

UNIVERSITY OF MINNESOTA
ST. ANTHONY FALLS LABORATORY
Engineering, Environmental and Geophysical Fluid Dynamics

Project Report No. 404

**Wind Energy Feasibility and Energy
Education Project
Lower Sioux Community**

by

Cesar Farell and Chris Ellis



Prepared for

OFFICE OF THE ENVIRONMENT
LOWER SIOUX COMMUNITY
Morton, Minnesota

July 24, 1997
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ABSTRACT

The results of wind speed and direction measurements carried out in the Lower Sioux Community during the twelve-month period from November 1, 1995, to October 31, 1996, are reported. The measurements were performed using six wind anemometers and six wind direction vanes installed at four sites in the community. The data presented include the monthly averages of the semi-hourly wind speeds and of their cubes, monthly wind roses, the probability distributions of the wind speeds and the parameters of Weibull distributions fitted to them, turbulence intensity data, and total energy roses for each month.

The data are presented so as to streamline a comparison with wind energy data at other area sites where comparable records may be available. Possible sites and methodology for such a comparison and errors which may arise in a potential extrapolation of the twelve-month record to longer time periods are discussed.

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1. INTRODUCTION

This report details the contribution of the St. Anthony Falls Laboratory (SAFL) to the Wind Energy Feasibility and Energy Education Project of the Lower Sioux Community, Morton, Minnesota. Specifically, the laboratory was charged with the collection of site-specific wind data for a period of one year, for eventual use in a cost analysis of wind energy production and turbine selection at the site. Original budget amounts had been provided by SAFL for an earlier 1994 Sioux Community proposal to the Department of Energy for a study involving three separate reservations. These amounts were reduced when the Lower Sioux application to EPA for the present single reservation study was submitted. While the approved budget was smaller than envisioned, it was still possible to install and operate six wind anemometers and six wind direction vanes at four sites in the community. This report summarizes the results of these measurements for the twelve-month period from November 1, 1995, to October 31, 1996. One anemometer and one wind direction vane were left installed for an additional six-month period until May 1997. The rental cost of these two units has been absorbed by the project, but data obtained during these additional months are not included in the report, except for one table.

The data are presented herein so as to streamline a comparison with wind energy data at other area sites where comparable records may be available, in particular from the Department of Public Service, State of Minnesota. Possible sites and methodology for such a comparison with a view to a potential extrapolation of the twelve-month record to longer time periods are discussed in the report.

2. SITE SELECTION

Four sites were selected as adequate locations for the wind measurement equipment after an initial visit to the Lower Sioux Community on August 18, 1995. Installation of the anemometers and direction vanes took place in October 1995 at the following locations:

Site 1, gravel pit:

Two anemometers and two wind direction vanes were installed at two heights on a 12 inch diameter pole supplied by Northern States Power, erected about 10 ft from the top of the gravel pit mound, on the northeast side of the mound. The NSP utility pole was 65 ft high and was buried 8 ft into the ground. One anemometer - wind direction set was placed on a mast attached to the top of the pole. The center plane of the anemometer cups and axis of the direction vane were 20.5 ft above the top of the mast. The measurement height above ground for this set was therefore 77.5 ft (23.62 m).

The second anemometer - wind direction set was placed with the axis of the vertical support pipe 6 ft to the south side of the utility pole. The measurement height above ground for this set was 32 ft (9.75 m).

Site 2, water plant:

Two anemometers and two wind direction vanes were installed at two heights on an NSP pole erected near the water plant. Elevations above ground for these two sets were the same as for the sets on the gravel pit utility pole: 77.5 ft (23.62 m) and 32 ft (9.75 m).

Site 3, hotel building:

One anemometer and one wind direction vane were installed on a mast placed on the north corner of the higher roof of the hotel (roof height 72 ft). While the preferred location was the southwest corner of this roof, the north corner location was chosen because of the convenience of placing the data logger down from the anemometer set on the lower roof level of the hotel (height 54 ft). The center plane of the anemometer cups and axis of the direction vane were 31 ft 4 in above the higher roof. The measurement height above ground for this set was therefore 103 ft 4 inch (31.50 m).

Site 4, water tower:

One anemometer and one wind direction vane were installed on a mast attached to the 3.5 ft railing around the top of the tower, with the center plane of the anemometer cups and axis of the direction vane 21 ft above the bottom of the railing. The height to the top center of the tower is 150 ft 1-1/4 in. The bottom of the railing is 8 inches below this height. The measurement height above ground for this set was, therefore, 170 ft 5 1/4 inch (51.95 m).

3. INSTRUMENTATION

The measurement of wind direction and speed was performed by six R. M. Young Model 03001-5 wind sentry sets furnished by Campbell Scientific. Each set consisted of one rotating cup anemometer generating a low level AC sine wave voltage signal with frequency directly proportional to wind speed, and one potentiometer-based wind vane. Data recording and logging was accomplished by four Campbell Scientific CR10 data loggers placed at each of the four measurement sites.

The frequency produced by the rotating cup anemometers was measured by the data loggers over a specified execution interval, selected as five seconds for the present measurements. The raw wind speed data consisted then of such five-second readings of anemometer output, denoted herein by U . At the water tower and hotel locations, the data loggers averaged the five-second anemometer readings U over fifteen-minute intervals and stored the mean \bar{U}_{15} and the standard deviation σ_{15} ($= \sqrt{u'^2}$, with $u' = U - \bar{U}$) of the fifteen-minute records. At this rate of data storage, the data loggers could run unattended for five to six weeks between data dumps. At the gravel pit and water plant locations, one data logger was used to service two anemometer sets, and averages \bar{U}_{30} and σ_{30} were obtained every thirty minutes to maintain the same five to six week unattended data logger run. The data loggers stored also the maximum of the five-second wind speed readings during each averaging period.

Starting in March 1996, the dataloggers were reprogrammed to calculate, in addition to the fifteen and thirty minute averages \bar{U}_{15} and \bar{U}_{30} , the average of the cube, $(U^3)_m$, of the five-second readings at each site over the same fifteen and thirty minute periods.

The output of the wind direction sensors was an analog DC voltage proportional to wind direction angle with a stable DC excitation voltage applied to the instrument potentiometer. The output of the direction sensors was read every five seconds by the dataloggers and the same fifteen or thirty minute averaging, depending on the site, was applied to these raw data to produce mean values Θ_{15} and Θ_{30} and the corresponding standard deviations.

The data was dumped manually within the five to six week unattended run time period by Office of the Environment personnel, who transferred the data to a computer and then transmitted it via the internet to SAFL for analysis. The thirty-minute wind speed averages \bar{U}_{30} at the six anemometer locations are given for each month from November 1995 to October 1996 in the figures in Appendix A. The corresponding maximum wind velocities for the thirty-minute periods are given in Appendix B.

4. METHODOLOGY FOR ANALYSIS OF WIND DATA

The wind speed and direction averages measured at the four sites over thirty-minute periods were used for the analysis of the wind records on a monthly and yearly basis. The thirty-minute averages \bar{U}_{30} and $\bar{\Theta}_{30}$ constituted the data for the monthly and yearly statistical analyses of results presented in Section 5.1. At the water tower and hotel locations, where the data loggers averaged the five-second anemometer readings over fifteen-minute intervals, the thirty-minute averages were obtained by averaging successive fifteen-minute mean and standard deviation values.

4.1 Selection of Averaging Time

The choice of the thirty minute averaging time was based on established practice and experience. As discussed in the Danish Wind Atlas (1981), a series of experiments carried out at an existing wind turbine using different averaging times T (Lundsager et al. 1979) showed that for values of T less than a minute considerable scatter resulted in the power curve $P(V)$ of the wind turbine, to the point that the curve could not be unequivocally determined from the data. On the other hand, too large a value of the averaging time may fail to reproduce with sufficient accuracy the variance and skewness of the wind distribution, leading to a possible underestimation of the potential for wind power production. While the optimum value of T , taking into account data storage, instrumentation and processing needs, is likely to be dependent on the intensity and scale of the wind turbulence at each site, it has been customary to adopt values of T between ten minutes and one hour.

Hourly averages have been used generally in analyses of wind power statistics (e.g. Salmon and Walmsley 1997; Tuller and Brett 1984; Hennessey 1977; Justus et al. 1976), although for wind turbines operating in complex terrain ten-minute averages may be preferable to obtain a more accurate prediction of turbine performance (e.g. Mouzakis et al. 1997). Hourly averages have been used in phase III of the Minnesota Wind Resource Assessment Program (1990, 1994) (obtained, incidentally, from two-second anemometer readings). In an earlier phase I of this program, average velocities over fifteen-minute intervals were recorded as part of the data collected by the Western Area Power Administration (Minnesota Wind Resource Assessment Program, June 1988). It should also be noted that the wind speed statistics calculated by the procedures outlined in the Danish Wind Atlas (1981) are considered to pertain to averages over T values between ten minutes and one hour.

4.2 Methodology for Analysis of Thirty-Minute Averages

For the analysis of the thirty-minute averages, Weibull distributions were used to represent the wind speed probability density functions, $f(V)$. The results are given in Section 5.1. For convenience, the symbol V has been used in the report to denote the thirty-minute averages \bar{U}_{30} ; for other averaging times, a subscript is used to denote the averaging time, e.g. \bar{U}_{15} denotes a fifteen-minute average of wind speed.

Wind speed probability density functions can be represented to an acceptable degree of approximation by Weibull distributions, as has been illustrated in a number of publications (Justus and Mikhail 1976; Hennessey 1977; Stewart and Essenwanger 1978). The wind conditions that favor the fitting of a Weibull distribution to wind speed data have been discussed by Tuller and Brett (1984), who have provided some theoretical justification for its use (or the use of variants thereof). The methodology of the Danish Wind Atlas (1981) to determine wind energy production is based entirely on the use of such distributions to represent wind conditions over classes of terrains with different roughness characteristics. A Weibull distribution is described by two parameters, a shape parameter C and a scaling parameter a . The cumulative distribution can be written as

$$F(V) = \int f(V) dV = 1 - \exp(-aV^C)$$

The probability density function $f(V)$ is given by

$$f(V) = aCV^{C-1} \exp(-aV^C)$$

The mean V_m and mean-square value $(V^2)_m$ of a Weibull distribution are given by the equations

$$(V)_m = A \Gamma(1+1/C), \quad (V^2)_m = A^2 \Gamma(1+2/C)$$

where Γ denotes the gamma function and the parameter $A = a^{(1/C)}$ has been introduced in place of the scaling parameter a , as done in the Danish Wind Atlas. The calculation of the parameters A and C for the measured wind distributions was carried out approximately by the so-called method of moments. From the preceding expressions for the mean and mean-square of a Weibull distribution, one obtains

$$(V_m)^2 / (V^2)_m = \Gamma^2(1+1/C) / \Gamma(1+2/C)$$

Using the measured V_m and $(V^2)_m$ values, this equation allows for the calculation of C, after which A can be obtained from the equation for the mean V_m .

4.3 Analysis of 5-Second Anemometer Readings

As described in Section 3, starting in March 1996, the dataloggers were reprogrammed to calculate also the average of the cube of the five-second readings at each site. Multiplied by $(1/2)\rho$, the U^3 averages give the mean energy flux per unit area or power density E_m over the averaging time interval,

$$E_m = (1/2) \rho (U^3)_m$$

The thirty-minute averages $(U^3)_{m,30}$ and the corresponding standard deviations σ_{30} of the five-second U readings were used to calculate the skewness β of the thirty-minute probability distributions using the equation

$$U^3_{m,30} = M^3 (1 + 3 (S/M)^2 + \sqrt{\beta} (S/M)^3)$$

The symbols $M = \bar{U}_{30}$ and $S = \sigma_{30}$ have been used for simplicity in this equation and also in Section 5.2, where the results of this analysis are presented.

5. PRESENTATION OF RESULTS

5.1 Analysis and Presentation of Thirty-Minute Averages

This section summarizes the data of direct interest to the cost analysis of wind energy production at the Lower Sioux Community site. In Appendix C, the monthly averages of the semi-hourly wind speeds $V = \bar{U}_{30}$ are presented as functions of time of day (48 averages per 24-hour period for each month from November 1995 to October 1996). The monthly averages of the cubes of the semi-hourly wind speeds are presented in Appendix D in the same fashion.

The wind roses in Appendix E show for each month the percentage of time the wind blows from a given direction. The roses have been constructed using 10-degree wind direction intervals, taking all thirty-minute average wind speeds $V = \bar{U}_{30}$ within each interval into account, regardless of the value of V .

In Appendix F the probability distributions of the average wind speeds V are presented for each anemometer location. For each month from November 1995 to October 1996, the probability distributions obtained from the measured V data using 1 m/s bins are given in tabular and graphical form together with the Weibull distributions fitted as described in Section 4.2. A separate sheet is provided for each month, containing six graphs, one for each location, and a twelve-column table showing the actual frequency values and the values of the fitted Weibull distributions. The values of the Weibull parameters C , A , and k for each distribution are given at the top of the table. In addition, the first sheet in the appendix contains the probability distributions of the V data for the entire year, presented in the same manner.

5.2 Results of Analysis of Five-Second Anemometer Readings

The methodology for analysis of the five-second anemometer readings was presented in Section 4.3. Table 1 shows the results of the calculations involving the skewness β of the thirty-minute probability distributions. The table presents monthly averages at the six anemometer locations of mean values $M = \bar{U}_{30}$, standard deviations $S = \sigma_{30}$, and the two terms $3(S/M)^2$ and $(\beta)^{1/2}(S/M)^3$ in the equation in Section 4.3. The table includes some results for a few months outside the period from November 1995 to October 1996.

In Appendix G, the directional contributions to the term $3(S/M)^2$, calculated by using 10-degree sectors to cover the directional rose, are given for the months of March

and June, 1996. These particular months were chosen due to the lower (March) and higher (June) relative turbulence intensities S/M. It should be noted that the averaged standard deviations were about the same for both months, the smaller March relative intensities resulting from higher mean velocities. In both cases, north and northeast directions were major contributors to the wind variance. This variance is due to contributions to the wind variability from atmospheric boundary layer turbulence, with periods between five seconds (the time period of the present anemometer readings) and thirty minutes. Because there is relatively little energy in atmospheric wind spectra for periods of the order of thirty minutes, there should be very little difference in the results of Section 5.1 if the measured fifteen-minute averages had been used instead of thirty-minute averages. In any case, the large intensities of the atmospheric boundary layer turbulence and their directional dependence should be noted. The extent of this relatively small scale wind velocity variability should be conveyed to the turbine manufacturers.

From the table, $\beta \approx 0$. Assuming $\beta = 0$, the thirty-minute U^3 averages for the months of October 1995 through February 1996, not available from the data loggers, were estimated. Using both the measured and estimated U^3 averages, a total energy rose was constructed by dividing the directional rose into 10 degree intervals and adding together all the U^3 contributions from each sector. This sum of sector contributions, multiplied by 1/2 hour (the time interval selected to obtain the averages), is presented in rose form in Appendix H for each of the twelve months. If multiplied by $(1/2)\rho$, the rose values in Appendix H would represent energy per unit area normal to the flow.

Table 1.

		M	S	$3(S/M)^2$	$\beta^5(S/M)^3$
		(m/s)	(m/s)		
October, 1995					
	Site 1, 24m	5.180	2.569	0.184	NA
	Site 1, 10m	4.192	2.311	0.275	NA
	Site 2, 24m	6.044	3.057	0.108	NA
	Site 2 10m	4.968	2.783	0.165	NA
	Site 3	4.426	2.189	0.110	NA
	Site 4	6.877	3.020	0.076	NA
November, 1995					
	Site 1, 24m	4.974	2.533	0.179	NA
	Site 1, 10m	4.104	2.320	0.246	NA
	Site 2, 24m	5.832	2.934	0.097	NA
	Site 2 10m	4.948	2.709	0.140	NA
	Site 3	5.643	2.899	0.103	NA
	Site 4	6.561	2.980	0.079	NA
December, 1995					
	Site 1, 24m	4.483	2.702	0.183	NA
	Site 1, 10m	3.693	2.553	0.273	NA
	Site 2, 24m	5.303	3.150	0.085	NA
	Site 2 10m	4.536	2.858	0.124	NA
	Site 3	6.989	3.234	0.073	NA
	Site 4	6.011	3.280	0.075	NA
January, 1996					
	Site 1, 24m	4.868	2.537	0.152	NA
	Site 1, 10m	4.007	2.280	0.241	NA
	Site 2, 24m	5.990	3.326	0.077	NA
	Site 2 10m	5.163	3.045	0.105	NA
	Site 3	5.765	2.578	0.088	NA
	Site 4	5.816	2.544	0.068	NA
February, 1996					
	Site 1, 24m	5.454	2.555	0.142	NA
	Site 1, 10m	4.456	2.430	0.211	NA
	Site 2, 24m	6.481	3.223	0.070	NA
	Site 2 10m	5.563	3.122	0.099	NA
	Site 3	6.685	3.320	0.092	NA
	Site 4	7.273	3.000	0.063	NA
March, 1996					
	Site 1, 24m	5.099	2.140	0.157	0.002
	Site 1, 10m	3.948	1.932	0.263	0.020
	Site 2, 24m	6.057	2.637	0.075	0.002
	Site 2 10m	5.164	2.542	0.100	0.003
	Site 3	5.780	2.514	0.089	0.017
	Site 4	6.801	2.594	0.071	0.012
April, 1996					
	Site 1, 24m	4.848	2.432	0.214	0.005
	Site 1, 10m	3.682	2.279	0.351	0.028
	Site 2, 24m	5.820	2.819	0.112	0.003
	Site 2 10m	4.939	2.591	0.151	0.011
	Site 3	5.423	2.710	0.126	0.028
	Site 4	6.471	2.877	0.098	0.021

Table 1.

May, 1996					
	Site 1, 24m	4.354	2.069	0.229	0.009
	Site 1, 10m	3.449	1.939	0.337	0.027
	Site 2, 24m	5.386	2.429	0.129	0.003
	Site 2 10m	4.506	2.220	0.184	0.010
	Site 3	4.959	2.361	0.140	0.032
	Site 4	5.896	2.481	0.105	0.025
June, 1996					
	Site 1, 24m	4.070	2.272	0.287	0.020
	Site 1, 10m	3.086	2.045	0.454	0.054
	Site 2, 24m	4.750	2.432	0.172	0.010
	Site 2 10m	3.798	2.206	0.279	0.029
	Site 3	4.651	2.657	0.160	0.050
	Site 4	5.523	2.649	0.125	0.041
July, 1996					
	Site 1, 24m	3.715	1.743	0.253	0.019
	Site 1, 10m	2.892	1.627	0.409	0.055
	Site 2, 24m	4.275	1.951	0.169	0.013
	Site 2 10m	3.353	1.825	0.276	0.029
	Site 3	4.229	1.986	0.148	0.056
	Site 4	5.047	2.031	0.106	0.040
August, 1996					
	Site 1, 24m	3.826	1.939	0.195	0.015
	Site 1, 10m	2.994	1.844	0.322	0.057
	Site 2, 24m	4.124	2.011	0.145	0.009
	Site 2 10m	2.883	1.762	0.325	0.042
	Site 3	4.428	2.311	0.120	0.055
	Site 4	5.254	2.203	0.077	0.028
September, 1996					
	Site 1, 24m	3.909	1.950	0.223	0.020
	Site 1, 10m	3.065	1.839	0.373	0.074
	Site 2, 24m	4.402	2.029	0.146	0.010
	Site 2 10m	3.216	1.751	0.325	0.052
	Site 3	4.408	2.186	0.138	0.049
	Site 4	5.374	2.267	0.097	0.036
October, 1996					
	Site 1, 24m	5.608	2.703	0.155	0.004
	Site 1, 10m	4.540	2.604	0.244	0.022
	Site 2, 24m	6.210	3.058	0.099	0.002
	Site 2 10m	4.921	2.942	0.182	0.018
	Site 3	5.970	2.758	0.089	0.020
	Site 4	7.320	2.997	0.071	0.015
November, 1996					
	Site 1, 24m	4.311	2.450	0.218	0.034
	Site 1, 10m	3.657	2.338	0.263	0.046
	Site 2, 24m	5.157	2.795	0.105	0.011
	Site 2 10m	4.433	2.604	0.140	0.011
	Site 3	NA	NA	NA	NA
	Site 4	5.582	2.696	0.075	0.047
December, 1996					
	Site 4	6.209	3.142	0.117	0.160
January, 1996					
	Site 4	7.433	3.596	0.143	0.273

6. COMPARISON WITH WIND DATA AT OTHER SITES

6.1 General Considerations

Two-site correlations between a candidate wind-turbine site (the target site) and a reference site have been used in some cases to extend in time relatively short-term records at the target site. Simultaneous data for the shorter time period are needed from both sites in order to use the long-term wind data at the reference site to extrapolate the target site data. Salmon and Walmsley (1997) and Mikitarenko et al. (1997) have recently examined this approach and tested possible correlation models.

In general, long-term wind estimates produced by extrapolation of data using correlation techniques must be viewed with caution, and some comments are in order. Firstly, short geographical distances between target and reference stations increase the likelihood that both stations are within the same air mass and have therefore similar atmospheric stability characteristics and correlated wind regimes. Distances used in recent data comparison are around 50 km to 80 kilometers (30 to 50 miles). Secondly, as shown by the data of Salmon and Walmsley (1997), even for geographically close target and reference stations, both wind rose and wind speed target station estimates may be subject to rather considerable errors. These errors may be reduced to some extent if a correlation model is used and if two years of short-term records are available at the target station. Thirdly, wind regimes result generally from a complex interaction between weather patterns and local topographic features, and topographic similarities between target and reference stations probably enhance the chances for a successful application of extrapolation techniques.

Incidentally, Salmon and Walmsley (1997) concluded from their data that a short-term record at a candidate wind turbine site must be at least one year long, preferably two if possible, and that monitoring periods between twelve and twenty-four months may produce worse estimates than twelve-month records, due to seasonal variations.

6.2. Department of Public Service Data Collection

Partial summaries of the wind data collected from 1984 to 1990 under the Wind Resource Assessment Program of the Department of Public Service (DPS) are given in a series of reports starting in 1986 and ending with Report 10, July - December 1990. A description of most of the sites where these data were collected, including location and physical and topographical characteristics broken down by eight compass directions, is given in a more recent DPS report dated May 1994, issued in conjunction with the start

of a new phase (phase IV) of the Wind Resource Assessment Program (WRAP). This latest report contains summaries of average monthly wind speeds for these sites for the years 1991 through 1993, in addition to the summaries of average monthly wind speeds for the earlier years from 1985 through 1990.

Taking into account location, topography, and the wind power density maps provided in the 1994 WRAP DPS report, wind data at the following sites were examined for possible comparison with the measurements at the Lower Sioux Community sites: Clements, St. James, Windom, Jackson, Madison Lake, Hamburg, and Granite Falls. However, as confirmed by Mr. Rory Artig, DPS engineer in charge of wind energy analysis, these data present shortcomings of one type or another, be it sheltering effects in certain directions, incomplete or interrupted data collection records, possible proprietary nature of the data obtained at some sites, and in one case lack of information on the actual site (Jackson, not included in the site descriptions given in the Appendix to the 1994 WRAP report). Of the seven sites listed, only Windom appears to be usable for comparison purposes. This site is however in an area with likely somewhat larger wind energy values than the Lower Sioux Community area, according to the energy estimates developed in the 1994 WRAP report.

A new phase IV of the wind resource assessment program was initiated in October 1993 by the Energy Technologies Group of the Department of Public Service. This new phase is using new sites and equipment. Data gathering at Windom is continuing, but not at the same site. The new site is in a high school inside the town and is fitted with a tip-up 30 m high tower with instrumentation at 10 m, 20 m, and 30 m heights. It began logging data in September 1995. The older data is in the form of 1 hour wind velocity averages and wind direction roses.

Data gathering at the Alberta and Rochester sites will continue in WRAP's phase IV. The main advantage of these two sites is the length of the wind data sets. The distance between each of these sites and the Lower Sioux Community site is however 100 miles or more, and this poses questions as to the feasibility of the correlation. Furthermore, the measurement height at the Rochester site is only 10 m. The old Alberta monitoring equipment was installed on a communication tower at 10 m and 30 m heights. The new equipment will be installed at these two heights and also at 50 m and 70 m, on a radio tower.

New radio tower setups with monitoring equipment at 30 m, 50 m, and 70 m have been operating since June 1995 at Brownton, Mountain Lake, and Montevideo under phase IV of the wind resource assessment program. The new site at Wabasso offers, however, the best possibility for data comparison with the Lower Sioux Community site, firstly because of the geographical proximity of the two sites and secondly because data collection has been proceeding at Wabasso since December 1994. The Wabasso equipment is installed on a stand-alone meteorological tower at three elevations: 10 m, 30 m, and 40 m. The raw wind speed data consist of two-second anemometer readings averaged over

ten-minute intervals. The wind direction is measured at two-second intervals.

6.3 Recommendation for Data Comparisons

The data in this report has been prepared so as to streamline a possible comparison with wind energy data at other area sites where comparable records may be available. In particular, Weibull probability distributions have been fitted to the data and the Weibull parameters a and C can be used in two-site correlation analyses. The difficulties inherent in this type of extrapolation techniques, however, as examined in Section 6.1, should be kept in mind. It is suggested that the Wabasso site offers the best possibility for comparison with the Lower Sioux site data, because of the proximity of the site and the fact that data collection has been proceeding at Wabasso since December 1994. The Windom site could also be examined, but the change in the location of the site under Phase IV of the wind resource assessment program of Minnesota's Department of Public Service and the appreciable distance from the Lower Sioux site may result in sizable errors in the extrapolated wind estimates.

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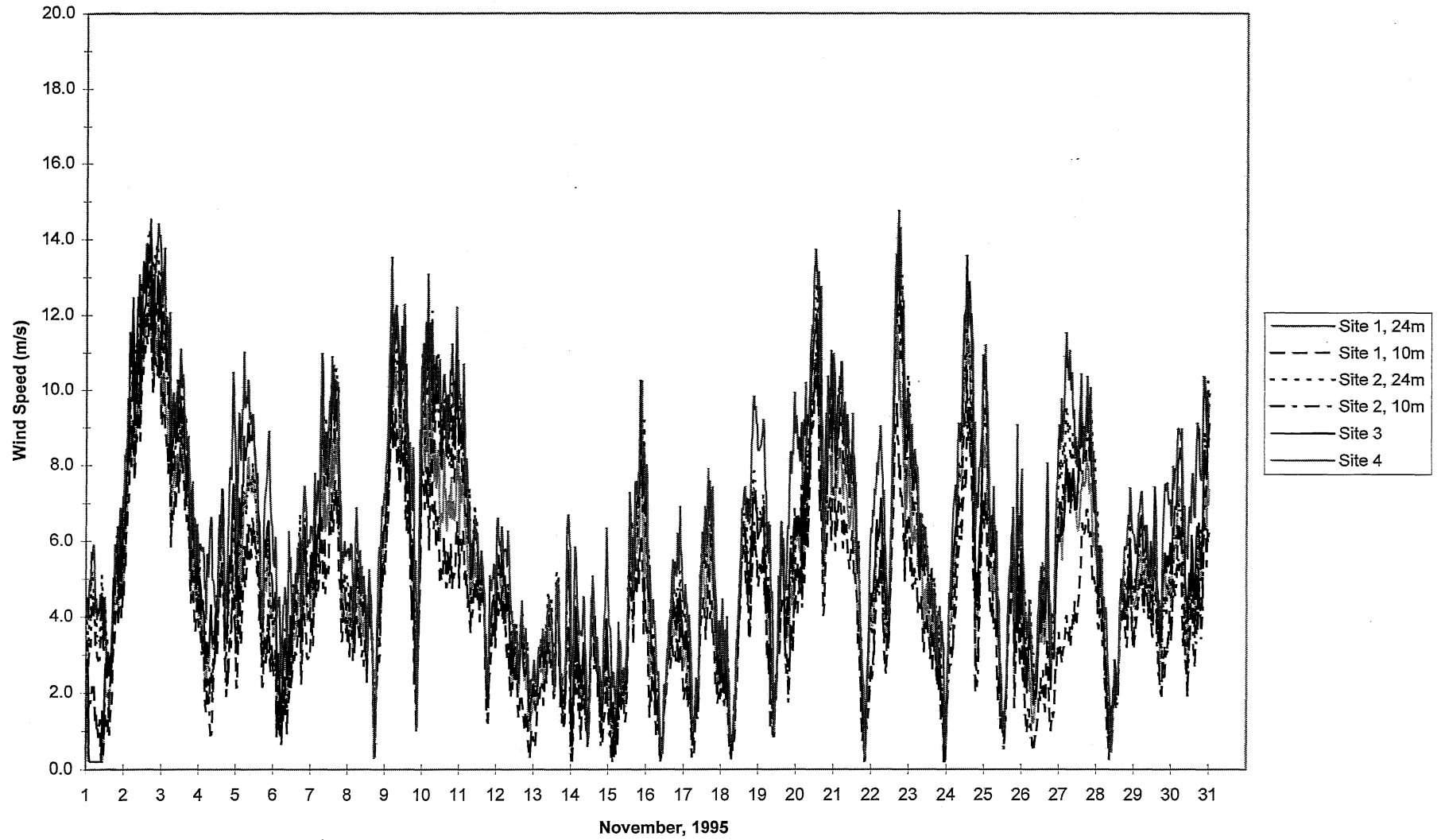
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APPENDIX A

