

# WIND DATA REPORT

## Orleans

27<sup>th</sup> October, 2003 – 3<sup>rd</sup> August, 2005

Prepared for

Massachusetts Technology Collaborative  
75 North Drive  
Westborough, MA 01581

by

Utama Abdulwahid  
James F. Manwell  
Anthony L. Rogers  
Anthony F. Ellis

October 20, 2005

---

---

Renewable Energy Research Laboratory  
University of Massachusetts, Amherst  
160 Governors Drive, Amherst, MA 01003

[www.ceere.org/rerl](http://www.ceere.org/rerl) • (413) 545-4359 • [rerl@ecs.umass.edu](mailto:rerl@ecs.umass.edu)



## Notice and Acknowledgements

This report was prepared by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst in the course of performing work sponsored by the Renewable Energy Trust (RET), as administered by the Massachusetts Technology Collaborative (MTC), pursuant to work order number 05-1. The opinions expressed in this report do not necessarily reflect those of MTC or the Commonwealth of Massachusetts, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

Further, MTC, the Commonwealth of Massachusetts, and RERL make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods or other information contained, described, disclosed, or referred to in this report. MTC, the Commonwealth of Massachusetts, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage directly or indirectly resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

---

---

Renewable Energy Research Laboratory  
University of Massachusetts, Amherst  
160 Governors Drive, Amherst, MA 01003

[www.ceere.org/rerl](http://www.ceere.org/rerl) • (413) 545-4359 • [rerl@ecs.umass.edu](mailto:rerl@ecs.umass.edu)



# TABLE OF CONTENTS

Table of Contents.....	1
Table of Figures.....	1
Executive Summary.....	2
SECTION 1 - Station Location.....	3
SECTION 2 - Instrumentation and Equipment.....	4
SECTION 3 - Data Collection and Maintenance.....	4
Data Statistics Summary.....	5
SECTION 4 - Significant Meteorological Events.....	6
SECTION 5 - Data Recovery and Validation.....	6
Test Definitions.....	6
Sensor Statistics.....	8
SECTION 6 - Data Summary.....	8
SECTION 7 - Graphs.....	10
Wind Speed Time Series.....	10
Wind Speed Distributions.....	10
Monthly Average Wind Speeds.....	11
Diurnal Average Wind Speeds.....	11
Turbulence Intensities.....	12
Wind Roses.....	12
APPENDIX A - Sensor Performance Report.....	13
Sensor Statistics.....	15
APPENDIX B - Plot Data.....	16
Wind Speed Distribution Data.....	16
Monthly Average Wind Speed Data.....	17
Diurnal Average Wind Speed Data.....	18
Wind Rose Data.....	19

# TABLE OF FIGURES

Figure 1 - Site location at Orleans site.....	3
Figure 2 - Wind Speed Time Series, October 2003 - August 2005.....	10
Figure 3 - Wind Speed Distribution, June 2004 - May 2005.....	10
Figure 4 - Monthly average wind speed.....	11
Figure 5 - Diurnal Wind Speed, June 2004 - May 2005.....	11
Figure 6 - Turbulence Intensity vs. Wind Speed, June 2004 - May 2005.....	12
Figure 7 - Wind Rose, June 2004 - May 2005.....	12

## EXECUTIVE SUMMARY

All the work presented in this Wind Data Report including installation and decommissioning of the meteorological tower and instrumentation, and the data analysis and reporting was performed by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst.

This wind measurement station was installed at the town watershed in Orleans, MA. Installed on October 27 of 2003, the station was in continuous operation until August 3<sup>rd</sup>, 2005, when it was taken down and dismantled. Two sets of two anemometers and one wind vane are mounted at 50 m (164.0 ft) and 40 m (131.2 ft), an additional vane and anemometer are mounted at 20 m (65.6 ft).

During the period of measurement, October 2003 – August 2005, the mean recorded wind speed at 50 m (164.0 ft) was 5.77 m/s (12.9 mph)\*; the prevailing wind direction at 40 m (131.2 ft) was SW. The gross data recovery percentage (the actual percentage of expected data received) was 99.2 % and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 88.0%. The net data recovery percentage is low because the 50 m (164.0 ft) wind vane had failed since November 2003.

Between June 2004 and May 2005, the mean recorded wind speed at 50 m (164.0 ft) was 5.59 m/s (12.5 mph), the prevailing wind direction at 40 m (131.2 ft) was SW. This time period was chosen because it provided a continuous year's worth of data for analysis.

Additional information about interpreting the data presented in this report can be found in the Fact Sheet, "Interpreting Your Wind Resource Data", produced by RERL and the Massachusetts Technology Collaborative (MTC). This document is found through the RERL website:

[http://www.ceere.org/rerl/about\\_wind/RERL\\_Fact\\_Sheet\\_6\\_Wind\\_resource\\_interpretation.pdf](http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_6_Wind_resource_interpretation.pdf).

