0.1	0.3	0.1	0.1	10.8	4.8
O	9	1.5	0.0	7.4	16.1	19.0	19.0	12.1	10.3	7.5	4.1	1.6	0.5	0.3	0.2	0.2	0.1	11.3	5.0
	12	1.1	0.0	6.9	16.5	19.2	13.6	10.6	10.5	9.2	5.3	3.2	1.9	0.6	0.5	0.2	0.5	12.1	5.4
U	15	0.5	0.1	4.7	13.3	16.1	14.5	15.6	12.4	9.6	5.0	4.0	1.6	0.9	0.9	0.4	0.5	12.9	5.8
	18	0.5	0.2	3.2	10.9	18.0	17.9	14.2	12.1	11.7	4.9	3.1	1.5	0.8	0.5	0.1	0.5	12.9	5.8
R	21	1.6	0.0	6.0	17.8	25.6	17.8	10.6	7.9	5.9	3.4	1.8	0.5	0.6	0.1	0.1	0.1	10.7	4.8
	24	1.9	0.1	7.7	20.4	23.2	16.7	11.2	8.6	5.9	2.6	0.9	0.3	0.2	0.2	0.1	0.0	10.4	4.6
ALL HOURS		1.4	0.1	6.4	16.1	20.7	16.9	12.4	10.1	7.7	3.9	2.2	0.8	0.5	0.4	0.2	0.2	11.4	5.1

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 170
Percentage Frequency Summary for Wind Speed
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (SUMMER)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV	AV
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	SPEED	SPEED
																		(MPH)	(M/SEC)
H	3	3.0	0.0	8.3	24.2	26.6	19.4	10.9	4.7	1.7	0.7	0.4	0.0	0.0	0.1	0.0	0.0	9.1	4.1
	6	2.1	0.0	8.2	19.6	29.0	18.8	13.8	5.7	1.9	0.6	0.1	0.1	0.1	0.0	0.0	0.0	9.5	4.2
O	9	2.0	0.0	7.3	19.4	31.1	19.3	10.2	6.4	2.6	1.0	0.2	0.1	0.1	0.2	0.0	0.0	9.5	4.3
	12	1.2	0.0	7.0	22.1	28.5	18.0	9.2	7.0	4.3	1.7	0.9	0.1	0.0	0.1	0.1	0.0	9.8	4.4
U	15	0.8	0.0	6.3	18.5	24.9	18.4	12.1	8.4	5.7	2.3	1.1	1.0	0.5	0.1	0.0	0.1	10.7	4.8
	18	0.6	0.0	4.4	14.7	20.6	19.5	15.4	10.3	7.6	2.8	2.5	0.4	0.4	0.6	0.0	0.3	11.7	5.2
R	21	1.8	0.0	6.0	20.6	29.7	19.0	9.6	6.2	3.7	1.2	0.8	0.6	0.1	0.4	0.0	0.1	9.9	4.4
	24	1.6	0.1	8.4	26.2	30.3	17.6	8.2	3.4	2.2	1.0	0.5	0.3	0.1	0.1	0.0	0.1	9.0	4.0
ALL HOURS		1.6	0.0	7.0	20.7	27.6	18.8	11.2	6.5	3.7	1.4	0.8	0.3	0.1	0.2	0.0	0.1	9.9	4.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 171
Percentage Frequency Summary for Wind Speed
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT (AUTUMN)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV SPEED (MPH)	AV SPEED (M/SEC)
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	AV SPEED (MPH)	AV SPEED (M/SEC)
H	3	1.6	0.0	6.5	15.6	21.6	18.6	14.4	9.6	7.5	2.0	1.4	0.4	0.1	0.6	0.1	0.0	11.0	4.9
	6	1.2	0.0	5.3	14.3	19.7	18.7	16.1	11.4	7.4	3.8	1.3	0.3	0.3	0.2	0.0	0.1	11.3	5.1
O	9	1.0	0.1	6.6	13.7	19.9	16.6	17.5	10.1	7.8	3.6	2.4	0.5	0.2	0.0	0.0	0.1	11.4	5.1
	12	0.8	0.1	7.4	14.0	18.7	15.5	13.6	9.2	10.5	5.0	2.9	0.7	0.9	0.5	0.2	0.1	11.9	5.3
U	15	0.6	0.1	6.4	14.8	16.8	13.7	12.3	13.2	9.7	6.1	3.0	1.3	1.3	0.6	0.2	0.3	12.5	5.6
	18	1.2	0.0	6.5	15.2	22.7	17.2	12.6	10.7	6.8	4.0	1.8	0.6	0.1	0.3	0.1	0.2	11.3	5.0
R	21	1.5	0.0	7.1	22.2	23.1	15.4	10.3	7.8	6.7	3.6	1.4	0.5	0.2	0.1	0.1	0.0	10.5	4.7
	24	1.8	0.0	7.1	19.9	20.8	17.9	12.2	7.9	6.7	3.2	1.9	0.3	0.1	0.2	0.0	0.1	10.6	4.7
ALL HOURS		1.2	0.0	6.6	16.2	20.4	16.7	13.6	10.0	7.9	3.9	2.0	0.6	0.4	0.3	0.1	0.1	11.3	5.1