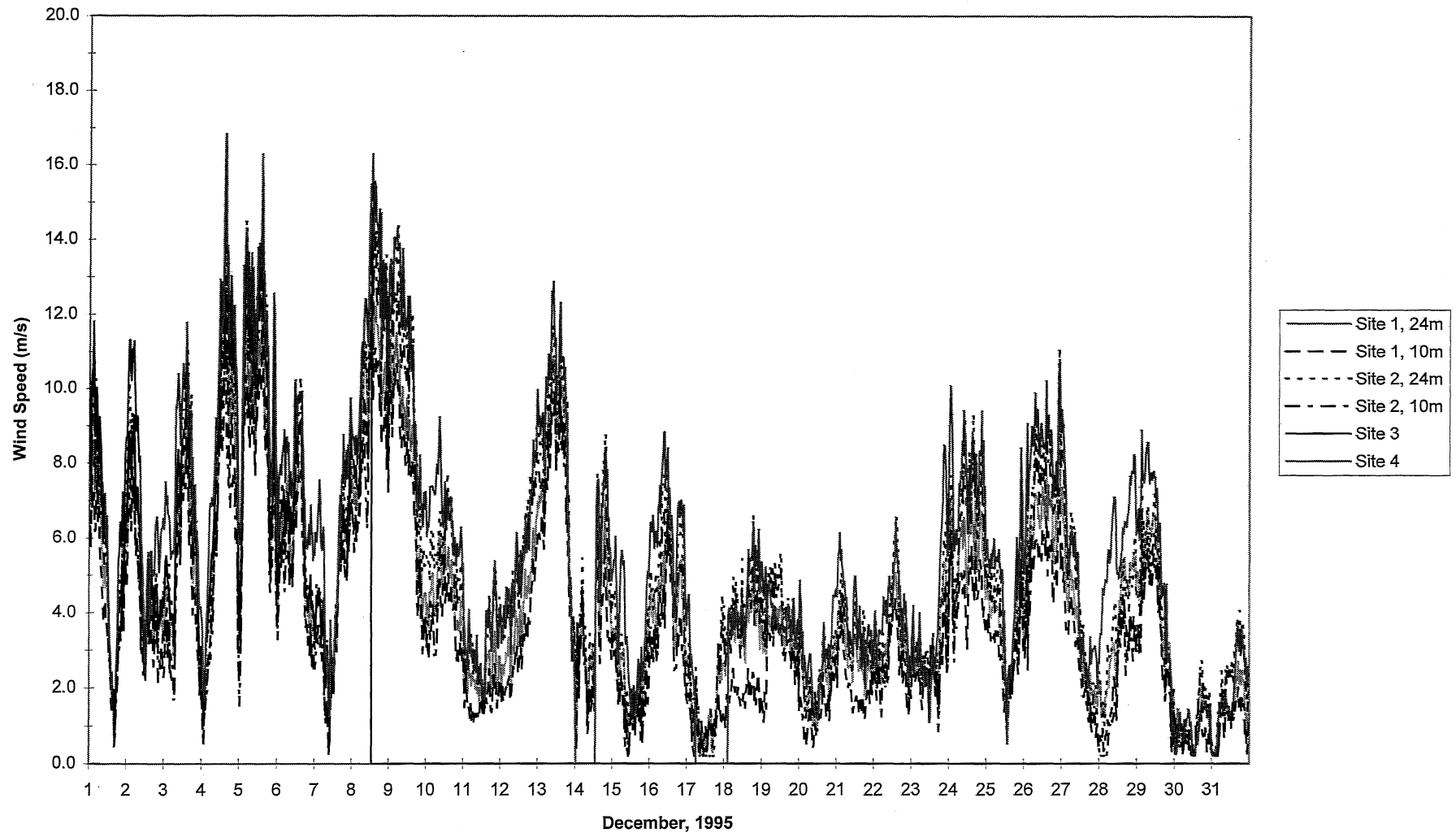
Thirty-Minute Wind Speed Averages

November 1995 - October 1996

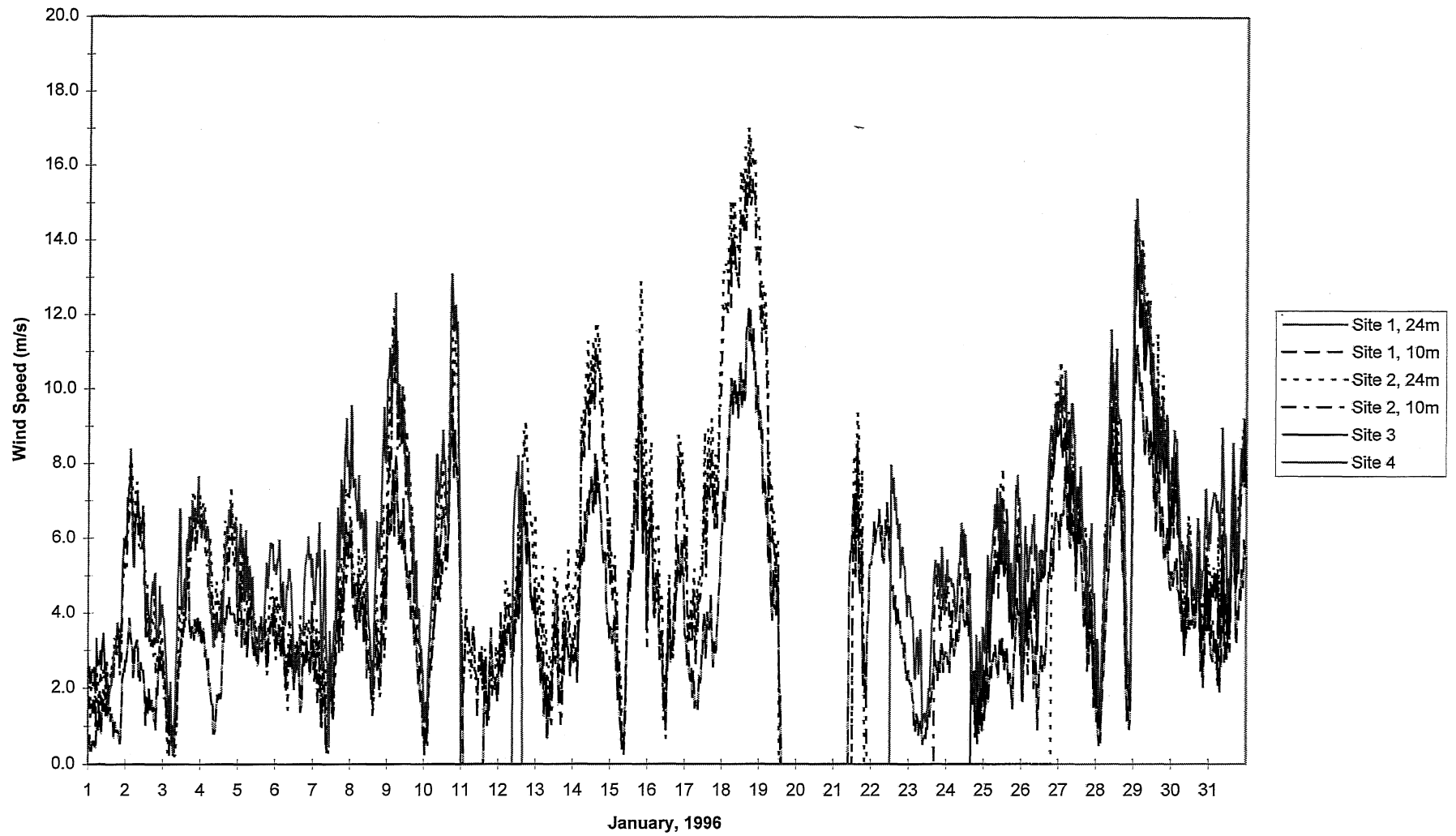
Mean Wind Speed



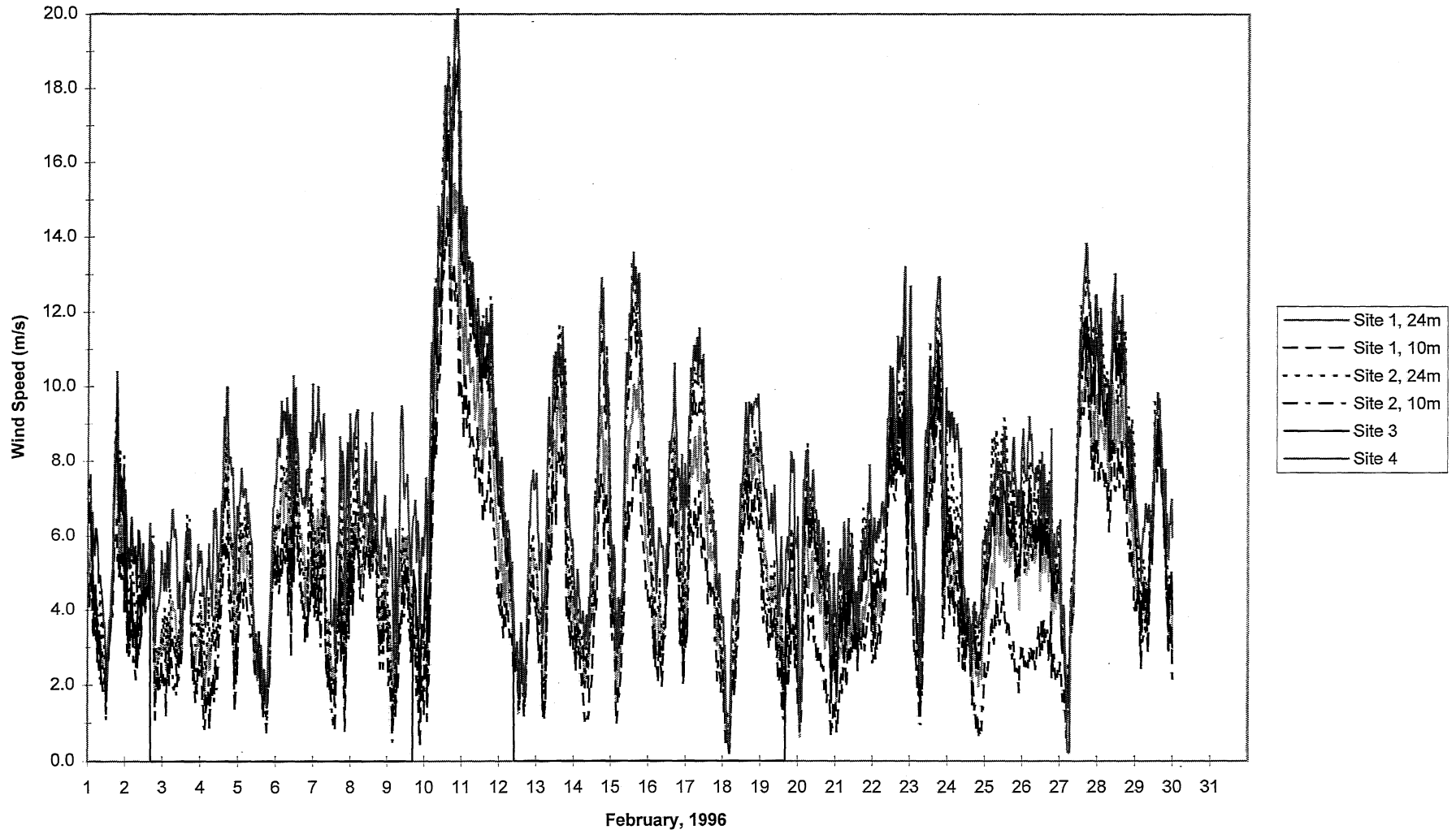
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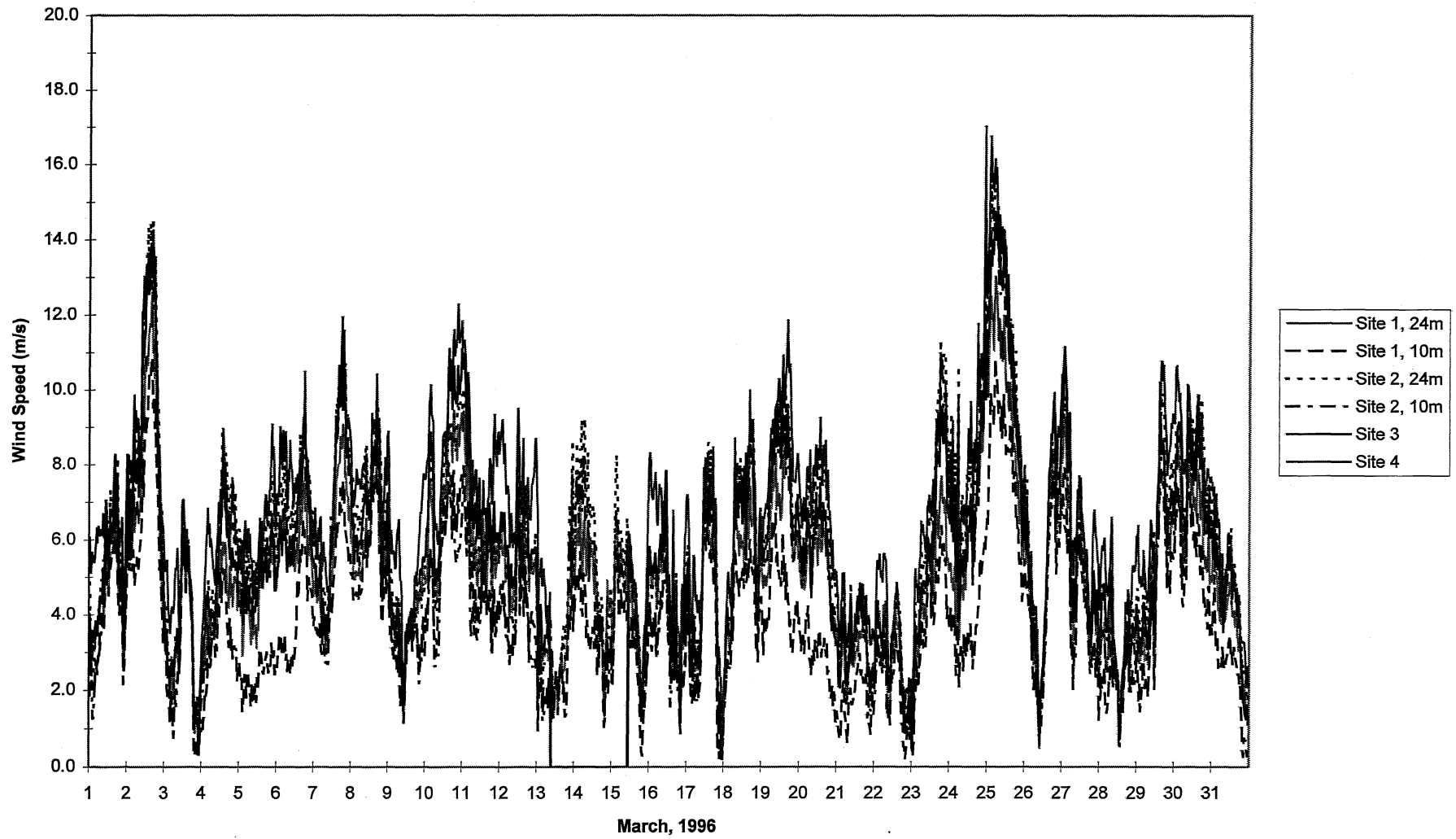
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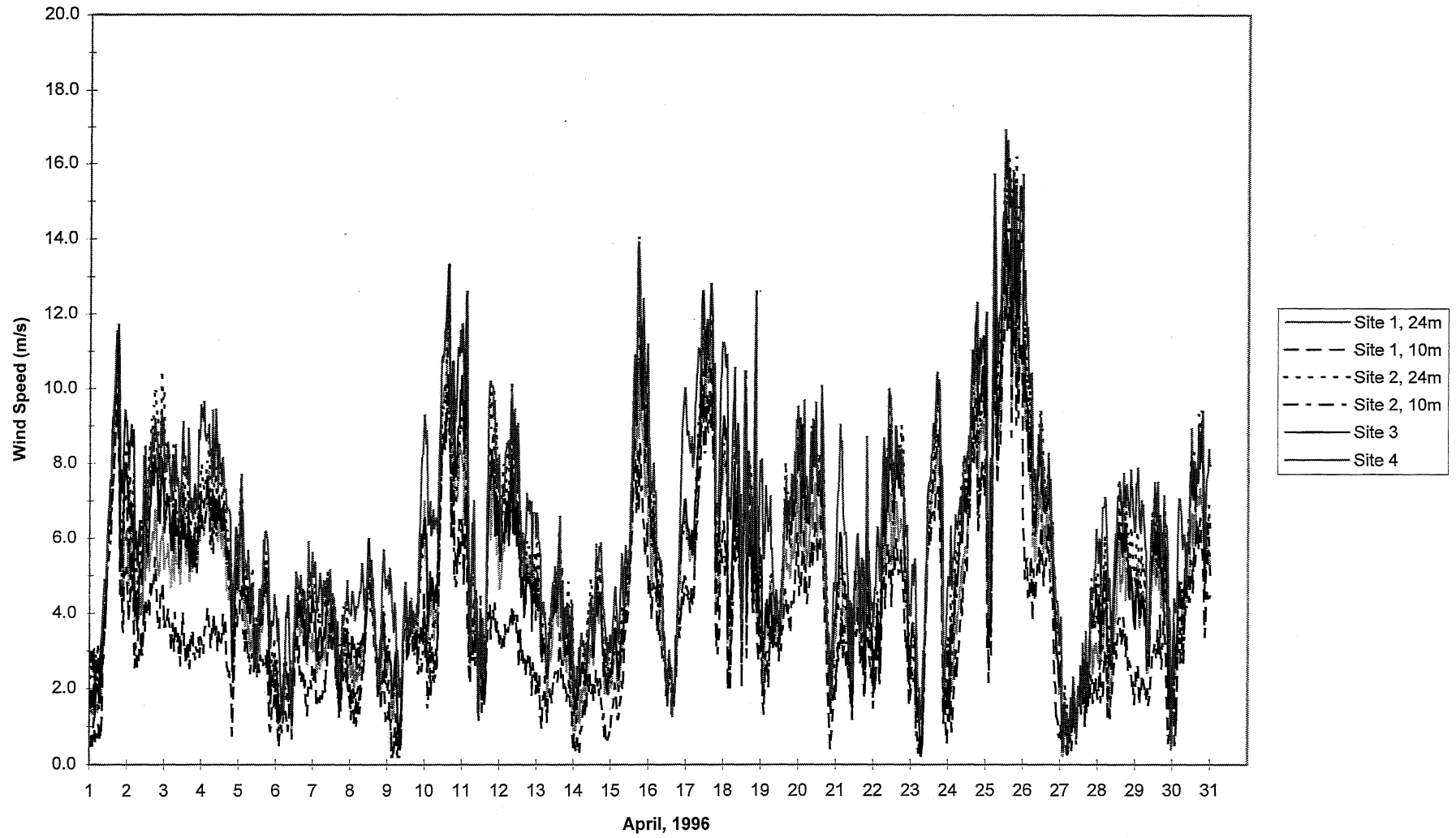
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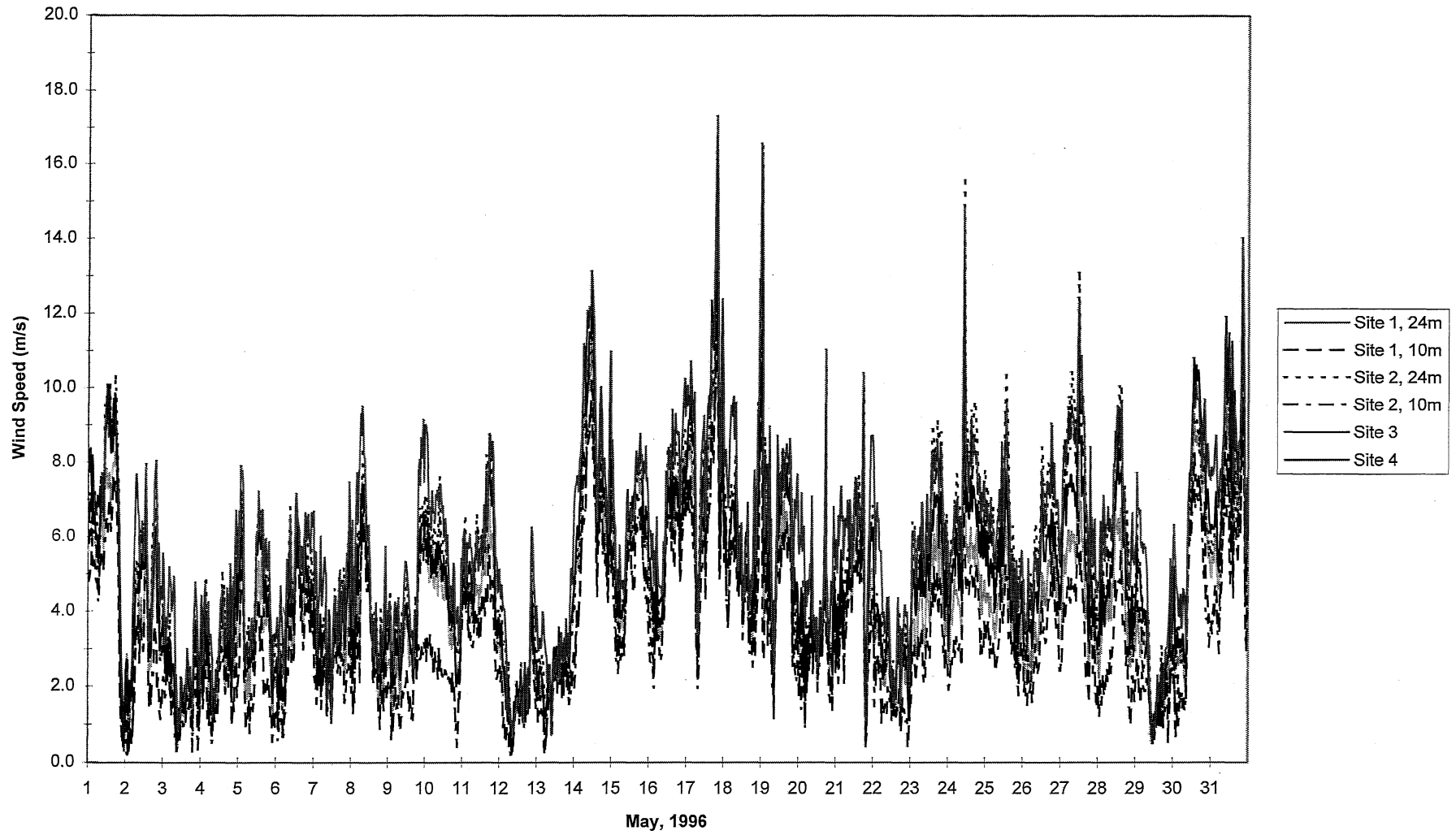
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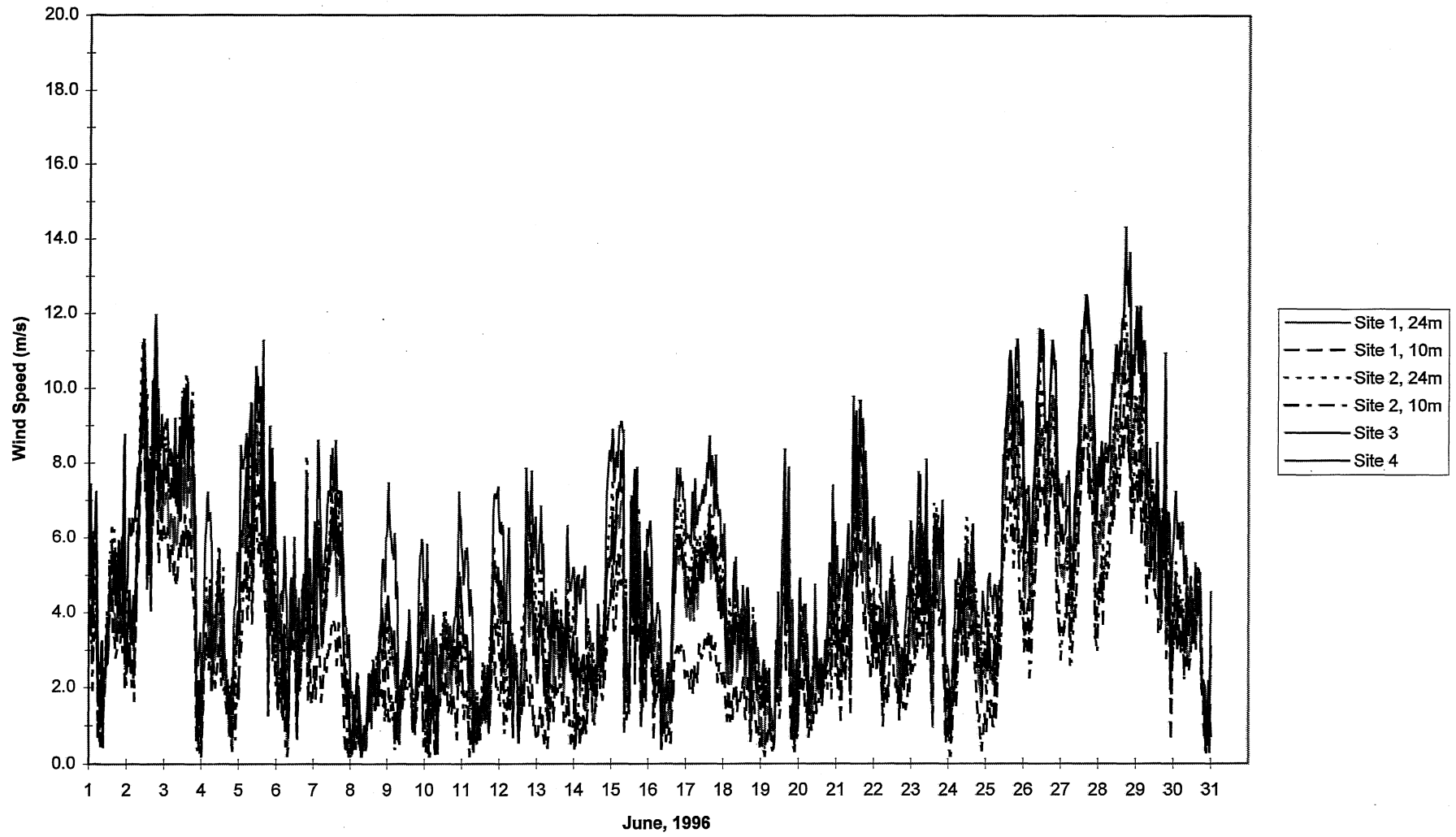
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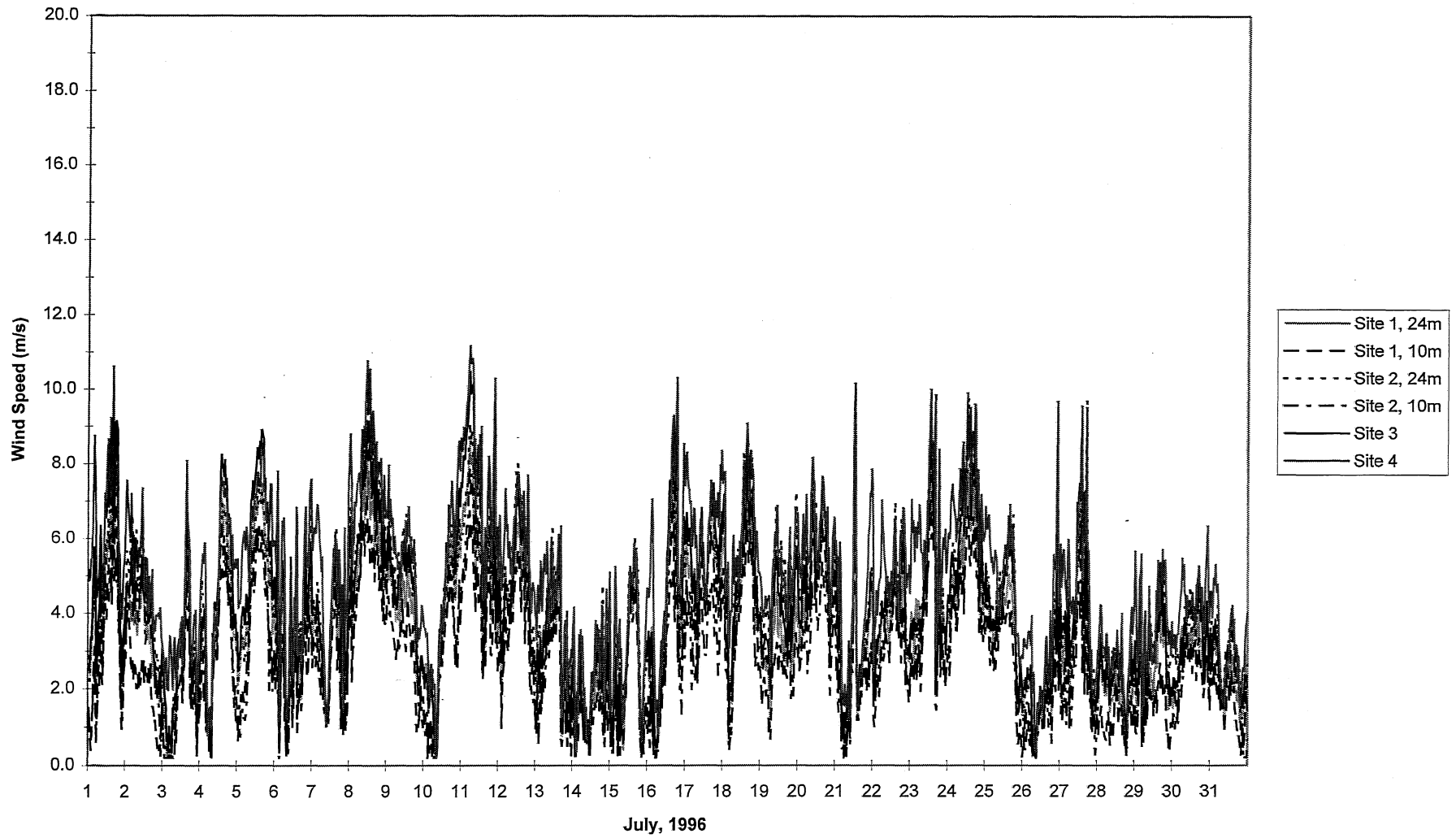
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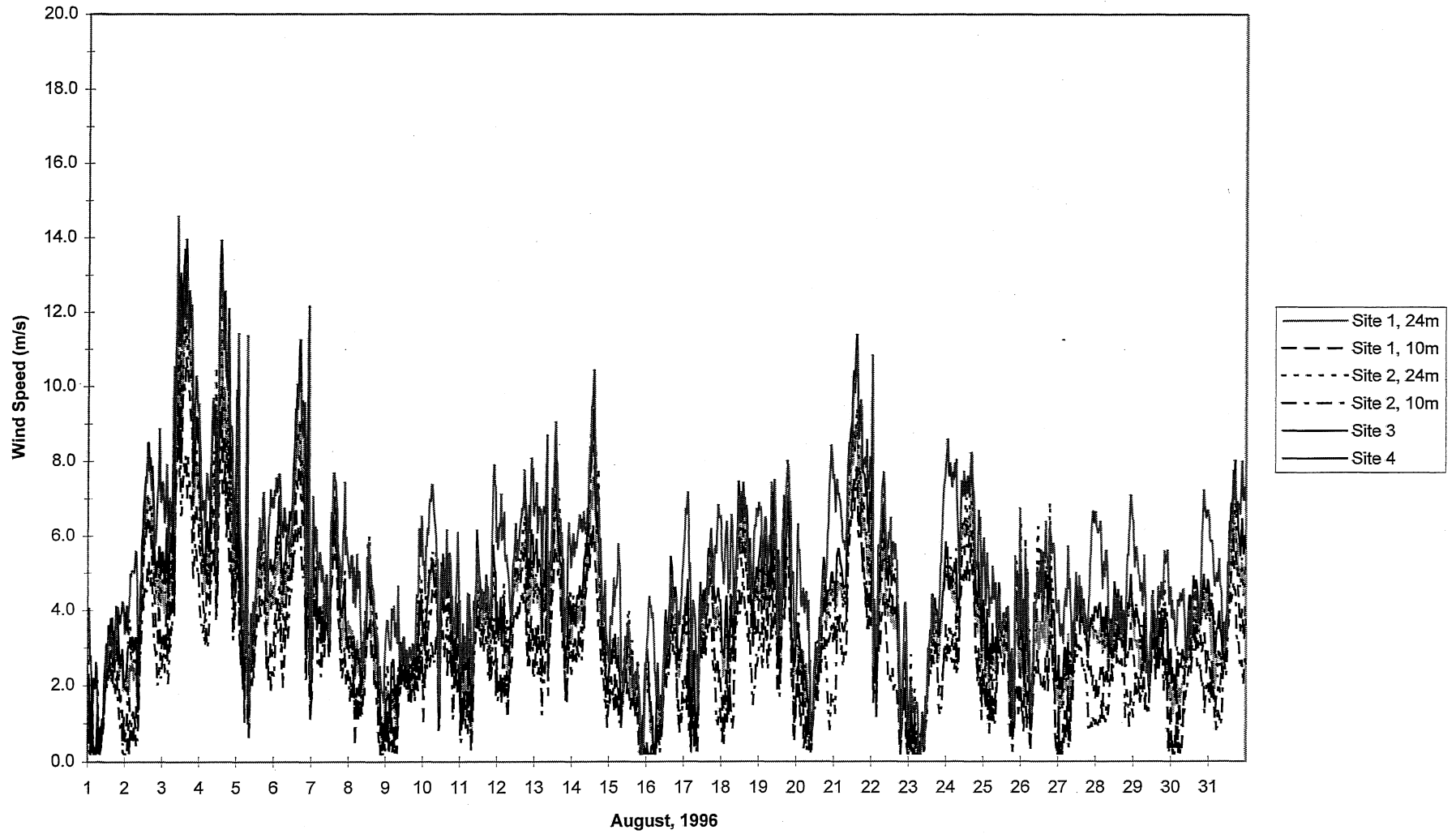
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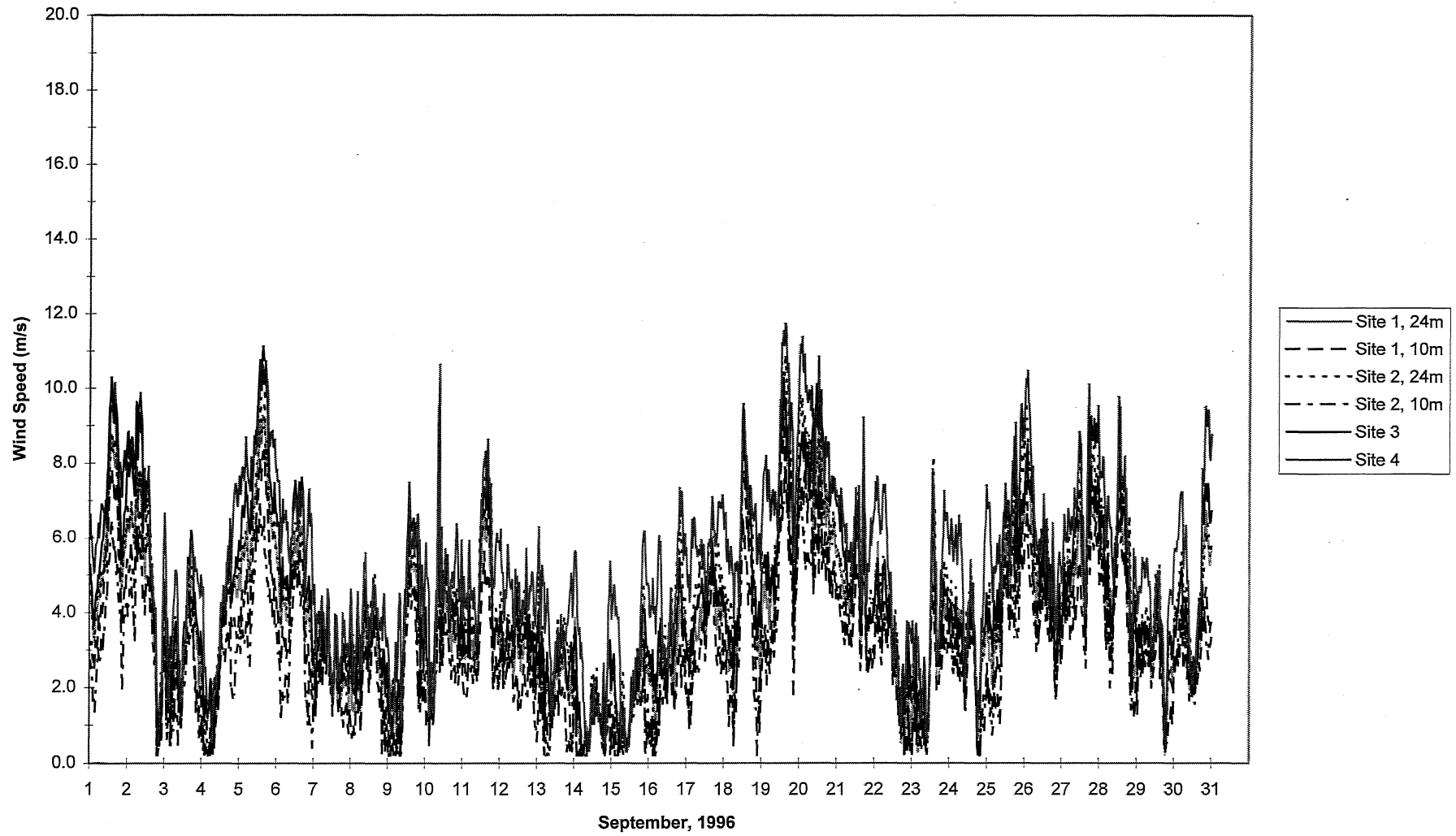
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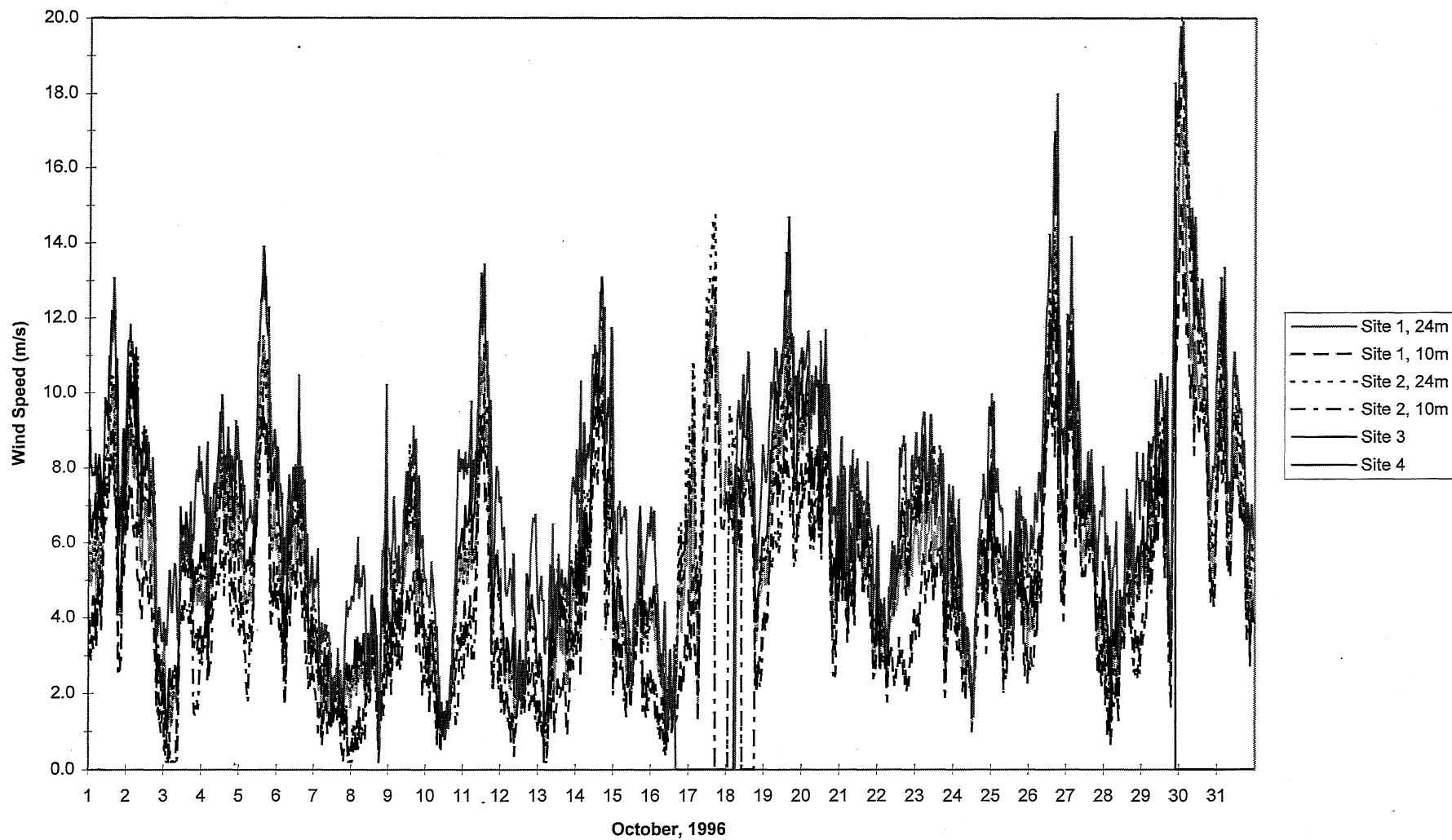
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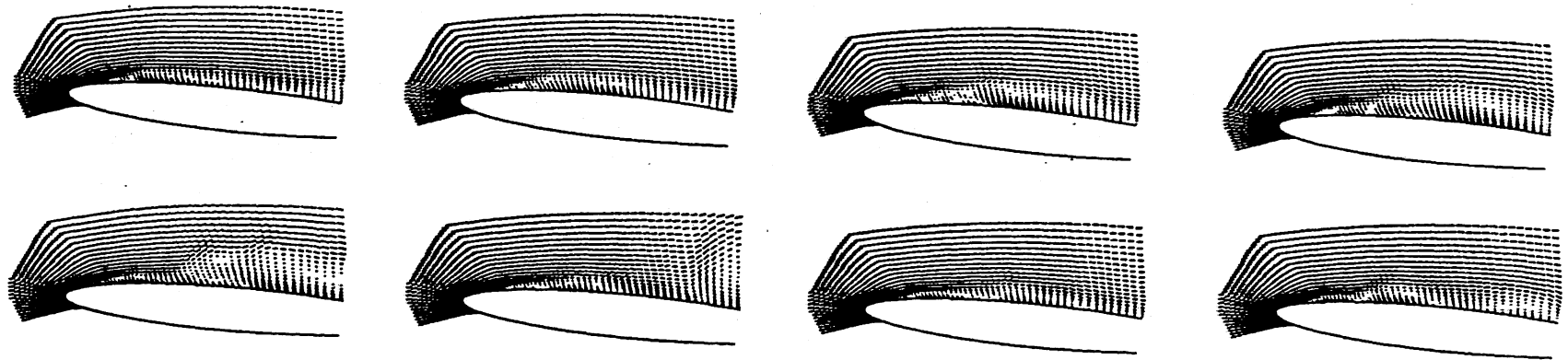
Mean Wind Speed



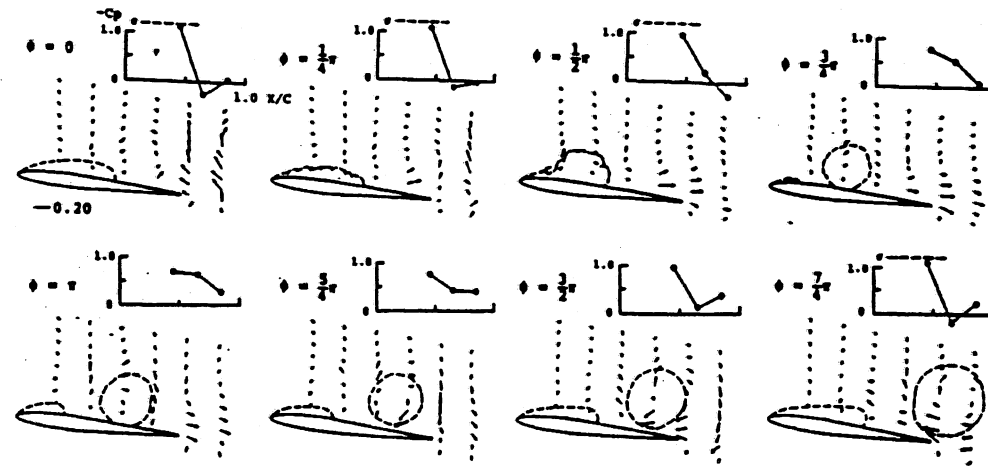
Mean Wind Speed



Velocity Field Comparison (E.N. Foil, $\alpha = 6.2^\circ$, $\sigma = 1.2$)



(a) Computation



(b) Experiment

Fig. 5-8 Comparison of computed velocity field with experimental result (Kubota et al., 1989) of flow over an E.N. foil at $\alpha=6.2^\circ$ under cavitating condition of $\sigma=1.2$.



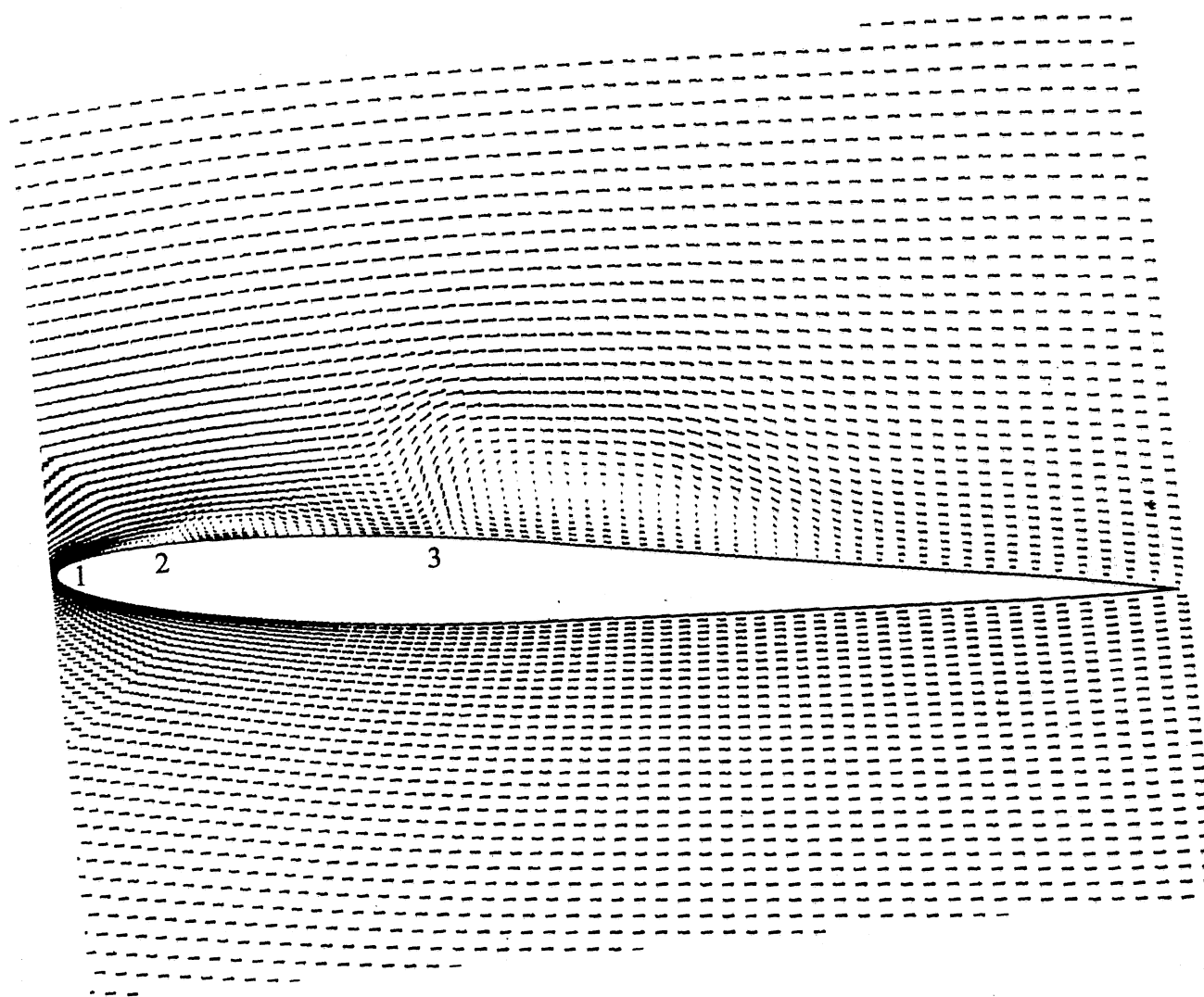
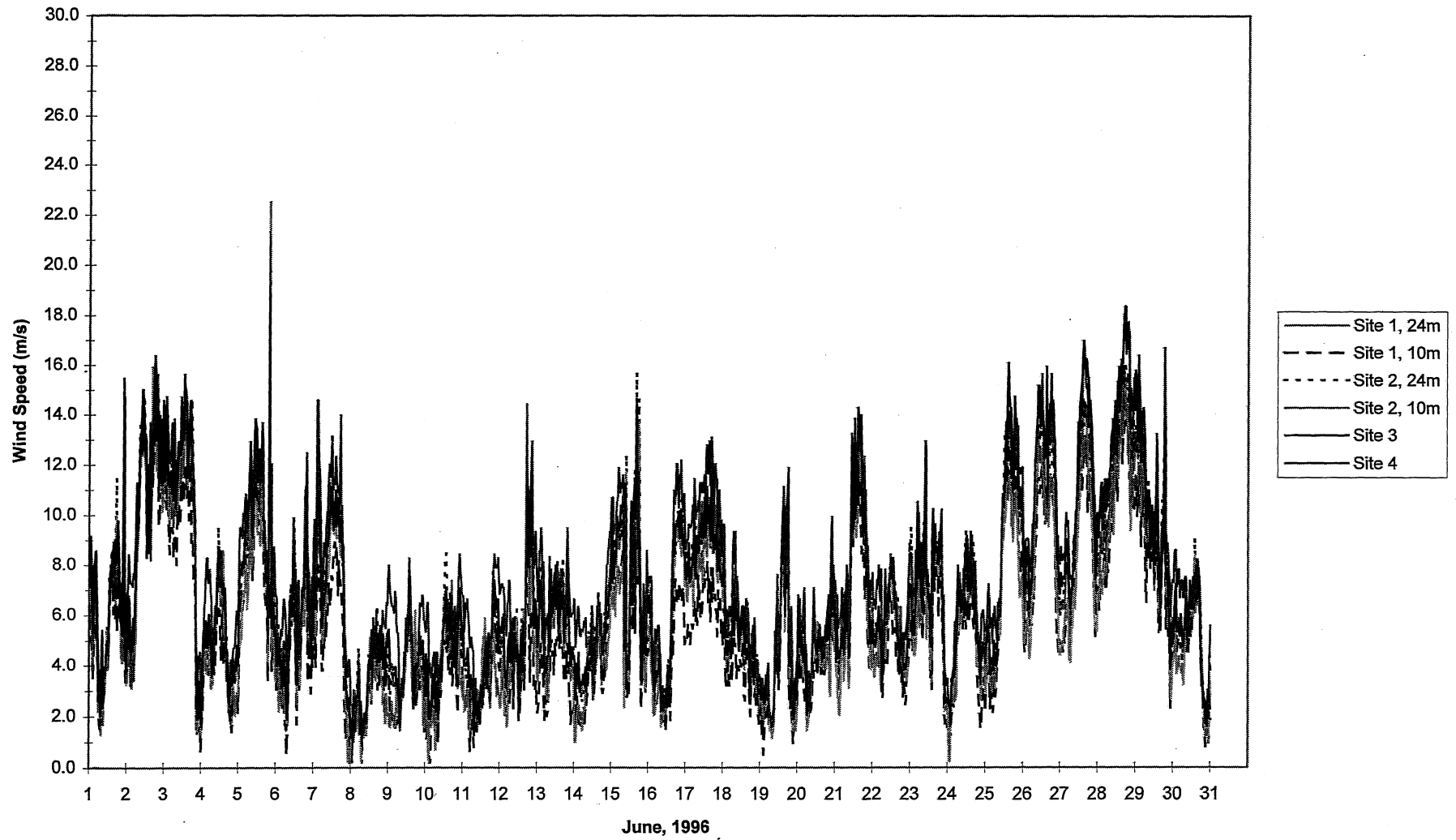
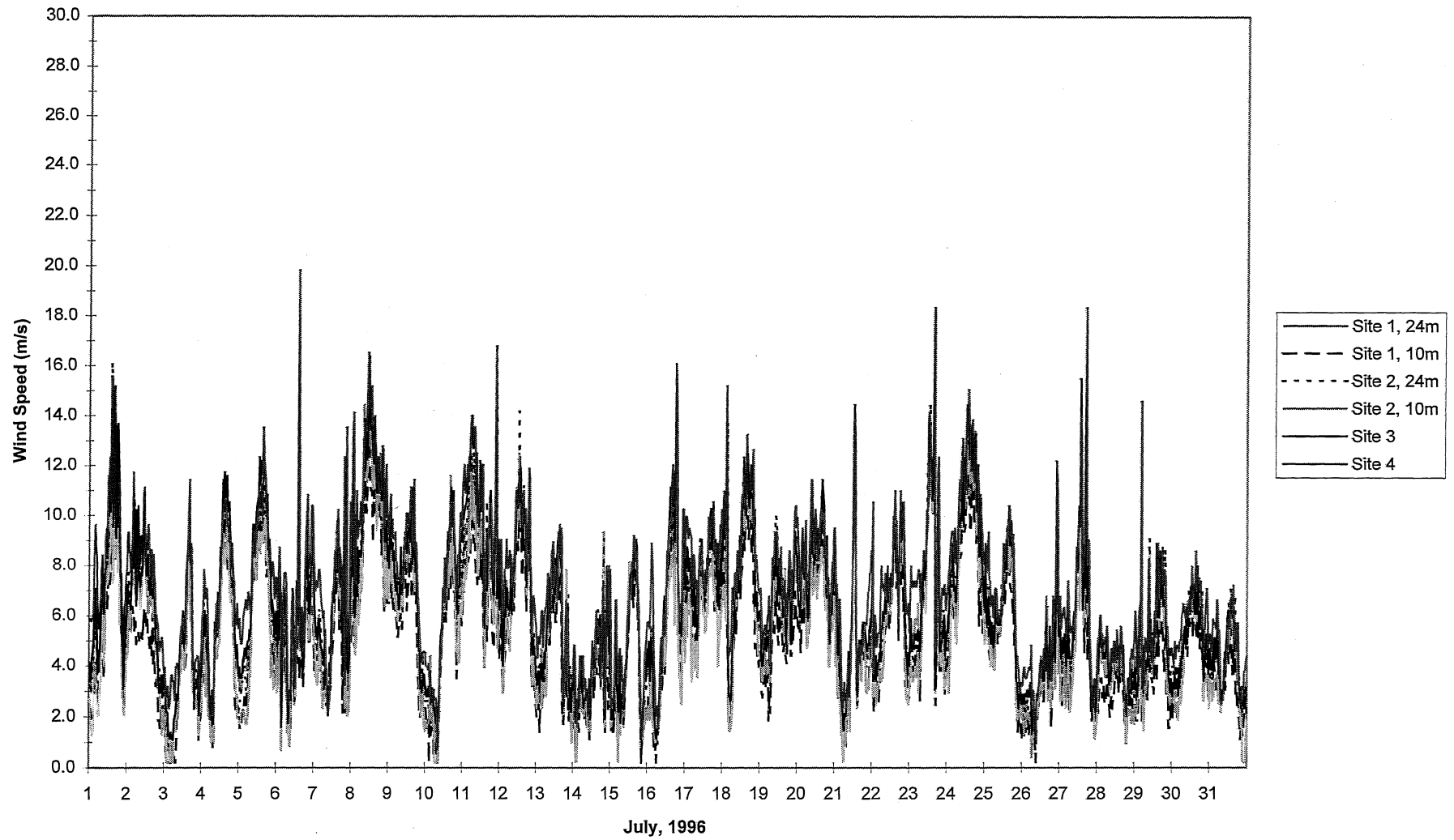


Fig. 5-9 Instantaneous velocity field around an E.N. foil at $\alpha=6.2^\circ$ under cavitating condition of $\sigma=1.2$.