\* 1 m/s = 2.24 mph

## SECTION 1 - Station Location

The Orleans site is located on the town watershed in Orleans, MA. The tower was on a cleared hilltop, surrounded by trees. The location of the tower base was measured to be at  $41.7584^{\circ}$  North,  $69.9933^{\circ}$  West referred to the NAD83 datum.



Figure 1 - Site location at Orleans site.  
Source: [www.topozone.com](http://www.topozone.com).

## **SECTION 2 - Instrumentation and Equipment**

The wind monitoring equipment was mounted on a 50 m (164.0 ft) Second Wind tower. All the remaining monitoring equipment comes from NRG Systems, and consists of the following items:

- Symphonie Data Logger
- Electrical enclosure box
- 5 – #40 Anemometers, standard calibration (Slope - 0.765 m/s, Offset – 0.350 m/s). Two anemometers were located at 50 m (164.0 ft), two at 40 m and one at a height of 20 m (65.6 ft).
- 3 - #200P Wind direction vanes. They were located at heights of 50, 40 and 20 m (164.0, 131.2 and 65.6 ft) each.
- 5 – Sensor booms, 54” length
- Lightning rod and grounding cable
- Shielded sensor wire

The data from the Symphonie logger was mailed to the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. These are then combined into 10-minute averages, and along with the standard deviation for those 10-minute periods, are put into a binary file. These binary files were converted to ASCII text files using the NRG software BaseStation®. These text files were then imported into a database software program where they were subjected to QA tests prior to using the data.

## **SECTION 3 - Data Collection and Maintenance**

No measurement of wind speed can be perfectly accurate. Errors occur due to anemometer manufacturing variability, anemometer calibration errors, the response of anemometers to turbulence and vertical air flow and due to air flows caused by the anemometer mounting system. Every effort is made to reduce the sources of these errors. Nevertheless, the values reported in this report have an expected uncertainty of about +/- 2% or +/- 0.2 m/s.

### Data Statistics Summary

Date	Mean Wind Speed	Max Wind Speed	Turbulence Intensity	Prevailing Wind Direction	Mean Wind Speed	Max Wind Speed	Turbulence Intensity	Prevailing Wind Direction	Mean Wind Speed	Max Wind Speed
Heights, units	50 m, [m/s]	50 m, [m/s]	50 m, [ ]	40 m, [ ]	40 m, [m/s]	40 m, [m/s]	40 m, [ ]	20 m, [ ]	20 m, [m/s]	20 m, [m/s]
November 2003	5.84	16.2	0.21	NW	5.28	15.1	0.23	NW	3.88	12.2
December 2003	7.47	17.3	0.2	NW	6.79	15.6	0.22	WSW	5.21	12.4
January 2004	6.94	14.4	0.21	WNW	6.2	12.9	0.24	WNW	4.85	10.2
February 2004	6.02	14.5	0.19	NW	5.43	13.4	0.21	NW	4.13	10.8
March 2004	6.46	13.8	0.21	NE	5.88	13.1	0.23	NE	4.44	10
April 2004	6.12	14.4	0.21	SW	5.59	13.5	0.23	SW	4.19	10.8
May 2004	-	-	-	-	-	-	-	-	-	-
June 2004	5.15	11.6	0.19	SW	4.71	10.9	0.21	SW	3.48	8.9
July 2004	4.48	10.9	0.2	SSW	4.1	10.2	0.22	SSW	2.98	8
August 2004	5.01	12.7	0.19	SW	4.59	11.7	0.22	SW	3.34	9.1
September 2004	5.08	14.8	0.18	S	4.6	13.2	0.2	S	3.24	9.6
October 2004	5.57	12.9	0.19	NW	5	11.3	0.21	NNE	3.49	9
November 2004	6	15.1	0.19	NNW	5.42	14.8	0.21	NNW	4.05	11.8
December 2004	6.37	17.8	0.19	NW	5.75	16.6	0.21	NW	4.09	13.5
January 2005	6.47	19.6	0.21	NNW	5.81	17.9	0.24	NNW	4.23	13.4
February 2005	5.86	13.2	0.2	NW	5.15	11.8	0.23	NW	3.84	9.5
March 2005	6.02	17.6	0.2	WNW	5.47	17.4	0.22	WNW	4.35	13.7
April 2005	5.72	13.9	0.21	SSW	5.25	13	0.22	SW	3.95	10.5
May 2005	5.41	15.8	0.22	NW	4.92	14.5	0.25	N	3.64	10.9
June 2005	5.19	11	0.2	SW	4.83	10.2	0.23	SW	3.66	8.4
July 2005	4.8	14	0.2	SW	4.4	12.9	0.22	SW	3.21	9.9
<b>Oct 03 – Aug 05</b>	<b>5.77</b>	<b>19.6</b>	<b>0.2</b>	<b>SW</b>	<b>5.23</b>	<b>17.9</b>	<b>0.22</b>	<b>SW</b>	<b>3.88</b>	<b>13.7</b>