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 172

Annual Wind Rose Distribution
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT

01/01/65 - 12/31/78

DIRECTION>		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION		
SPEED (MPH)																			SPEED (M/SEC)		
	1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4	
	3.4- 5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5- 2.4	
S	5.6- 7.6	0.9	0.6	0.6	0.5	0.4	0.2	0.3	0.3	0.6	0.4	0.4	0.3	0.2	0.2	0.3	0.4	6.6	2.5- 3.4	S	
	7.8- 9.8	1.9	1.2	1.2	1.0	0.8	0.5	0.6	0.8	1.6	1.3	1.6	1.0	0.5	0.5	0.6	0.8	15.9	3.5- 4.4		
P	10.1-12.1	1.9	1.5	1.7	1.1	0.9	0.5	0.5	0.5	1.4	2.1	3.4	1.9	0.7	0.7	0.9	0.8	20.5	4.5- 5.4	P	
	12.3-14.3	1.2	1.0	1.4	0.8	0.6	0.4	0.2	0.2	0.4	1.4	3.7	2.3	0.7	0.9	0.8	0.6	16.6	5.5- 6.4		
E	14.5-16.6	0.7	0.6	0.9	0.5	0.2	0.2	0.1	0.0	0.1	0.6	3.1	2.6	0.7	0.7	0.8	0.5	12.3	6.5- 7.4	E	
	16.8-18.8	0.5	0.5	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.2	2.2	2.3	0.7	0.7	0.8	0.4	9.3	7.5- 8.4		
D	19.0-21.0	0.4	0.2	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.1	1.5	2.4	0.6	0.7	0.8	0.4	7.7	8.5- 9.4	D	
	21.3-23.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.3	0.4	0.4	0.5	0.2	4.0	9.5-10.4		
M	23.5-25.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8	0.4	0.3	0.3	0.1	2.6	10.5-11.4	M	
	25.7-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.6	11.5-12.4		
S	28.0-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.6	12.5-13.4	S	
	30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.4	13.5-14.4		
/	32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5-15.4	/
	34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5-16.4	
H	36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4	H
	39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4	
U	41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4	U
	43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4	
R	45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4	R
	57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4	
	68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
	79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
	>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
	CALM																		1.5	CALM	
	TOTAL	7.9	5.8	7.0	4.3	3.3	1.9	1.8	1.8	4.2	6.0	17.3	15.6	5.2	5.5	6.4	4.5	100.0	TOTAL		
	AV SPD (MPH)	9.8	10.1	10.3	9.2	8.7	9.2	8.1	7.2	7.6	9.4	12.5	14.3	14.3	14.3	14.1	11.9	10.7	AV SPD (MPH)		
	AV SPD (M/S)	4.4	4.5	4.6	4.1	3.9	4.1	3.6	3.2	3.4	4.2	5.6	6.4	6.4	6.4	6.3	5.3	4.8	AV SPD (M/S)		