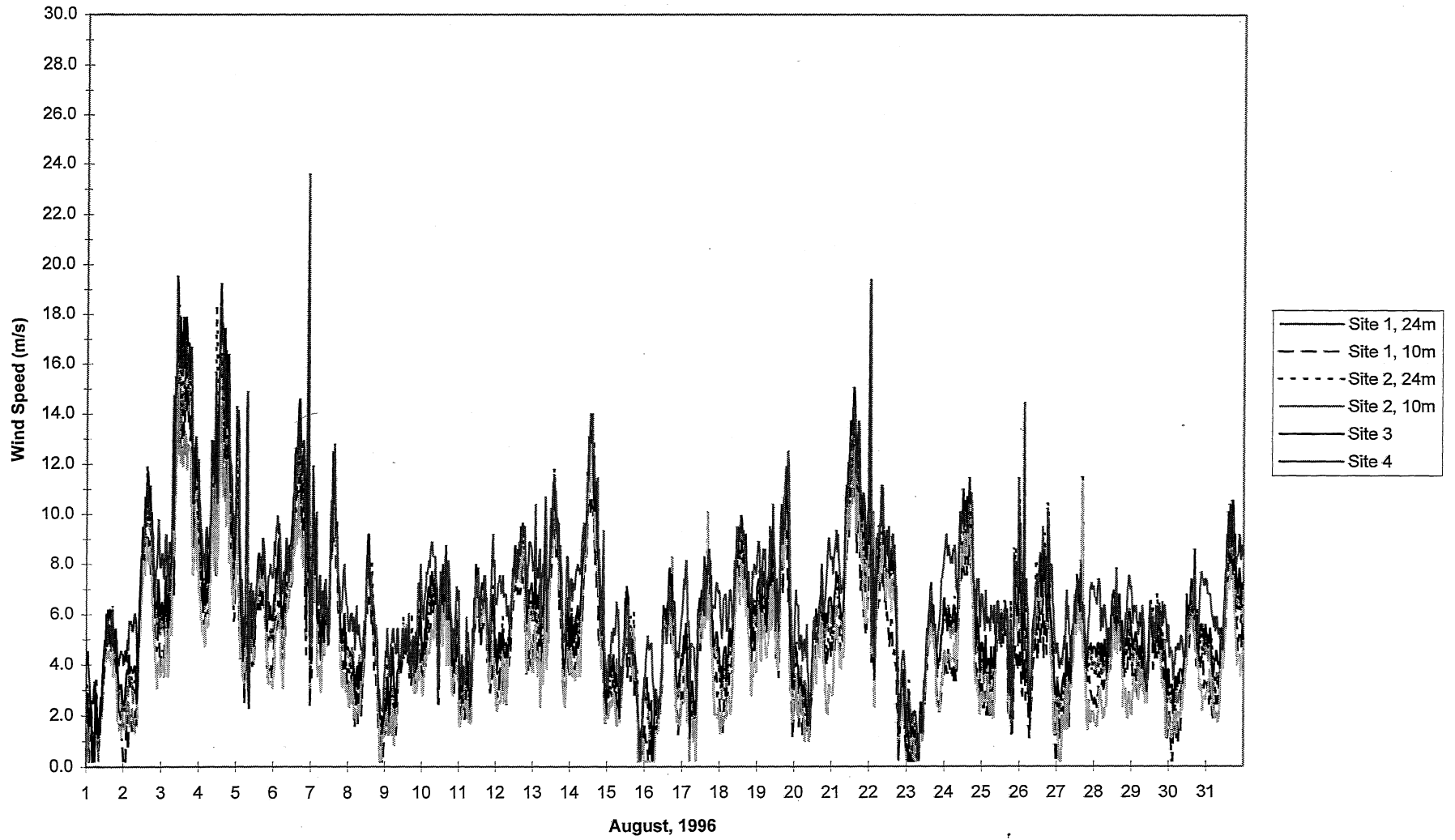
Maximum Wind Speed



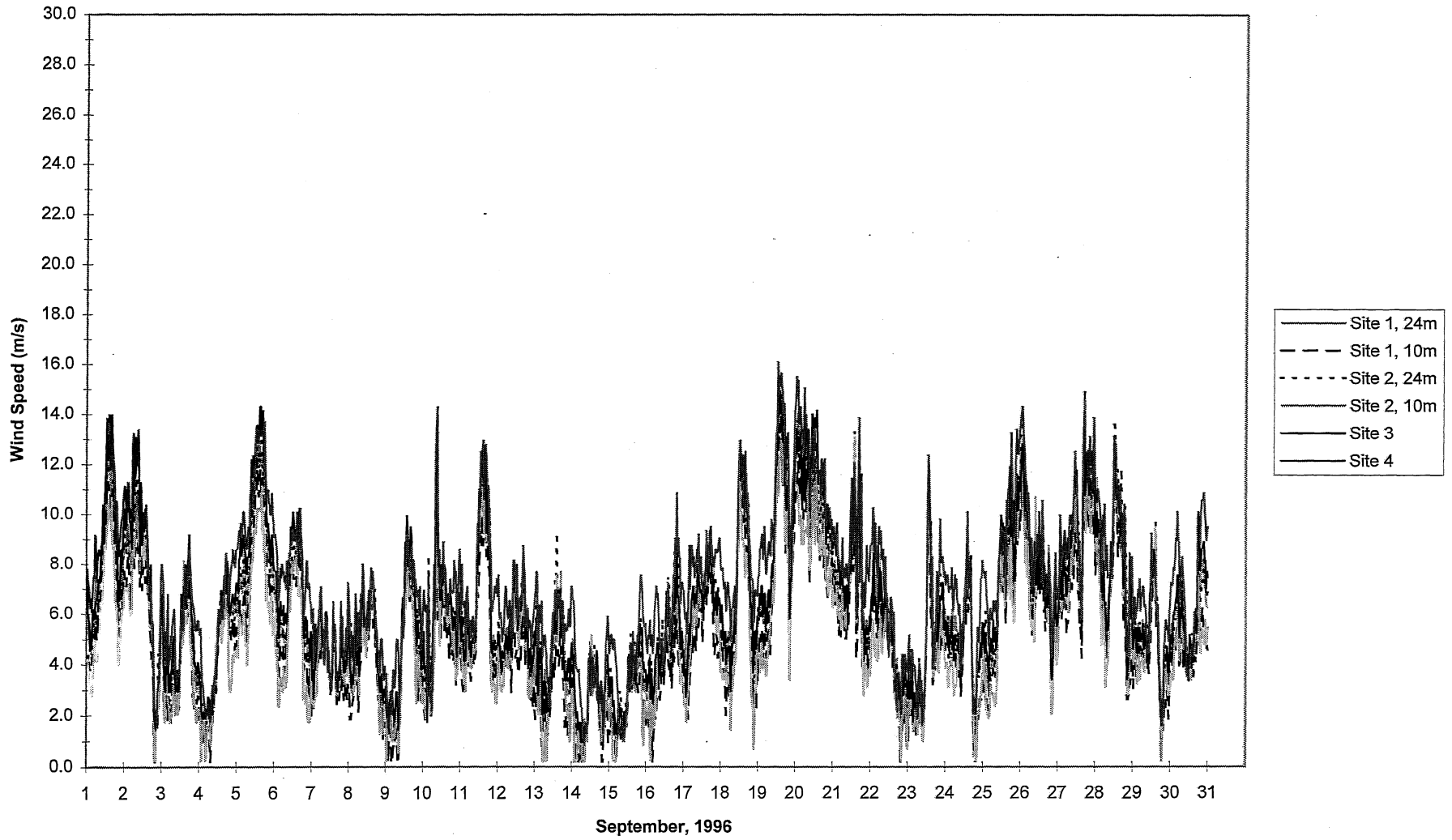
Maximum Wind Speed



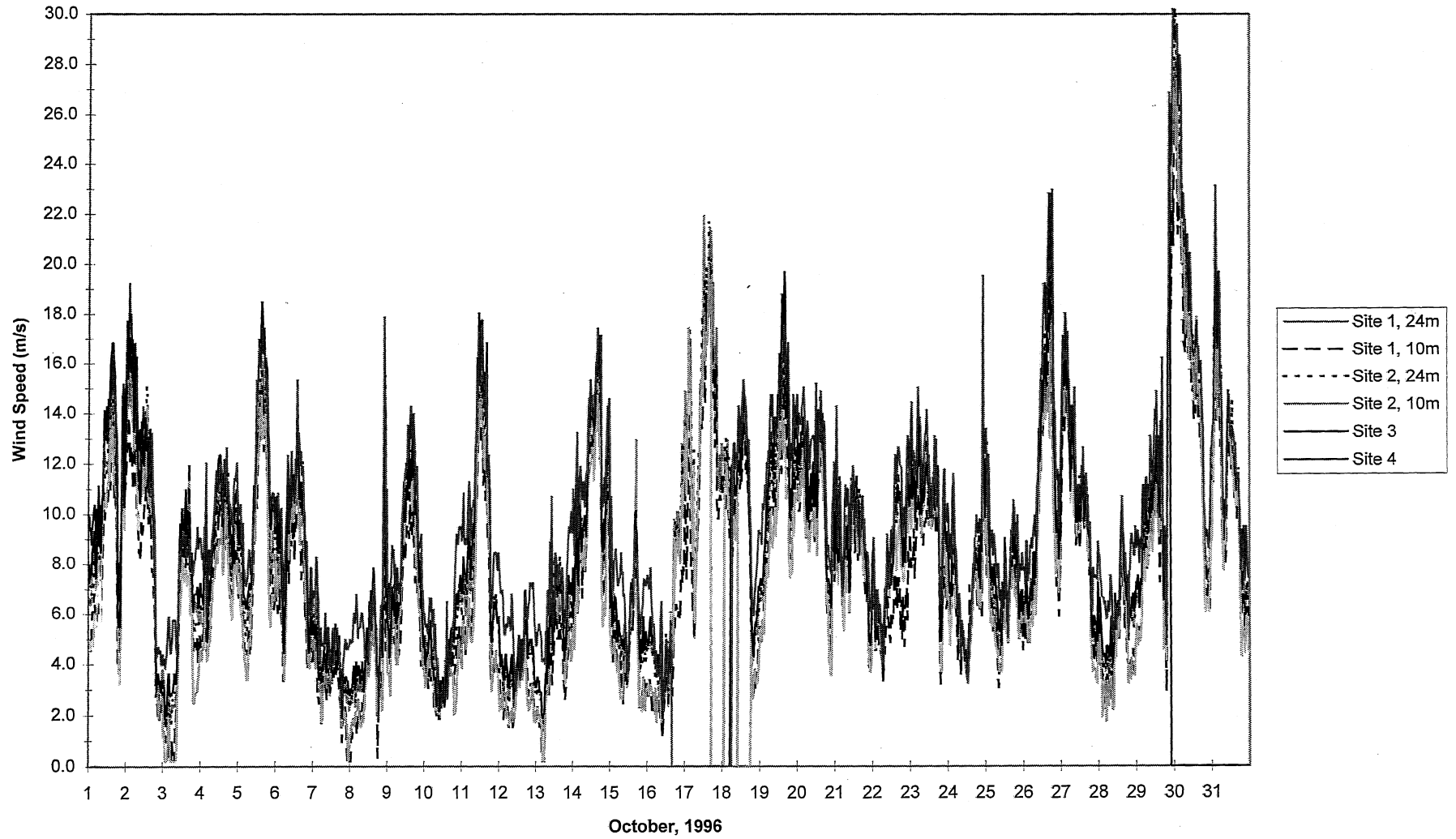
Maximum Wind Speed



Maximum Wind Speed



Maximum Wind Speed



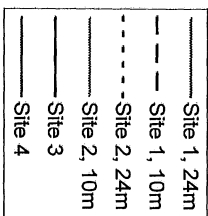
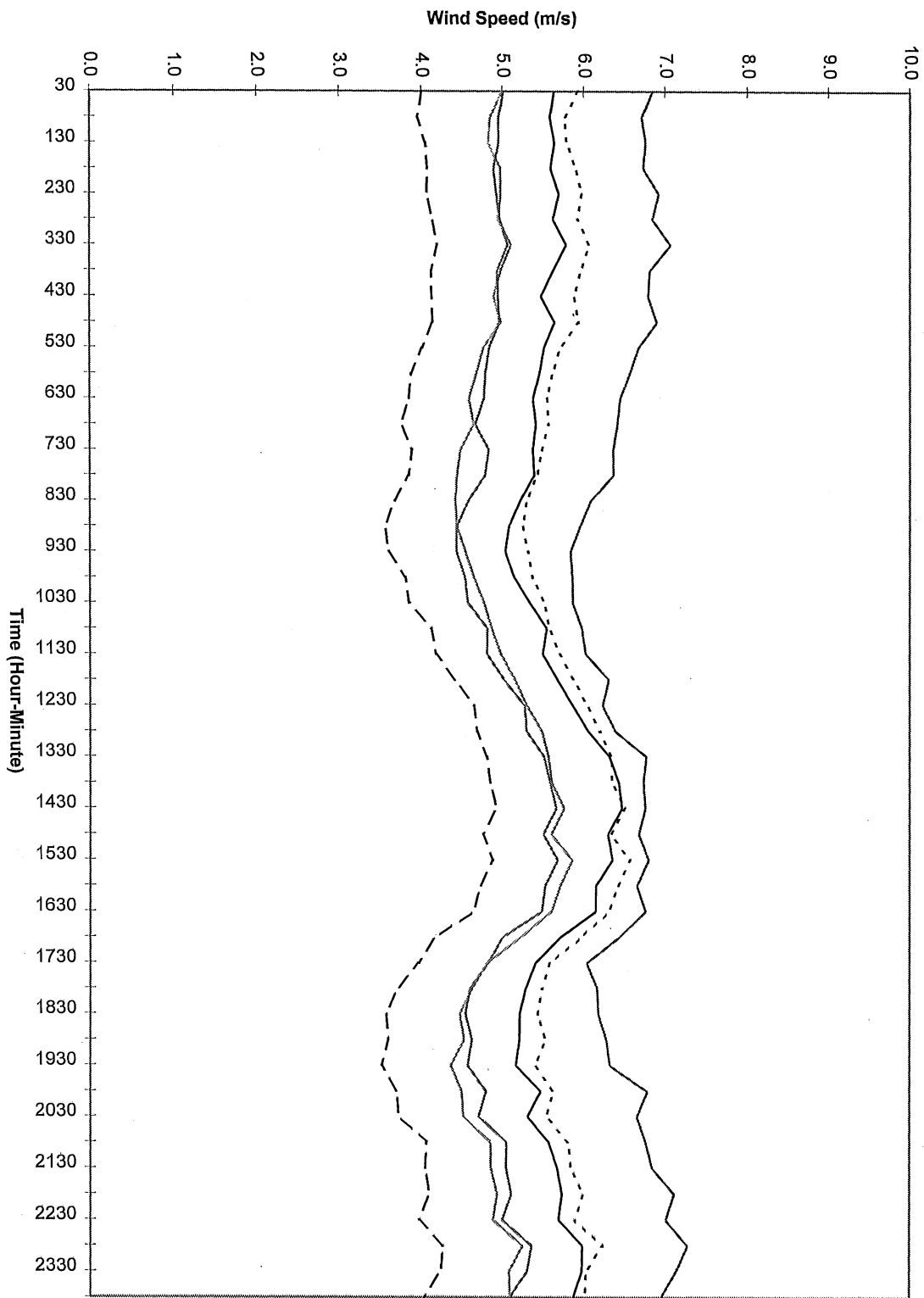
C

APPENDIX C

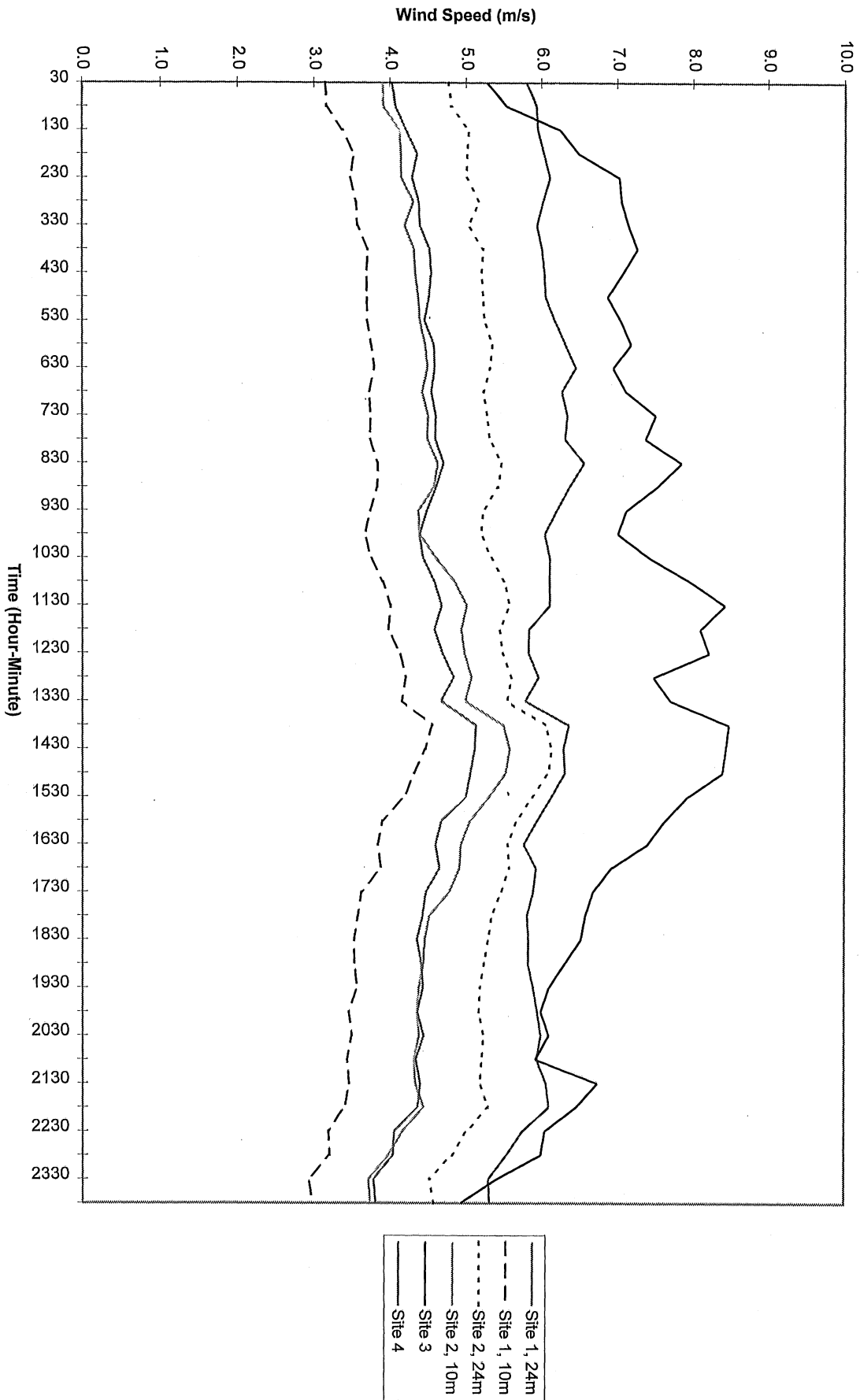
Monthly Averages of Semi-Hourly Wind Speeds

November 1995 - October 1996

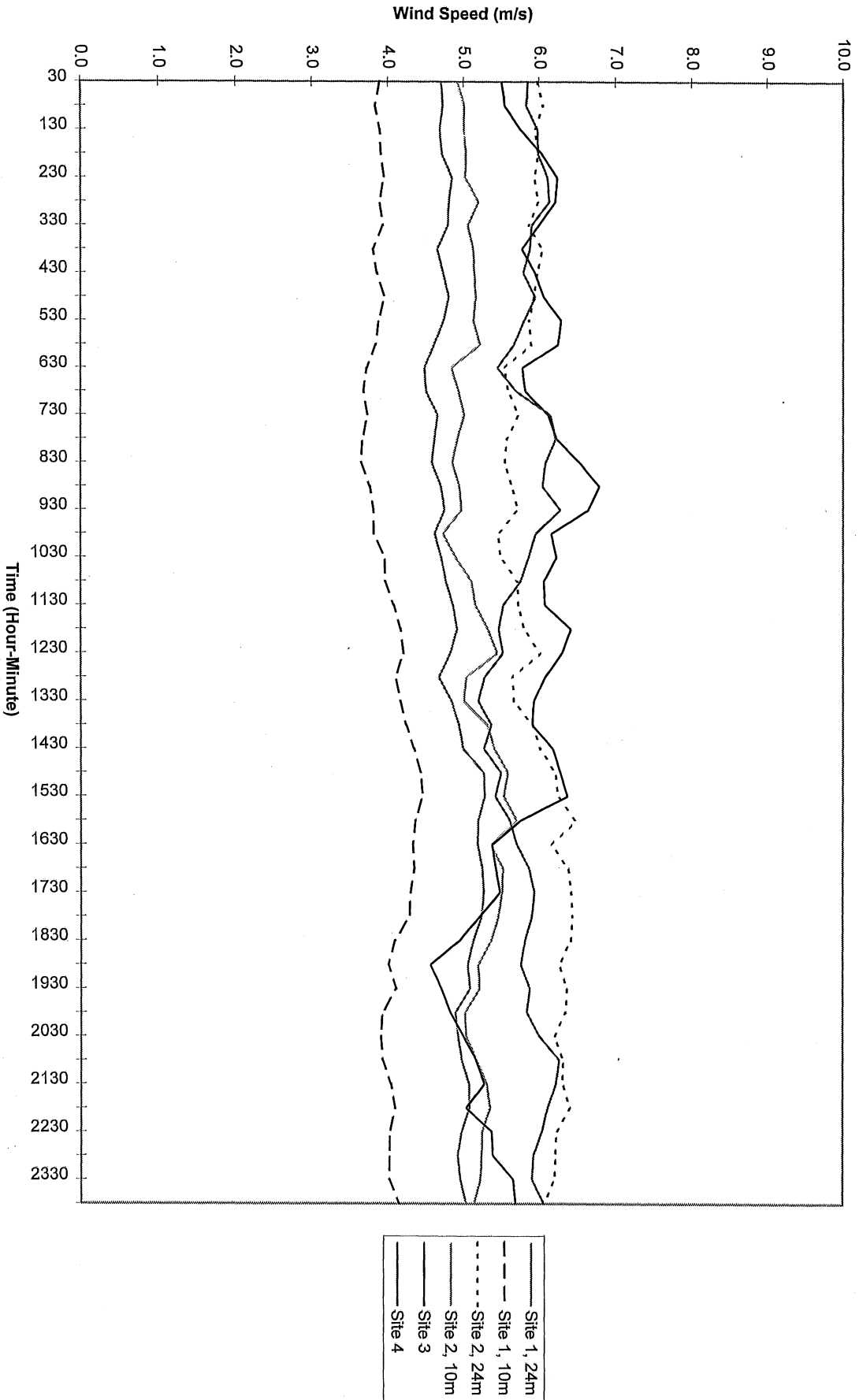
Semi-Hourly Averaged Mean WindSpeeds, November, 1995



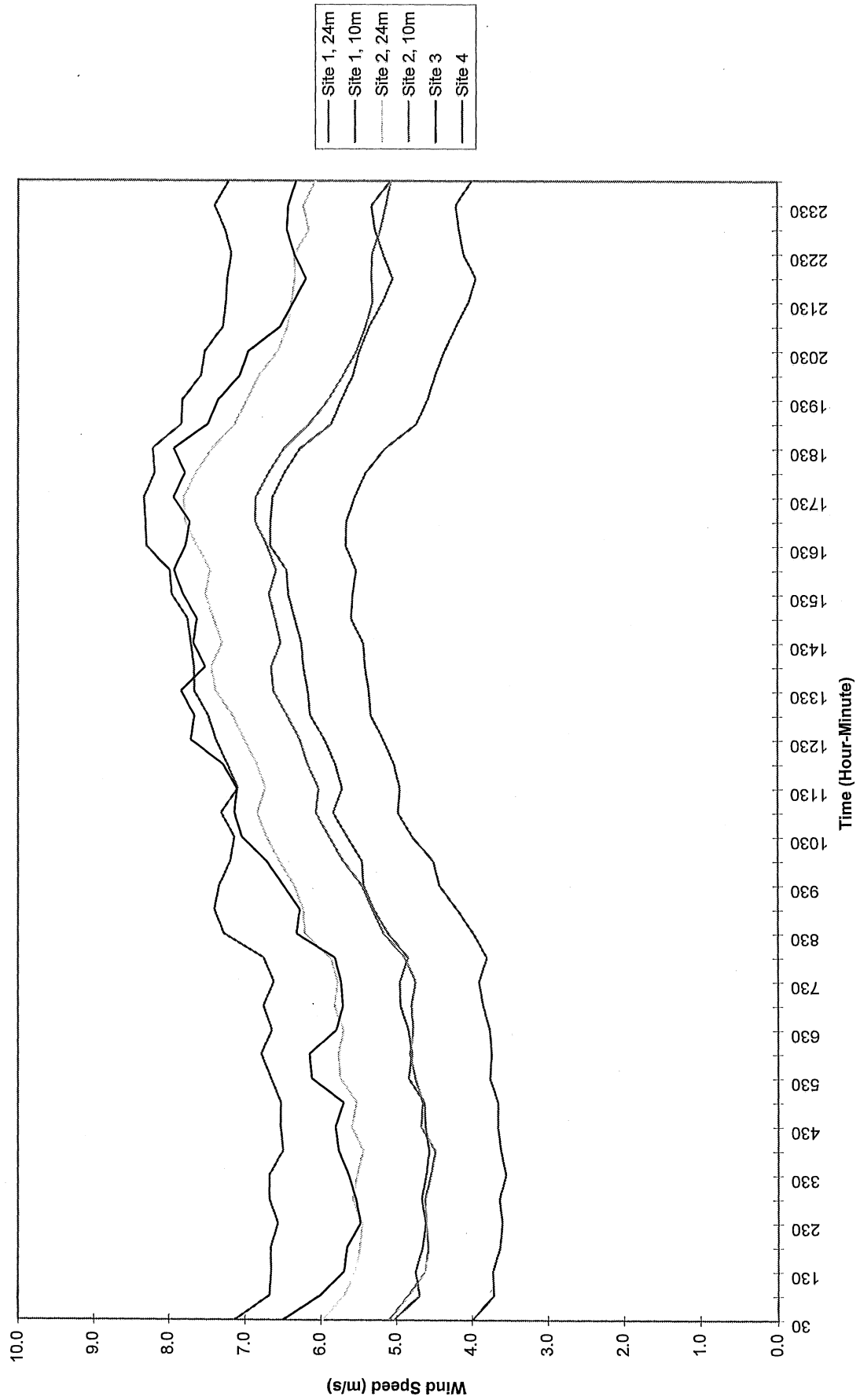
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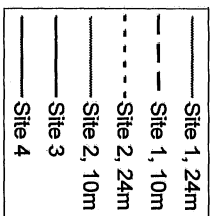
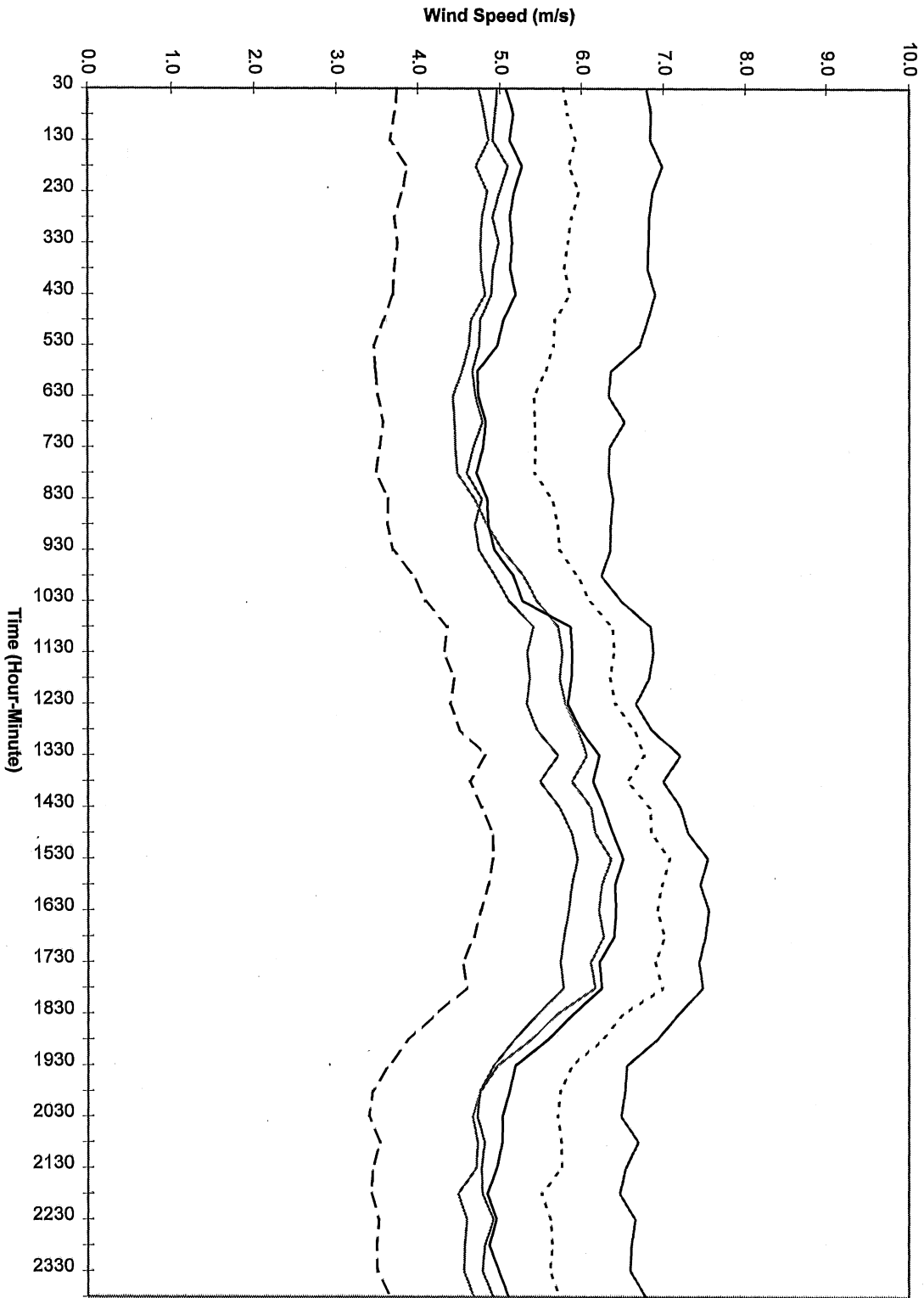
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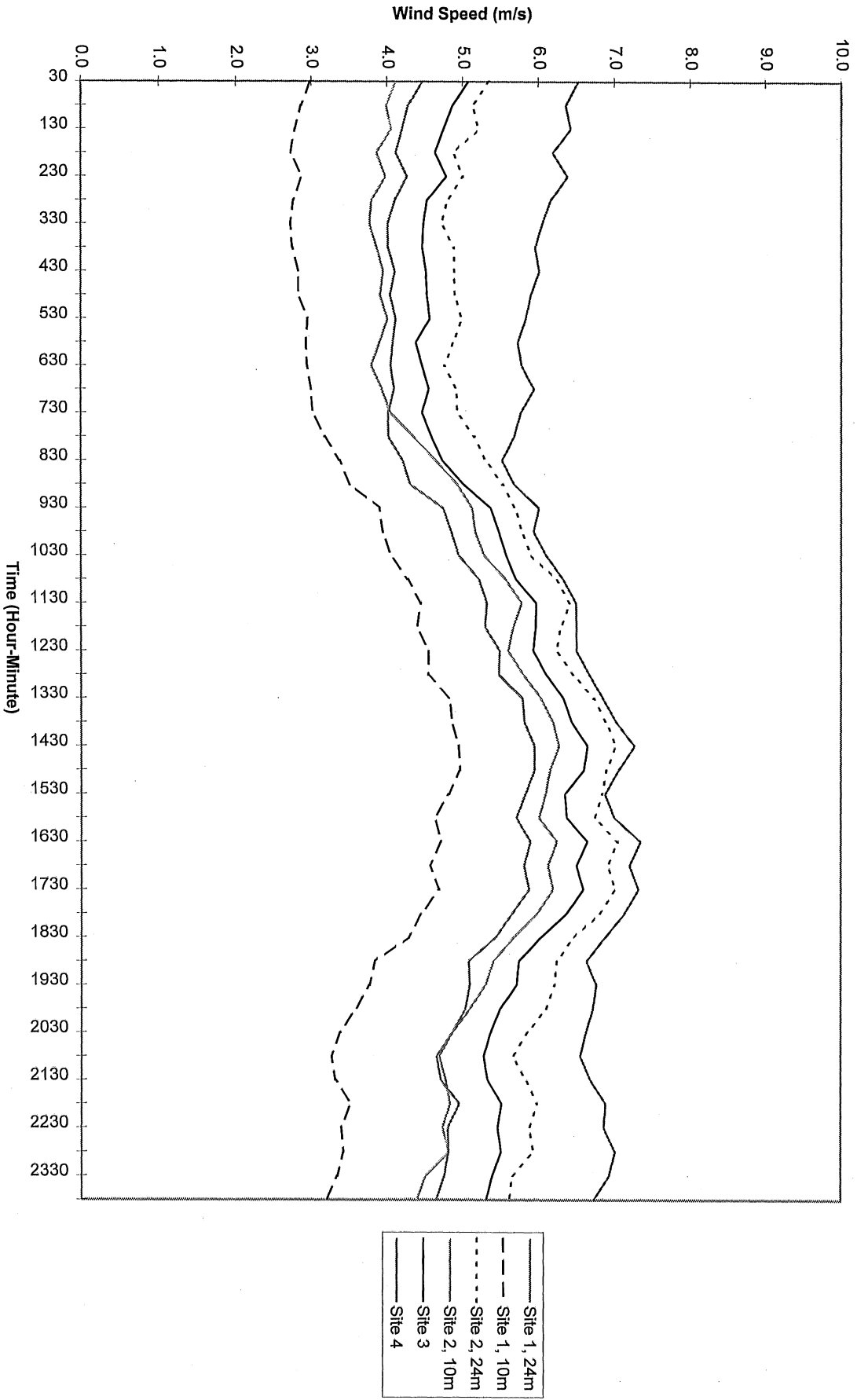
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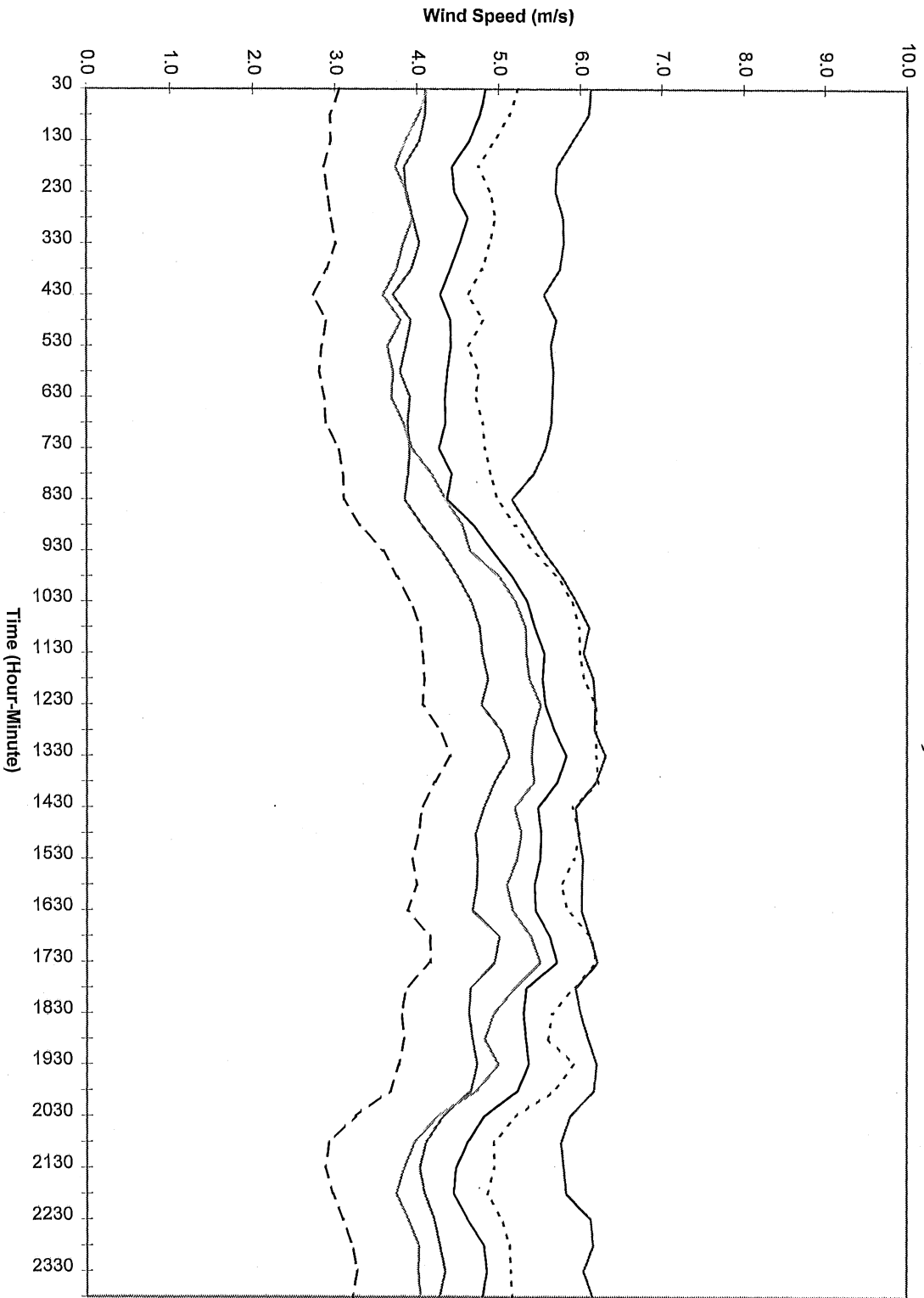
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Semi-Hourly Averaged Mean WindSpeeds, April, 1996

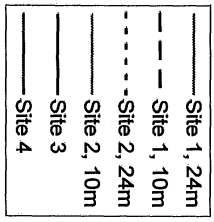
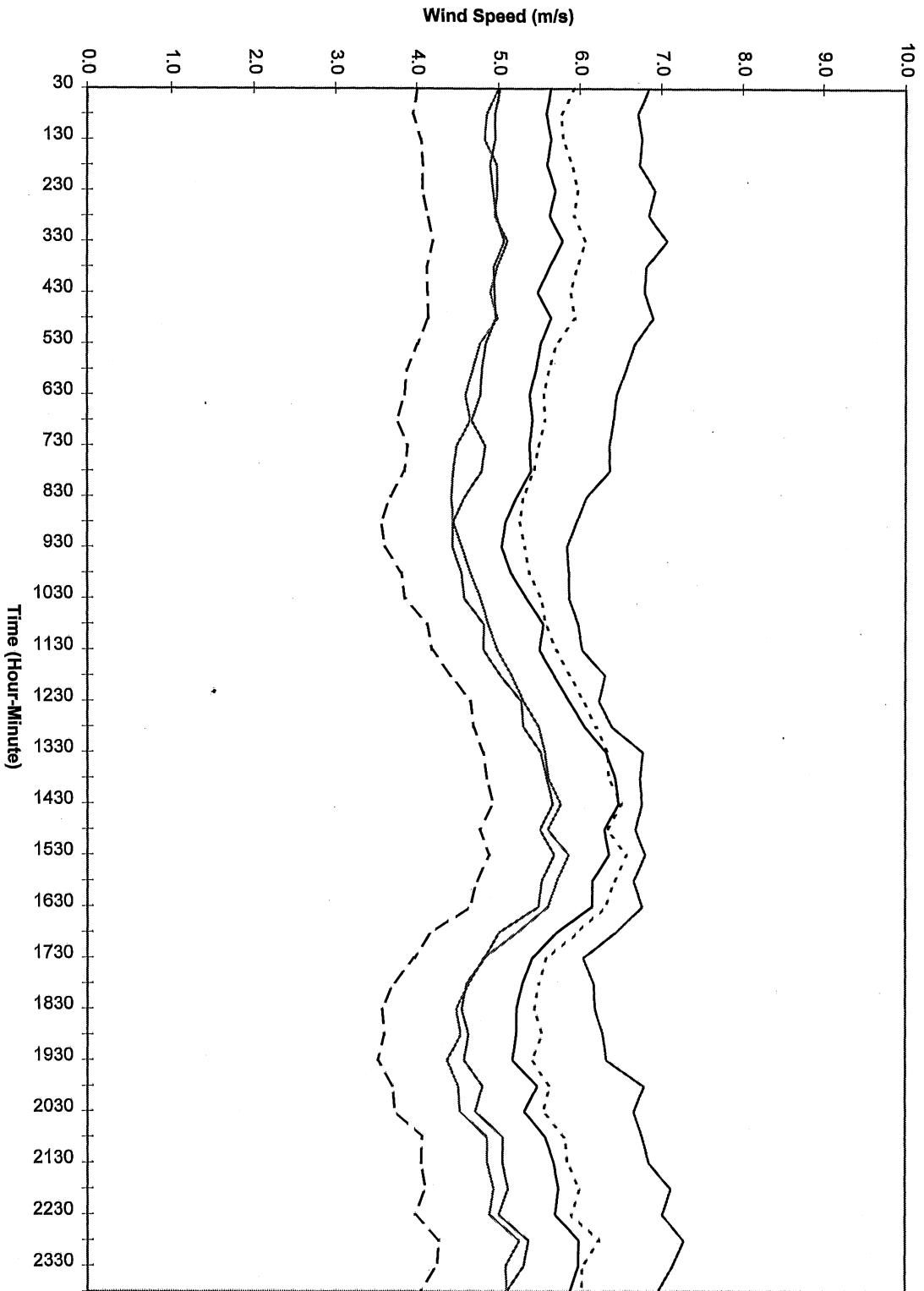