## SECTION 4 - Significant Meteorological Events

The following significant meteorological events occurred during the measurement period:

- 13 November 2003 – High wind
- 5, 6 & 7 December 2003 – Winter storm
- 18 February 2004 – Winter Storm
- 1 December 2004 – High Wind
- 26 December 2004 – Winter Storm
- 22 January 2005 – Winter Storm
- 24 February 2005 – Heavy Snow
- 1 March 2005 – Winter Storm
- 8 March 2005 – High Wind
- 7 – May 2005 – High Wind
- 24 May 2005 – High Wind

Source: <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms>

## SECTION 5 - Data Recovery and Validation

All raw wind data were subjected to a series of tests and filters to weed out data that are faulty or corrupted. Definitions of these quality assurance (QA) controls are given below under Test Definitions and Sensor Statistics. These control filters were designed to automate the quality control process and used many of the previous hand-worked data sets made at UMass to affect a suitable emulation. The gross percentage of data recovered (ratio of the number of raw data points received to data points expected) and net data recovered (ratio of raw data points which passed all QA control tests to data points expected) are shown below.

Gross Data Recovered [%]	99.2
Net Data Recovered [%]	88.0

The gross data recovered is low at 88.0 % because of the failed 50 m (164.0 ft) wind vane. Disregarding the 50 m (164.0 ft) wind vane data, the gross data recovered is 98.9%.

### Test Definitions

All raw data were subjected to a series of validation tests, as described below. The sensors tested and the parameters specific to each sensor are given in the Sensor Performance Report, which is included in APPENDIX A. Data that were flagged as invalid were not included in the statistics presented in this report.

**MinMax Test:** All sensors are expected to report data values within a range specified by the sensor and logger manufacturers. If a value falls outside this range, it is flagged as

invalid. A data value from the sensor listed in Test Field 1 (TF1) is flagged if it is less than Factor 1 (F1) or greater than Factor 2. This test has been applied to the following sensors (as applicable): wind speed, wind speed standard deviation, wind direction, temperature, and solar insolation.

$$F1 > TF1 > F2$$

**MinMax T Test:** This is a MinMax test for wind direction standard deviation with different ranges applied for high and low wind speeds. A wind direction standard deviation data value (TF1) is flagged either if it is less than Factor 1, if the wind speed (TF2) is less than Factor 4 and the wind direction standard deviation is greater than Factor 2, or if the wind speed is greater than or equal to Factor 4 and the wind direction standard deviation is greater than Factor 3.

$$\begin{aligned} & (TF1 < F1) \\ & \text{or } (TF2 < F4 \text{ and } TF1 > F2) \\ & \text{or } (TF2 \geq F4 \text{ and } TF1 > F3) \end{aligned}$$

**Icing Test:** An icing event occurs when ice collects on a sensor and degrades its performance. Icing events are characterized by the simultaneous measurements of near-zero standard deviation of wind direction, non-zero wind speed, and near- or below-freezing temperatures. Wind speed, wind speed standard deviation, wind direction, and wind direction standard deviation data values are flagged if the wind direction standard deviation (CF1) is less than or equal to Factor 1 (F1), the wind speed (TF1) is greater than Factor 2 (F2), and the temperature (CF2) is less than Factor 3 (F3). To exit an icing event, the wind direction standard deviation must be greater than Factor 4.

$$CF1 \leq F1 \text{ and } TF1 > F2 \text{ and } CF2 < F3$$

**CompareSensors Test:** Where primary and redundant sensors are used, it is possible to determine when one of the sensors is not performing properly. For anemometers, poor performance is characterized by low data values. Therefore, if one sensor of the pair reports values significantly below the other, the low values are flagged. At low wind speeds (Test Fields 1 and 2 less than or equal to Factor 3) wind speed data are flagged if the absolute difference between the two wind speeds is greater than Factor 1. At high wind speeds (Test Fields 1 or 2 greater than Factor 3) wind speed data are flagged if the absolute value of the ratio of the two wind speeds is greater is greater than Factor 2.

$$\begin{aligned} & [ TF1 \leq F3 \text{ and } TF2 \leq F3 \text{ and } \text{abs}(TF1 - TF2) > F1 ] \\ & \text{or } [ (TF1 > F3 \text{ or } TF2 > F3) \text{ and } (\text{abs}(1 - TF1 / TF2) > F2 \text{ or } \text{abs}(1 - TF2 / TF1) > F2) ] \end{aligned}$$

## Sensor Statistics

**Expected Data Points:** the total number of sample intervals between the start and end dates (inclusive).

**Actual Data Points:** the total number of data points recorded between the start and end dates.

**% Data Recovered:** the ratio of actual and expected data points (this is the *gross data recovered percentage*).

**Hours Out of Range:** total number of hours for which data were flagged according to MinMax and MinMaxT tests. These tests flag data, which fall outside of an expected range.