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Figure IV - 19
Annual Wind Rose
BILLINGS NWS AIRPORT — YELLOWSTONE COUNTY
(1965 - 1978)

KEY

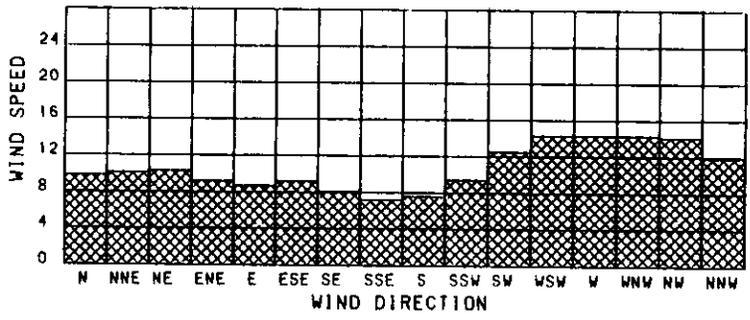
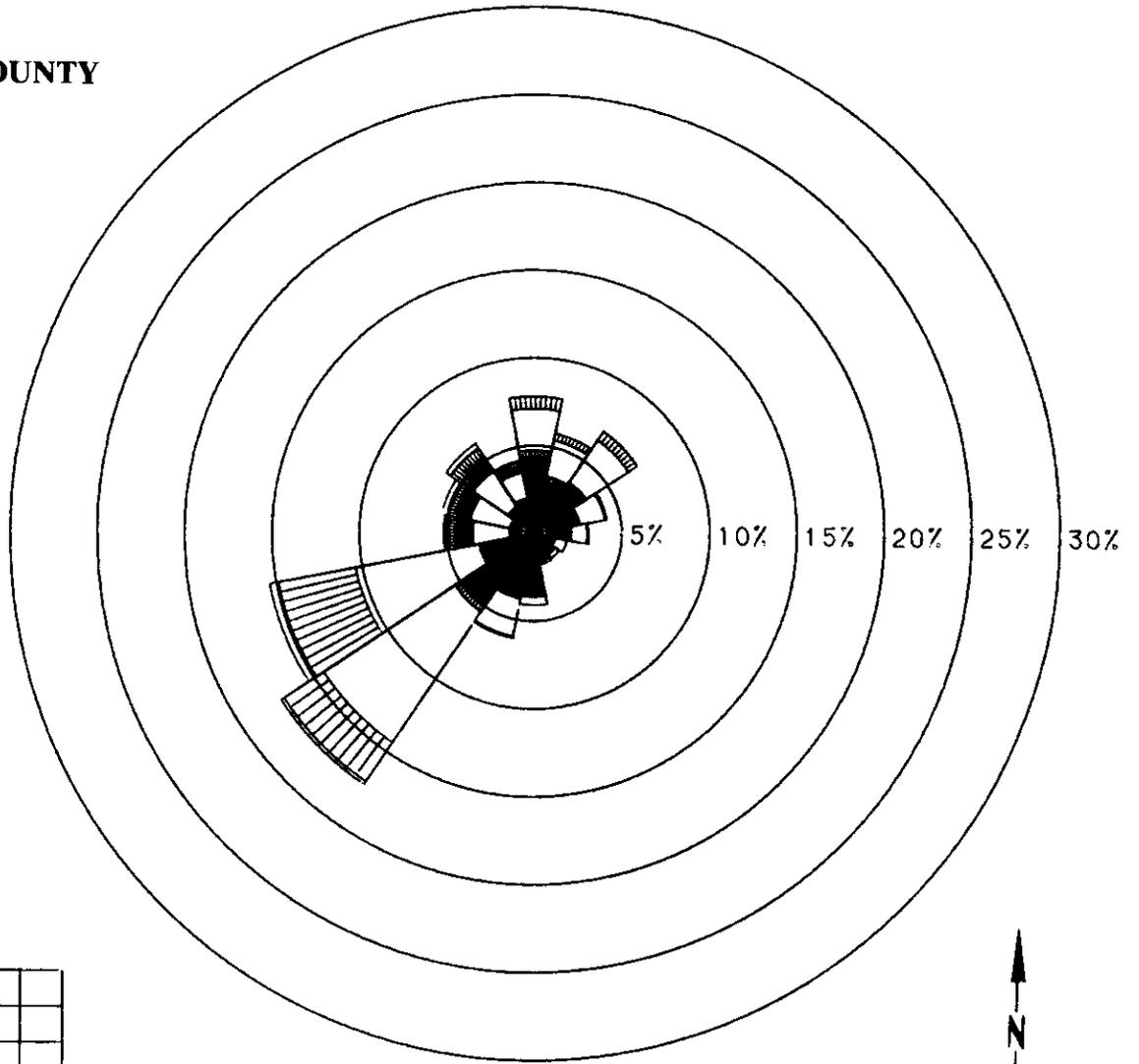
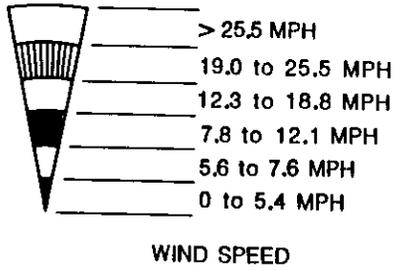