Semi-Hourly Averaged Mean Wind Speeds, May, 1996

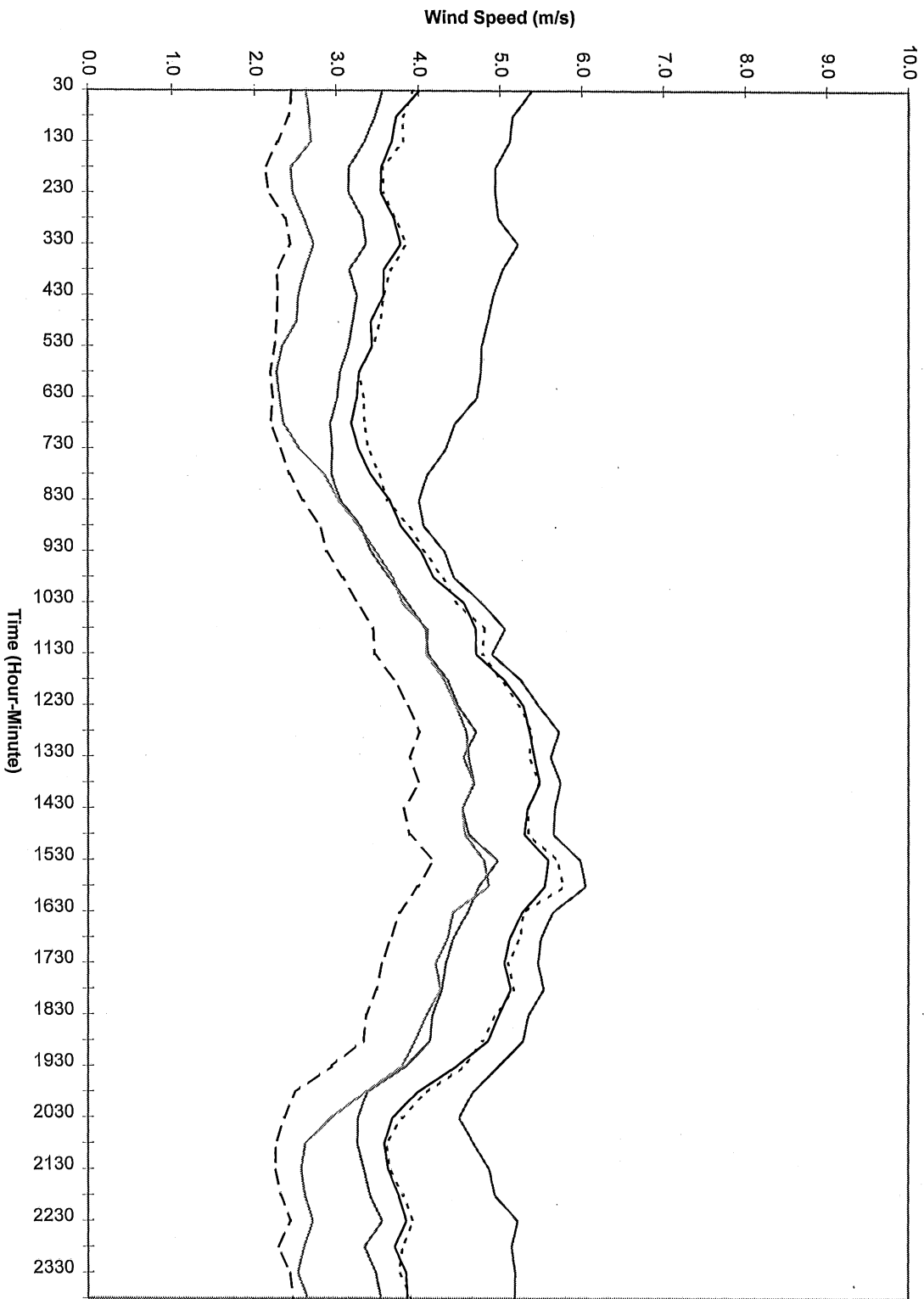


Site 1, 24m
Site 1, 10m
Site 2, 24m
Site 2, 10m
Site 3
Site 4

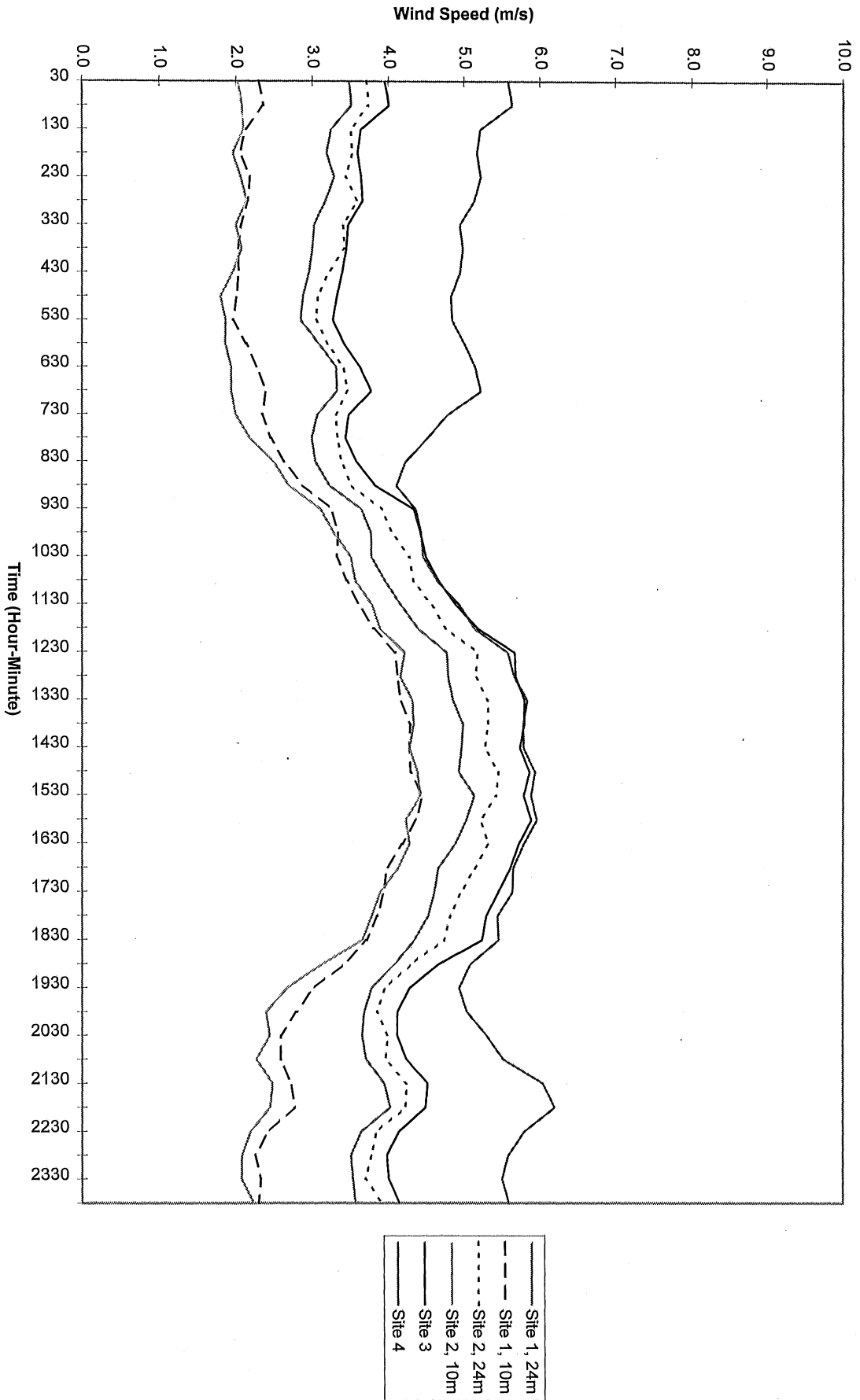
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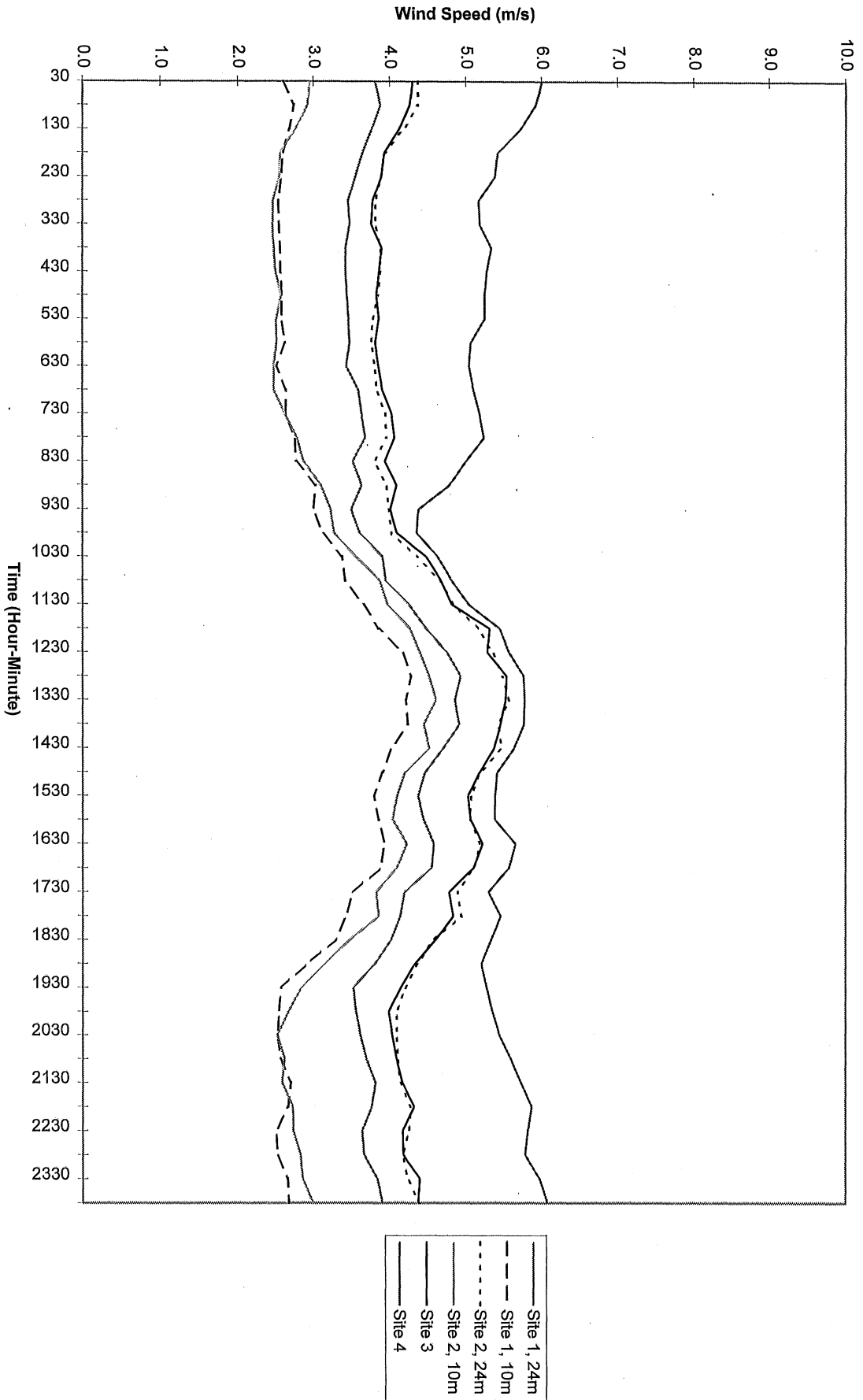
Semi-Hourly Averaged Mean Wind Speeds, July, 1996



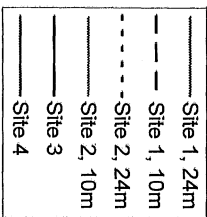
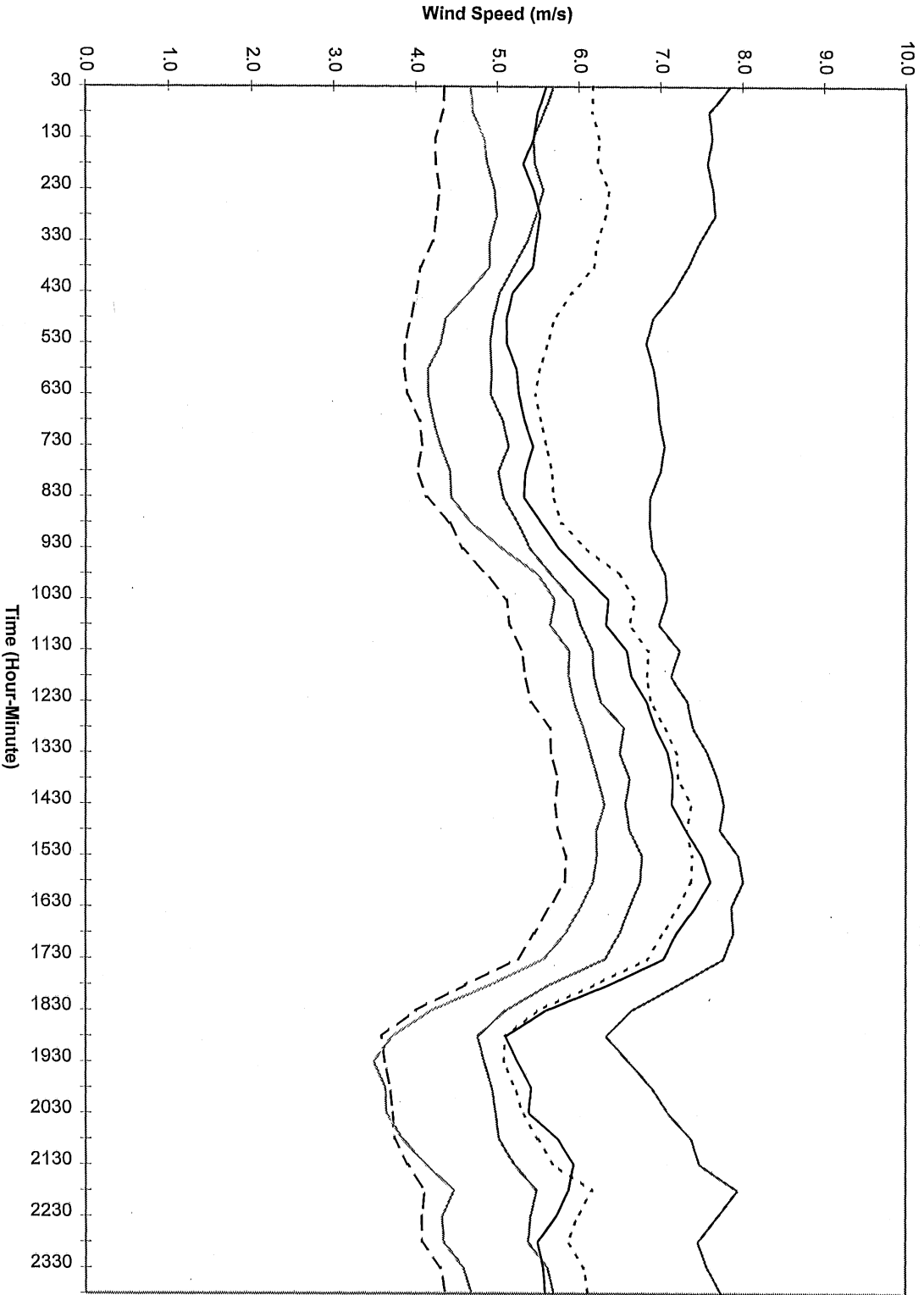
Semi-Hourly Averaged Mean Wind Speeds, August, 1996



Semi-Hourly Averaged Mean Wind Speeds, September, 1996



Semi-Hourly Averaged Mean Wind Speeds, October, 1996



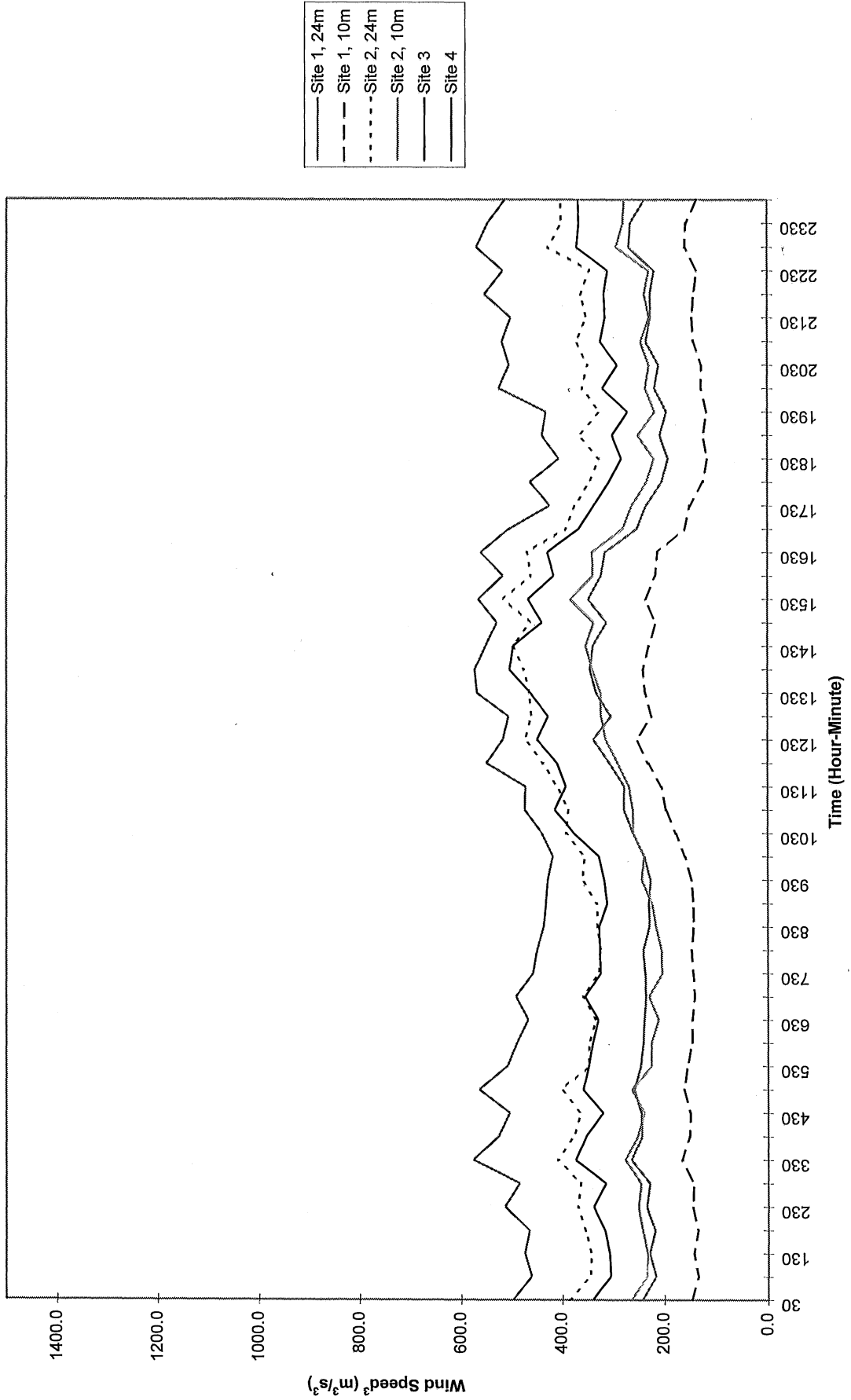
APPENDIX D

Monthly Averages of Semi-Hourly Cubed Wind Speeds

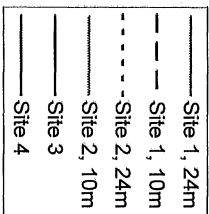
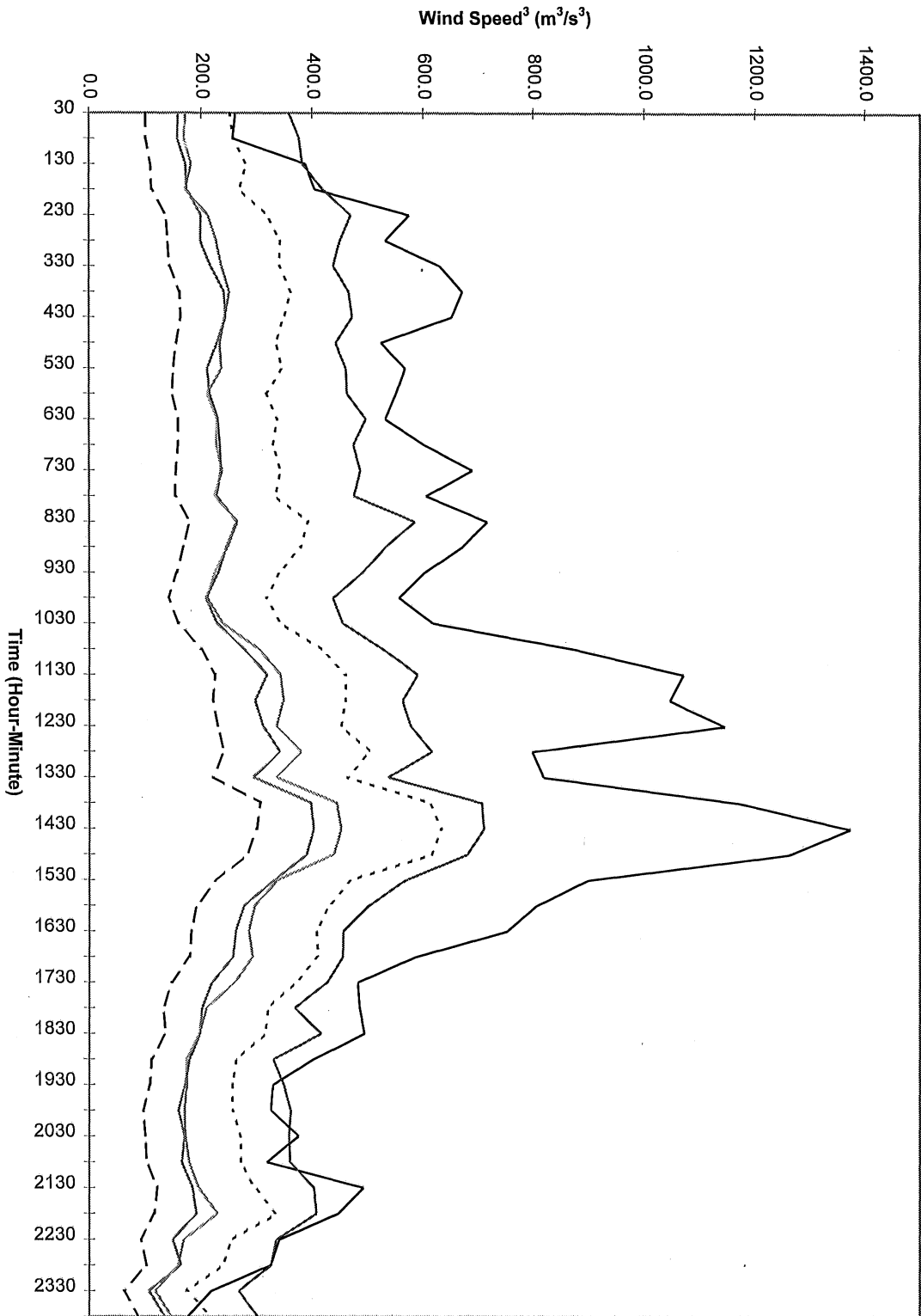
November 1995 - October 1996

D

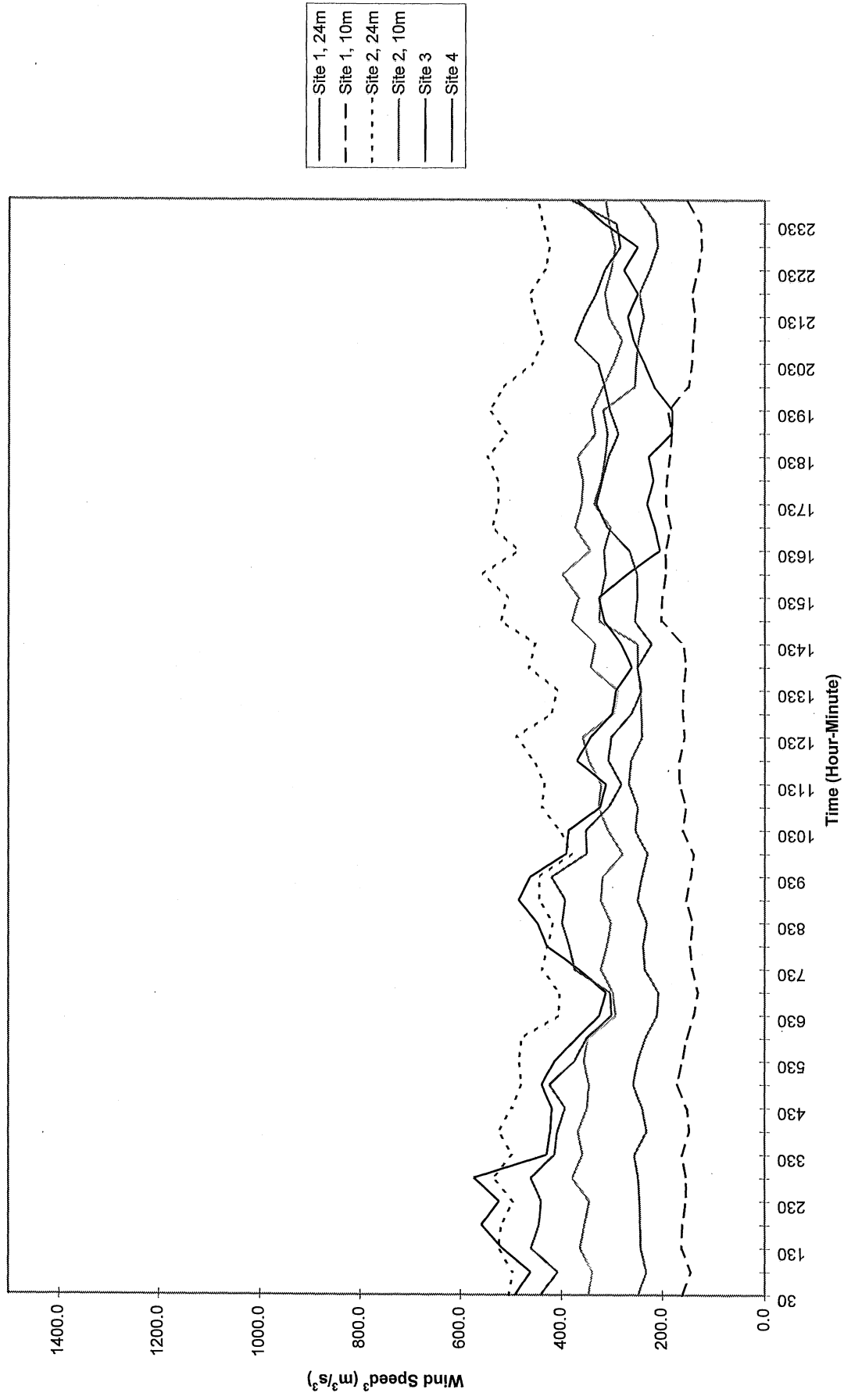
Semi-Hourly Averaged Mean Wind Speed³, November, 1995



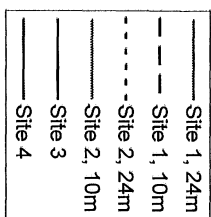
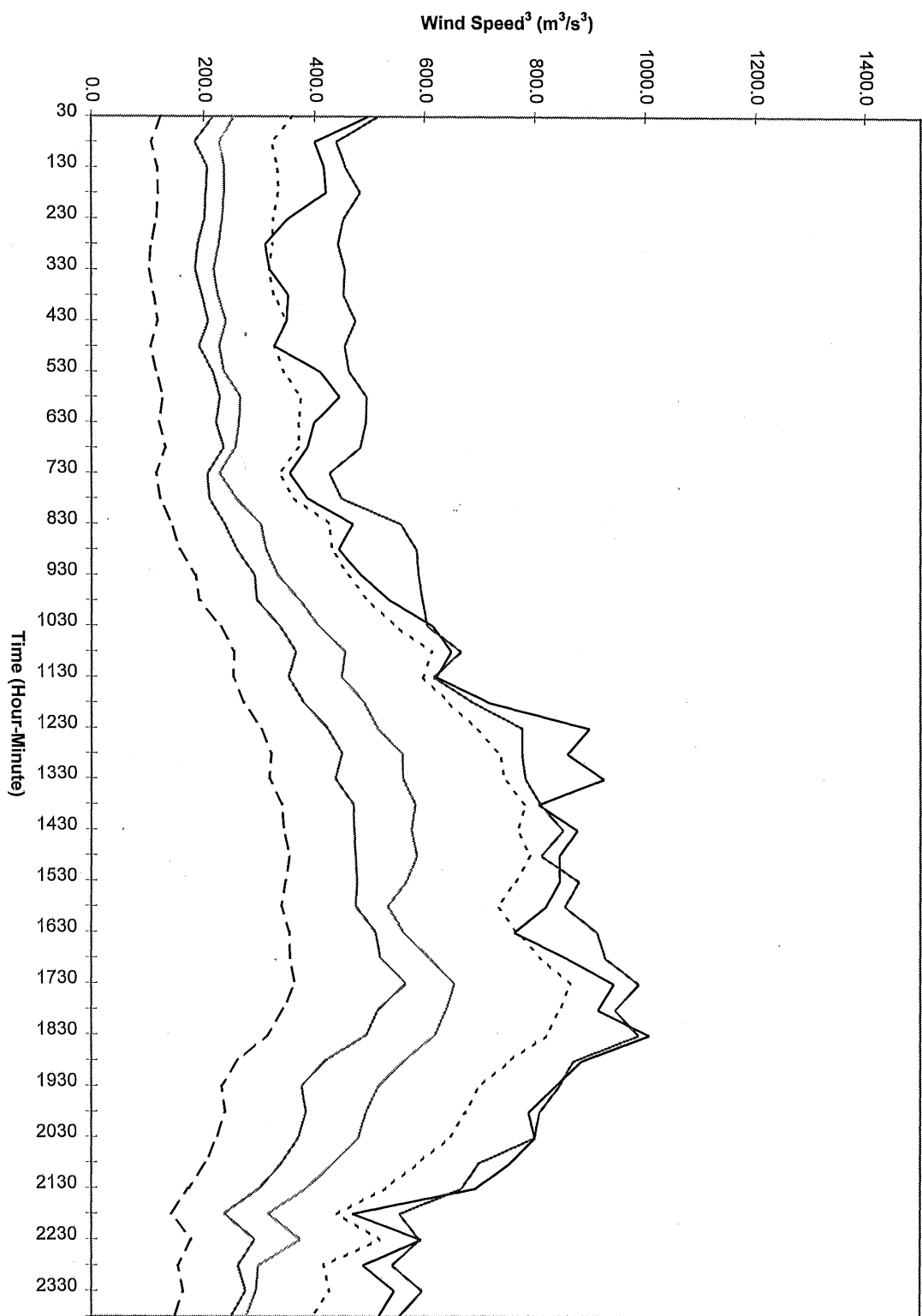
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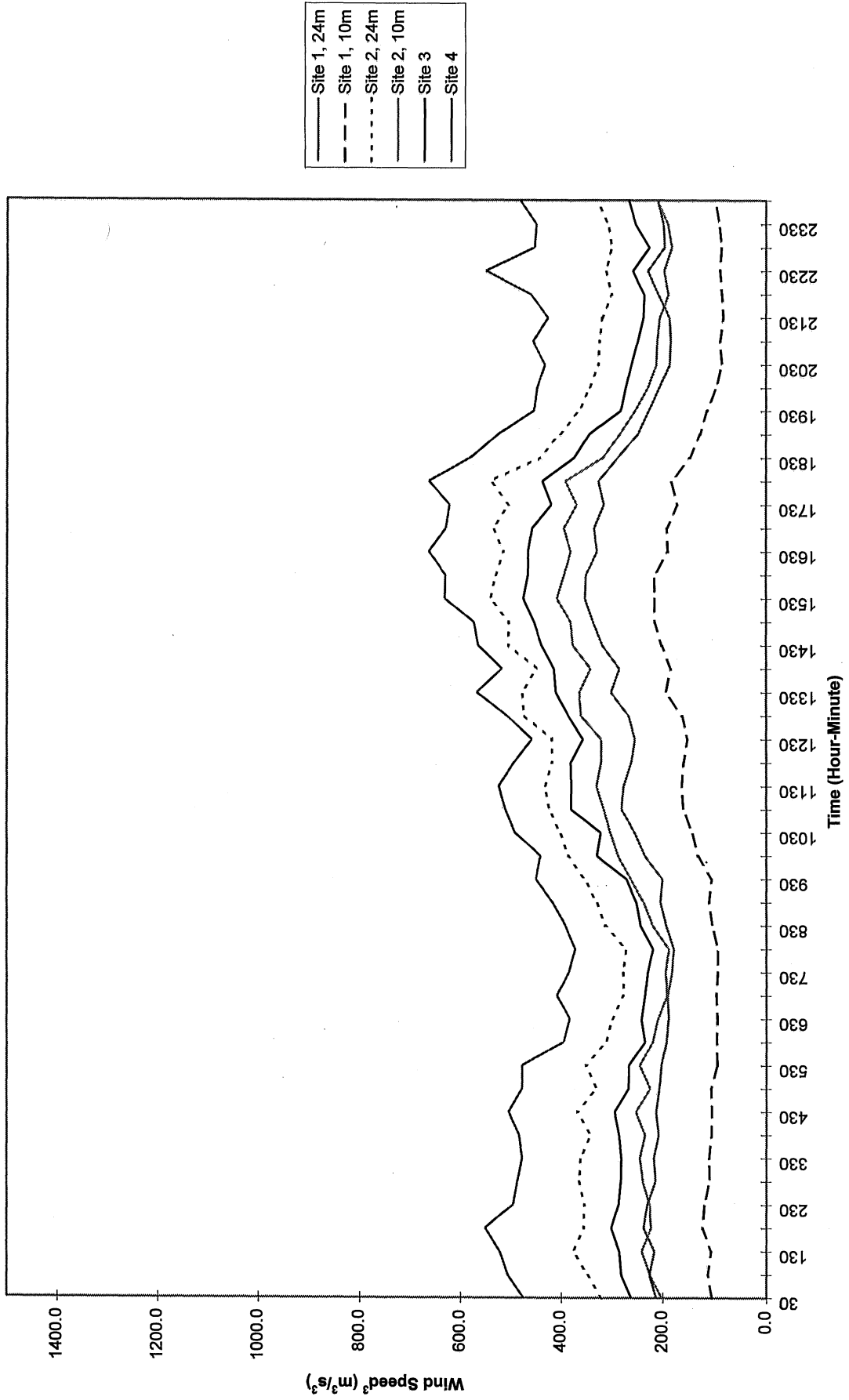
Semi-Hourly Averaged Mean Wind Speed³, January, 1996



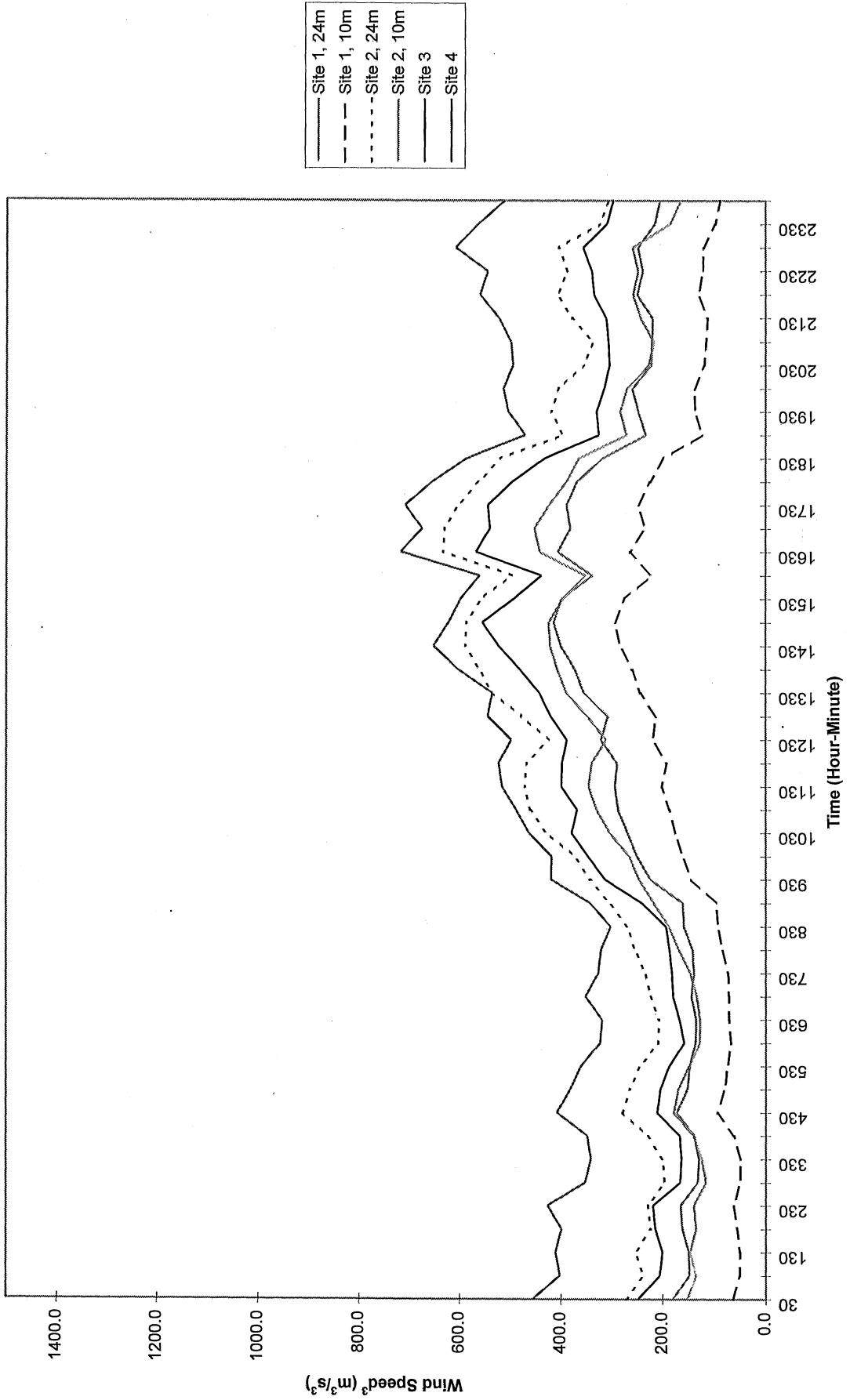
Semi-Hourly Averaged Mean Wind Speed³, February, 1996



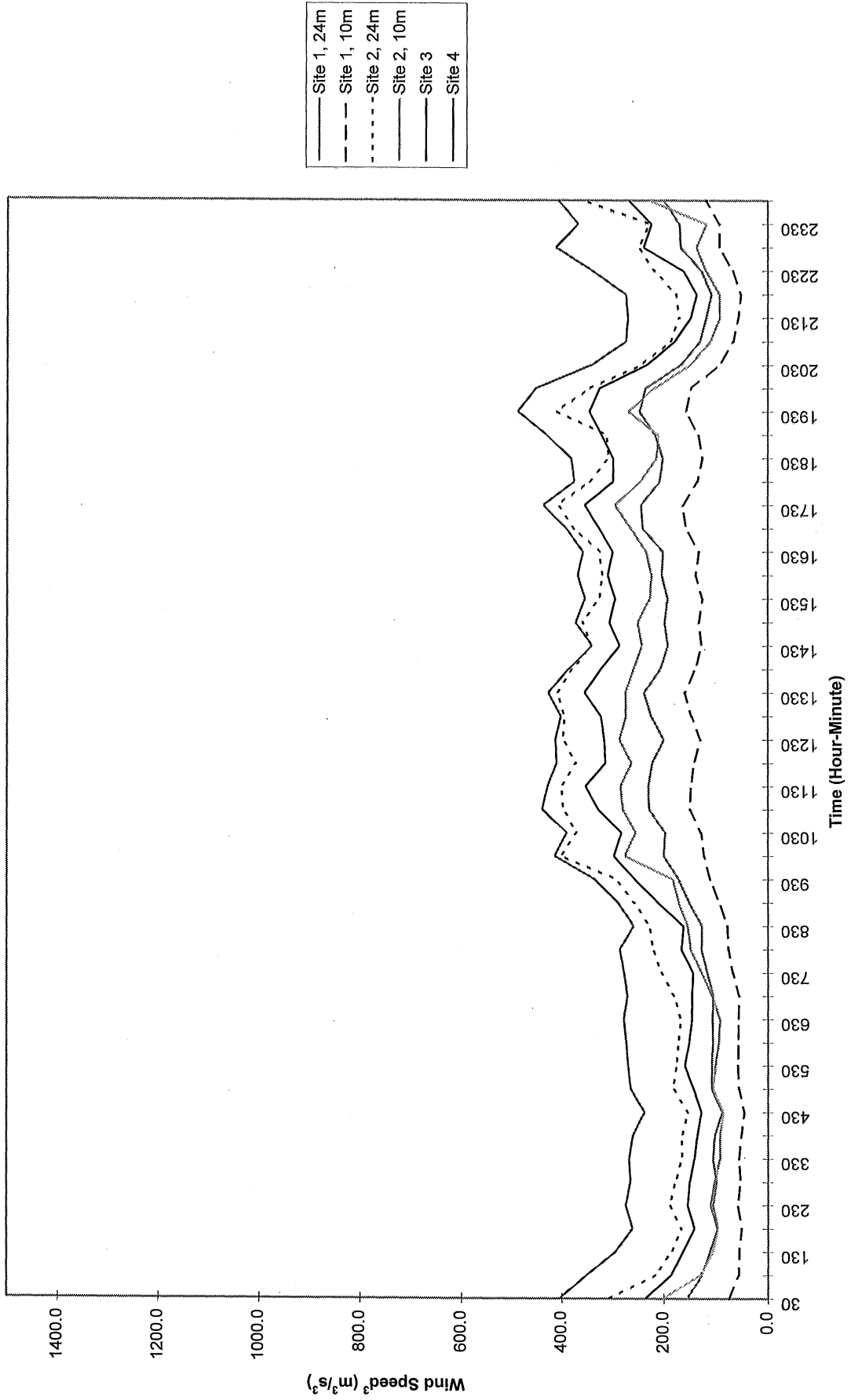
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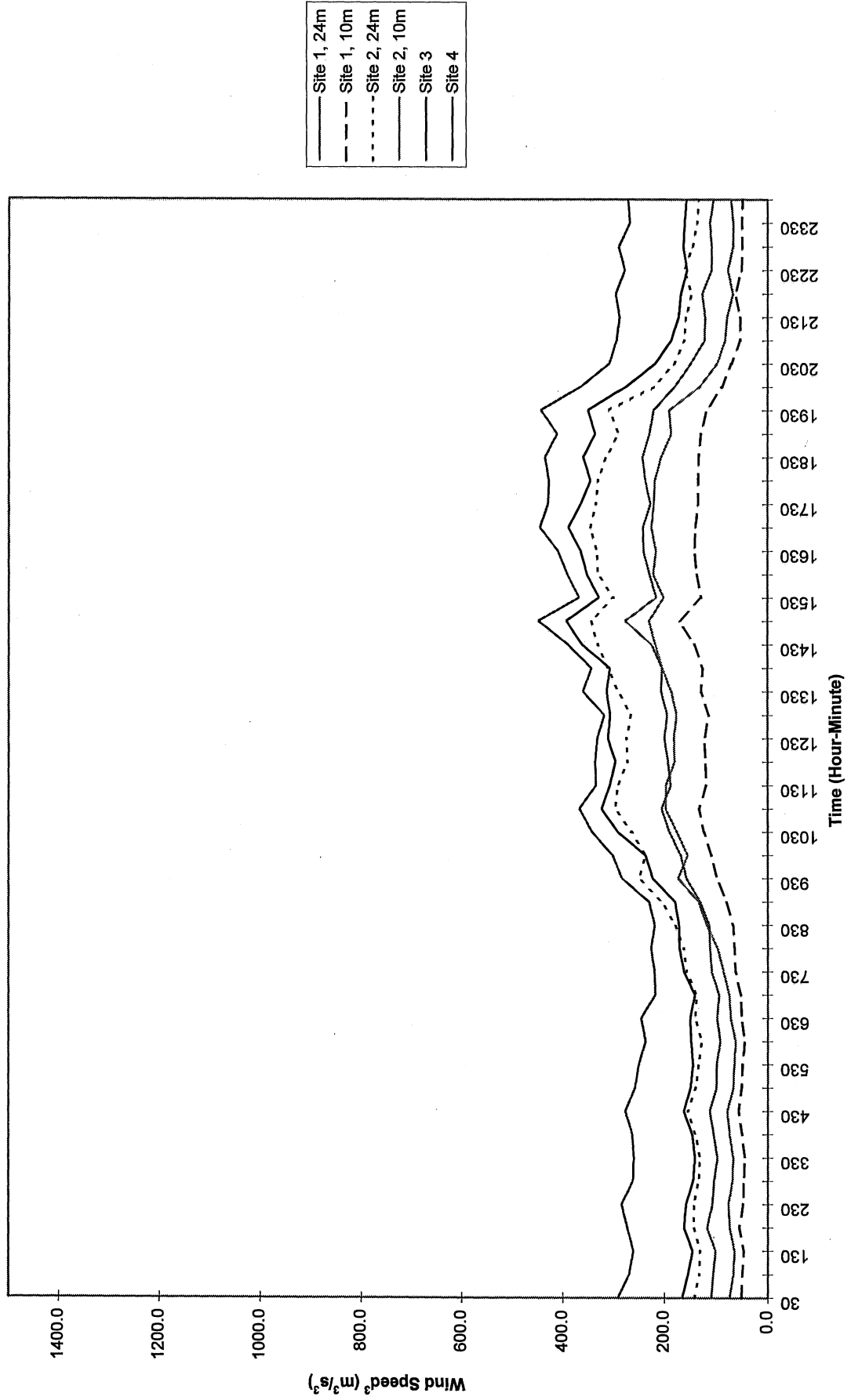
Semi-Hourly Averaged Mean Wind Speed³, April, 1996



