

# FINAL WIND DATA REPORT

## Presque Isle

November 21, 2004 – July 7, 2006

Prepared for  
United States Department of Energy  
And the University of Maine at Presque Isle  
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Presque Isle, ME 04769

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## EXECUTIVE SUMMARY

All the work presented in this Wind Data Report including installation and commissioning 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.

The Renewable Energy Research Laboratory (RERL) and the University of Maine, Presque Isle (UMPI) installed wind monitoring equipment at the UMPI campus on November 21, 2004. Anemometers and wind direction vanes were installed at 10 m, 30 m, and 39 m above the tower base. Data stored on memory chips were received via mail once per month. This wind resource assessment project was made possible with funding assistance from the United States Department of Energy (DOE).

This is the final wind data report for this site. The met tower has been taken down and data collection/reporting activities are now finalized. The entire dataset runs from November 21, 2004 until July 7, 2006. At 39 m, the mean recorded wind speed was 4.49 m/s (10.04 mph)<sup>1</sup> and the winds were predominantly from the North and South-Southeast. The average wind shear power-law factor is 0.32, and is calculated from data from the 39 m and 30 m anemometers. The average turbulence intensity at 39 m was 0.21, well within the normal values recorded by the RERL at wind monitoring sites it maintains in Massachusetts.

The gross data recovery percentage (the actual percentage of expected data received) was 100% and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 93.7%.

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) at:

[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)

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<sup>1</sup> 1 m/s = 2.237 mph

## SECTION 1 - Station Location

The Presque Isle station is located on the campus of UMPI in Presque Isle, Maine on the edge of an athletic field to the southwest of the main group of buildings. The site is indicated on a topographical map in Figure 1. The Northern Maine Regional Airport (callsign: KPQI) is approximately 3 km to the northwest. The tower base coordinates (using the NAD27 datum) are 46.669 N Latitude and -68.021 E Longitude.