Table IV - 173
Coefficients of Weibull Distribution
YELLOWSTONE COUNTY - BILLINGS NWS AIRPORT
01/01/65 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.7220	2.9830
FEBRUARY	7.3980	3.1830
MARCH	6.8560	3.2820
APRIL	7.5060	2.7540
MAY	6.0330	2.4200
JUNE	5.6440	2.5900
JULY	5.4440	2.3910
AUGUST	5.4340	2.4310
SEPTEMBER	5.8100	2.4890
OCTOBER	6.1670	2.5460
NOVEMBER	6.8720	3.3120
DECEMBER	7.5440	3.0810
YEAR	6.1590	2.4710

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

CUSTER FAA AIRPORT

YELLOWSTONE COUNTY

The Custer airport is located about 1 mile northeast of Custer at 46 09 00 N and 107 31 00 W (Site No. 142 on Map II-1). Elevation at the airport site is 2,880 feet. Meteorological data were collected at this site for a short time in the late 1940s and early 1950s by the Federal Aviation Administration.

These data, collected primarily for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of a change in anemometer height, the data set was broken into two parts for analysis: January 1, 1948, through May 31, 1949; and June 1, 1949, through May 30, 1950. Only data from the latter of the two periods were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Custer consists of summaries derived from hourly observations made from June 1, 1949, through May 30, 1950. The anemometer was mounted on a rooftop at a height of 10.1 meters.

Average monthly wind speeds at the site varied from 7.6 miles per hour in August to 10.5 miles per hour in April. Average annual wind speed was 8.7 miles per hour.

Average monthly wind power ranged from 49.0 watts/m² in August to 137.0 watts/m² in April. Average annual wind power was 79.0 watts/m².