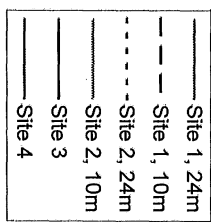
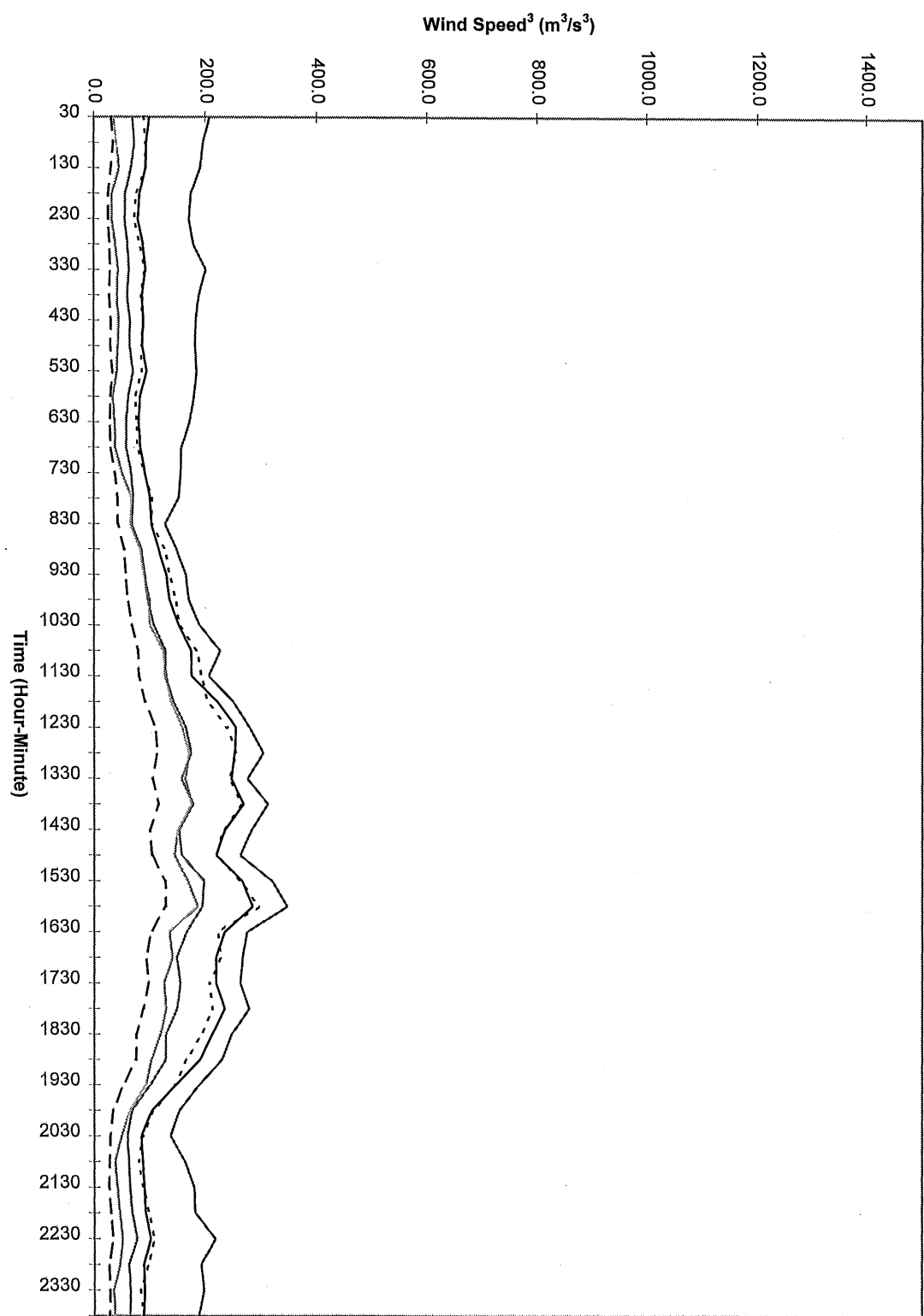
Semi-Hourly Averaged Mean Wind Speed³, May, 1996



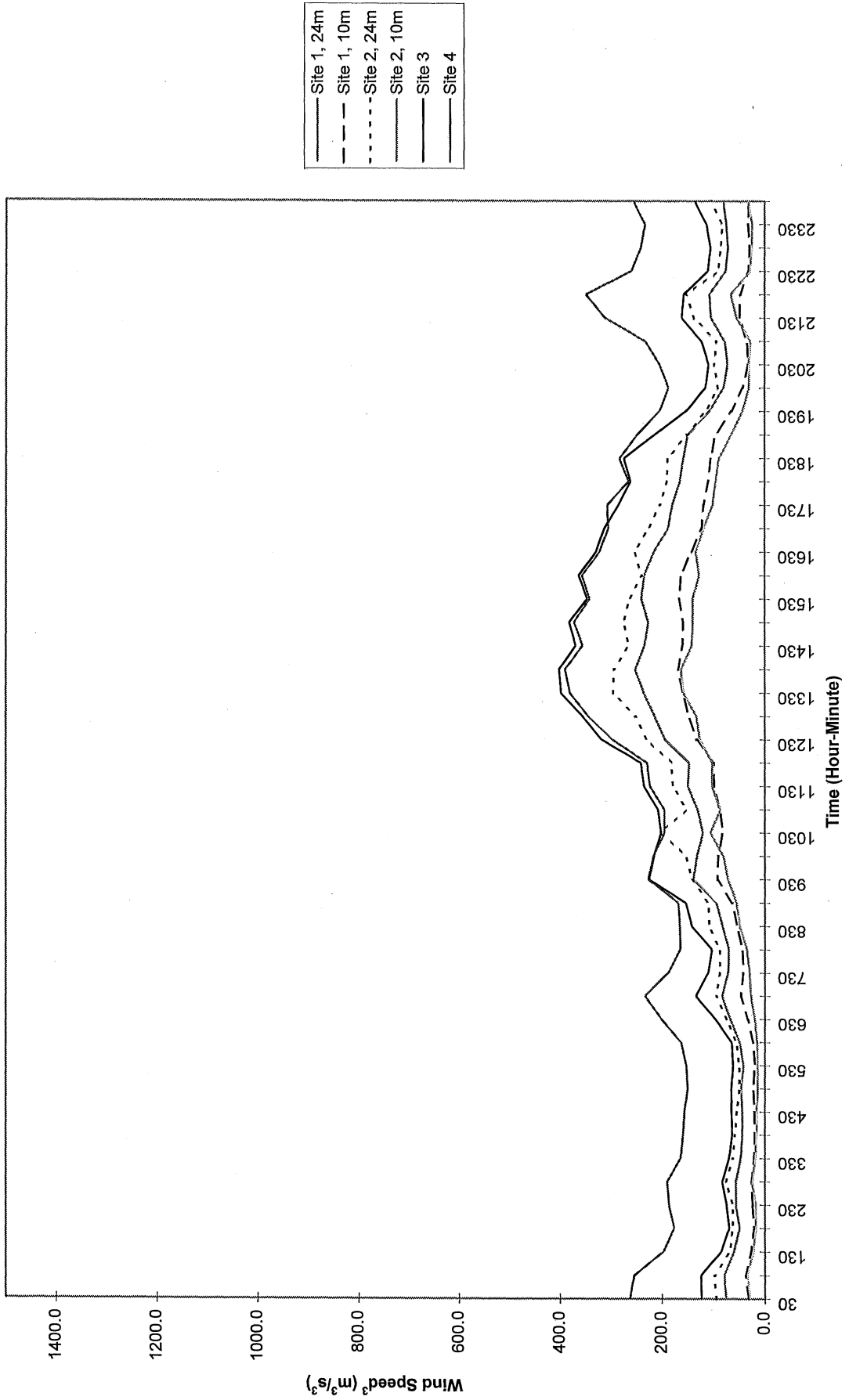
Semi-Hourly Averaged Mean Wind Speed³, June, 1996



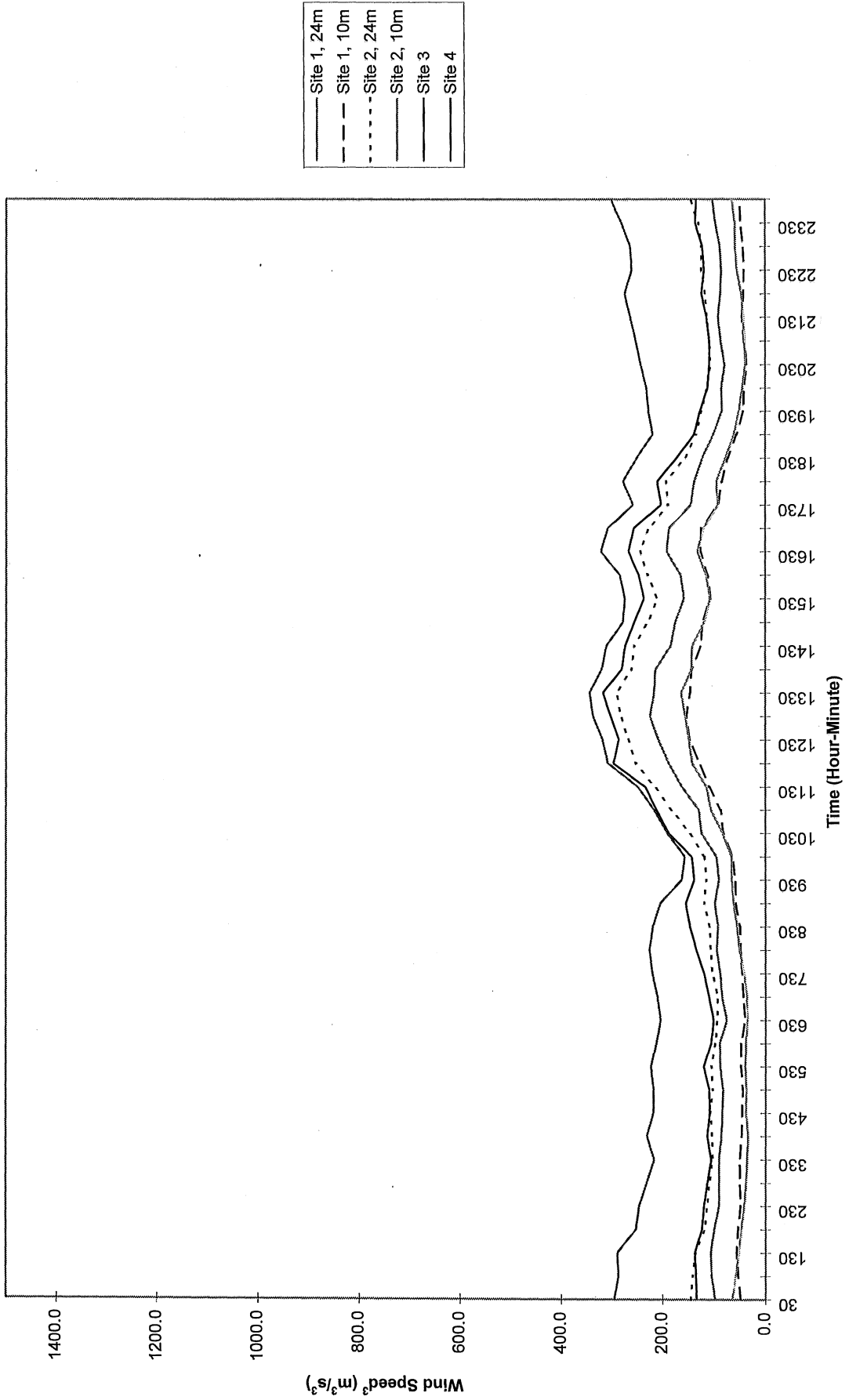
Semi-Hourly Averaged Mean Wind Speed³, July, 1996



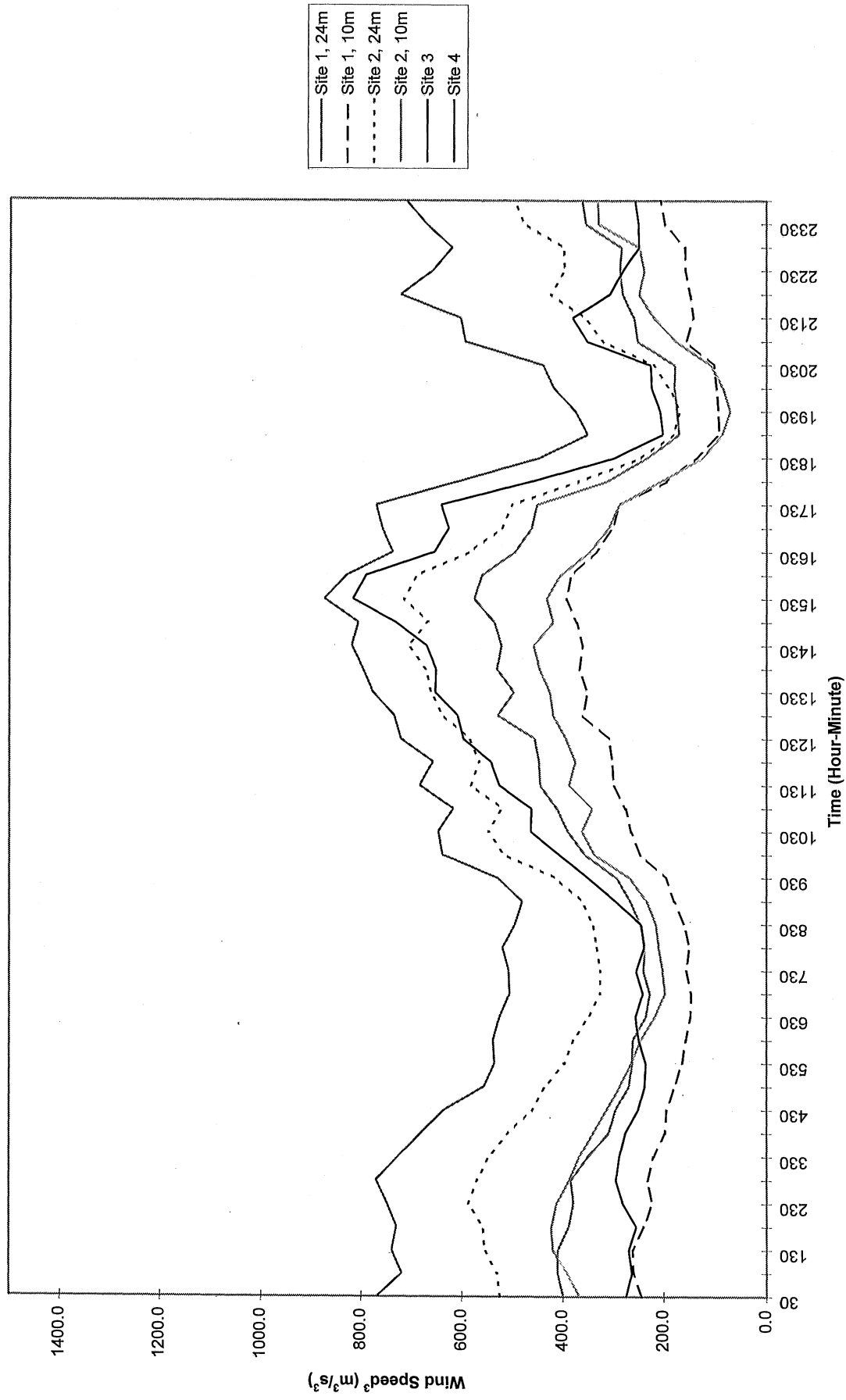
Semi-Hourly Averaged Mean Wind Speed³, August, 1996



Semi-Hourly Averaged Mean Wind Speed³, September, 1996



Semi-Hourly Averaged Mean Wind Speed³, October, 1996



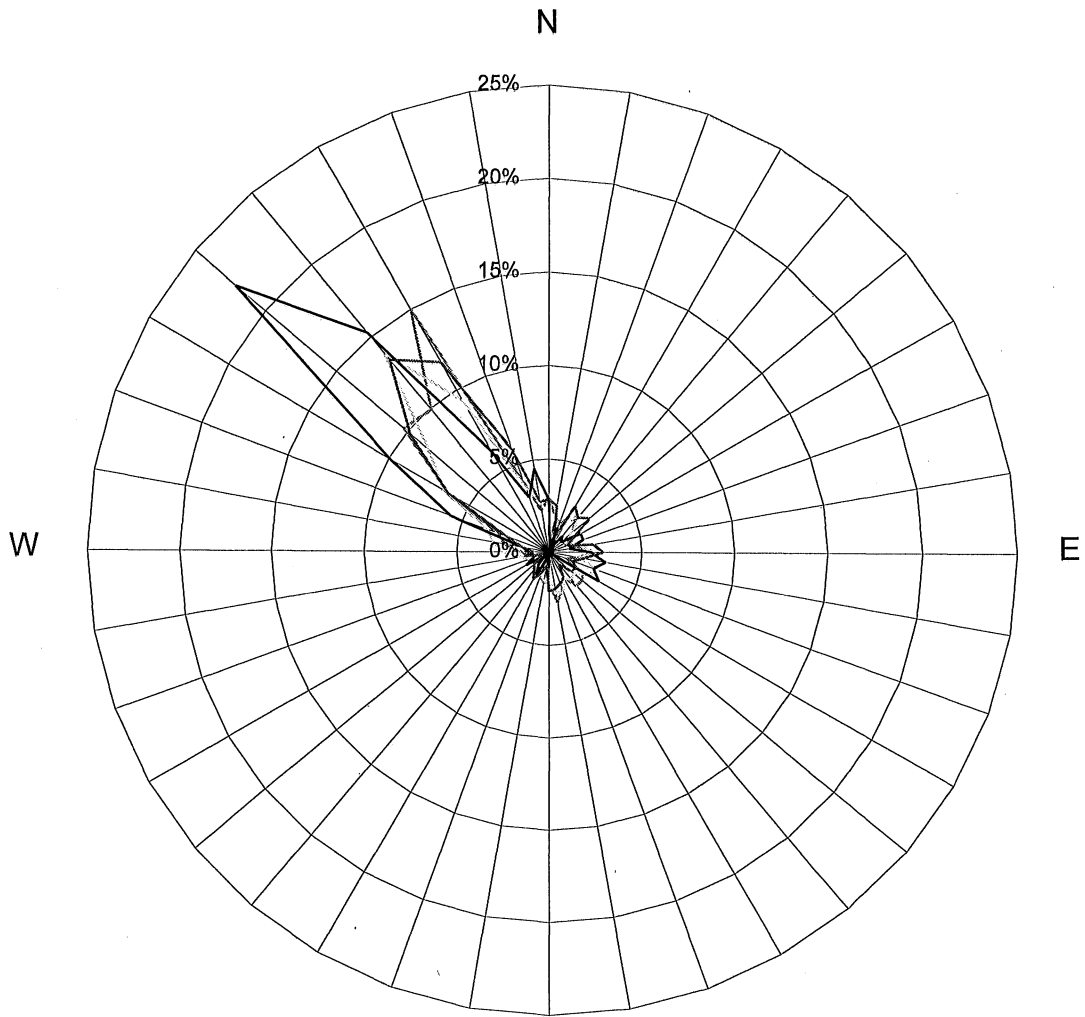
APPENDIX E

Monthly Wind Roses - All Wind Speeds V

November 1995 - October 1996

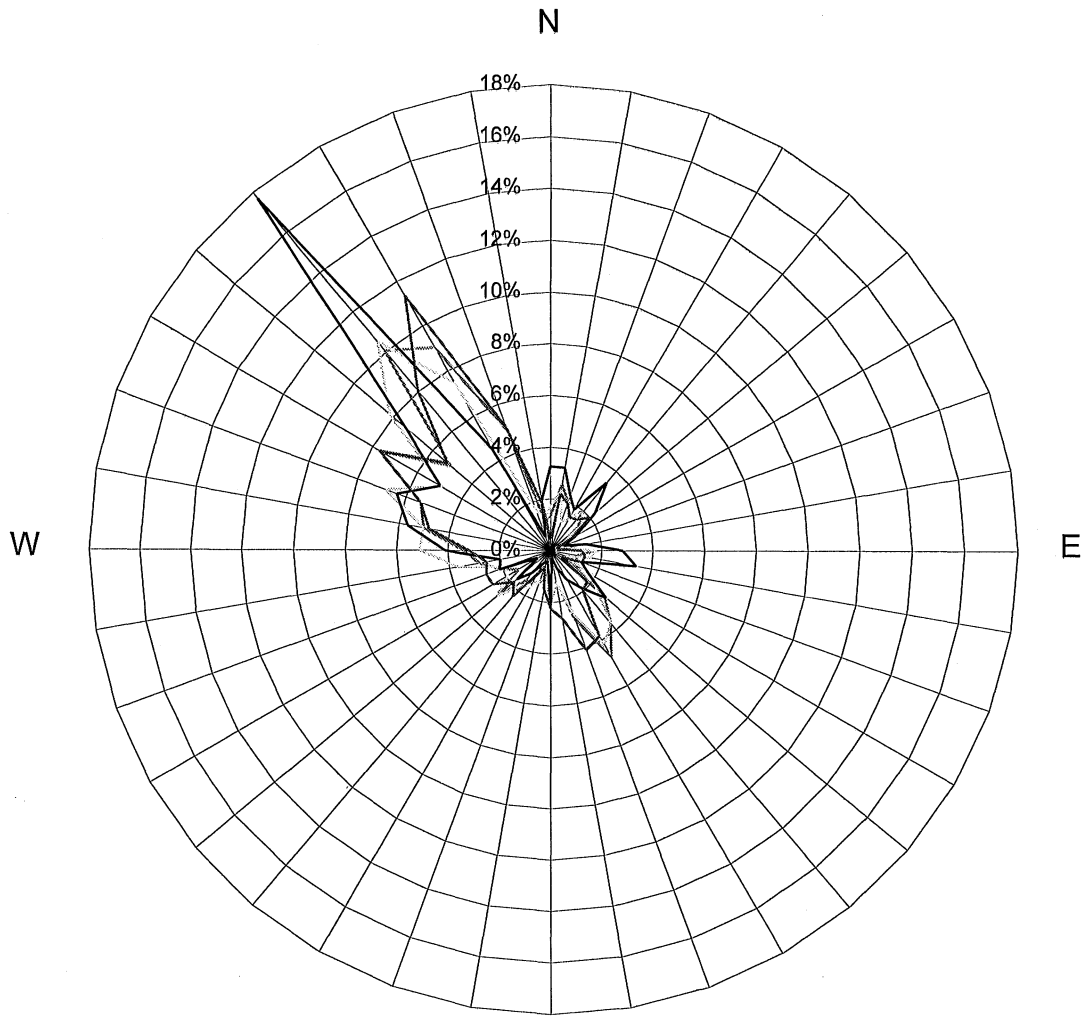
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Wind Rose, All Mean Wind Speeds, January, 1996



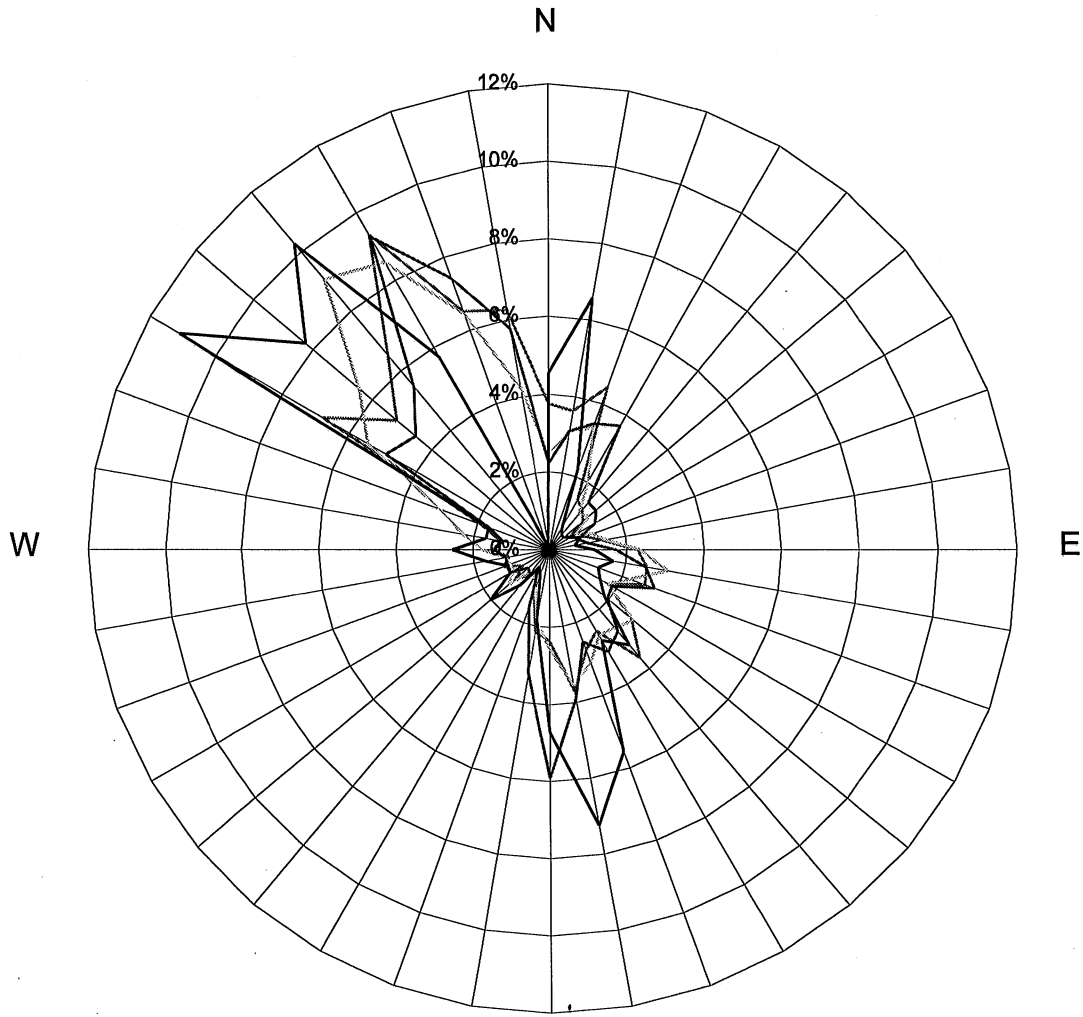
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Wind Rose, All Mean Wind Speeds, February, 1996



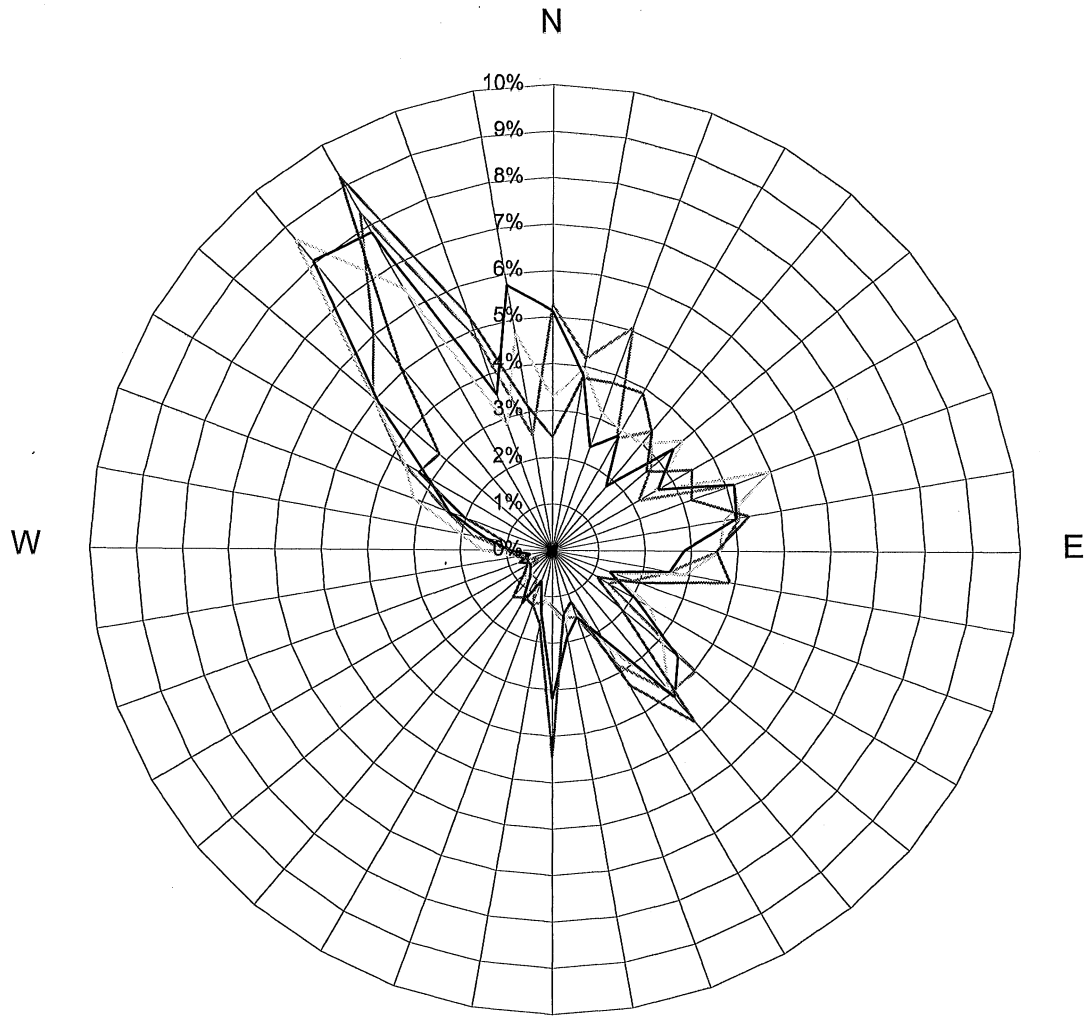
— Site 1 Site 2 — Site 3 — Site 4

Wind Rose, All Mean Wind Speeds, March, 1996



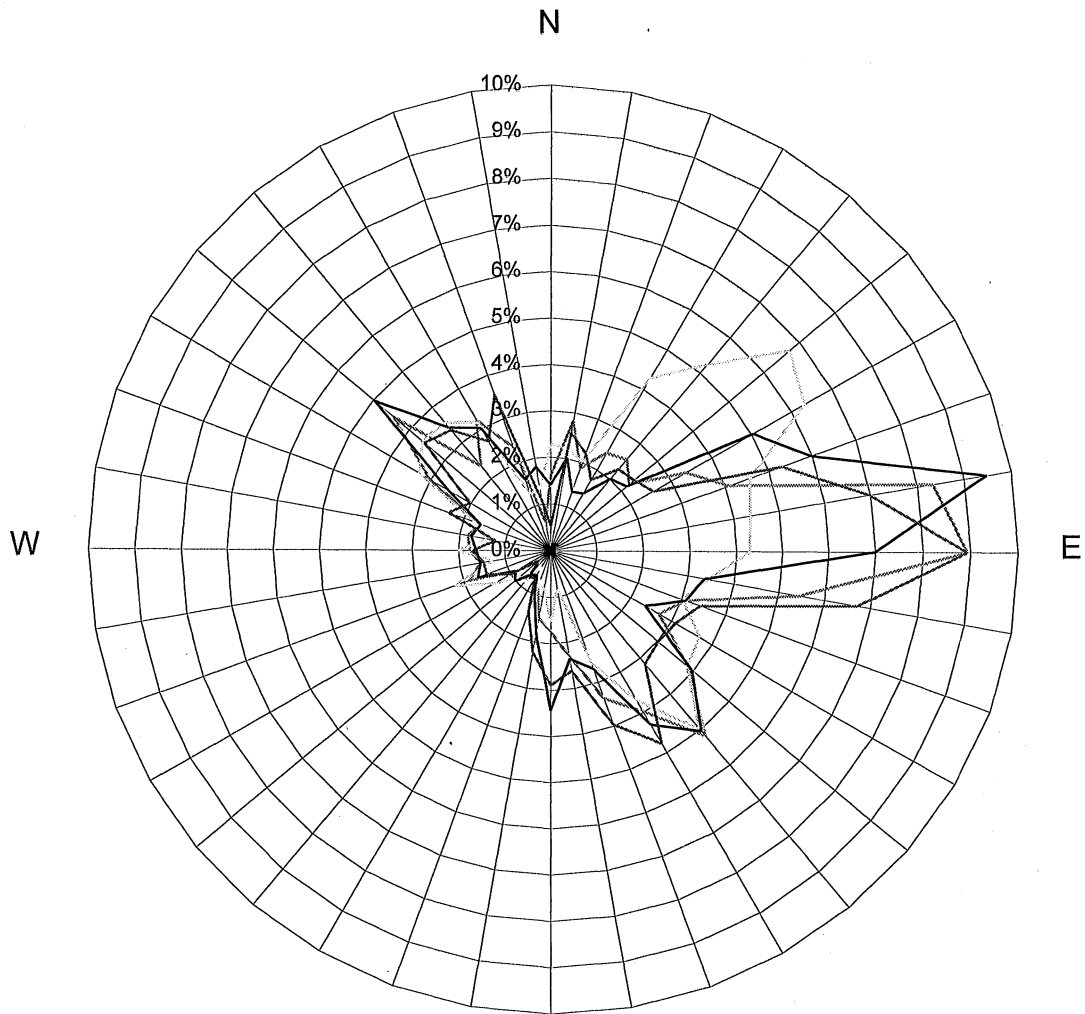
— Site 1 Site 2 - - - - Site 3 - - - - Site 4

Wind Rose, All Mean Wind Speeds, April, 1996



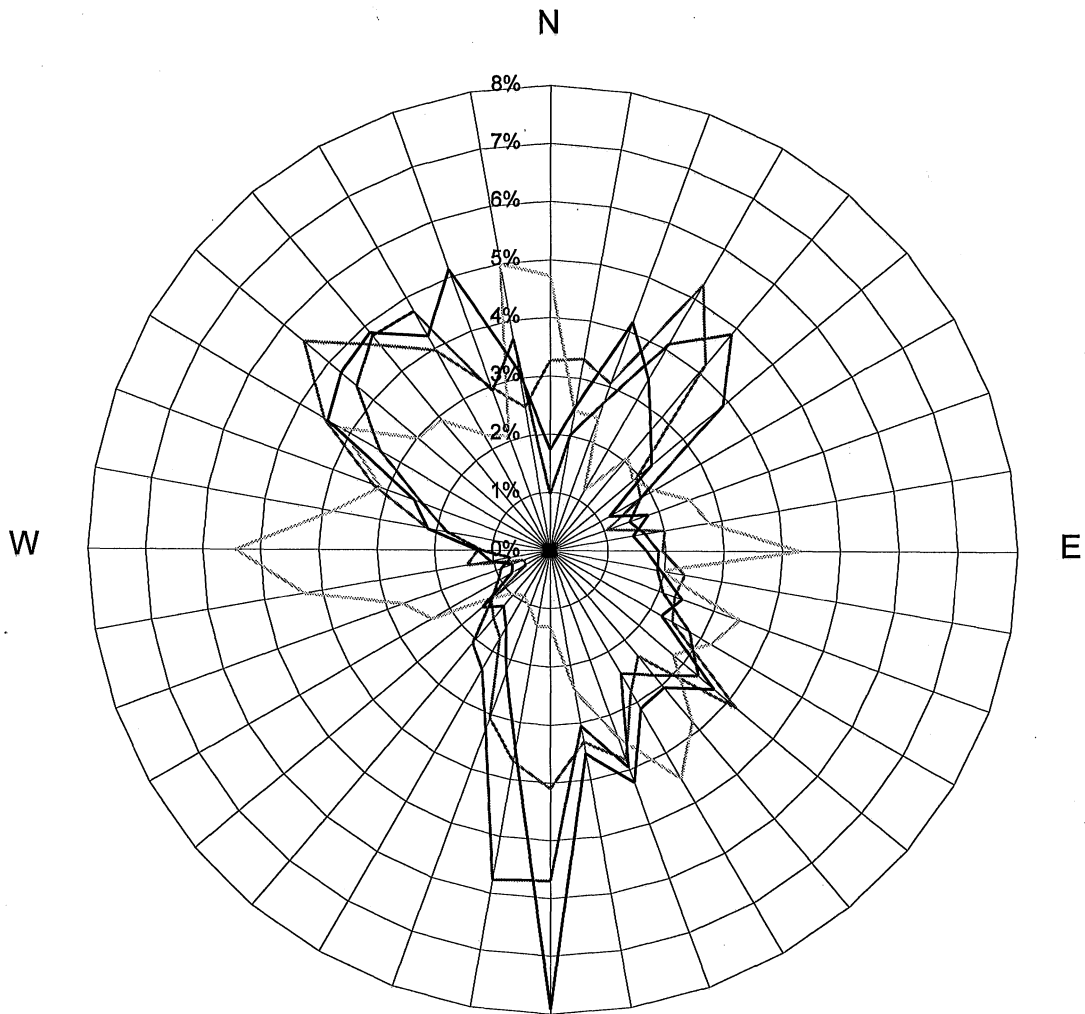
— Site 1 Site 2 — Site 3 — Site 4

Wind Rose, All Mean Wind Speeds, May, 1996



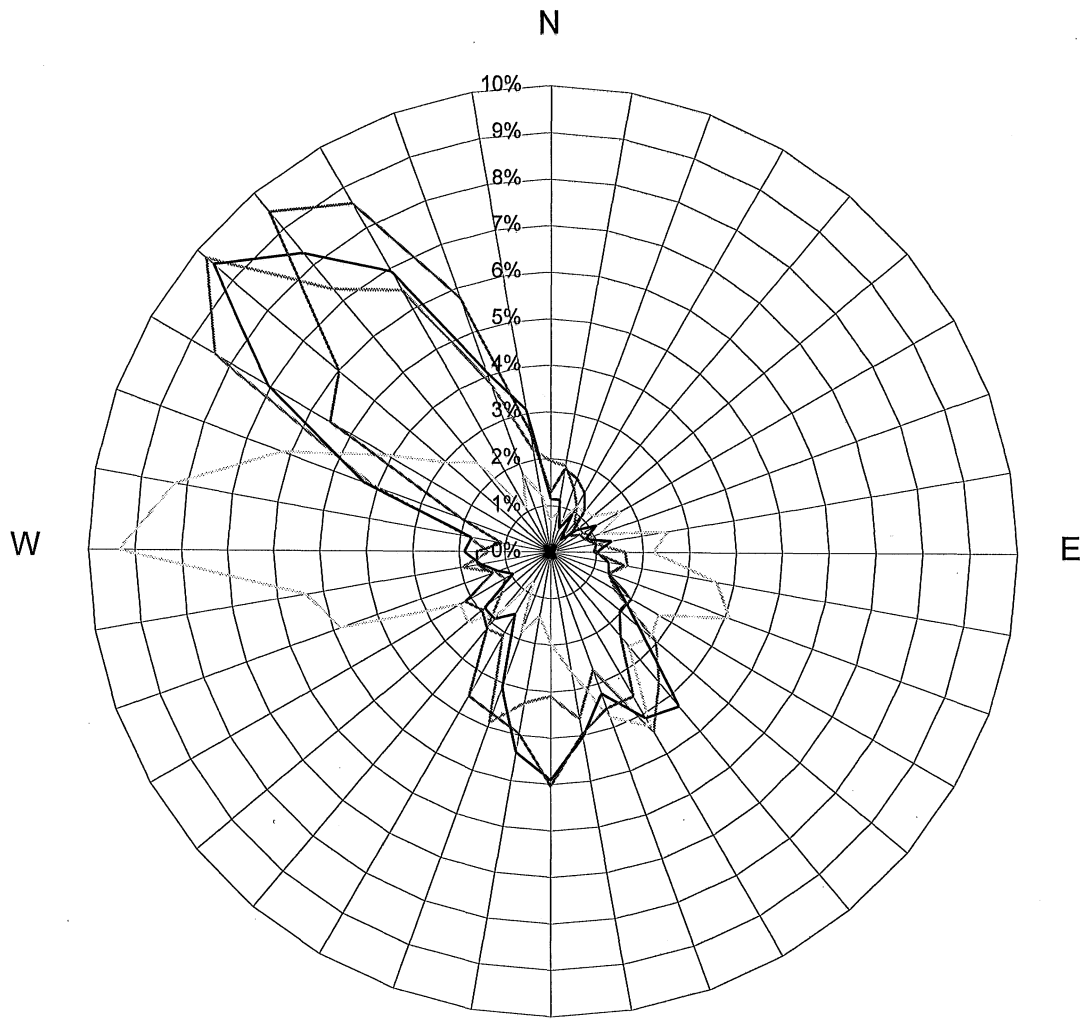
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Wind Rose, All Mean Wind Speeds, June, 1996