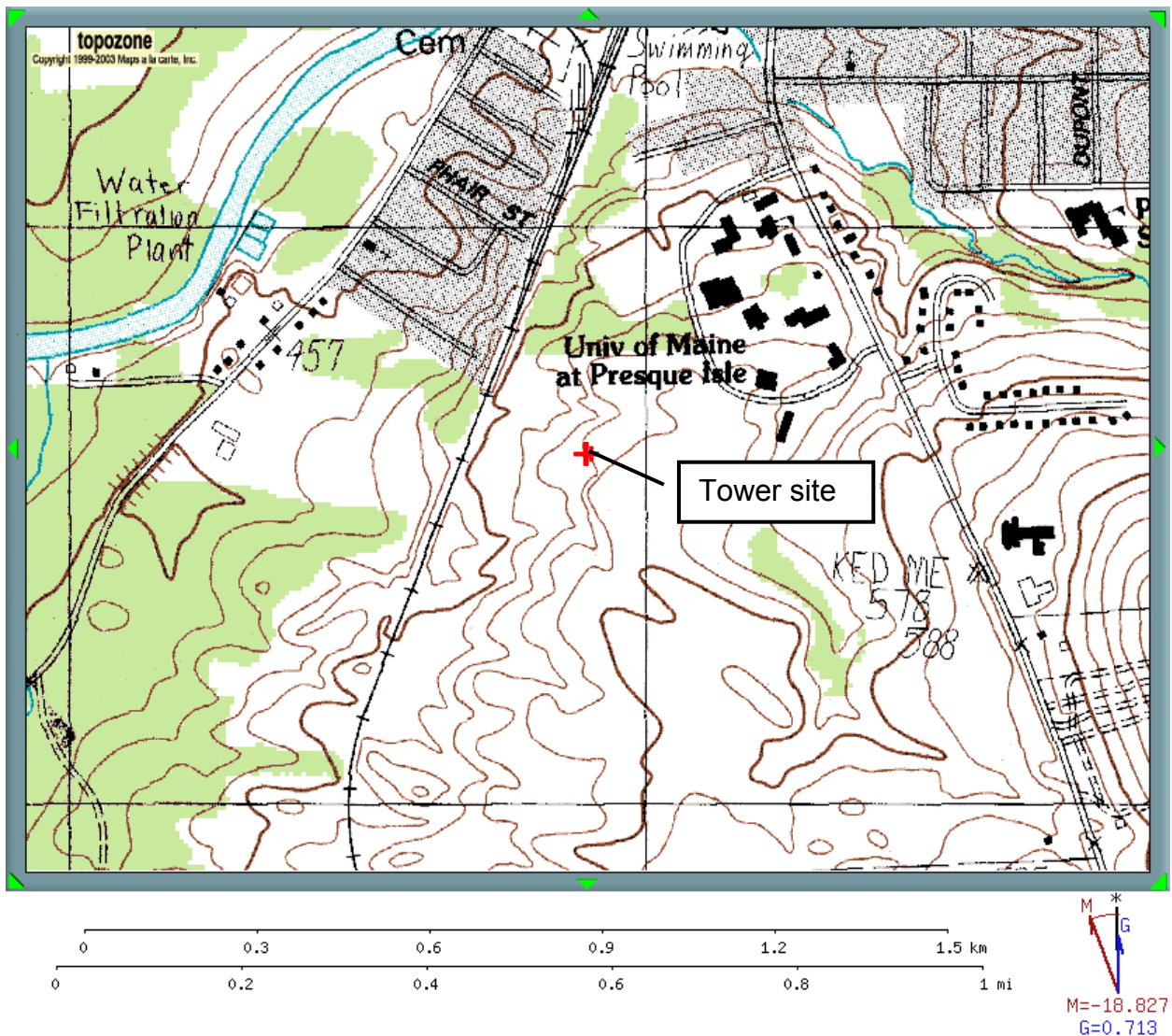


Figure 1 – Map of Presque Isle site.

Source: [www.topozone.com](http://www.topozone.com).

## SECTION 2 - Instrumentation and Equipment

Wind monitoring equipment is mounted on a standard WindMast™ 40-meter tall, 6 in diameter, tilt-up guyed tower purchased from Second Wind Inc. Figure 2 shows a picture of the completed installation. Anchors for the tower were placed by UMPI according to RERL instructions. FAA approval (required due to the proximity to the nearby airport) was granted with no tower modifications or lighting requirements. Wind vanes and anemometers are located at three heights on the tower: 10 m, 30 m, and 39 m. Redundant anemometers exist at 30 m and 39 m. The installed equipment and models are as follows:

- Symphonie Data Logger
- 5 – #40 Anemometers, standard calibration (Slope - 0.765 m/s, Offset – 0.350 m/s)
- 3 - #200P Wind direction vanes
- 5 – Sensor booms, 54” length
- Lightning rod and grounding cable
- Shielded sensor wire



Figure 2 – 40 m data tower in Presque Isle soon after installation.

The data from the Symphonie logger has been mailed to the Renewable Energy Research Laboratory at the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. These data 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 are converted to ASCII text files using the NRG software BaseStation®. These text files are then imported into a database software program where they are subjected to quality assurance (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.

There have been no data collection issues nor have there been any maintenance issues.