**Hours of Icing:** total number of hours for which data were flagged according to Icing tests. This test uses the standard deviation of wind direction, air temperature, and wind speed to determine when sensor icing has occurred. It should be noted that, while this test is tuned to detect sensor icing events, it is possible for the conditions that are representative of icing to occur at other times. The error due to this possibility is considered to be insignificant.

**Hours of Fault:** total number of hours for which data were flagged according to CompareSensors tests. These tests compare two sensors (e.g. primary and redundant anemometers installed at the same height) and flag data points where one sensor differs significantly from the other.

**% Data Good:** the filter results are subtracted from the gross data recovery percentage to yield the *net data recovered percentage*.

## SECTION 6 - Data Summary

This report contains several types of wind data graphs. Unless otherwise noted, each graph represents data from 1 quarter (3 months). The following graphs are included:

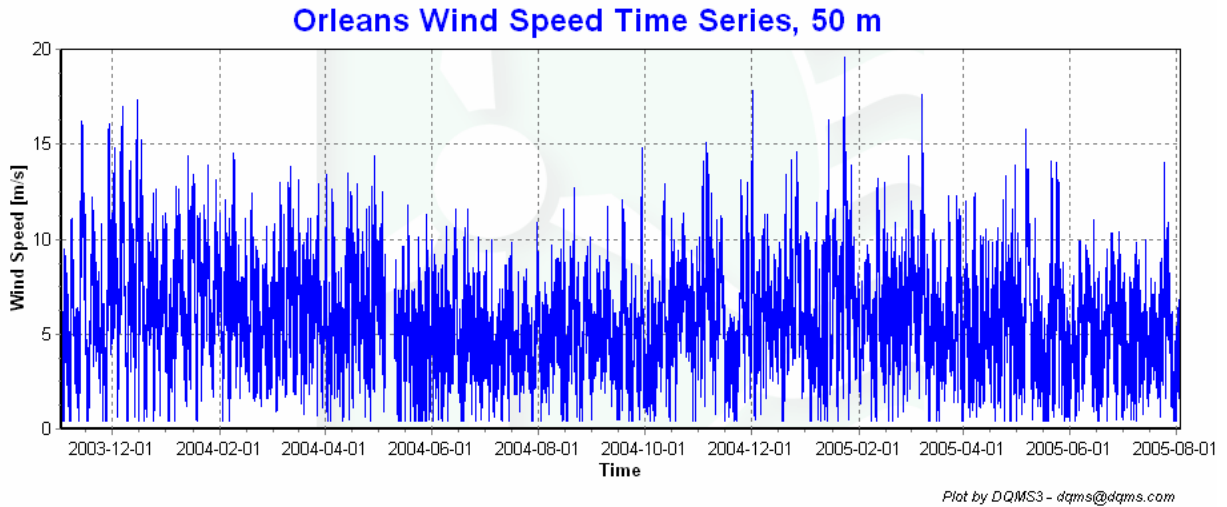
- Time Series – 10-minute average wind speeds are plotted against time in Figure 2. The graph shows that the winds in the summer months are generally lower. Most 10-minute averages above 15 m/s (33 mph) occur during the winter months
- Wind Speed Distribution – A histogram plot giving the percentage of time that the wind is at a given wind speed. Figure 3 shows that the maximum percentage is between 4 and 5 m/s (8.76 and 11.18 mph).

- Monthly Average – A plot of the monthly average wind speed over a 18-month period is given in Figure 4. This graph shows the trends in the wind speed from November 2003 - July 2005. Data for the month of May 2004 is missing because the data card arrived at the lab containing missing data.
- Diurnal – A plot of the average wind speed for each hour of the day is given in Figure 5. This graph shows a peak wind speed between 12 PM and 1 PM.
- Turbulence Intensity – A plot of turbulence intensity as a function of wind speed. Turbulence Intensity is calculated as the standard deviation of the wind speed divided by the wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. This graph is given in Figure 6.
- Wind Rose – A plot, by compass directions showing the percentage of time that the wind comes from a given direction and the average wind speed in that direction. The spring wind rose, in Figure 7, shows that the wind tends to be predominantly from the SW and the NW at the 40 m height and that the mean wind speed is relatively equal from all directions with no dominant direction. (The 50 m (164.0 ft) wind data was used for the plot but 40 m wind direction data was used due to the failure of the vane at 50m.)