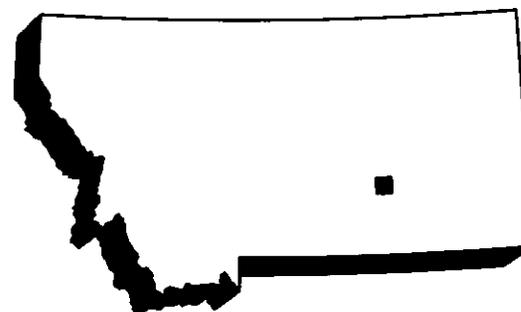


Table IV - 174
Monthly Wind Speed Distribution
YELLOWSTONE COUNTY - CUSTER FAA AIRPORT
06/01/49 - 05/30/50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	5.5	7.3	4.3	4.0	2.7	1.7	3.2	3.5	5.3	2.7	1.8	3.9	3.9	CALM (<0.5)
1.1- 3.1	9.0	7.5	8.6	5.7	7.1	7.6	8.7	9.0	9.6	5.2	6.1	7.4	7.7	0.5- 1.4
3.4- 5.4	21.4	23.7	18.8	16.5	22.0	24.9	25.4	25.6	25.4	20.3	23.6	20.8	22.4	1.5- 2.4
5.6- 7.6	13.2	15.8	13.0	11.1	12.5	13.2	16.7	19.1	18.6	12.6	19.6	16.0	15.2	2.5- 3.4
7.8- 9.8	12.2	12.7	9.9	14.7	10.1	14.7	15.9	17.0	10.7	13.4	13.7	15.1	13.5	3.5- 4.4
10.1-12.1	25.1	20.0	23.9	20.1	24.6	19.3	16.8	15.7	15.0	20.0	14.6	20.4	19.4	4.5- 5.4
12.3-14.3	5.9	4.9	7.3	3.5	8.3	4.9	3.1	2.0	4.4	6.0	3.7	4.6	4.7	5.5- 6.4
14.5-16.6	4.4	5.1	5.8	5.1	5.6	5.0	3.4	3.0	4.0	5.8	4.7	4.3	4.6	6.5- 7.4
16.8-18.8	2.6	1.9	4.3	7.6	3.6	4.5	2.4	2.2	3.1	5.8	3.9	2.3	3.7	7.5- 8.4
19.0-21.0	0.4	0.6	1.9	5.8	2.1	2.5	2.0	1.7	1.8	4.6	2.6	3.0	2.4	8.5- 9.4
21.3-23.3	0.3	0.3	0.8	1.9	1.5	0.8	0.3	0.1	0.6	0.9	1.2	0.8	0.8	9.5-10.4
23.5-25.5	0.0	0.0	0.3	1.2	0.0	0.3	1.1	0.4	0.7	1.2	1.1	0.7	0.6	10.5-11.4
25.7-27.7	0.0	0.1	0.4	0.8	0.0	0.3	0.1	0.4	0.6	0.4	1.2	0.5	0.4	11.5-12.4
28.0-30.0	0.0	0.0	0.1	0.8	0.0	0.1	0.9	0.3	0.3	0.4	0.6	0.3	0.3	12.5-13.4
30.2-32.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.1	13.5-14.4
32.4-34.4	0.0	0.1	0.4	0.6	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	14.5-15.4
34.7-36.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	15.5-16.4
36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	16.5-17.4
39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	17.5-18.4
41.4-43.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	18.5-19.4
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE SPEED (MPH)	8.1	7.8	9.2	10.5	8.9	8.7	8.1	7.6	7.8	9.8	9.4	8.7	8.7	
AVERAGE SPEED (M/SEC)	3.6	3.5	4.1	4.7	4.0	3.9	3.6	3.4	3.5	4.4	4.2	3.9	3.9	
AVERAGE WIND POWER (WATTS/M**2)	53.0	52.0	87.0	137.0	68.0	70.0	63.0	49.0	62.0	108.0	125.0	74.0	79.0	

ANEMOMETER HEIGHT = 33.0 FEET = 10.1 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

LAUREL NEW FARM

YELLOWSTONE COUNTY

The Laurel New Farm site is located about 2 miles east of Laurel at 45 40 07 N and 108 44 25 W (Site No. 145 on Map II-1). Elevation at the site is 3,270 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of particulates and sulfur dioxide.

Wind data collected during the period from November 13, 1980, through May 17, 1982, were available for analysis. The data set contains hourly averages of wind speed and wind direction recorded by a data acquisition system that scanned each parameter several times per minute. The measurement device was a Climatronics electronic anemometer and wind vane on a 10-meter tower.

Winds were monitored long enough to adequately represent the wind resource at the location. Because the site sits on a level valley floor, the data are representative of the immediate area only. Data recovery ranged from 25.7 percent in August to 99.8 percent in February and April. Overall data recovery was 81.9 percent.

Average annual wind speed at the site was 7.8 miles per hour. Average monthly wind speeds ranged from 4.3 miles per hour in August to 9.5 miles per hour in February.

Average annual wind power was 63.6 watts/m². Average monthly wind power values ranged from 8.6 watts/m² in September to 96.0 watts/m² in February.