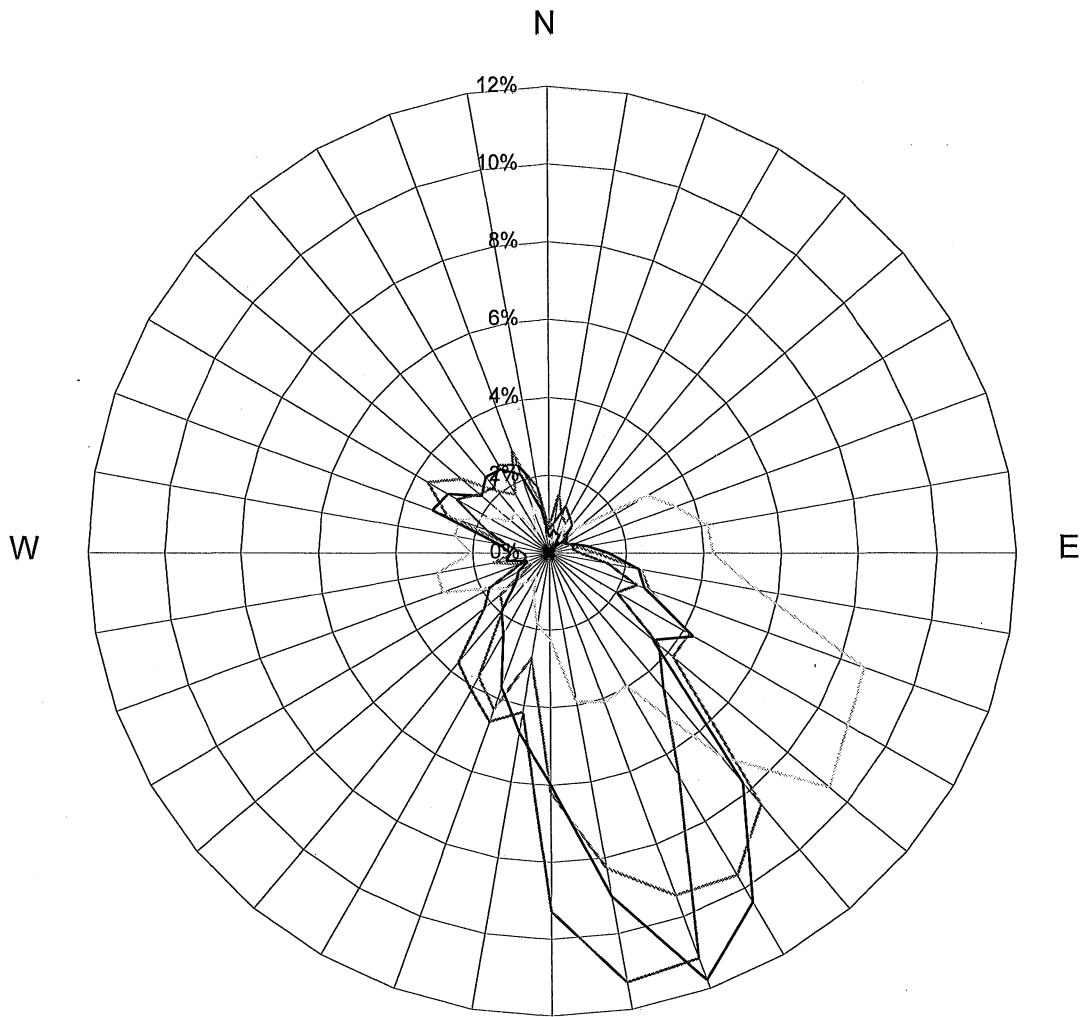
— Site 1 Site 2 - - - Site 3 - · - Site 4

Wind Rose, All Mean Wind Speeds, July, 1996



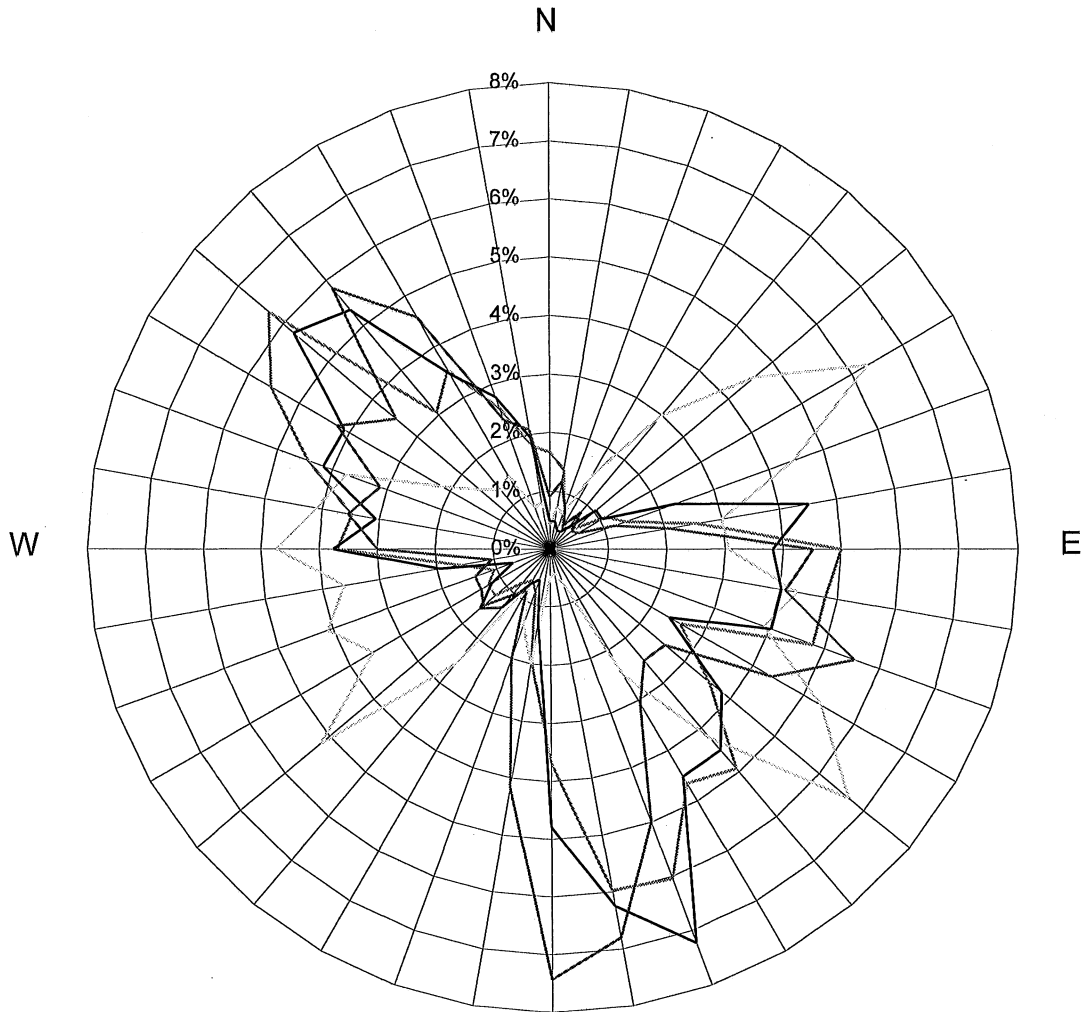
— Site 1 Site 2 — Site 3 — Site 4

Wind Rose, All Mean Wind Speeds, August, 1996



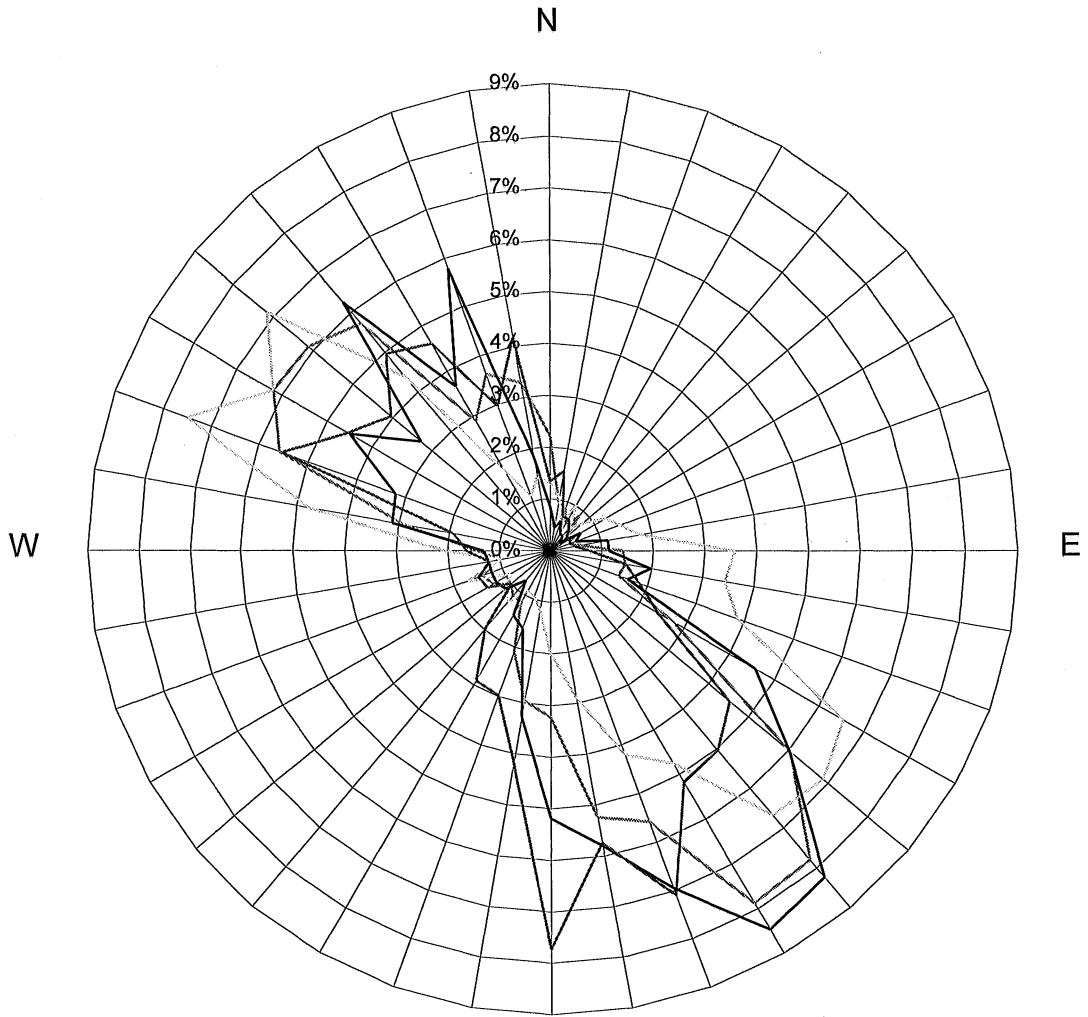
Site 1 Site 2 Site 3 Site 4

Wind Rose, All Mean Wind Speeds, September, 1996



Site 1 Site 2 Site 3 Site 4

Wind Rose, All Mean Wind Speeds, October, 1996



— Site 1 ··· Site 2 - - - Site 3 - · - Site 4

APPENDIX F

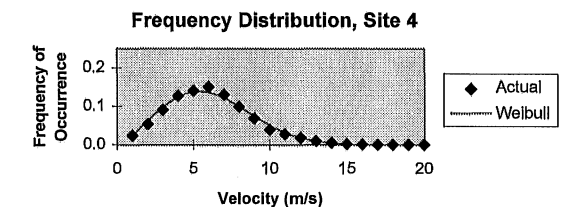
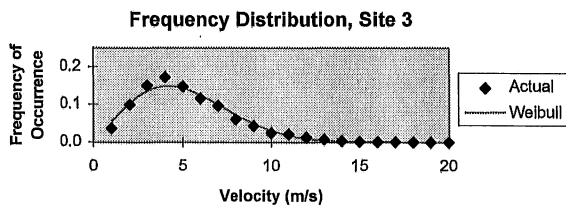
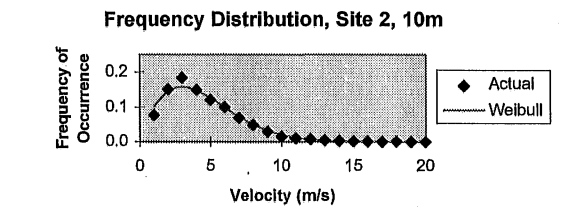
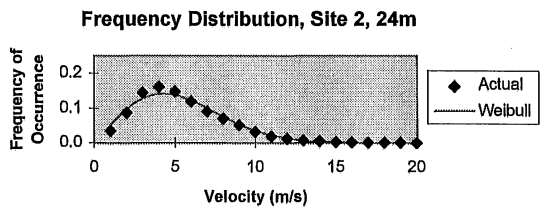
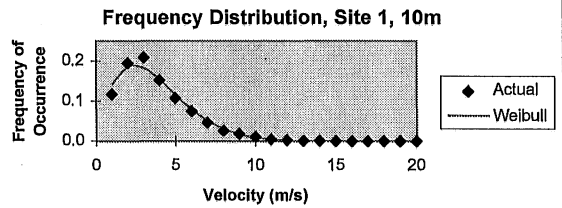
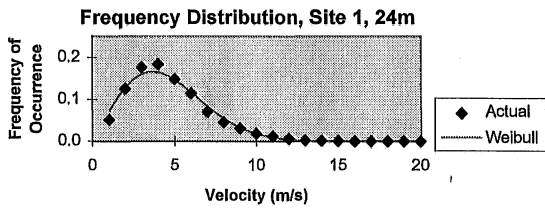
Probability Distributions of Thirty-Minute Wind Speeds

November 1995 - October 1996

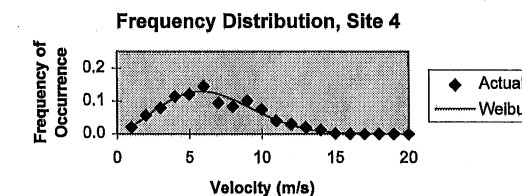
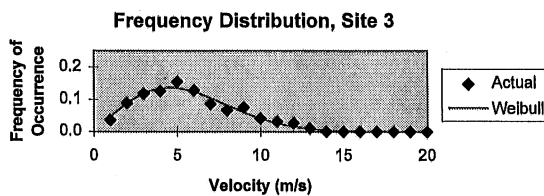
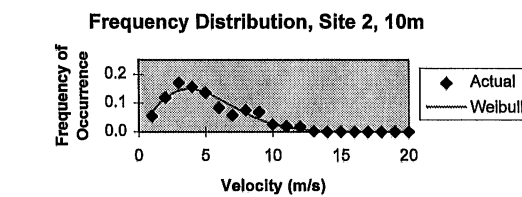
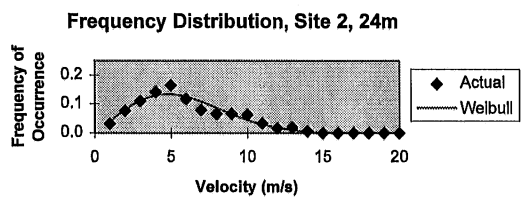
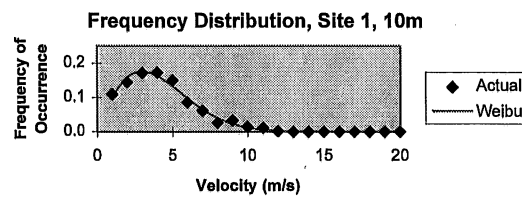
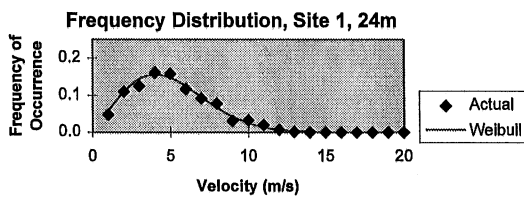
F

November 1, 1995 through October 31, 1996

	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.596		3.655		5.368		4.403		5.185		6.107	
$(V^2)_m$ (m ² /s ²)	26.860		18.319		36.673		26.354		34.031		45.040	
$(V_m^2)/(V^2)_m$	0.786		0.729		0.786		0.736		0.790		0.828	
C	2.004		1.687		2.004		1.721		2.031		2.330	
A (m/s)	5.175		4.116		6.045		4.958		5.838		6.877	
a	0.037		0.092		0.027		0.064		0.028		0.011	
Frequency of Occurrence												
Velocity (m/s)	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.051	0.072	0.118	0.141	0.035	0.053	0.078	0.103	0.037	0.055	0.024	0.026
2	0.126	0.128	0.195	0.186	0.087	0.098	0.151	0.146	0.099	0.103	0.054	0.062
3	0.177	0.160	0.209	0.183	0.145	0.128	0.184	0.159	0.151	0.135	0.090	0.097
4	0.184	0.165	0.153	0.155	0.162	0.141	0.150	0.149	0.173	0.148	0.128	0.124
5	0.148	0.147	0.108	0.117	0.148	0.138	0.121	0.127	0.147	0.143	0.141	0.138
6	0.115	0.117	0.075	0.080	0.120	0.123	0.101	0.099	0.116	0.124	0.150	0.136
7	0.070	0.084	0.047	0.051	0.092	0.100	0.069	0.073	0.097	0.099	0.130	0.122
8	0.046	0.055	0.027	0.030	0.070	0.076	0.049	0.050	0.060	0.072	0.100	0.100
9	0.031	0.033	0.018	0.017	0.051	0.054	0.030	0.033	0.043	0.049	0.069	0.075
10	0.018	0.018	0.011	0.009	0.032	0.035	0.015	0.020	0.025	0.031	0.040	0.051
11	0.012	0.009	0.005	0.004	0.018	0.022	0.010	0.012	0.021	0.018	0.029	0.032
12	0.006	0.004	0.002	0.002	0.012	0.013	0.008	0.007	0.013	0.010	0.019	0.018
13	0.002	0.002	0.001	0.001	0.007	0.007	0.005	0.004	0.007	0.005	0.010	0.010
14	0.002	0.001	0.001	0.000	0.005	0.004	0.003	0.002	0.003	0.002	0.006	0.005
15	0.001	0.000	0.000	0.000	0.003	0.002	0.002	0.001	0.001	0.001	0.003	0.002
16	0.000	0.000	0.000	0.000	0.002	0.001	0.001	0.000	0.000	0.000	0.002	0.001
17	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.000
18	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

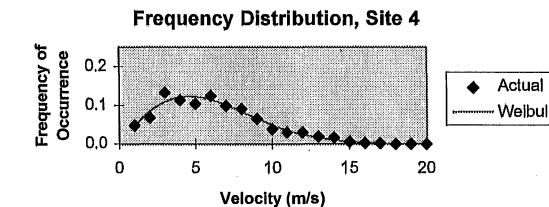
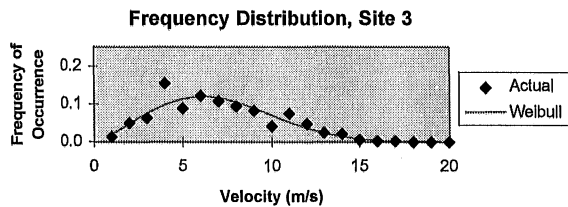
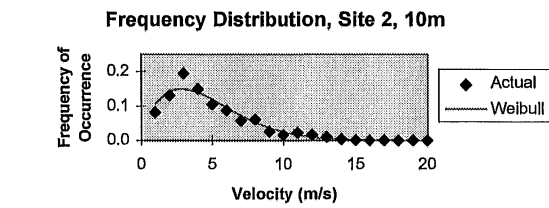
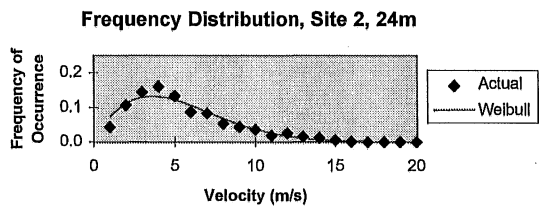
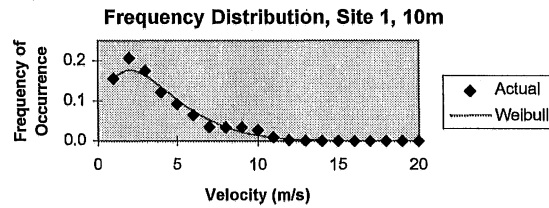
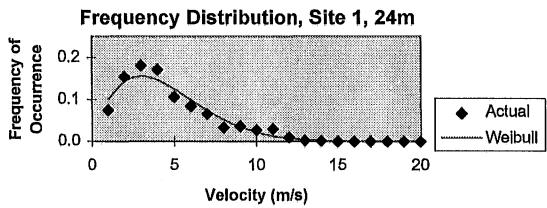


November, 1995												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.974		4.104		5.832		4.948		5.643		6.561	
$(V^2)_m$ (m ² /s ²)	31.146		22.222		42.619		31.820		40.239		51.922	
$(V_m)^2/(V^2)_m$	0.794		0.758		0.798		0.770		0.791		0.829	
C	2.058		1.835		2.087		1.904		2.038		2.339	
A (m/s)	5.600		4.621		6.567		5.572		6.354		7.388	
a	0.029		0.060		0.020		0.038		0.023		0.009	
Frequency of Occurrence												
Velocity (m/s)	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.048	0.058	0.110	0.104	0.032	0.040	0.055	0.070	0.037	0.046	0.020	0.022
2	0.110	0.110	0.145	0.159	0.076	0.080	0.119	0.117	0.089	0.088	0.057	0.053
3	0.126	0.144	0.172	0.176	0.110	0.112	0.171	0.144	0.118	0.119	0.079	0.084
4	0.162	0.156	0.174	0.163	0.142	0.130	0.157	0.149	0.126	0.134	0.115	0.110
5	0.158	0.148	0.151	0.134	0.165	0.134	0.137	0.137	0.155	0.135	0.122	0.126
6	0.117	0.125	0.086	0.098	0.117	0.126	0.084	0.116	0.129	0.124	0.146	0.130
7	0.092	0.096	0.061	0.066	0.080	0.109	0.058	0.090	0.086	0.105	0.095	0.122
8	0.078	0.067	0.026	0.041	0.065	0.087	0.075	0.065	0.067	0.082	0.083	0.106
9	0.031	0.043	0.033	0.023	0.066	0.065	0.069	0.044	0.075	0.060	0.101	0.084
10	0.032	0.025	0.015	0.012	0.063	0.045	0.025	0.028	0.042	0.041	0.075	0.062
11	0.020	0.014	0.012	0.006	0.034	0.030	0.019	0.016	0.032	0.027	0.040	0.043
12	0.007	0.007	0.002	0.003	0.017	0.018	0.018	0.009	0.028	0.016	0.030	0.027
13	0.001	0.003	0.000	0.001	0.019	0.010	0.002	0.005	0.011	0.009	0.020	0.016
14	0.000	0.001	0.000	0.000	0.007	0.006	0.000	0.002	0.001	0.005	0.012	0.009
15	0.000	0.001	0.000	0.000	0.000	0.003	0.000	0.001	0.000	0.002	0.001	0.004
16	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.002
17	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



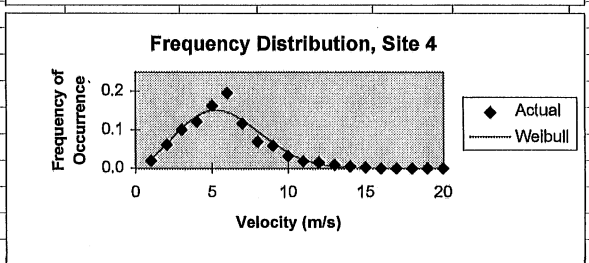
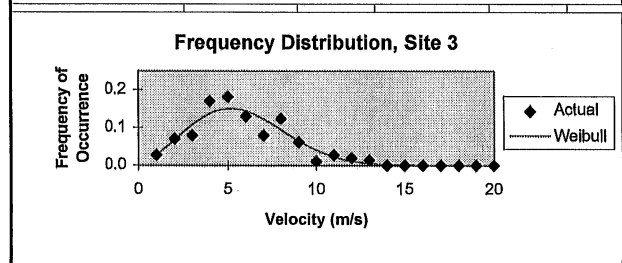
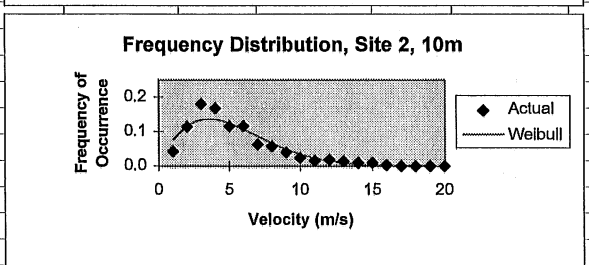
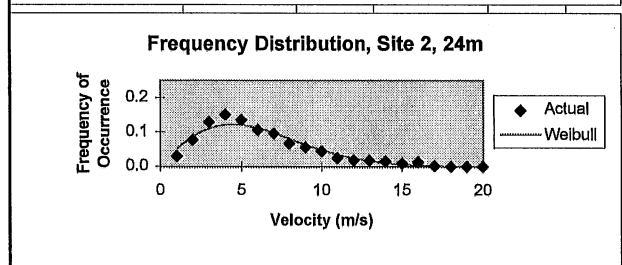
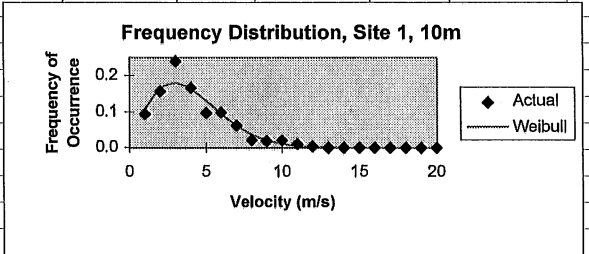
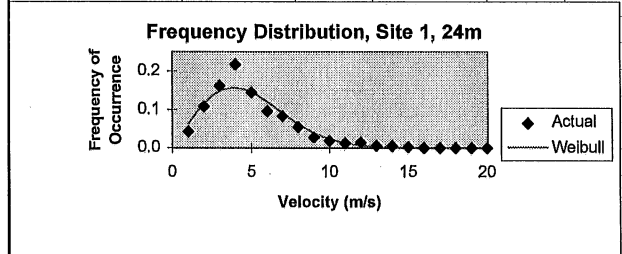
December, 1995												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.483		3.693		5.303		4.536		6.989		6.011	
$(V_m^2)_m$ (m ² /s ²)	27.396		20.152		38.031		28.732		59.273		46.888	
$(V_m)^2/(V_m^2)_m$	0.734		0.677		0.739		0.716		0.824		0.771	
C	1.711		1.472		1.735		1.628		2.294		1.910	
A (m/s)	5.048		4.158		5.971		5.107		7.869		6.769	
a	0.063		0.123		0.045		0.070		0.009		0.026	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.075	0.101	0.157	0.160	0.044	0.075	0.082	0.107	0.014	0.020	0.048	0.048
2	0.155	0.143	0.208	0.178	0.107	0.112	0.131	0.142	0.050	0.047	0.068	0.084
3	0.181	0.155	0.175	0.163	0.144	0.129	0.195	0.150	0.064	0.075	0.134	0.109
4	0.171	0.147	0.123	0.135	0.161	0.131	0.151	0.140	0.155	0.098	0.113	0.121
5	0.107	0.126	0.093	0.104	0.134	0.122	0.106	0.120	0.089	0.114	0.104	0.122
6	0.085	0.100	0.065	0.076	0.088	0.106	0.088	0.096	0.122	0.120	0.125	0.114
7	0.066	0.074	0.035	0.053	0.084	0.087	0.058	0.073	0.108	0.117	0.099	0.100
8	0.034	0.052	0.034	0.035	0.054	0.068	0.062	0.053	0.094	0.105	0.091	0.083
9	0.036	0.035	0.034	0.023	0.044	0.051	0.026	0.037	0.083	0.089	0.065	0.065
10	0.028	0.022	0.028	0.014	0.036	0.037	0.017	0.025	0.042	0.070	0.038	0.049
11	0.030	0.013	0.009	0.009	0.019	0.025	0.023	0.016	0.075	0.052	0.030	0.035
12	0.010	0.008	0.003	0.005	0.026	0.017	0.017	0.010	0.047	0.036	0.030	0.024
13	0.002	0.004	0.001	0.003	0.015	0.011	0.010	0.006	0.025	0.024	0.019	0.016
14	0.001	0.002	0.000	0.002	0.012	0.007	0.003	0.003	0.022	0.014	0.017	0.010
15	0.000	0.001	0.000	0.001	0.005	0.004	0.001	0.002	0.006	0.008	0.006	0.006
16	0.000	0.001	0.000	0.000	0.001	0.002	0.000	0.001	0.003	0.004	0.003	0.004
17	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.003	0.002	0.001	0.002
18	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



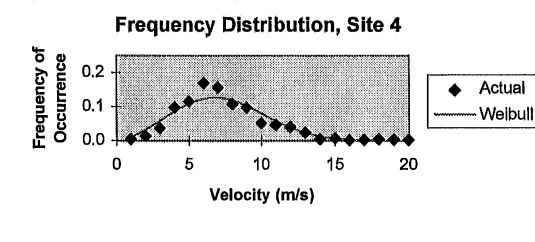
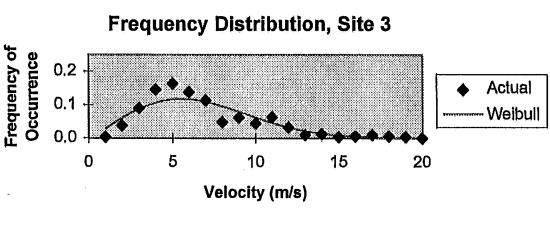
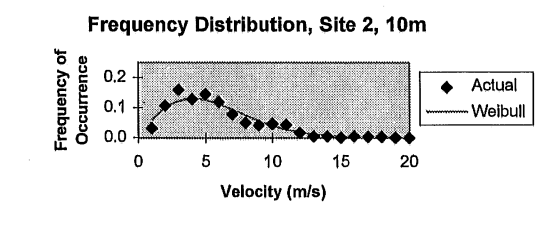
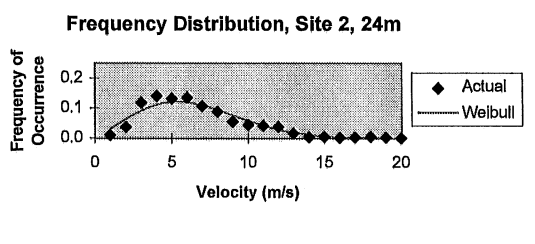
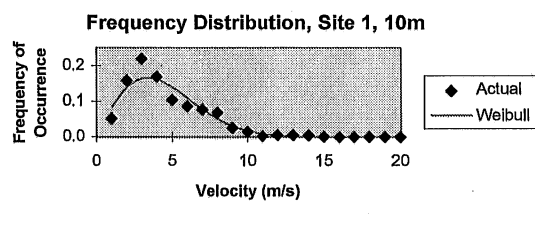
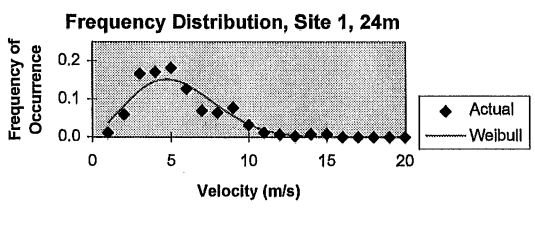
January, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.868		4.007		5.990		5.163		5.765		5.816	
$(V^2)_m$ (m ² /s ²)	30.123		21.255		46.935		35.917		39.862		40.288	
$(V_m)^2/(V^2)_m$	0.787		0.756		0.764		0.742		0.834		0.839	
C	2.011		1.824		1.868		1.750		2.386		2.435	
A (m/s)	5.481		4.512		6.745		5.813		6.491		6.548	
a	0.033		0.064		0.028		0.046		0.012		0.010	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.044	0.064	0.094	0.110	0.029	0.051	0.043	0.077	0.028	0.027	0.020	0.025
2	0.108	0.116	0.157	0.165	0.077	0.087	0.115	0.116	0.071	0.068	0.062	0.064
3	0.162	0.148	0.240	0.180	0.129	0.110	0.181	0.134	0.079	0.108	0.101	0.104
4	0.218	0.157	0.167	0.164	0.152	0.121	0.168	0.135	0.170	0.137	0.122	0.136
5	0.145	0.146	0.098	0.132	0.135	0.121	0.116	0.125	0.181	0.150	0.163	0.150
6	0.097	0.121	0.099	0.095	0.106	0.112	0.116	0.107	0.130	0.144	0.196	0.146
7	0.084	0.092	0.062	0.063	0.096	0.098	0.063	0.087	0.079	0.123	0.117	0.126
8	0.055	0.063	0.021	0.038	0.068	0.081	0.057	0.067	0.125	0.095	0.070	0.097
9	0.028	0.040	0.019	0.021	0.056	0.064	0.040	0.049	0.062	0.065	0.060	0.067
10	0.019	0.024	0.020	0.011	0.044	0.048	0.024	0.034	0.011	0.041	0.033	0.041
11	0.012	0.013	0.011	0.005	0.025	0.035	0.015	0.023	0.028	0.023	0.019	0.023
12	0.014	0.006	0.004	0.002	0.018	0.024	0.018	0.015	0.020	0.011	0.016	0.011
13	0.006	0.003	0.000	0.001	0.018	0.016	0.014	0.009	0.014	0.005	0.010	0.005
14	0.005	0.001	0.000	0.000	0.016	0.010	0.009	0.006	0.000	0.002	0.005	0.002
15	0.002	0.001	0.000	0.000	0.010	0.006	0.010	0.003	0.000	0.001	0.002	0.001
16	0.000	0.000	0.000	0.000	0.013	0.004	0.003	0.002	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.001	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



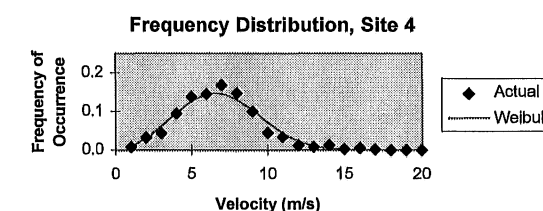
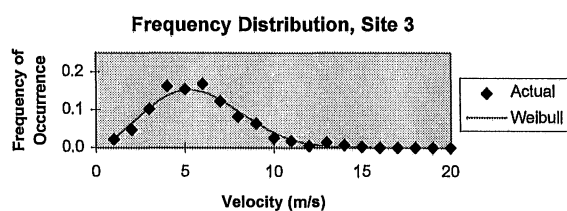
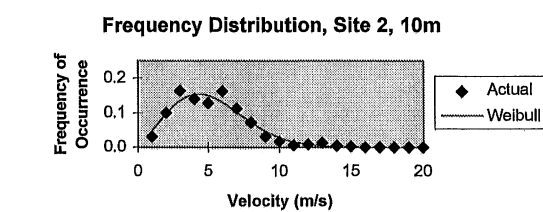
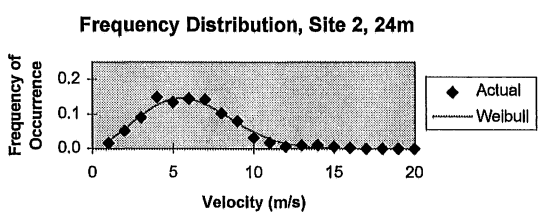
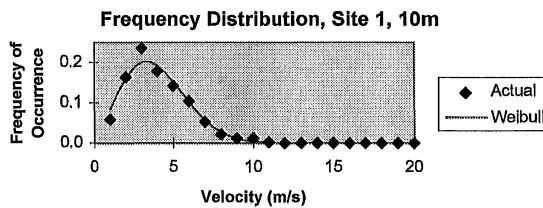
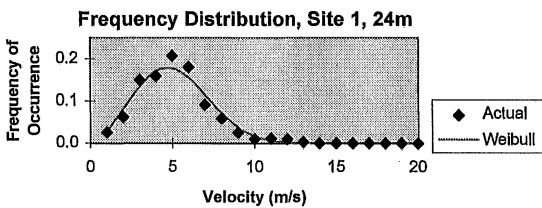
February, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	5.454		4.456		6.481		5.563		6.685		7.273	
$(V^2)_m$ (m ² /s ²)	36.264		25.756		52.378		40.684		55.697		61.884	
$(V_m)^2/(V^2)_m$	0.820		0.771		0.802		0.761		0.802		0.855	
C	2.259		1.910		2.116		1.851		2.116		2.609	
A (m/s)	6.141		5.017		7.297		6.264		7.527		8.189	
a	0.017		0.046		0.015		0.033		0.014		0.004	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.012	0.037	0.052	0.084	0.011	0.031	0.032	0.060	0.004	0.029	0.005	0.011
2	0.060	0.083	0.159	0.139	0.037	0.064	0.107	0.099	0.038	0.060	0.014	0.032
3	0.167	0.122	0.220	0.164	0.119	0.092	0.161	0.122	0.091	0.087	0.037	0.059
4	0.172	0.147	0.169	0.162	0.142	0.112	0.129	0.130	0.146	0.107	0.098	0.086
5	0.182	0.151	0.104	0.141	0.132	0.121	0.146	0.126	0.164	0.117	0.116	0.109
6	0.126	0.138	0.086	0.110	0.136	0.120	0.121	0.113	0.139	0.118	0.170	0.124
7	0.070	0.113	0.078	0.078	0.108	0.111	0.078	0.095	0.113	0.110	0.157	0.127
8	0.065	0.083	0.069	0.051	0.089	0.095	0.050	0.075	0.048	0.096	0.108	0.120
9	0.078	0.056	0.026	0.031	0.056	0.077	0.042	0.057	0.062	0.080	0.098	0.103
10	0.032	0.034	0.014	0.017	0.045	0.059	0.047	0.041	0.045	0.062	0.052	0.082
11	0.011	0.018	0.003	0.009	0.043	0.042	0.044	0.028	0.064	0.046	0.047	0.059
12	0.006	0.009	0.006	0.004	0.038	0.029	0.017	0.018	0.033	0.032	0.040	0.039
13	0.002	0.004	0.006	0.002	0.017	0.019	0.006	0.012	0.010	0.022	0.024	0.024
14	0.007	0.002	0.004	0.001	0.004	0.011	0.005	0.007	0.013	0.014	0.005	0.013
15	0.007	0.001	0.001	0.000	0.005	0.007	0.001	0.004	0.004	0.008	0.007	0.007
16	0.000	0.000	0.000	0.000	0.002	0.004	0.005	0.002	0.006	0.005	0.002	0.003
17	0.000	0.000	0.000	0.000	0.003	0.002	0.004	0.001	0.010	0.003	0.003	0.001
18	0.000	0.000	0.000	0.000	0.006	0.001	0.004	0.001	0.006	0.001	0.004	0.000
19	0.000	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.004	0.001	0.004	0.000
20	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.000



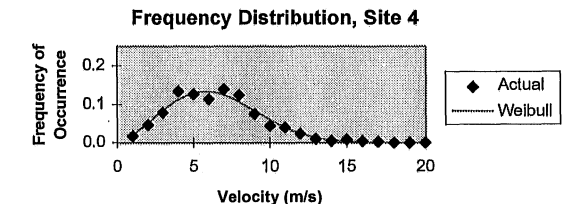
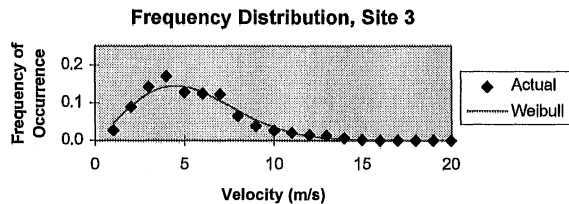
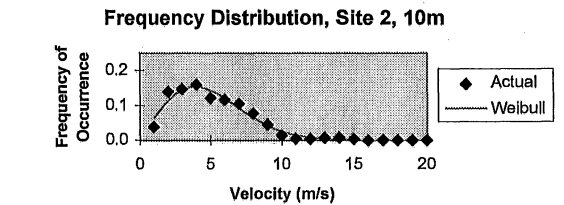
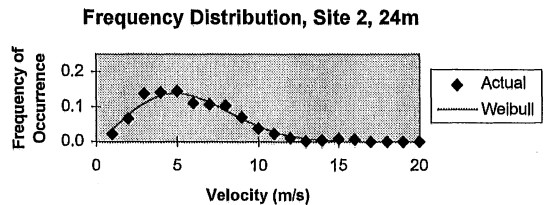
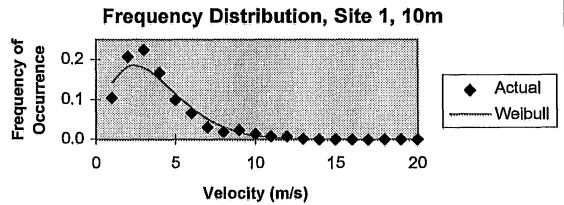
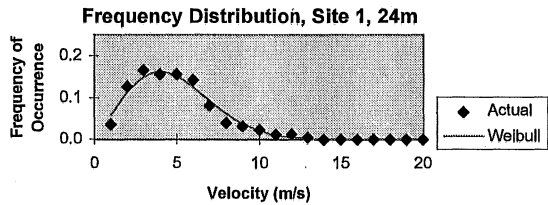
March, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	5.099		3.948		6.057		5.164		5.780		6.801	
$(V^2)_m$ (m ² /s ²)	30.575		19.314		43.638		33.119		39.720		52.975	
$(V_m)^2/(V^2)_m$	0.850		0.807		0.841		0.805		0.841		0.873	
C	2.552		2.154		2.456		2.139		2.456		2.843	
A (m/s)	5.741		4.445		6.820		5.814		6.508		7.658	
a	0.012		0.040		0.009		0.023		0.010		0.003	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.026	0.029	0.058	0.083	0.015	0.022	0.031	0.048	0.022	0.024	0.008	0.009
2	0.063	0.081	0.165	0.161	0.052	0.057	0.100	0.099	0.048	0.064	0.032	0.031
3	0.150	0.134	0.236	0.200	0.091	0.095	0.165	0.136	0.103	0.105	0.043	0.062
4	0.159	0.170	0.179	0.193	0.150	0.126	0.140	0.153	0.163	0.137	0.094	0.096
5	0.207	0.178	0.142	0.153	0.134	0.144	0.128	0.150	0.154	0.152	0.138	0.126
6	0.181	0.155	0.104	0.102	0.145	0.144	0.163	0.131	0.168	0.148	0.146	0.144
7	0.091	0.115	0.053	0.057	0.143	0.129	0.113	0.103	0.123	0.127	0.169	0.145
8	0.060	0.072	0.022	0.028	0.103	0.103	0.072	0.073	0.082	0.097	0.148	0.130
9	0.026	0.038	0.012	0.011	0.080	0.075	0.031	0.047	0.064	0.066	0.100	0.103
10	0.011	0.017	0.012	0.004	0.032	0.049	0.017	0.028	0.025	0.040	0.044	0.072
11	0.011	0.006	0.002	0.001	0.017	0.028	0.007	0.015	0.018	0.021	0.034	0.044
12	0.010	0.002	0.000	0.000	0.006	0.015	0.009	0.008	0.005	0.010	0.012	0.024
13	0.003	0.001	0.000	0.000	0.010	0.007	0.013	0.003	0.014	0.004	0.009	0.011
14	0.000	0.000	0.000	0.000	0.010	0.003	0.005	0.001	0.006	0.002	0.013	0.004
15	0.000	0.000	0.000	0.000	0.005	0.001	0.003	0.001	0.002	0.001	0.003	0.001
16	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.005	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