## SECTION 7 - Graphs

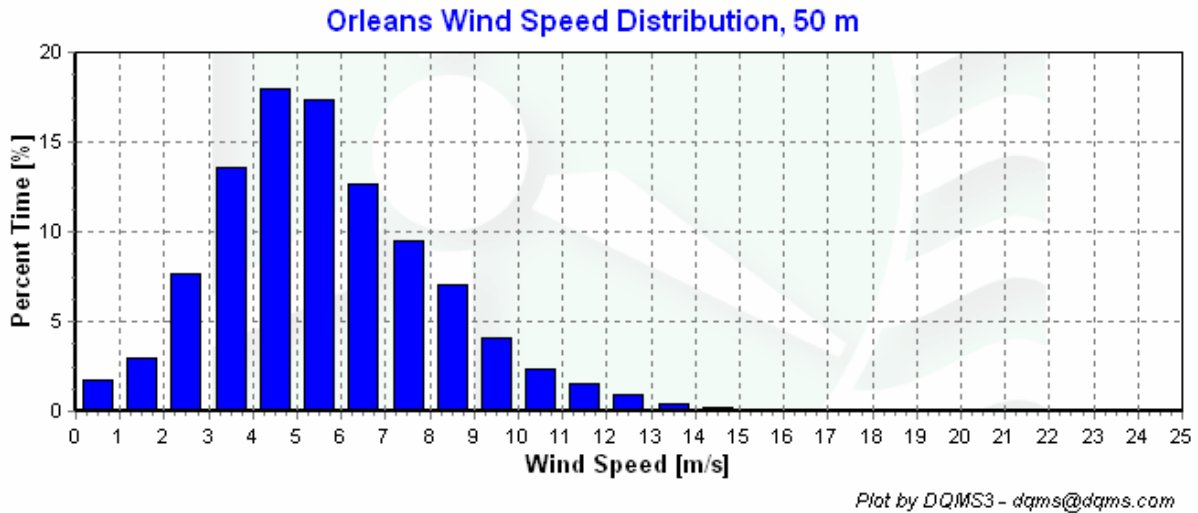
Data for the wind speed histograms, monthly and diurnal average plots, and wind roses are included in APPENDIX B.