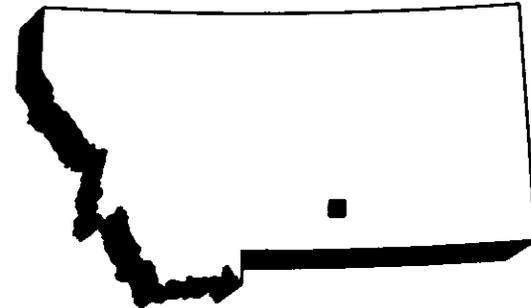


Table IV - 175
 Monthly Wind Speed Distribution
YELLOWSTONE COUNTY - LAUREL NEW FARM
 11/13/80 - 05/17/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR			
	CALM	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.5	0.4	2.4	0.1	2.5	0.6	CALM	
	0.1-1.0	1.8	0.9	1.1	0.5	0.9	0.3	0.3	2.6	1.6	1.4	1.5	4.7	1.6	0.1-	0.4
	1.1-2.0	6.3	2.8	4.9	2.6	6.5	4.5	3.9	15.7	9.7	7.3	4.0	4.9	5.1	0.5-	0.9
S	2.1-3.0	9.3	7.5	11.7	7.7	11.9	10.7	15.5	17.3	23.1	13.5	11.3	8.6	10.8	1.0-	1.3
P	3.1-4.0	8.1	7.0	11.3	8.1	8.7	11.0	16.5	15.2	20.5	10.5	7.0	7.6	9.5	1.4-	1.8
E	4.1-5.0	7.8	7.6	11.2	10.2	12.3	14.6	16.5	19.4	12.1	12.0	7.2	7.6	10.1	1.9-	2.2
E	5.1-6.0	6.0	6.0	7.3	8.5	10.2	6.9	12.4	6.8	9.7	6.5	5.7	4.8	7.2	2.3-	2.7
D	6.1-7.0	9.2	7.2	7.7	8.6	10.4	7.2	10.3	7.3	8.3	9.9	9.0	6.1	8.3	2.8-	3.1
	7.1-8.0	6.6	5.3	5.7	6.4	5.5	6.0	5.2	3.7	4.4	4.9	6.5	4.9	5.6	3.2-	3.6
M	8.1-9.0	7.2	7.2	8.3	6.5	6.6	5.4	4.9	4.2	4.8	7.8	7.0	6.6	6.8	3.7-	4.0
I	9.1-10.0	5.9	5.1	4.2	5.6	4.5	3.9	2.3	3.7	2.4	3.2	5.1	5.3	4.7	4.1-	4.5
L	10.1-11.0	4.9	7.0	6.2	5.3	4.5	4.5	2.8	1.6	1.6	4.1	5.3	5.7	5.1	4.6-	4.9
E	11.1-12.0	4.0	4.4	4.1	4.2	3.4	3.9	2.3	0.5	0.6	3.2	3.3	4.2	3.7	5.0-	5.4
S	12.1-13.0	4.4	6.3	3.9	3.7	2.6	4.8	2.3	1.0	0.4	1.7	6.0	4.1	3.9	5.5-	5.8
/	13.1-14.0	4.1	4.0	2.7	3.3	2.3	3.3	1.3	0.0	0.2	3.6	3.6	5.1	3.3	5.9-	6.3
H	14.1-15.0	4.1	5.1	2.2	4.7	2.4	2.4	1.6	0.0	0.2	1.8	4.3	4.5	3.4	6.4-	6.7
O	15.1-16.0	2.6	3.5	1.9	2.9	1.4	2.4	0.5	0.0	0.0	1.5	2.1	2.4	2.2	6.8-	7.2
U	16.1-17.0	1.7	2.6	0.8	2.5	1.5	1.2	0.5	0.0	0.0	1.2	2.3	2.6	1.8	7.3-	7.6
R	17.1-18.0	1.9	2.8	0.7	2.2	0.7	1.8	0.5	0.0	0.0	1.4	2.1	2.6	1.7	7.7-	8.0
	18.1-19.0	1.0	1.9	0.6	1.7	0.4	0.9	0.3	0.5	0.0	1.1	1.9	1.3	1.1	8.1-	8.5
	19.1-20.0	1.3	1.9	0.8	1.5	0.6	1.8	0.0	0.0	0.0	0.6	1.2	1.4	1.1	8.6-	8.9
	20.1-25.0	1.7	3.0	1.1	2.0	2.4	2.7	0.0	0.0	0.0	0.5	3.3	1.8	1.8	9.0-	11.2
	25.1-30.0	0.1	1.0	1.3	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.6	11.3-	13.4
	30.1-35.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	13.5-	15.6
	35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-	17.9
	>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9	
	AVERAGE															
	SPEED (MPH)	8.1	9.5	7.6	8.8	7.1	7.8	5.7	4.3	4.4	6.5	8.6	8.3	7.8		
	AVERAGE															
	SPEED (M/SEC)	3.6	4.2	3.4	3.9	3.2	3.5	2.5	1.9	1.9	2.9	3.8	3.7	3.5		
	AVERAGE															
	WIND POWER															
	(WATTS/M**2)	64.6	96.0	66.2	81.2	47.9	59.3	20.4	9.9	8.6	37.9	75.5	79.4	63.6		
	PERCENT DATA															
	RECOVERY	76.2	99.8	95.8	99.8	88.6	46.5	52.0	25.7	69.9	88.4	79.3	99.7	81.9		