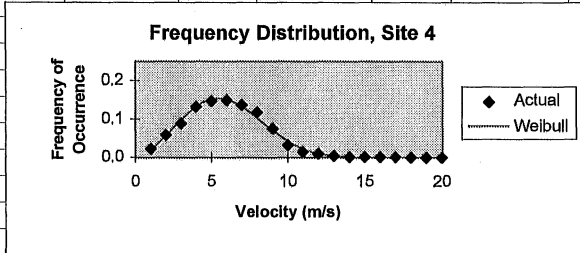
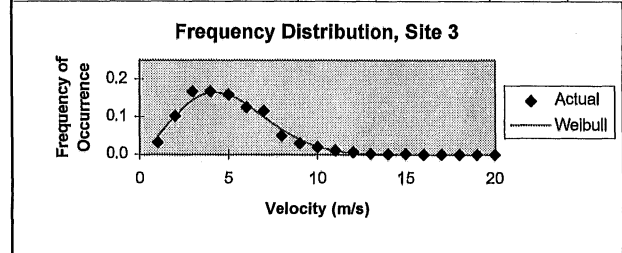
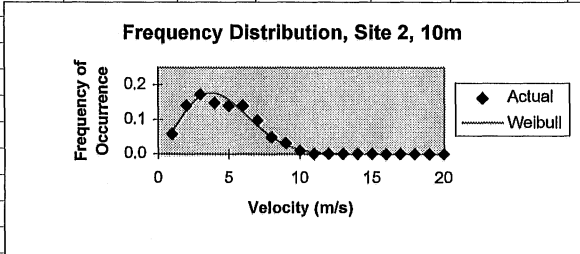
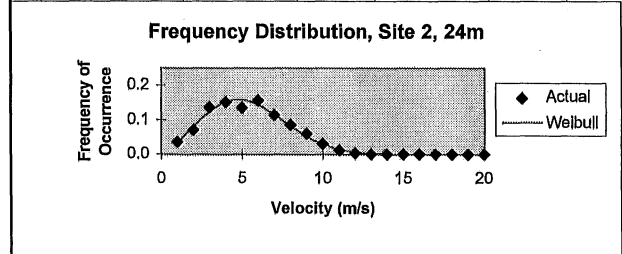
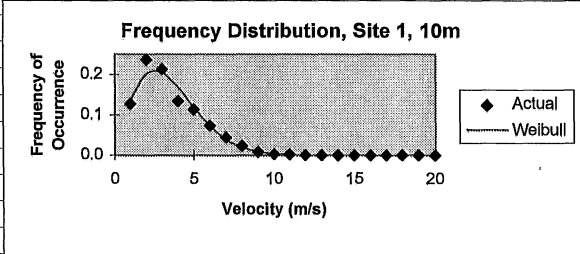
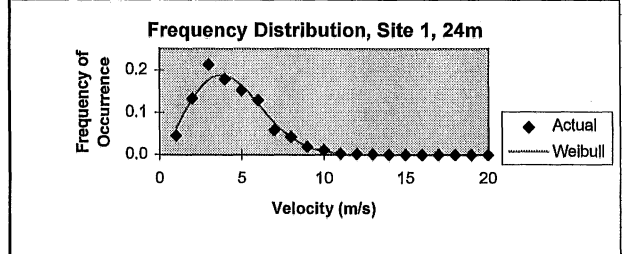
April, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.848		3.682		5.820		4.939		5.423		6.471	
$(V^2)_m$ (m ² /s ²)	29.418		18.751		41.818		31.104		36.742		50.144	
$(V_m)^2/(V^2)_m$	0.799		0.723		0.810		0.784		0.800		0.835	
C	2.094		1.659		2.177		1.991		2.101		2.396	
A (m/s)	5.459		4.146		6.554		5.562		6.106		7.286	
a	0.029		0.094		0.017		0.033		0.022		0.009	

Velocity (m/s)	Frequency of Occurrence											
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.037	0.058	0.106	0.143	0.022	0.036	0.039	0.063	0.027	0.046	0.017	0.020
2	0.127	0.113	0.208	0.184	0.066	0.076	0.140	0.114	0.090	0.091	0.047	0.052
3	0.166	0.150	0.225	0.180	0.138	0.110	0.147	0.145	0.143	0.126	0.079	0.085
4	0.157	0.162	0.168	0.152	0.142	0.132	0.160	0.154	0.171	0.143	0.135	0.112
5	0.156	0.152	0.100	0.116	0.144	0.139	0.122	0.143	0.129	0.143	0.127	0.130
6	0.143	0.126	0.067	0.081	0.112	0.131	0.117	0.121	0.126	0.129	0.115	0.134
7	0.082	0.094	0.031	0.052	0.108	0.113	0.105	0.093	0.124	0.106	0.140	0.125
8	0.040	0.063	0.019	0.031	0.104	0.090	0.077	0.065	0.065	0.079	0.125	0.107
9	0.033	0.038	0.024	0.018	0.070	0.066	0.045	0.043	0.039	0.055	0.076	0.084
10	0.024	0.021	0.014	0.010	0.038	0.044	0.014	0.026	0.026	0.035	0.044	0.060
11	0.013	0.011	0.008	0.005	0.023	0.028	0.004	0.014	0.021	0.021	0.041	0.040
12	0.013	0.005	0.008	0.002	0.010	0.016	0.003	0.008	0.015	0.012	0.024	0.024
13	0.006	0.002	0.001	0.001	0.002	0.009	0.008	0.004	0.013	0.006	0.010	0.013
14	0.000	0.001	0.000	0.000	0.005	0.004	0.007	0.002	0.007	0.003	0.005	0.007
15	0.000	0.000	0.000	0.000	0.008	0.002	0.003	0.001	0.002	0.001	0.008	0.003
16	0.000	0.000	0.000	0.000	0.006	0.001	0.000	0.000	0.000	0.001	0.004	0.001
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



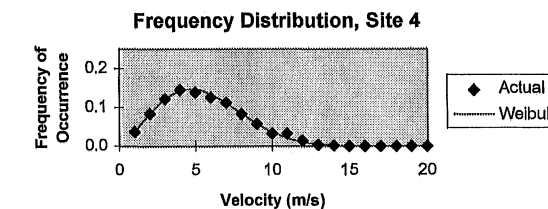
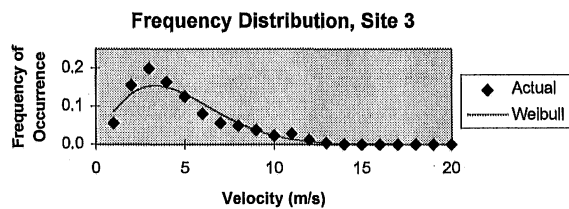
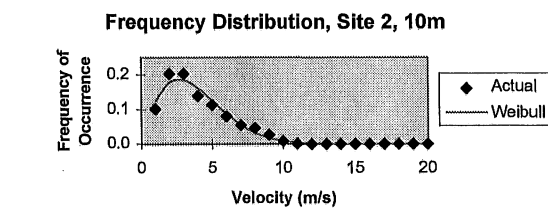
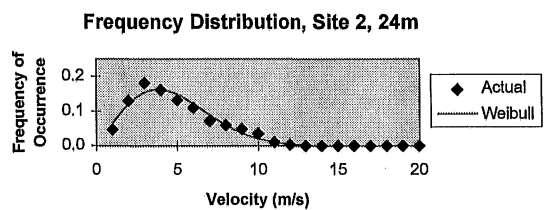
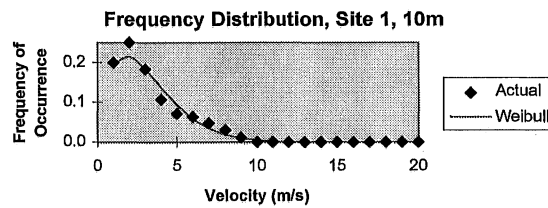
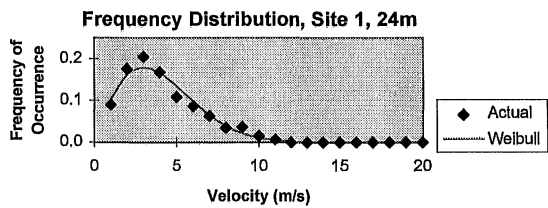
May, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.354		3.449		5.386		4.506		4.959		5.896	
$(V^2)_m$ (m ² /s ²)	23.232		15.652		34.904		25.231		30.162		40.916	
$(V_m)^2/(V^2)_m$	0.816		0.760		0.831		0.805		0.815		0.850	
C	2.226		1.846		2.358		2.139		2.218		2.552	
A (m/s)	4.902		3.883		6.065		5.074		5.584		6.639	
a	0.029		0.082		0.014		0.031		0.022		0.008	

Frequency of Occurrence													
Velocity (m/s)	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4		
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	
1	0.046	0.063	0.128	0.139	0.036	0.033	0.058	0.064	0.032	0.048	0.024	0.020	
2	0.133	0.132	0.237	0.202	0.071	0.080	0.141	0.127	0.103	0.103	0.059	0.057	
3	0.214	0.178	0.214	0.205	0.136	0.124	0.173	0.167	0.168	0.145	0.089	0.098	
4	0.179	0.187	0.135	0.170	0.152	0.152	0.149	0.176	0.168	0.164	0.133	0.133	
5	0.153	0.164	0.115	0.120	0.136	0.159	0.140	0.157	0.160	0.159	0.148	0.152	
6	0.130	0.121	0.075	0.074	0.157	0.145	0.140	0.122	0.126	0.134	0.150	0.152	
7	0.058	0.077	0.045	0.040	0.115	0.116	0.097	0.083	0.117	0.100	0.137	0.133	
8	0.043	0.042	0.024	0.020	0.085	0.083	0.049	0.050	0.050	0.067	0.118	0.103	
9	0.020	0.020	0.009	0.009	0.060	0.053	0.031	0.027	0.031	0.040	0.075	0.070	
10	0.011	0.008	0.003	0.003	0.030	0.030	0.010	0.013	0.019	0.021	0.032	0.042	
11	0.003	0.003	0.002	0.001	0.012	0.015	0.001	0.005	0.011	0.010	0.015	0.022	
12	0.002	0.001	0.001	0.000	0.004	0.007	0.001	0.002	0.007	0.004	0.010	0.010	
13	0.001	0.000	0.000	0.000	0.001	0.003	0.001	0.001	0.003	0.002	0.004	0.004	
14	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.002	0.001	0.001	0.001	
15	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.002	0.000	0.001	0.000	
16	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	
17	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	



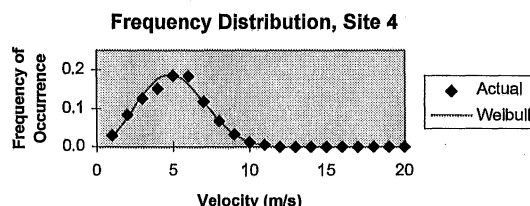
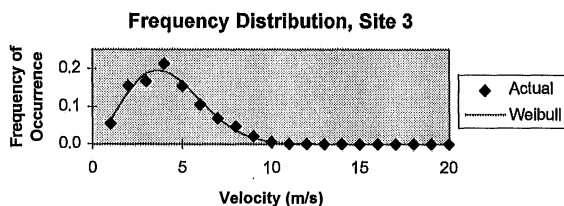
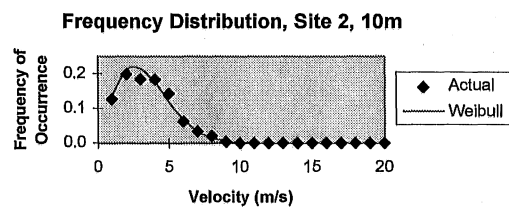
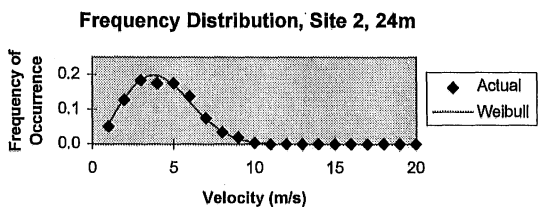
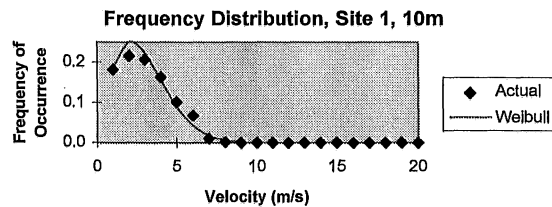
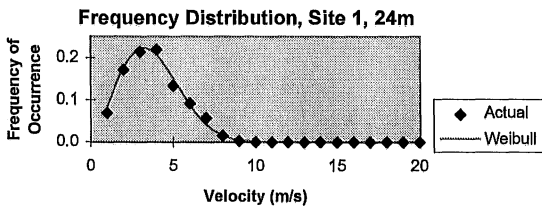
June, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	4.070		3.086		4.750		3.798		4.651		5.523	
$(V^2)_m$ (m ² /s ²)	21.724		13.703		28.467		19.285		28.682		37.516	
$(V_m)^2/(V^2)_m$	0.763		0.695		0.792		0.748		0.754		0.813	
C	1.863		1.541		2.045		1.781		1.813		2.201	
A (m/s)	4.583		3.475		5.348		4.276		5.237		6.219	
a	0.059		0.147		0.032		0.075		0.050		0.018	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.090	0.103	0.201	0.195	0.047	0.064	0.101	0.124	0.056	0.086	0.038	0.039
2	0.176	0.161	0.251	0.215	0.130	0.120	0.203	0.178	0.156	0.133	0.084	0.083
3	0.205	0.179	0.183	0.185	0.182	0.154	0.203	0.186	0.199	0.153	0.122	0.121
4	0.169	0.166	0.107	0.138	0.162	0.163	0.140	0.163	0.165	0.151	0.146	0.143
5	0.108	0.135	0.072	0.094	0.133	0.149	0.113	0.126	0.126	0.133	0.140	0.147
6	0.086	0.098	0.063	0.059	0.111	0.122	0.080	0.087	0.081	0.108	0.126	0.135
7	0.063	0.065	0.047	0.034	0.072	0.089	0.054	0.055	0.057	0.081	0.113	0.111
8	0.035	0.039	0.030	0.019	0.060	0.060	0.047	0.032	0.050	0.057	0.083	0.084
9	0.037	0.022	0.011	0.010	0.048	0.036	0.027	0.017	0.038	0.037	0.058	0.058
10	0.015	0.011	0.000	0.005	0.035	0.020	0.008	0.009	0.024	0.023	0.033	0.036
11	0.007	0.005	0.000	0.002	0.010	0.010	0.001	0.004	0.029	0.014	0.033	0.021
12	0.000	0.002	0.000	0.001	0.003	0.005	0.000	0.002	0.012	0.008	0.015	0.011
13	0.000	0.001	0.000	0.000	0.000	0.002	0.000	0.001	0.004	0.004	0.003	0.005
14	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.002	0.001	0.002
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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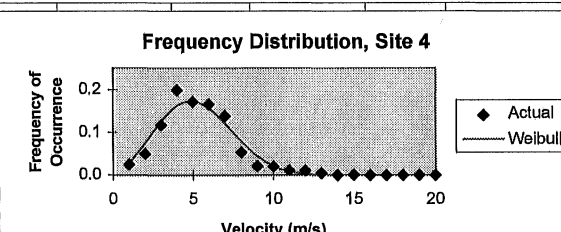
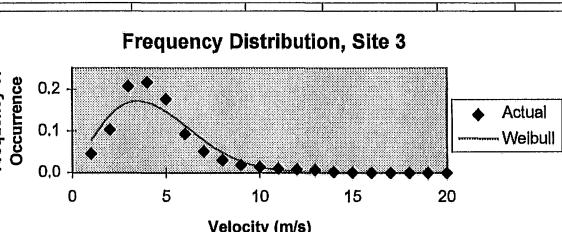
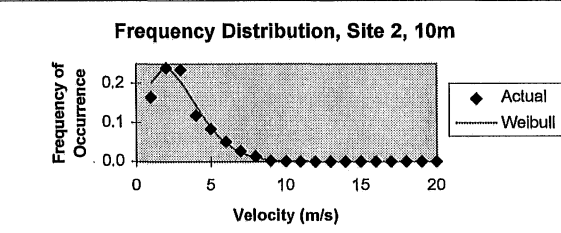
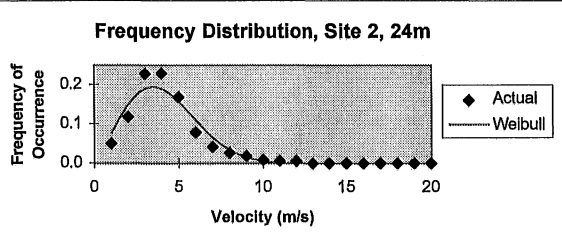
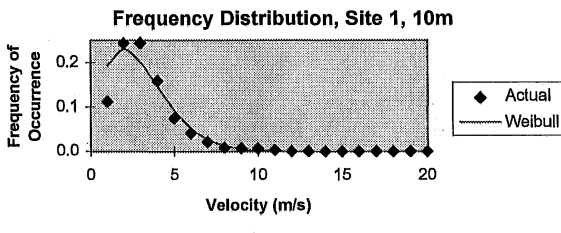
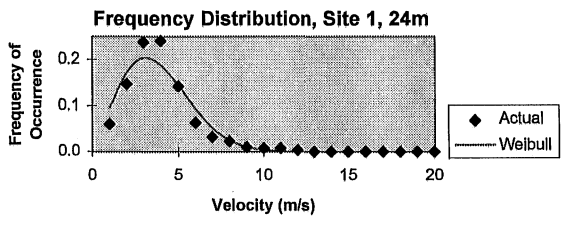
July, 1996													
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4		
V_m (m/s)	3.715		2.892		4.275		3.353		4.229		5.047		
$(V^2)_m$ (m^2/s^2)	16.836		11.009		22.079		14.570		21.826		29.595		
$(V_m)^2/(V^2)_m$	0.820		0.760		0.828		0.772		0.819		0.861		
C	2.259		1.846		2.330		1.916		2.251		2.682		
A (m/s)	4.183		3.256		4.814		3.775		4.762		5.683		
a	0.039		0.113		0.026		0.078		0.030		0.009		

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.069	0.086	0.183	0.186	0.051	0.058	0.128	0.139	0.055	0.065	0.030	0.025
2	0.171	0.177	0.216	0.250	0.128	0.132	0.200	0.211	0.155	0.139	0.084	0.077
3	0.214	0.222	0.208	0.224	0.185	0.185	0.185	0.216	0.167	0.186	0.126	0.135
4	0.220	0.207	0.163	0.156	0.175	0.198	0.183	0.175	0.214	0.193	0.152	0.177
5	0.134	0.151	0.102	0.090	0.176	0.171	0.143	0.118	0.154	0.165	0.185	0.187
6	0.092	0.089	0.068	0.043	0.138	0.122	0.063	0.068	0.106	0.117	0.183	0.163
7	0.058	0.042	0.011	0.018	0.075	0.073	0.034	0.034	0.070	0.071	0.118	0.117
8	0.015	0.016	0.001	0.006	0.034	0.036	0.020	0.015	0.046	0.036	0.068	0.069
9	0.003	0.005	0.000	0.002	0.019	0.015	0.003	0.006	0.021	0.016	0.033	0.033
10	0.000	0.001	0.000	0.001	0.004	0.005	0.000	0.002	0.005	0.006	0.011	0.013
11	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.001	0.002	0.006	0.004
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



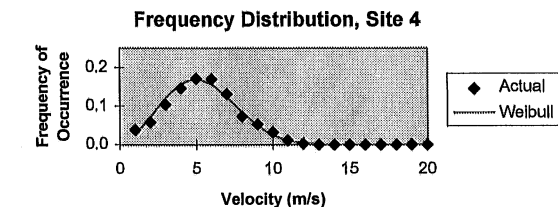
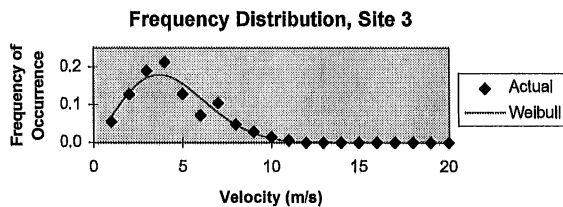
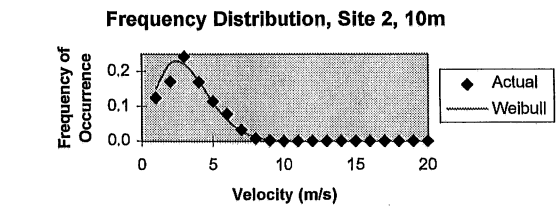
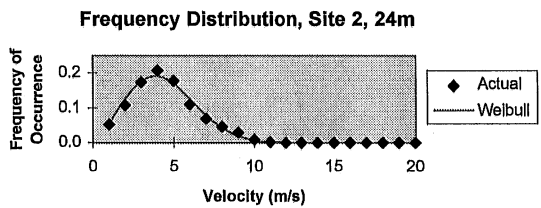
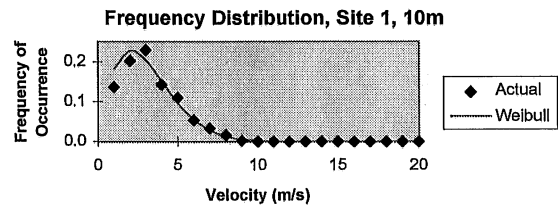
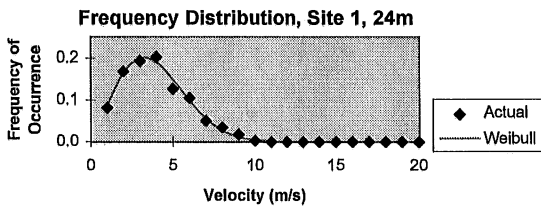
August, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	3.826		2.994		4.124		2.883		4.428		5.254	
$(V^2)_m$ (m^2/s^2)	18.395		12.364		21.052		11.417		24.940		32.454	
$(V_m)^2/(V^2)_m$	0.796		0.725		0.808		0.728		0.786		0.851	
C	2.073		1.668		2.162		1.682		2.004		2.563	
A (m/s)	4.308		3.372		4.644		3.247		4.986		5.916	
a	0.048		0.132		0.036		0.138		0.040		0.011	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.060	0.096	0.113	0.193	0.050	0.075	0.165	0.202	0.046	0.077	0.026	0.027
2	0.148	0.172	0.243	0.230	0.118	0.149	0.241	0.239	0.103	0.137	0.050	0.075
3	0.237	0.204	0.244	0.201	0.229	0.190	0.235	0.205	0.207	0.168	0.118	0.126
4	0.241	0.189	0.160	0.147	0.230	0.190	0.118	0.144	0.217	0.169	0.200	0.163
5	0.143	0.145	0.076	0.093	0.169	0.157	0.084	0.088	0.177	0.147	0.173	0.174
6	0.064	0.094	0.042	0.053	0.079	0.110	0.051	0.047	0.094	0.114	0.167	0.157
7	0.032	0.053	0.022	0.027	0.042	0.066	0.027	0.023	0.051	0.078	0.139	0.121
8	0.023	0.025	0.009	0.013	0.027	0.034	0.013	0.010	0.030	0.049	0.054	0.079
9	0.010	0.011	0.007	0.006	0.019	0.015	0.003	0.004	0.019	0.028	0.021	0.045
10	0.007	0.004	0.007	0.002	0.009	0.006	0.001	0.001	0.013	0.014	0.020	0.021
11	0.007	0.001	0.003	0.001	0.007	0.002	0.000	0.000	0.010	0.007	0.011	0.008
12	0.003	0.000	0.000	0.000	0.005	0.001	0.000	0.000	0.008	0.003	0.011	0.003
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.001	0.005	0.001
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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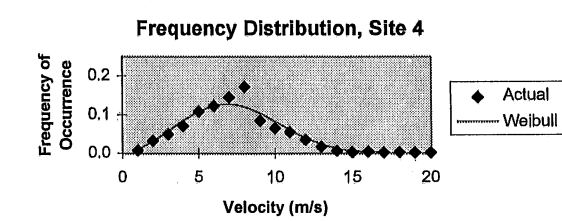
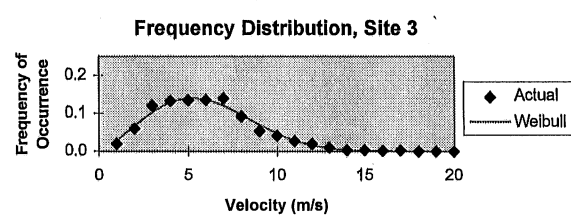
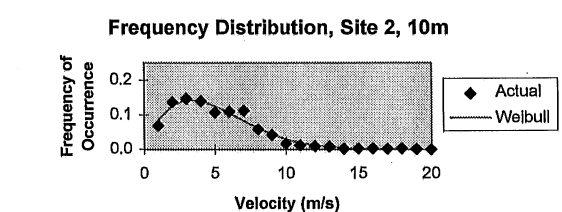
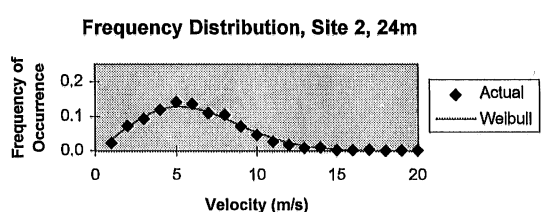
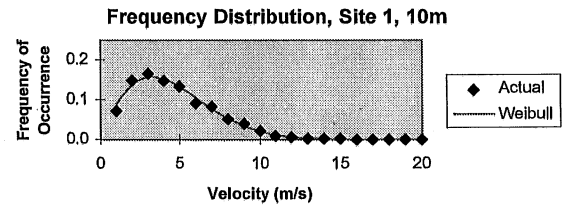
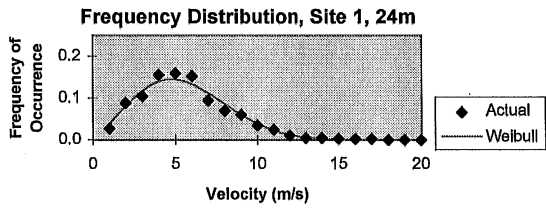
September, 1996	Site 1, 24m	Site 1, 10m	Site 2, 24m	Site 2, 10m	Site 3	Site 4
V_m (m/s)	3.909	3.065	4.402	3.216	4.408	5.374
$(V^2)_m$ (m^2/s^2)	19.078	12.778	23.493	13.404	24.204	34.021
$(V_m)^2/(V^2)_m$	0.801	0.735	0.825	0.771	0.803	0.849
C	2.109	1.716	2.303	1.910	2.124	2.541
A (m/s)	4.401	3.452	4.957	3.621	4.963	6.052
a	0.044	0.119	0.025	0.086	0.033	0.010

Frequency of Occurrence												
Velocity (m/s)	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.081	0.089	0.138	0.182	0.053	0.056	0.124	0.150	0.055	0.068	0.038	0.026
2	0.169	0.165	0.203	0.227	0.108	0.126	0.172	0.223	0.128	0.133	0.058	0.072
3	0.194	0.201	0.230	0.205	0.174	0.176	0.244	0.221	0.190	0.172	0.104	0.120
4	0.203	0.190	0.143	0.152	0.208	0.191	0.170	0.172	0.213	0.178	0.147	0.156
5	0.126	0.149	0.110	0.098	0.178	0.169	0.115	0.111	0.129	0.156	0.172	0.169
6	0.106	0.099	0.055	0.056	0.110	0.126	0.078	0.061	0.072	0.119	0.170	0.156
7	0.051	0.056	0.034	0.029	0.070	0.080	0.033	0.028	0.105	0.079	0.132	0.124
8	0.035	0.027	0.016	0.013	0.046	0.043	0.007	0.012	0.047	0.046	0.074	0.085
9	0.017	0.012	0.003	0.006	0.029	0.019	0.001	0.004	0.029	0.024	0.053	0.050
10	0.003	0.004	0.000	0.002	0.009	0.008	0.000	0.001	0.015	0.011	0.031	0.025
11	0.000	0.001	0.000	0.001	0.002	0.002	0.000	0.000	0.006	0.005	0.010	0.011
12	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.002	0.002	0.004
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



October, 1996												
	Site 1, 24m		Site 1, 10m		Site 2, 24m		Site 2, 10m		Site 3		Site 4	
V_m (m/s)	5.608		4.540		6.210		4.921		5.970		7.320	
$(V^2)_m$ (m ² /s ²)	38.748		27.384		47.905		32.866		43.243		62.560	
$(V_m)^2/(V^2)_m$	0.812		0.753		0.805		0.737		0.824		0.856	
C	2.193		1.807		2.139		1.725		2.294		2.621	
A (m/s)	6.315		5.112		6.992		5.541		6.722		8.242	
a	0.018		0.052		0.016		0.052		0.013		0.004	

Velocity (m/s)	Frequency of Occurrence											
	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull	Actual	Weibull
1	0.028	0.038	0.072	0.090	0.023	0.033	0.069	0.085	0.021	0.029	0.009	0.010
2	0.089	0.081	0.148	0.138	0.073	0.069	0.138	0.125	0.060	0.067	0.033	0.031
3	0.104	0.118	0.166	0.157	0.093	0.099	0.147	0.141	0.120	0.103	0.050	0.058
4	0.155	0.140	0.149	0.153	0.120	0.120	0.140	0.139	0.133	0.129	0.072	0.085
5	0.159	0.144	0.134	0.133	0.142	0.128	0.107	0.125	0.135	0.140	0.109	0.108
6	0.153	0.134	0.091	0.106	0.137	0.125	0.110	0.105	0.136	0.136	0.123	0.123
7	0.095	0.112	0.083	0.078	0.110	0.112	0.112	0.083	0.139	0.120	0.145	0.127
8	0.070	0.086	0.052	0.054	0.105	0.094	0.058	0.062	0.092	0.096	0.173	0.120
9	0.060	0.060	0.040	0.035	0.071	0.073	0.043	0.044	0.053	0.071	0.085	0.104
10	0.035	0.039	0.022	0.021	0.047	0.054	0.017	0.030	0.042	0.047	0.066	0.083
11	0.025	0.023	0.009	0.012	0.027	0.037	0.012	0.020	0.027	0.029	0.055	0.060
12	0.011	0.013	0.006	0.007	0.018	0.024	0.010	0.012	0.020	0.017	0.035	0.040
13	0.005	0.006	0.002	0.003	0.010	0.014	0.008	0.007	0.010	0.009	0.018	0.025
14	0.005	0.003	0.003	0.002	0.010	0.008	0.002	0.004	0.004	0.004	0.008	0.014
15	0.003	0.001	0.002	0.001	0.003	0.004	0.003	0.002	0.003	0.002	0.004	0.007
16	0.002	0.000	0.000	0.000	0.003	0.002	0.003	0.001	0.002	0.001	0.005	0.003
17	0.002	0.000	0.000	0.000	0.004	0.001	0.002	0.000	0.002	0.000	0.003	0.001
18	0.000	0.000	0.000	0.000	0.001	0.000	0.003	0.000	0.000	0.000	0.004	0.000
19	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.002	0.000
20	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.000



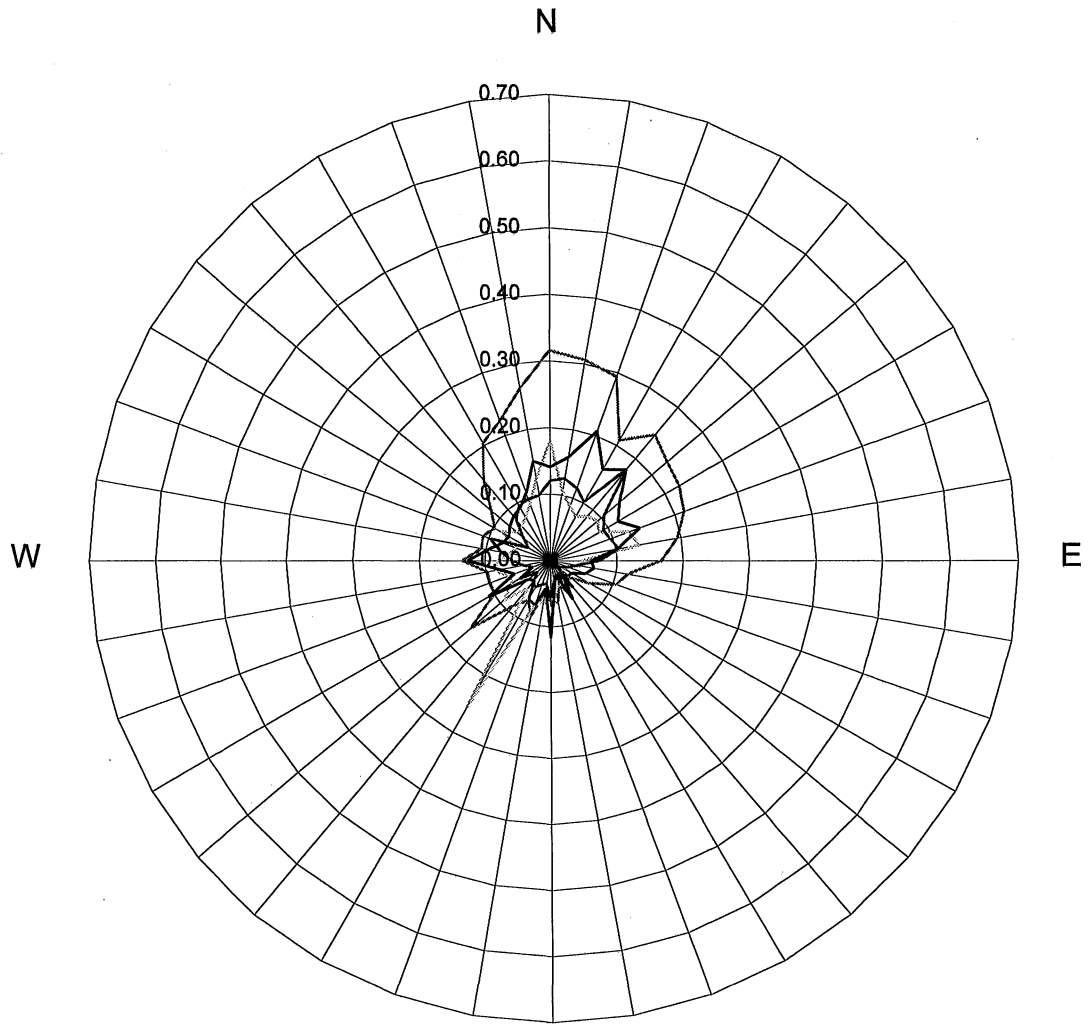
APPENDIX G

Wind Variance Roses

March and June, 1996

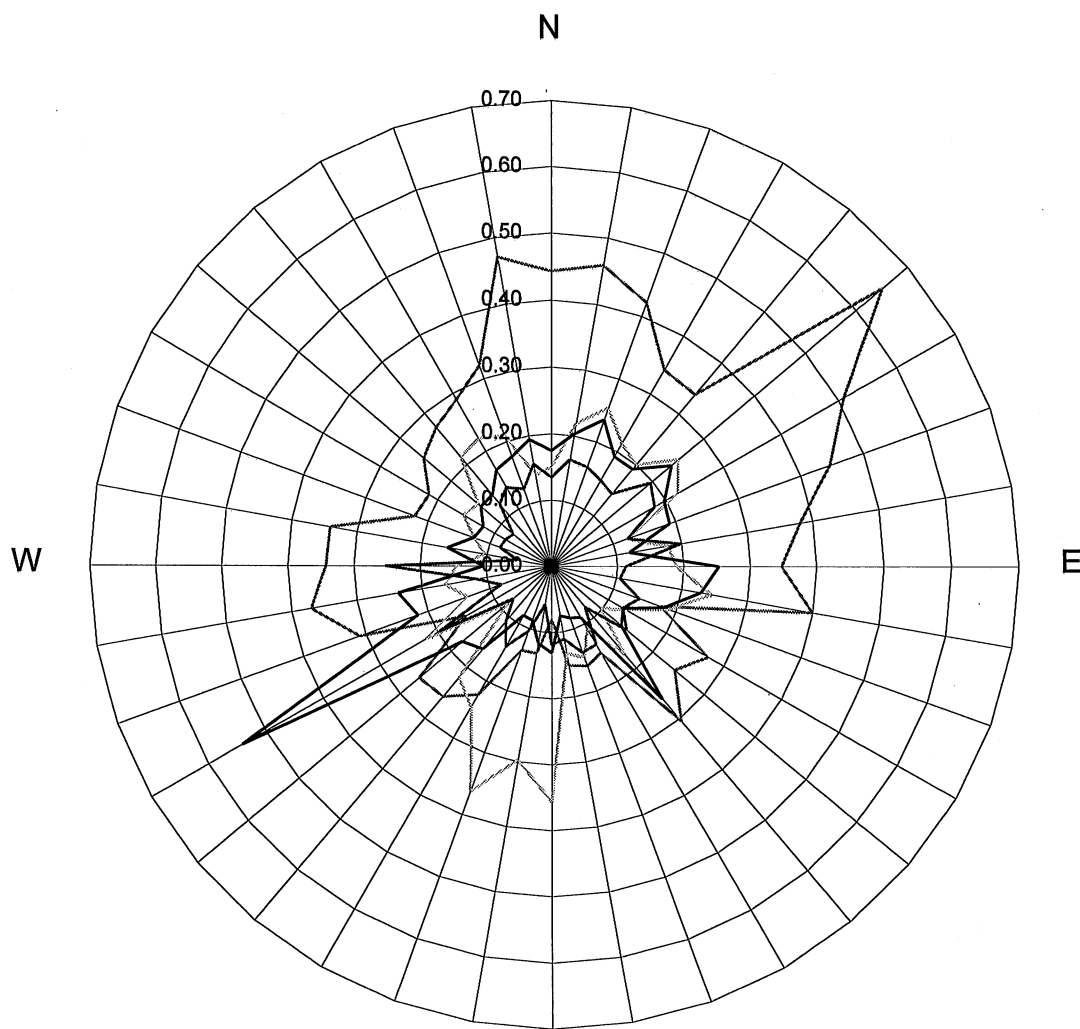
G

Rose of $3(S/M)^2$, March, 1996



— Site 1, 24m - - - Site 2, 24m — Site 3 — Site 4

Rose of $3(S/M)^2$, June, 1996



Site 1, 24m Site 2, 24m Site 3 Site 4

Average value of 3*(S/M)^2 vs. Direction, March, 1996						
Direction	Site 1, 24m	Site 1, 10m	Site 2, 24m	Site 2, 10m	Site 3	Site 4
0	0.316	0.723	0.179	0.155	0.141	0.120
10	0.306	0.761	0.106	0.123	0.157	0.125
20	0.294	0.707	0.088	0.122	0.207	0.116
30	0.209	0.807	0.077	0.103	0.158	0.102
40	0.246	0.704	0.087	0.138	0.177	0.178
50	0.230	0.769	0.093	0.126	0.136	0.105
60	0.224	0.564	0.085	0.201	0.118	0.092
70	0.215	0.474	0.125	0.164	0.144	0.096
80	0.194	0.360	0.136	0.069	0.102	0.105
90	0.167	0.226	0.047	0.040	0.061	0.073
100	0.118	0.170	0.045	0.063	0.066	0.040
110	0.105	0.157	0.024	0.052	0.056	0.028
120	0.068	0.180	0.026	0.076	0.037	0.019
130	0.040	0.060	0.022	0.043	0.034	0.015
140	0.036	0.051	0.029	0.061	0.029	0.053
150	0.061	0.101	0.039	0.081	0.067	0.021
160	0.036	0.047	0.039	0.146	0.022	0.028
170	0.064	0.083	0.043	0.105	0.035	0.030
180	0.062	0.110	0.079	0.103	0.117	0.056
190	0.047	0.081	0.062	0.107	0.043	0.035
200	0.089	0.070	0.072	0.090	0.071	0.038
210	0.069	0.118	0.256	0.098	0.067	0.046
220	0.089	0.208	0.054	0.242	0.039	0.042
230	0.159	0.319	0.094	0.143	0.044	0.027
240	0.098	0.125	0.067	0.209	0.109	0.055
250	0.098	0.163	0.068	0.122	0.058	0.029
260	0.097	0.135	0.085	0.167	0.078	0.042
270	0.134	0.235	0.081	0.095	0.126	0.058
280	0.107	0.141	0.063	0.071	0.097	0.076
290	0.109	0.118	0.055	0.095	0.078	0.097
300	0.097	0.100	0.087	0.082	0.073	0.039
310	0.117	0.139	0.066	0.073	0.080	0.054
320	0.158	0.194	0.068	0.085	0.087	0.081
330	0.204	0.269	0.075	0.085	0.091	0.094
340	0.223	0.366	0.090	0.114	0.108	0.098
350	0.263	0.539	0.125	0.168	0.151	0.099
Average	0.143	0.288	0.079	0.112	0.091	0.067

Average value of $3*(S/M)^2$ vs. Direction, June, 1996						
Direction	Site 1, 24m	Site 1, 10m	Site 2, 24m	Site 2, 10m	Site 3	Site 4
0	0.443	0.922	0.150	0.278	0.175	0.134
10	0.459	0.964	0.219	0.266	0.203	0.163
20	0.422	0.989	0.254	0.297	0.235	0.160
30	0.341	0.764	0.214	0.169	0.192	0.150
40	0.338	0.745	0.200	0.266	0.192	0.143
50	0.650	0.793	0.251	0.317	0.237	0.196
60	0.509	1.036	0.221	0.306	0.197	0.180
70	0.446	1.017	0.121	0.533	0.190	0.123
80	0.381	0.820	0.178	0.219	0.120	0.198
90	0.347	0.662	0.189	0.278	0.253	0.113
100	0.399	0.409	0.244	0.321	0.229	0.106
110	0.175	0.352	0.189	0.294	0.181	0.142
120	0.273	0.214	0.130	0.305	0.125	0.125
130	0.243	0.381	0.098	0.493	0.138	0.148
140	0.305	0.229	0.173	0.377	0.261	0.080
150	0.150	0.233	0.109	0.384	0.088	0.136
160	0.160	0.275	0.146	0.347	0.083	0.138
170	0.152	0.174	0.133	0.221	0.076	0.111
180	0.080	0.156	0.357	0.256	0.130	0.118
190	0.133	0.181	0.298	0.256	0.117	0.058
200	0.135	0.154	0.363	0.215	0.086	0.104
210	0.224	0.140	0.245	0.124	0.086	0.140
220	0.257	0.304	0.219	0.290	0.163	0.109
230	0.262	0.325	0.087	0.224	0.177	0.076
240	0.150	0.297	0.221	0.585	0.541	0.197
250	0.309	0.370	0.136	0.359	0.216	0.082
260	0.370	0.473	0.164	0.326	0.236	0.116
270	0.342	0.482	0.145	0.350	0.103	0.252
280	0.341	0.369	0.103	0.181	0.161	0.052
290	0.221	0.357	0.125	0.358	0.126	0.084
300	0.215	0.280	0.155	0.213	0.120	0.081
310	0.253	0.306	0.145	0.225	0.140	0.076
320	0.272	0.406	0.214	0.180	0.140	0.123
330	0.289	0.503	0.222	0.248	0.168	0.137
340	0.321	0.849	0.210	0.183	0.176	0.124
350	0.471	0.723	0.140	0.429	0.195	0.157
Average	0.301	0.490	0.188	0.296	0.174	0.129