### Wind Speed Time Series



**Figure 2 - Wind Speed Time Series, October 2003 - August 2005**

### Wind Speed Distributions



**Figure 3 - Wind Speed Distribution, June 2004 - May 2005**

### Monthly Average Wind Speeds

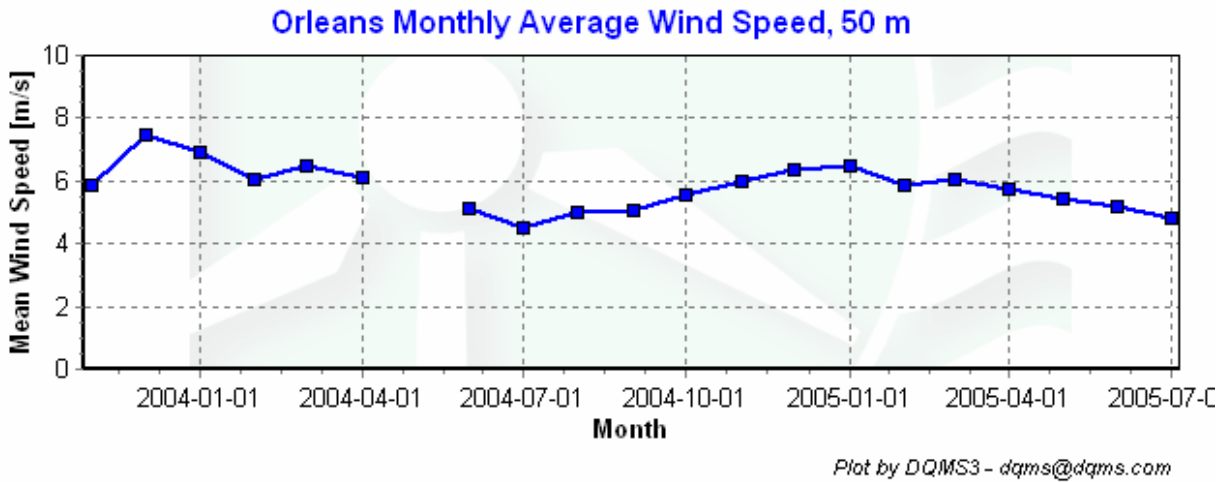


Figure 4 - Monthly average wind speed

### Diurnal Average Wind Speeds

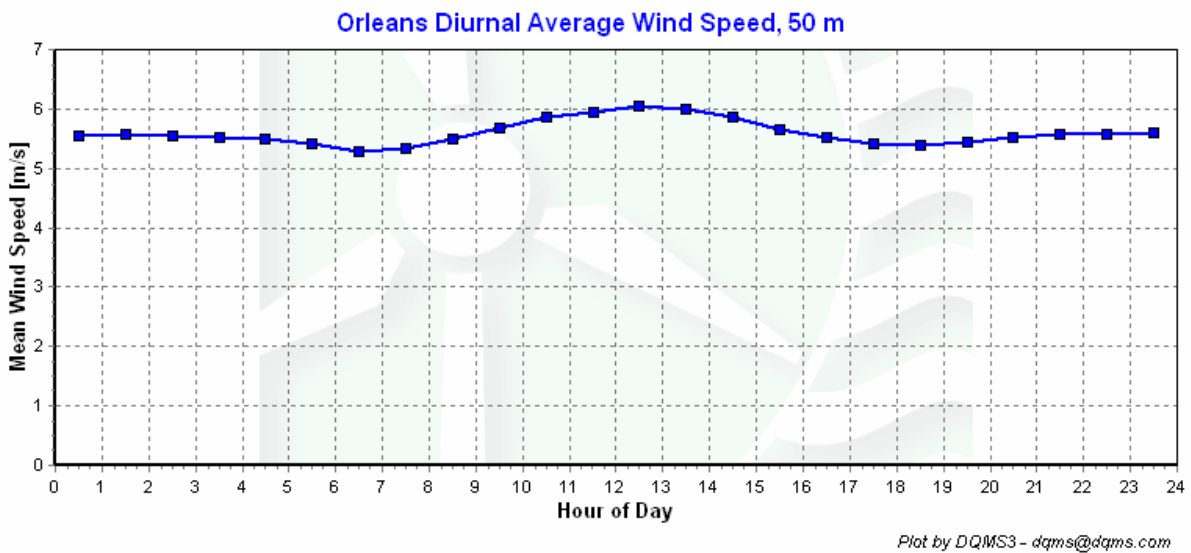
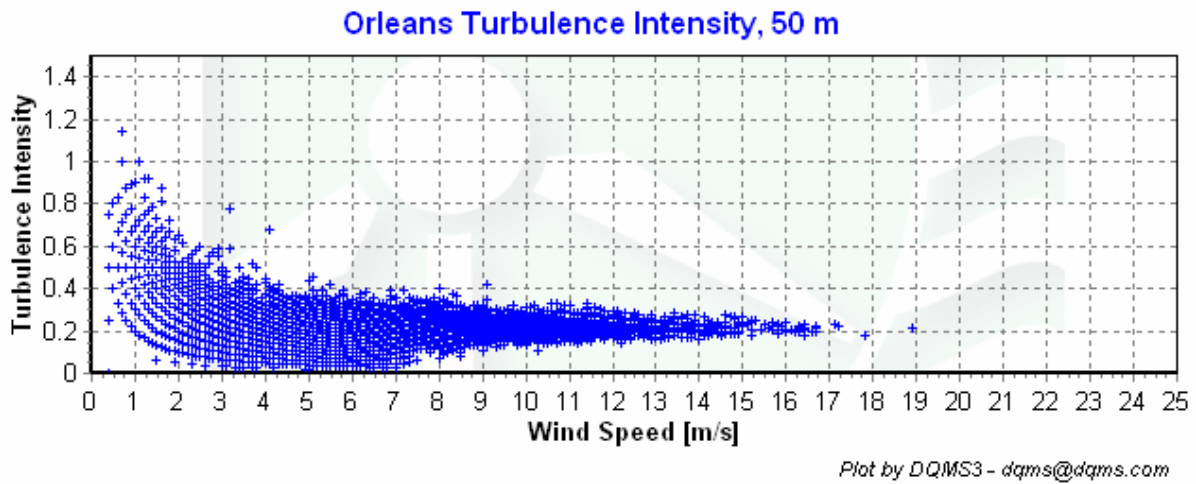


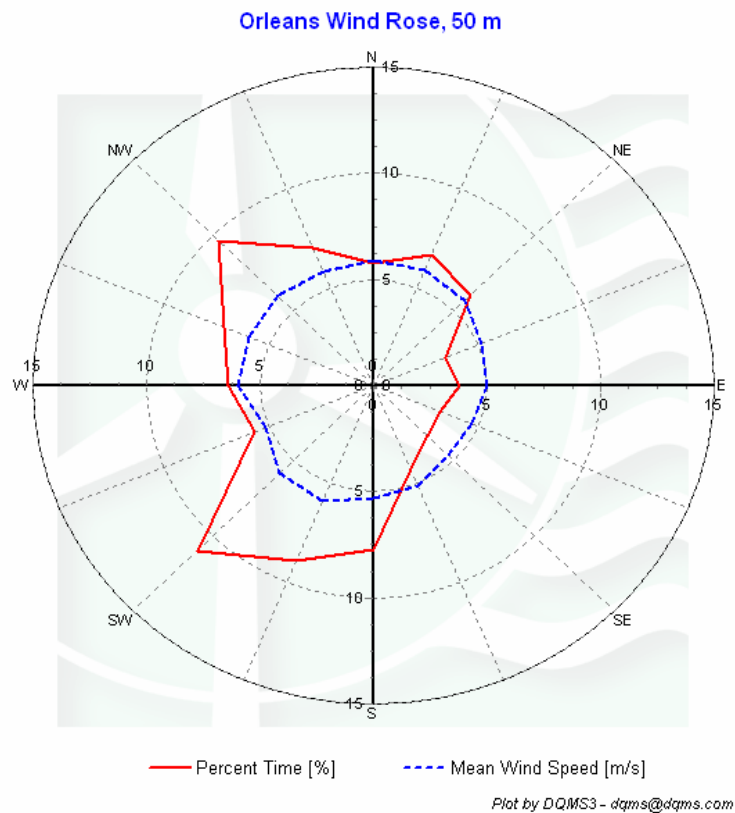
Figure 5 - Diurnal Wind Speed, June 2004 - May 2005