ANEMOMETER HEIGHT = 10 METERS = 33 FEET
 NUMBER OF OBSERVATIONS = 10830
 PERCENTAGE DATA RECOVERY = 81.9

SOURCE: GEORESEARCH, INC.

SHAWNEE PARK

YELLOWSTONE COUNTY

The Shawnee Park air monitoring site is located in a residential area approximately 6 miles northeast of downtown Billings at 45 49 28 N and 108 23 56 W (Site No. 149 on Map II-1) near the intersection of Interstate 94 and Interstate 90. Elevation at the park is 3,123 feet. The site was established by the Montana Air Quality Bureau to measure concentrations of ozone and sulfur dioxide in the area.

Wind data have been collected at the site since January 22, 1981. Data through April 30, 1982, were available for analysis. The data set contains hourly averages for wind speed and direction manually reduced from strip-chart records. The wind measuring instrument was a Meteorology Research, Inc., mechanical recording anemometer and wind vane set on the monitoring trailer roof 4 meters above ground level.

Winds were monitored long enough to adequately represent the wind resource at the location. Data recovery was greater than 80 percent, except during March and from August through October. Overall data recovery was 74.2 percent. Since the site is located in a residential area on the Yellowstone Valley floor, the data are representative only of the immediate area.

Average annual wind speed was 5.9 miles per hour. Average monthly wind speeds varied from 4.5 miles per hour in August to 7.1 miles per hour in April.

Average monthly wind power ranged from 8.9 watts/m² in September to 45.4 watts/m² in April. Average annual wind power was 28.2 watts/m².

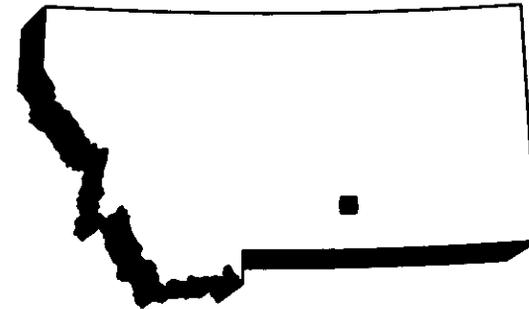


Table IV - 176
Monthly Wind Speed Distribution
YELLOWSTONE COUNTY - SHAWNEE PARK
01/22/81 - 04/30/82