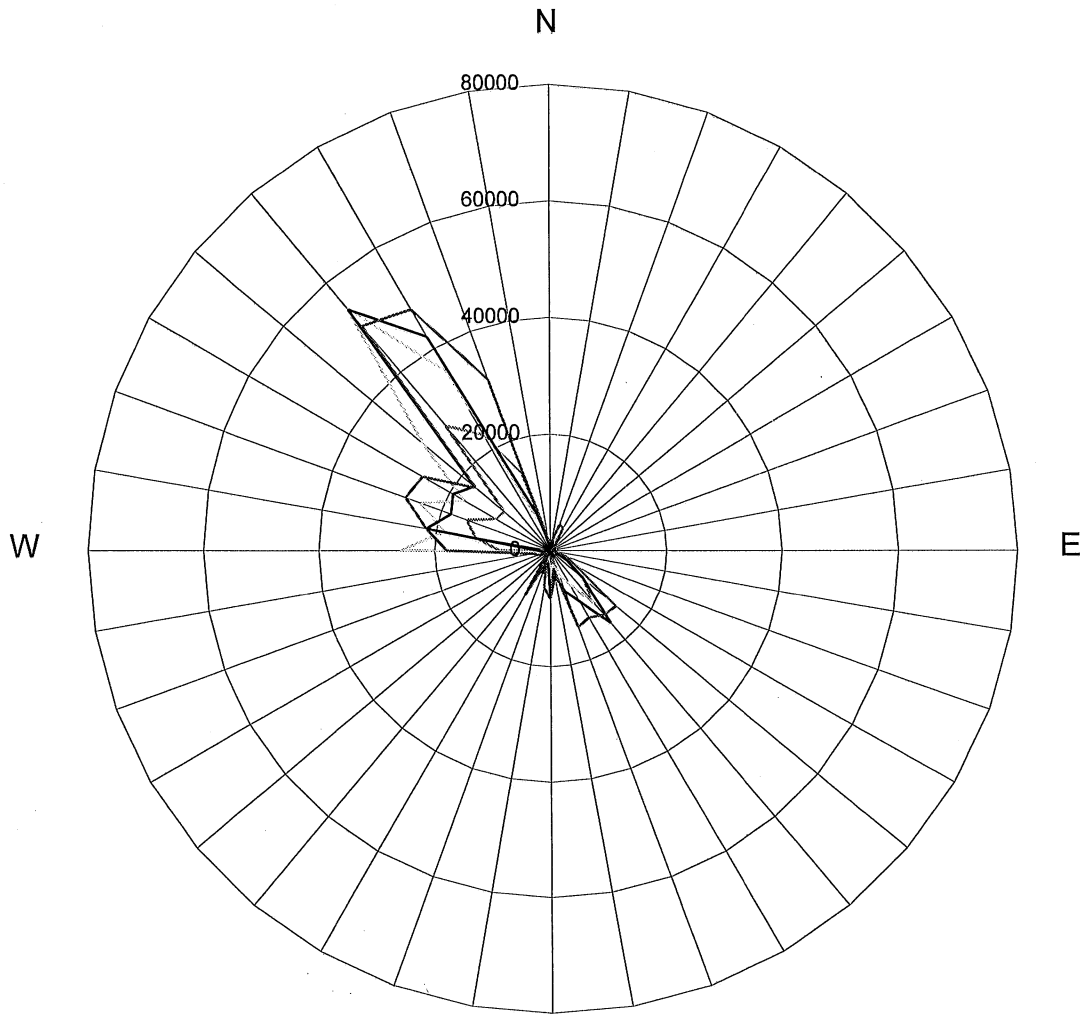
APPENDIX H

Energy Wind Roses

November 1995 - October 1996

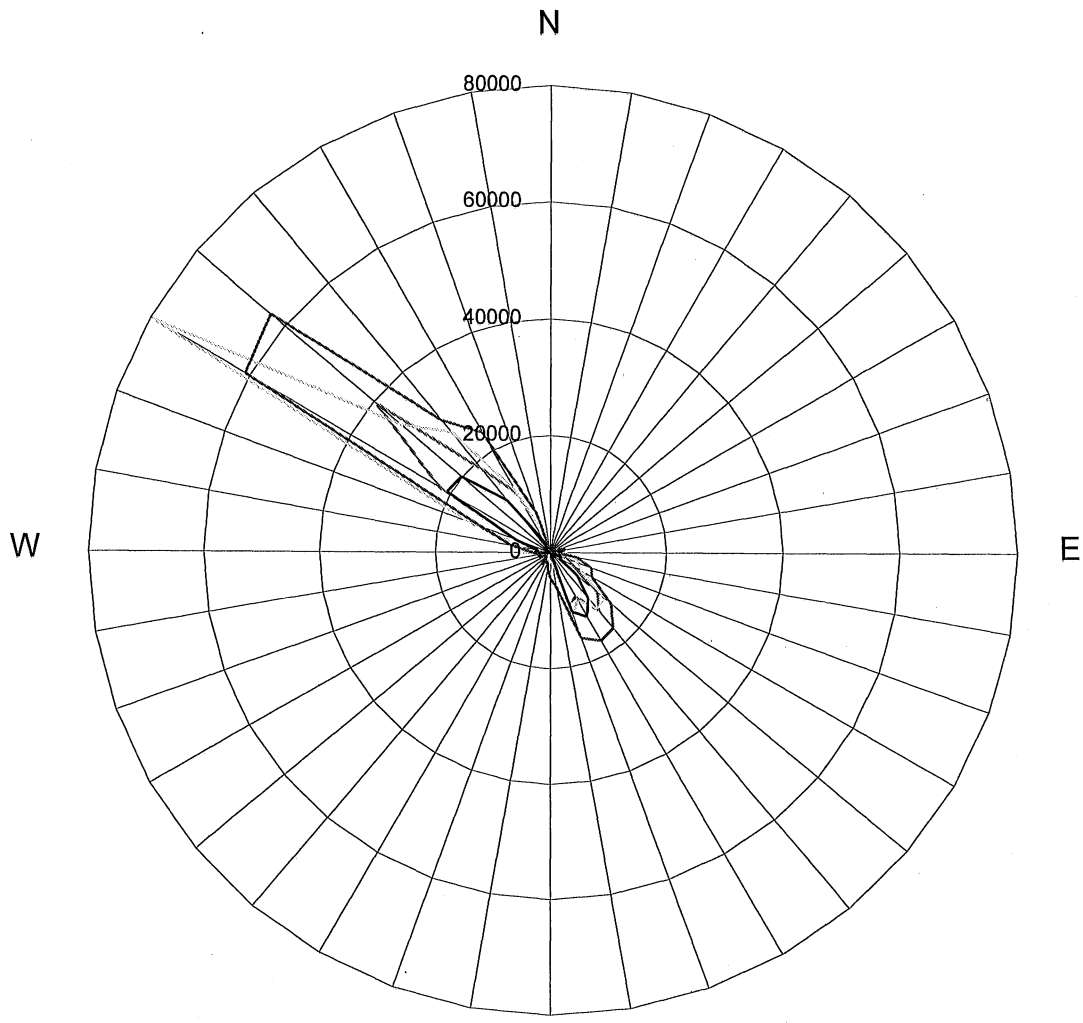
H

Wind Energy Rose, [(m/sec)³*hrs], November, 1995



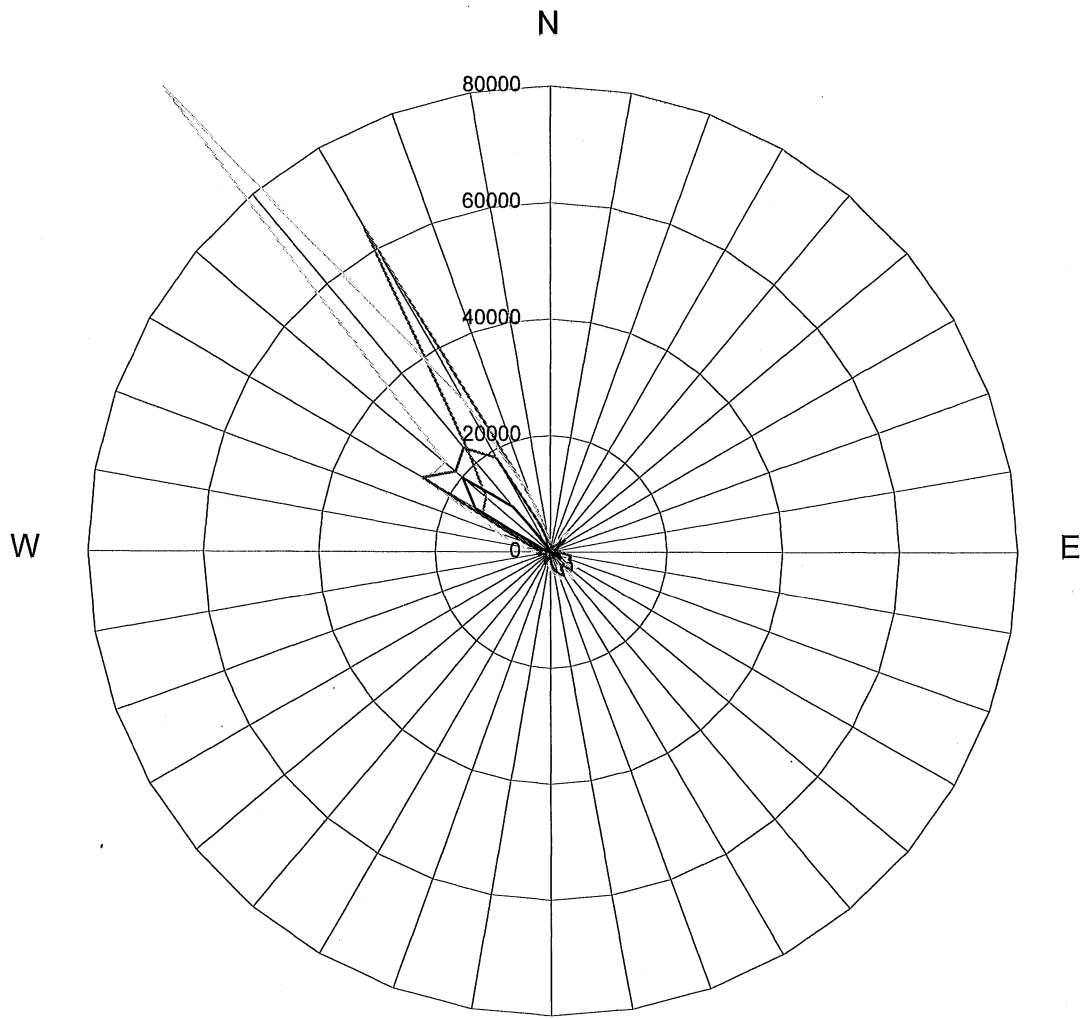
— Site 1, 24m - - - Site 2, 24m . . . Site 3 - . - Site 4

Wind Energy Rose, [(m/sec)³*hrs], December, 1995



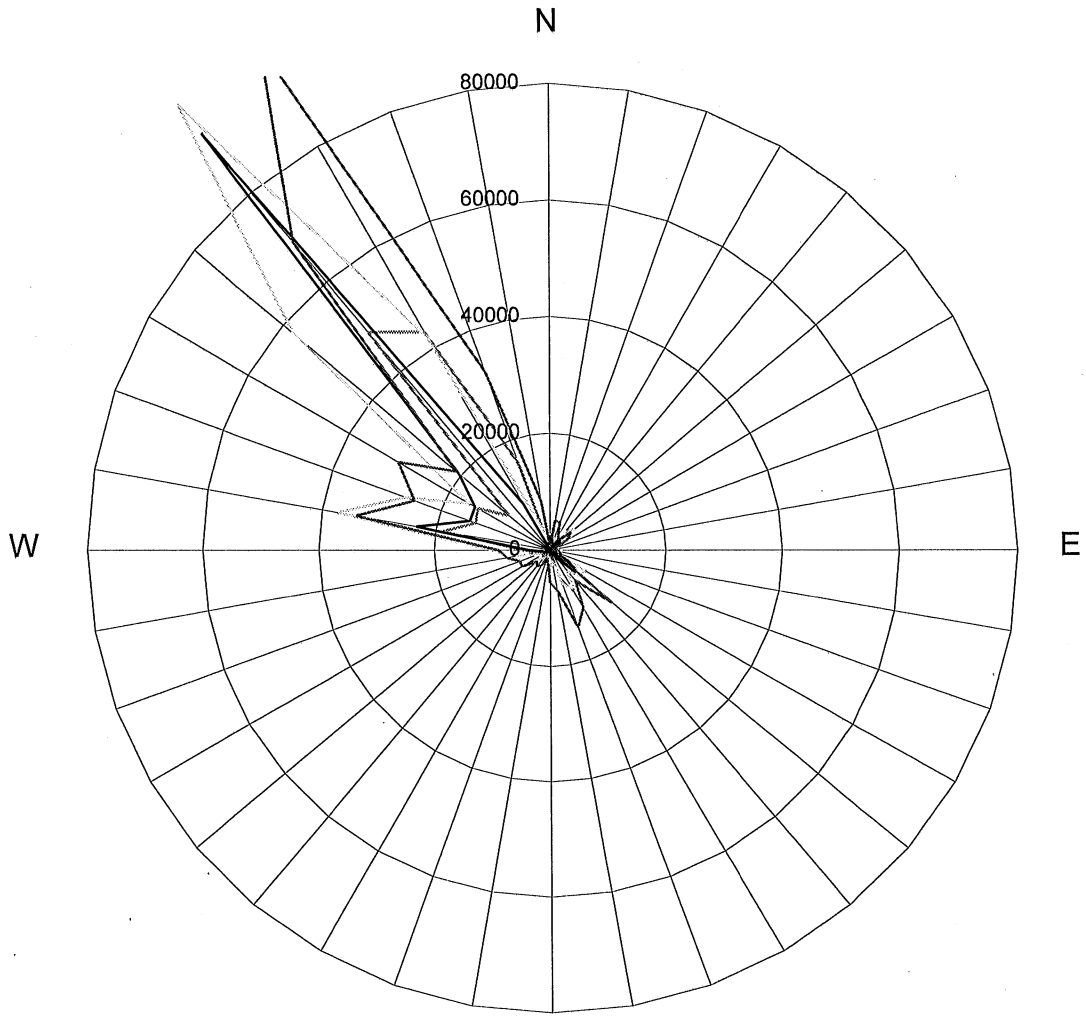
— Site 1, 24m — Site 2, 24m — Site 3 — Site 4

Wind Energy Rose, [(m/sec)³*hrs], January, 1996



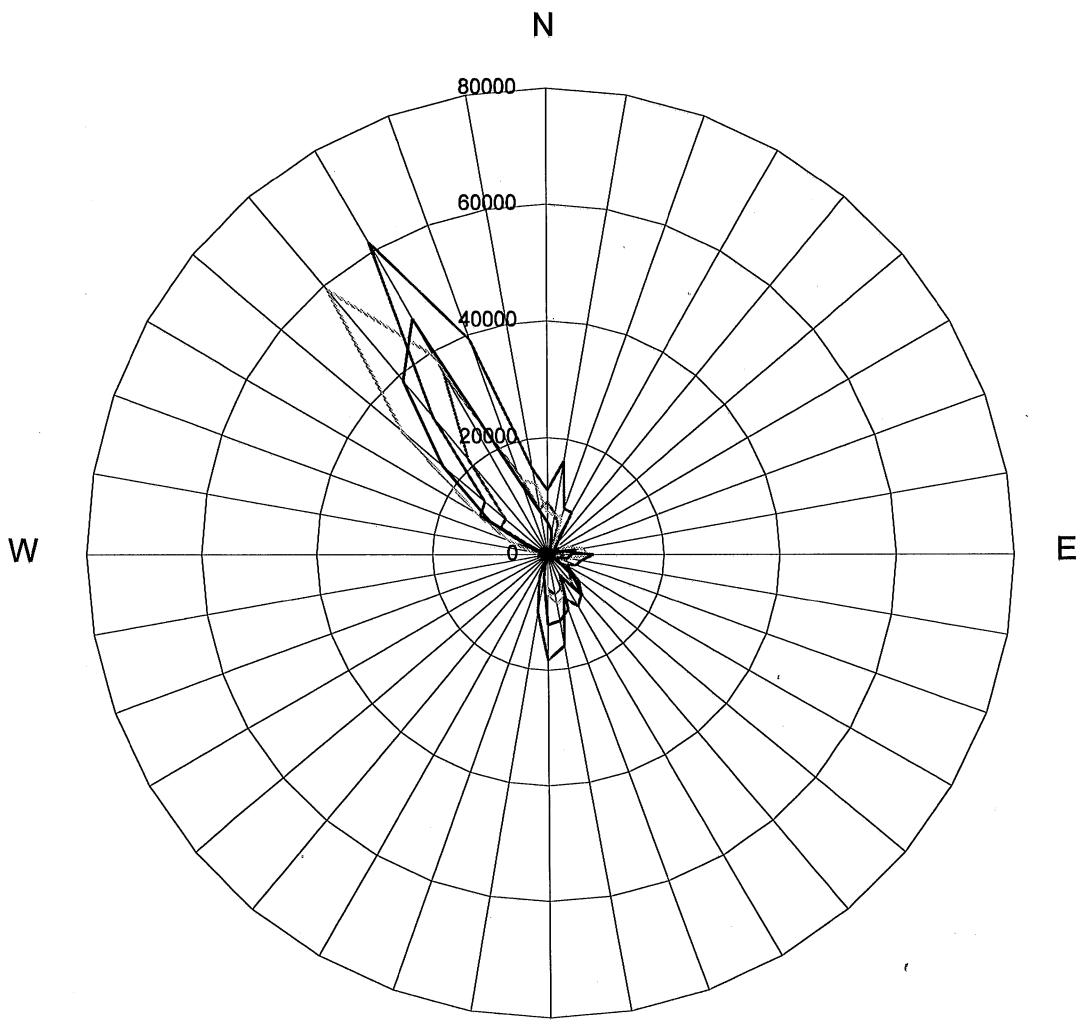
— Site 1, 24m Site 2, 24m — Site 3 — Site 4

Wind Energy Rose, [(m/sec)³*hrs], February, 1996



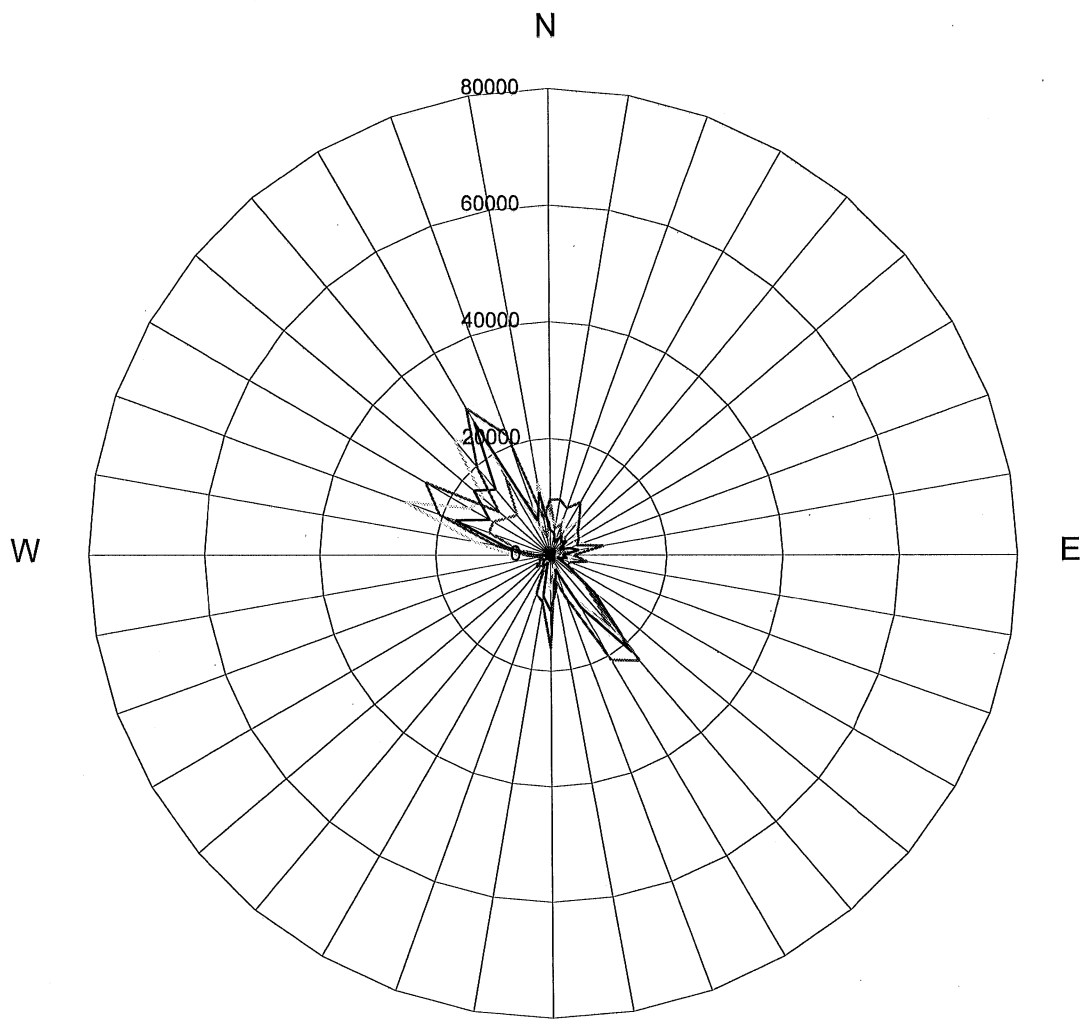
— Site 1, 24m Site 2, 24m — Site 3 — Site 4

Wind Energy Rose, [(m/sec)³*hrs], March, 1996



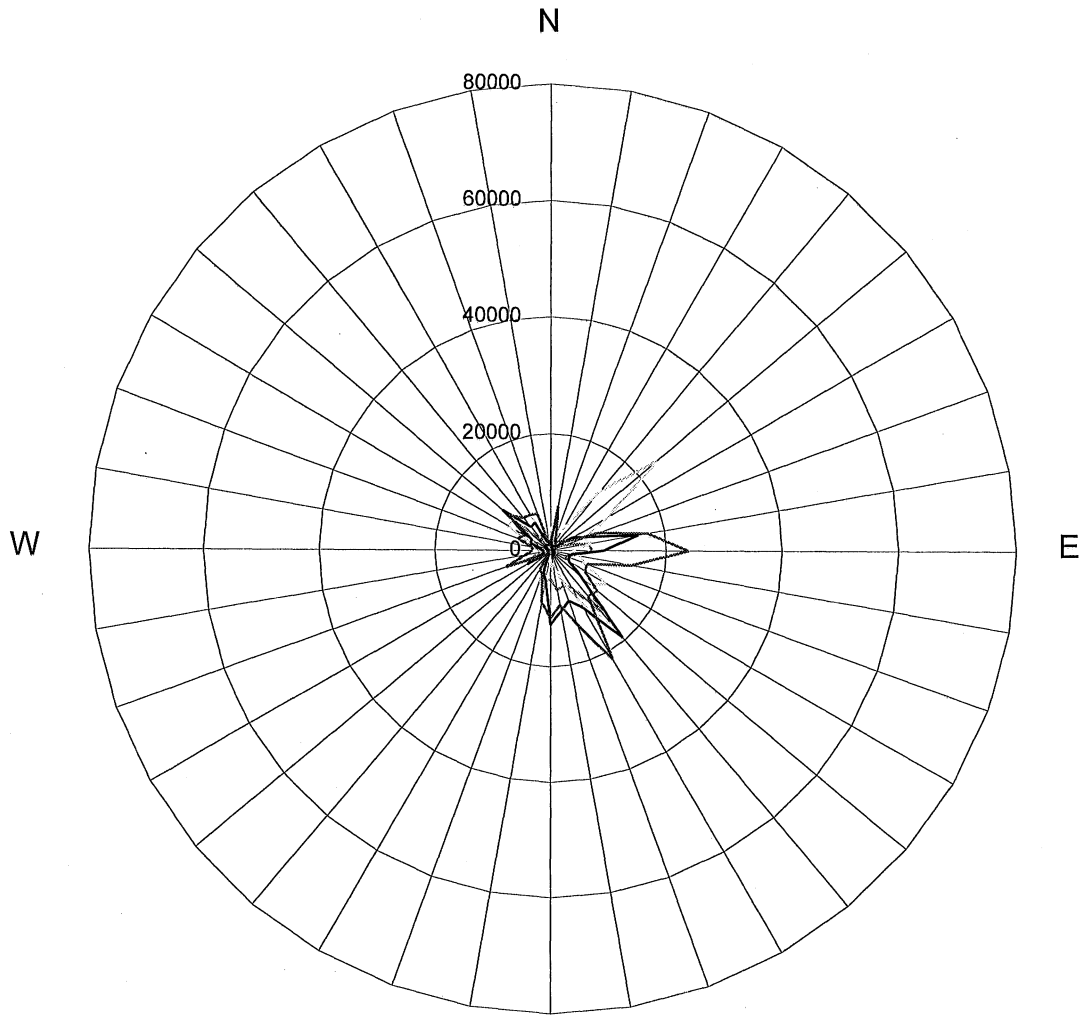
— Site 1, 24m - - - Site 2, 24m . . . Site 3 - · - Site 4

Wind Energy Rose, [(m/sec)³*hrs], April, 1996



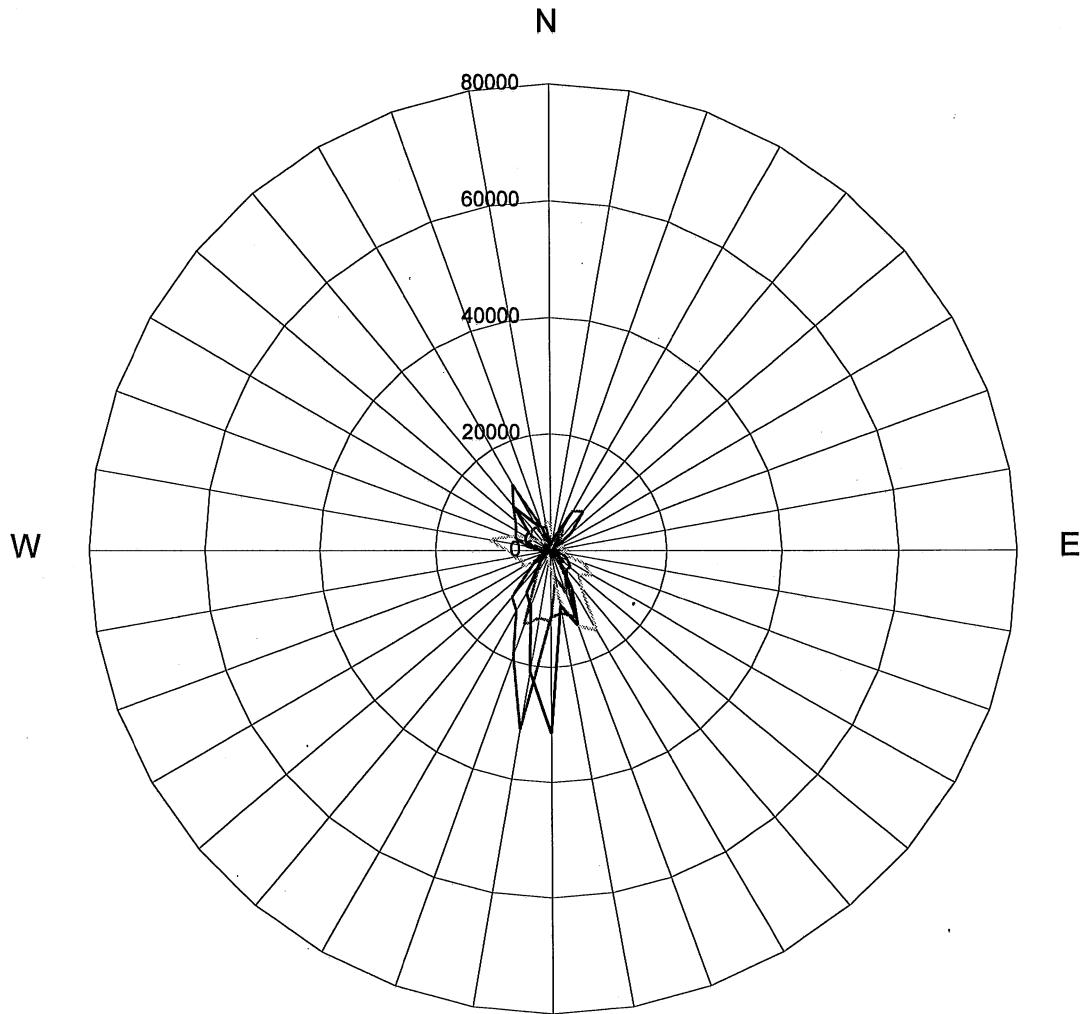
— Site 1, 24m - - - Site 2, 24m . . . Site 3 - · - Site 4

Wind Energy Rose, [(m/sec)³*hrs], May, 1996



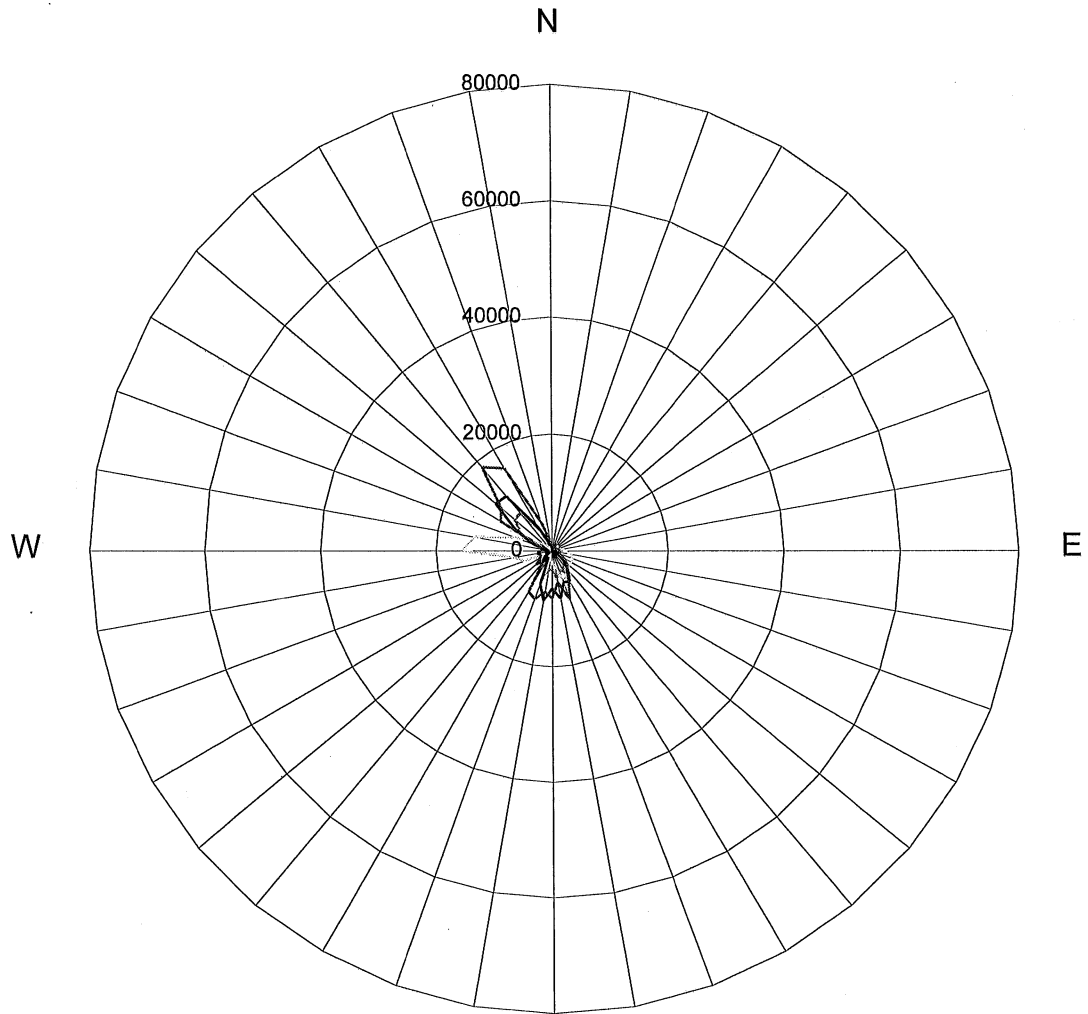
Site 1, 24m Site 2, 24m Site 3 Site 4

Wind Energy Rose, [(m/sec)³*hrs], June, 1996



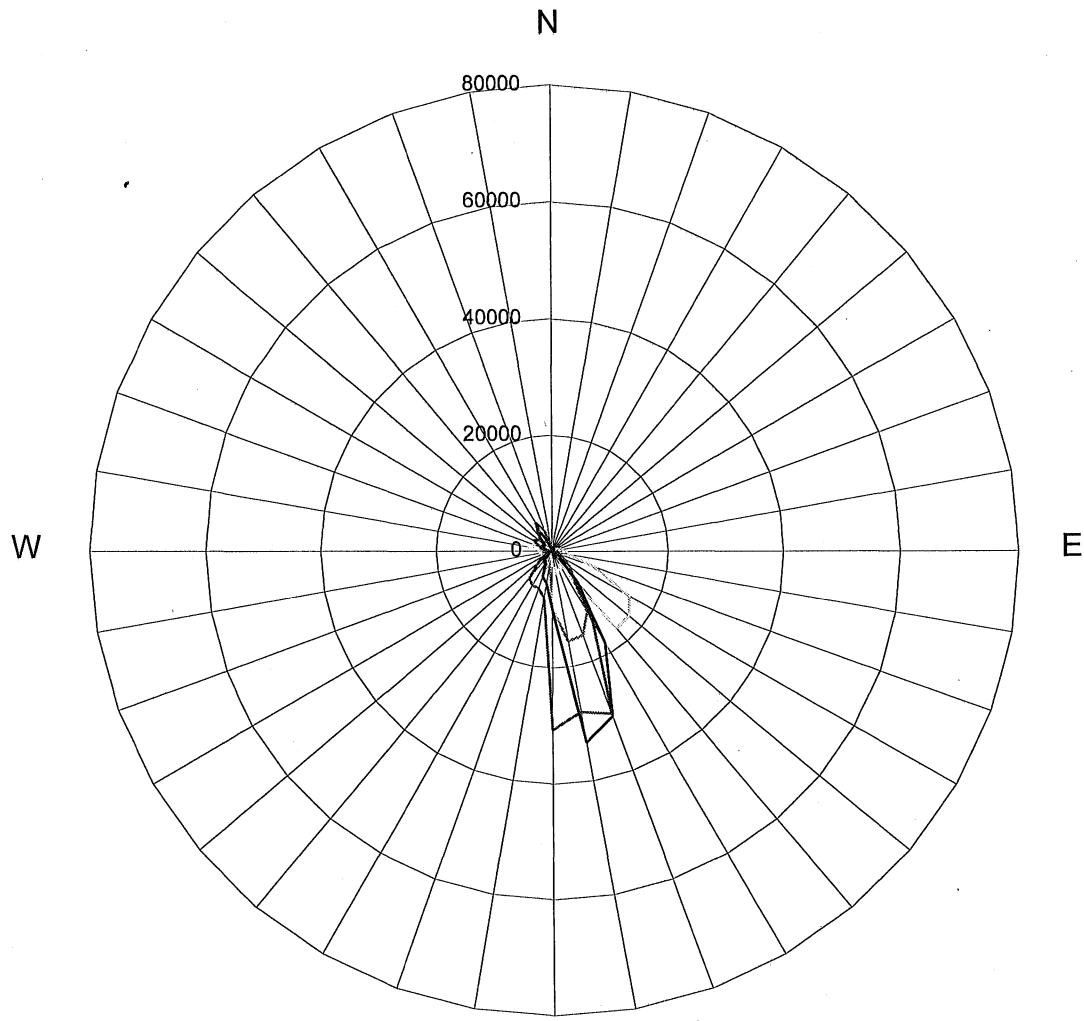
— Site 1, 24m Site 2, 24m - - - Site 3 - · - Site 4

Wind Energy Rose, [(m/sec)³*hrs], July, 1996



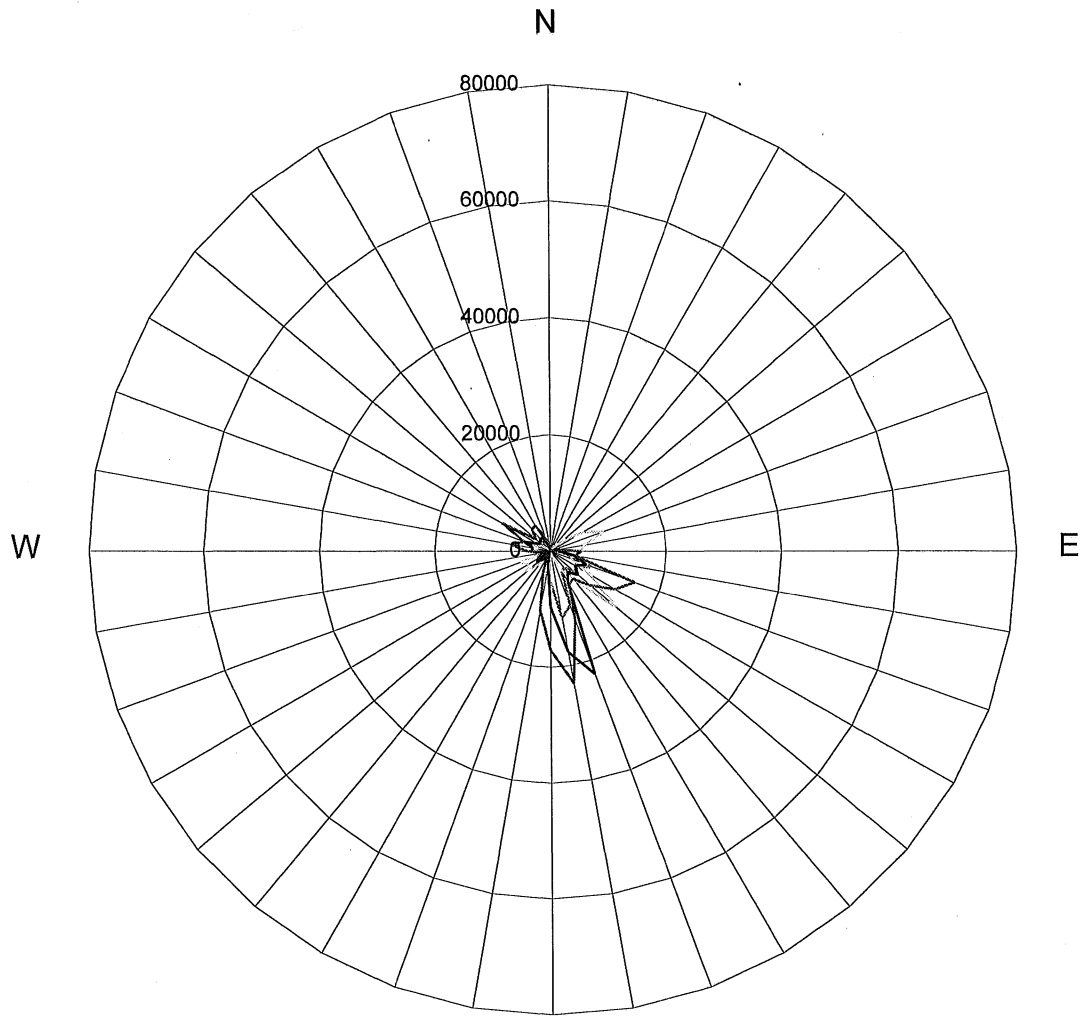
— Site 1, 24m - - - Site 2, 24m . . . Site 3 - . - Site 4

Wind Energy Rose, [(m/sec)³*hrs], August, 1996



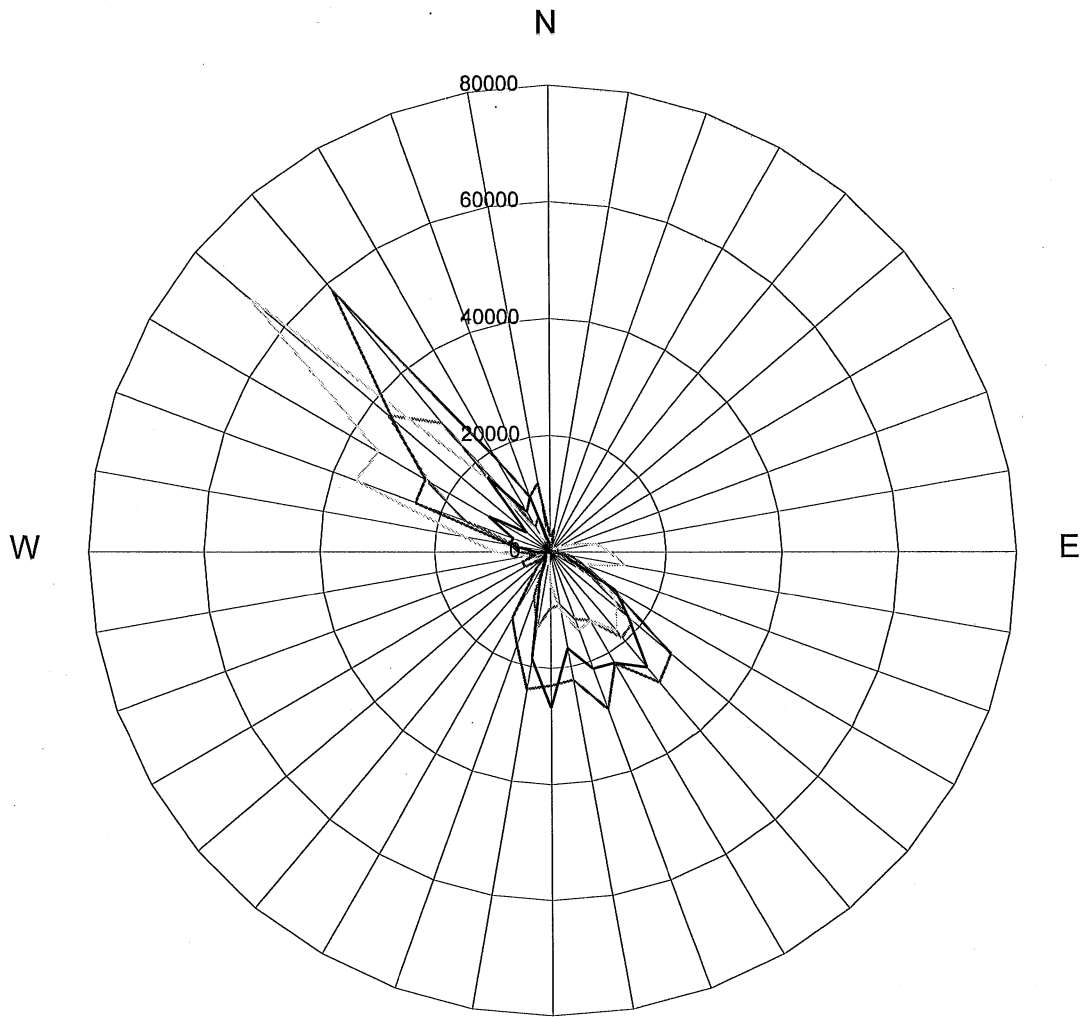
— Site 1, 24m - - - Site 2, 24m . . . Site 3 - . - Site 4

Wind Energy Rose, [(m/sec)³*hrs], September, 1996



— Site 1, 24m - - - Site 2, 24m ··· Site 3 - - - Site 4

Wind Energy Rose, [(m/sec)³*hrs], October, 1996



— Site 1, 24m - - - Site 2, 24m . . . Site 3 - · - Site 4