## Turbulence Intensities



**Figure 6 - Turbulence Intensity vs. Wind Speed, June 2004 - May 2005**

## Wind Roses



**Figure 7 - Wind Rose, June 2004 - May 2005**

# APPENDIX A - Sensor Performance Report

## Test Definitions

TestOrder	TestField1	TestField2	TestField3	CalcField1	CalcField2	TestType	Factor1	Factor2	Factor3	Factor4
1						TimeTest Insert				
2	Etmp2aDEGC					MinMax	-30	60		
3	Etmx2aDEGC					MinMax	-30	60		
4	Etmn2aDEGC					MinMax	-30	60		
5	EtmpSD2aDEGC					MinMax	-30	60		
10	Anem50aMS					MinMax	0	90		
11	Anem50bMS					MinMax	0	90		
12	Anem40aMS					MinMax	0	90		
13	Anem40bMS					MinMax	0	90		
14	Anem20aMS					MinMax	0	90		
15	Anem50yMS					MinMax	0	90		
16	Anem40yMS					MinMax	0	90		
20	AnemSD50aMS					MinMax	0	4		
21	AnemSD50bMS					MinMax	0	4		
22	AnemSD40aMS					MinMax	0	4		
23	AnemSD40bMS					MinMax	0	4		
24	AnemSD20aMS					MinMax	0	4		
25	AnemSD50yMS					MinMax	0	4		
26	AnemSD40yMS					MinMax	0	4		
30	Vane50aDEG					MinMax	0	359.9		
31	Vane40aDEG					MinMax	0	359.9		
32	Vane20aDEG					MinMax	0	359.9		
50	Turb50zNONE					MinMax	0	2		
51	Turb40zNONE					MinMax	0	2		
60	Wshr0zNONE					MinMax	-100	100		
70	Pwr50zWMS					MinMax	0	5000		
71	Pwr40zWMS					MinMax	0	5000		
200	VaneSD50aDEG	Anem50yMS				MinMaxT	0	100	100	10
201	VaneSD40aDEG	Anem40yMS				MinMaxT	0	100	100	10
202	VaneSD20aDEG	Anem20aMS				MinMax	0	100	100	10
300	Anem50aMS	AnemSD50aMS	Vane50aDEG	VaneSD40aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
301	Anem50bMS	AnemSD50bMS	Vane50aDEG	VaneSD40aDEG	Etmp2aDEGC	Icing	0.5	1	2	10

302	Anem40aMS	AnemSD40aMS	Vane40aDEG	VaneSD40aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
303	Anem40bMS	AnemSD40bMS	Vane40aDEG	VaneSD40aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
304	Anem20aMS	AnemSD20aMS	Vane20aDEG	VaneSD20aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
400	Anem50aMS	Anem50bMS				CompareSensors	1	0.25	3	0
401	Anem40aMS	Anem40bMS			CompareSensors	1	0.25	3	0	401
500	Amax50aMS					MinMax	0	90		
501	Amax50bMS					MinMax	0	90		
502	Amax40aMS					MinMax	0	90		
503	Amax40bMS					MinMax	0	90		
504	Amax20aMS					MinMax	0	90		
510	Amin50aMS					MinMax	0	90		
511	Amin50bMS					MinMax	0	90		
512	Amin40aMS					MinMax	0	90		
513	Amin40bMS					MinMax	0	90		
514	Amin20aMS					MinMax	0	90		
520	Vmax50aDEG					MinMax	0	359.9		
521	Vmax40aDEG					MinMax	0	359.9		
522	Vmax20aDEG					MinMax	0	359.9		
530	Vmin50aDEG					MinMax	0	359.9		
531	Vmin40aDEG					MinMax	0	359.9		
532	Vmin20aDEG					MinMax	0	359.9		

### Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Anem50aMS	93096	92252	99.093	6	327.667	4.667	96.913
AnemSD50aMS	93096	92252	99.093	6	327.667	4.667	96.913
Amax50aMS	93096	92252	99.093	0	0	0	99.093
Amin50aMS	93096	92252	99.093	0	0	0	99.093
Anem50bMS	93096	92252	99.093	6.667	320.333	9.333	96.926
AnemSD50bMS	93096	92252	99.093	6.667	320.333	9.333	96.926
Amax50bMS	93096	92252	99.093	0	0	0	99.093
Amin50bMS	93096	92252	99.093	0	0	0	99.093
Anem40aMS	93096	92252	99.093	5.333	319.5	12.833	96.917
AnemSD40aMS	93096	92252	99.093	5.333	319.5	12.833	96.917
Amax40aMS	93096	92252	99.093	0	0	0	99.093
Amin40aMS	93096	92252	99.093	0	0	0	99.093
Anem40bMS	93096	92252	99.093	6.667	316	38.167	96.768
AnemSD40bMS	93096	92252	99.093	6.667	316	38.167	96.768
Amax40bMS	93096	92252	99.093	0	0	0	99.093
Amin40bMS	93096	92252	99.093	0	0	0	99.093
Anem20aMS	93096	92252	99.093	0	244	0	97.521
AnemSD20aMS	93096	92252	99.093	2.5	244	0	97.505
Amax20aMS	93096	92252	99.093	0	0	0	99.093
Amin20aMS	93096	92252	99.093	0	0	0	99.093
Vane50aDEG	93096	93036	99.936	0	0	14067.17	6.678
VaneSD50aDEG	93096	93036	99.936	0	0	14067.17	6.678
Vmax50aDEG	93096	93036	99.936	0	0	14067.17	6.678
Vmin50aDEG	93096	93036	99.936	0	0	14067.17	6.678
Vane40aDEG	93096	92252	99.093	8	328.833	0	96.923
VaneSD40aDEG	93096	92252	99.093	8	328.833	0	96.923
Vmax40aDEG	93096	92252	99.093	2.167	0	0	99.079
Vmin40aDEG	93096	92252	99.093	0	0	0	99.093
Vane20aDEG	93096	92252	99.093	0	244	0	97.521
VaneSD20aDEG	93096	92252	99.093	3.667	244	0	97.497
Vmax20aDEG	93096	92252	99.093	0	0	0	99.093
Vmin20aDEG	93096	92252	99.093	0	0	0	99.093
Etmp2aDEGC	93096	92252	99.093	0	0	0	99.093
EtmpSD2aDEGC	93096	92252	99.093	0	0	0	99.093
Etmx2aDEGC	93096	92252	99.093	0	0	0	99.093
Etmn2aDEGC	93096	92252	99.093	0	0	0	99.093
Total	3351456	3324208	99.187	73.667	4200.667	56398.67	88.037

## APPENDIX B - Plot Data

### Wind Speed Distribution Data

Bin Center Wind Speed [m/s]	Percent of Time [%]
0.5	1.71
1.5	3
2.5	7.63
3.5	13.56
4.5	17.91
5.5	17.37
6.5	12.7
7.5	9.49
8.5	6.99
9.5	4.1
10.5	2.39
11.5	1.48
12.5	0.95
13.5	0.37
14.5	0.16
15.5	0.06
16.5	0.07
17.5	0.03
18.5	0.02
19.5	0.01
20.5	0
21.5	0
22.5	0
23.5	0
24.5	0

**Table 1 - Wind Speed Distribution, June 2004 - May 2005**

### Monthly Average Wind Speed Data

<b>Date</b>	<b>10 min Mean [m/s]</b>
November 2003	5.84
December 2003	7.47
January 2004	6.94
February 2004	6.02
March 2004	6.46
April 2004	6.12
May 2004	
June 2004	5.15
July 2004	4.48
August 2004	5.01
September 2004	5.08
October 2004	5.57
November 2004	6
December 2004	6.37
January 2005	6.47
February 2005	5.86
March 2005	6.02
April 2005	5.72
May 2005	5.41
June 2005	5.19
July 2005	4.8

**Table 2 - Wind Speed Averages**

### **Diurnal Average Wind Speed Data**

Hour of Day	Average Wind Speed [m/s]
0	5.56
1	5.57
2	5.53
3	5.52
4	5.49
5	5.42
6	5.28
7	5.33
8	5.49
9	5.68
10	5.87
11	5.96
12	6.04
13	6
14	5.86
15	5.66
16	5.52
17	5.41
18	5.4
19	5.45
20	5.52
21	5.57
22	5.58
23	5.59

**Table 3 - Diurnal Average Wind Speeds, June 2004 - May 2005**

### Wind Rose Data

<b>Direction</b>	<b>Percent Time [%], 40 m</b>	<b>Mean Wind Speed [m/s], 50 m</b>
<b>N</b>	5.74	5.91
<b>NNE</b>	6.67	5.91
<b>NE</b>	6.04	5.66
<b>ENE</b>	3.45	5.13
<b>E</b>	3.77	5.01
<b>ESE</b>	3.19	4.66
<b>SE</b>	3.36	4.62
<b>SSE</b>	4.28	5.12
<b>S</b>	7.75	5.27
<b>SSW</b>	8.93	5.89
<b>SW</b>	10.98	5.82
<b>WSW</b>	5.71	5.15
<b>W</b>	6.38	5.98
<b>WNW</b>	7.12	5.95
<b>NW</b>	9.64	5.98
<b>NNW</b>	7	5.78

**Table 4 - Wind Rose, Time Percentage and Mean Wind Speed by Direction,  
June 2004 - May 2005**