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
	CALM	1.5	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	CALM	
	0.1-1.0	1.0	0.8	0.5	0.8	0.7	0.6	0.6	1.0	0.5	1.7	0.6	0.7	0.1- 0.4	
	1.1-2.0	10.0	6.3	8.1	5.9	7.8	6.8	5.4	11.7	6.8	8.7	11.0	7.8	0.5- 0.9	
S P E E D	2.1-3.0	14.4	10.7	19.9	11.3	13.7	12.0	14.0	17.9	11.8	20.3	16.4	20.8	14.4	1.0- 1.3
	3.1-4.0	11.6	11.7	14.4	10.1	14.8	14.0	21.3	15.1	22.7	13.0	15.3	16.5	13.8	1.4- 1.8
	4.1-5.0	10.4	11.1	10.4	9.3	15.1	12.9	12.3	16.1	17.7	12.1	14.4	12.7	12.1	1.9- 2.2
	5.1-6.0	10.8	8.7	9.2	11.1	9.9	12.8	11.9	11.4	15.5	8.2	15.3	10.8	11.1	2.3- 2.7
	6.1-7.0	9.8	10.6	9.3	8.0	9.1	9.0	7.9	8.9	8.2	10.8	9.3	6.5	9.0	2.8- 3.1
M I L E S / H O U R	7.1-8.0	5.4	7.9	5.9	6.9	7.3	6.4	8.6	6.7	6.4	5.6	5.7	7.1	6.8	3.2- 3.6
	8.1-9.0	3.9	7.5	4.7	5.8	5.9	6.1	6.5	4.0	4.5	4.3	1.9	3.0	5.1	3.7- 4.0
	9.1-10.0	3.4	3.9	3.3	5.7	3.4	4.0	3.6	3.5	3.2	4.3	2.9	2.0	3.8	4.1- 4.5
	10.1-11.0	3.6	3.2	3.6	4.6	3.0	3.3	2.5	2.0	1.8	2.6	1.7	2.5	3.1	4.6- 4.9
	11.1-12.0	3.0	2.9	1.4	3.4	2.2	3.1	1.5	0.2	0.0	1.7	1.1	2.2	2.3	5.0- 5.4
	12.1-13.0	2.9	2.8	1.7	3.6	1.3	1.8	0.8	1.0	0.5	1.3	1.1	1.6	2.1	5.5- 5.8
	13.1-14.0	2.3	2.4	1.7	2.8	1.1	1.1	1.0	0.0	0.5	2.2	1.5	1.2	1.7	5.9- 6.3
	14.1-15.0	1.6	2.7	1.4	2.2	1.3	2.2	0.6	0.0	0.0	0.9	0.8	1.4	1.6	6.4- 6.7
	15.1-16.0	1.7	1.6	0.7	2.0	0.7	1.1	0.2	0.2	0.0	1.3	0.6	0.9	1.1	6.8- 7.2
	16.1-17.0	0.9	0.9	0.5	2.2	0.8	1.4	0.2	0.2	0.0	0.0	0.3	0.9	1.0	7.3- 7.6
	17.1-18.0	0.8	1.3	0.9	0.8	0.9	0.7	0.2	0.0	0.0	0.9	0.0	0.4	0.7	7.7- 8.0
	18.1-19.0	0.5	1.5	0.2	1.0	0.8	0.1	0.6	0.0	0.0	0.0	0.1	0.4	0.6	8.1- 8.5
	19.1-20.0	0.1	0.5	0.5	0.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.4	8.6- 8.9
	20.1-25.0	0.3	0.5	1.7	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	9.0-11.2
	25.1-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	11.3-13.4
	30.1-35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5-15.6
	35.1-40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7-17.9
	>40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>17.9
AVERAGE															
SPEED (MPH)															
	5.8	6.7	5.7	7.1	5.7	6.0	5.2	4.5	4.7	5.2	4.8	5.2	5.9		
AVERAGE															
SPEED (M/SEC)															
	2.6	3.0	2.5	3.2	2.5	2.7	2.3	2.0	2.1	2.3	2.2	2.3	2.6		
AVERAGE															
WIND POWER															
(WATTS/M**2)															
	29.6	39.2	31.7	45.4	23.7	25.6	15.7	9.6	8.9	18.9	14.1	27.1	28.2		
PERCENT DATA															
RECOVERY															
	90.1	86.8	38.8	99.1	100.0	99.9	64.3	54.2	30.6	31.1	100.0	93.0	74.2		

ANEMOMETER HEIGHT = 4 METERS = 13 FEET
 NUMBER OF OBSERVATIONS = 8266
 PERCENTAGE DATA RECOVERY = 74.2

SOURCE: GEORESEARCH, INC.