### 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	Turbulence Intensity	Prevailing Wind Direction	Wind Shear Coefficient
Height units	39 m, [m/s]	39 m, [m/s]	39 m, [ ]	39 m, [ ]	30 m, [m/s]	30 m, [m/s]	30 m, [ ]	30 m, [ ]	10 m, [m/s]	10 m, [m/s]	10 m, [ ]	10 m, [ ]	39m--30m [ ]
Dec 2004	4.69	14.4	0.21	SSE	4.5	13.8	0.22	NW	3.42	12.4	0.26	WNW	0
Jan 2005	4.66	13.6	0.2	N	4.37	13	0.22	N	3.29	11.7	0.26	N	0.32
Feb 2005	4.05	14.7	0.21	SSE	3.81	13.6	0.21	N	2.82	11	0.25	N	0.46
Mar 2005	4.49	11.2	0.2	N	4.18	10.4	0.22	N	2.98	8.6	0.28	N	0.34
Apr 2005	5.27	14.9	0.2	N	4.87	14	0.21	N	3.64	10.9	0.26	N	0.29
May 2005	4.5	14.7	0.22	SE	4.18	13.4	0.24	SE	3.25	10.4	0.29	SE	0.35
Jun 2005	4.15	13.6	0.23	SW	3.86	12.2	0.24	SW	2.91	8.9	0.28	S	0.29
Jul 2005	3.56	11.1	0.24	SSE	3.26	10.6	0.25	S	2.23	9.3	0.32	S	0.33
Aug 2005	3.91	12.1	0.22	SW	3.59	11.4	0.24	SW	2.56	9.4	0.28	S	0.35
Sep 2005	4.42	17.4	0.21	SW	4.07	16.9	0.22	SW	2.99	13.2	0.27	202.5	0.35
Oct 2005	4.43	11.1	0.21	E	3.99	10.2	0.23	E	2.89	8.4	0.28	E	0.44
Nov 2005	5	14.9	0.19	SSE	4.64	14.3	0.22	S	3.4	12.2	0.25	S	0.35
Dec 2005	--	--	--	--	--	--	--	--	--	--	--	--	--
Jan 2006	--	--	--	--	--	--	--	--	--	--	--	--	--
Feb 2006	5.19	18.9	0.2	WNW	4.93	18.1	0.22	WNW	3.87	15.7	0.24	WNW	0.3
Mar 2006	4.48	12.3	0.2	N	4.07	11.1	0.23	N	3.04	8.7	0.29	NW	0.43
Apr 2006	4.92	16.3	0.22	NE	4.78	15.3	0.22	NE	3.36	11.8	0.26	NE	0.23
May 2006	3.85	12.2	0.23	SSE	3.62	11.6	0.23	SW	2.69	9	0.28	SW	0.18
Jun 2006	4.12	11	0.22	SW	3.89	10.6	0.23	SW	2.87	9.2	0.29	S	0.17
<b>Dec<sup>'04</sup> – Jun<sup>'06</sup></b>	<b>4.49</b>	<b>18.9</b>	<b>0.21</b>	<b>N</b>	<b>4.17</b>	<b>18.1</b>	<b>0.22</b>	<b>N</b>	<b>3.1</b>	<b>15.9</b>	<b>0.27</b>	<b>S</b>	<b>0.32</b>

Wind data statistics in the table are reported when more than 90% of the data during the reporting period are valid. In cases when a larger amount of data are missing, the percent of the available data that are used to determine the data statistics is noted.

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  $\pm 2\%$  or  $\pm 0.2$  m/s, whichever is greater.

When data at multiple heights are available, shear coefficients,  $\alpha$ , have been determined—in this case from the anemometry located at 50 m and 38 m. They can be used in the following formula to estimate the average wind speed,  $U(z)$ , at height  $z$ , when the average wind speed,  $U(z_r)$ , at height  $z_r$  is known:

$$U(z)=U(z_r)\left(\frac{z}{z_r}\right)^\alpha$$

The change in wind speed with height is a very complicated relationship related to atmospheric conditions, wind speed, wind direction, time of day and time of year. This formula may not provide the correct answer at any given site. Nevertheless the calculated shear coefficient, based on measurements at two heights, can be used to characterize the degree of increase in wind speed with height at a site.

## **SECTION 4- Significant Meteorological Events**

No significant wind events were reported for Presque Isle during data collection.

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

There were, however, several sensor icing events, which is typical for the New England winter climate. During the months of December 2005 and January 2006, sensor-icing events were severe enough to allow collection of only 79.4% and 64.1% of the monthly data-respectively.

## **SECTION 5 - Data Recovery and Validation**

All raw wind data are 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 percentage (ratio of raw data points which passed all QA control tests to data points expected) are shown below.

Gross Data Recovered [%]	99.972
Net Data Recovered [%]	93.745

The gross data recovery percentage (the actual percentage of expected data received) was excellent: nearly 100%, and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was almost 94%. The net recovery percentage is within the normal range and reflects the periods when data could not be recovered due primarily to icing of the sensors.

### **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 which 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.

$$F1 > TF1 > F2$$

**MinMaxT 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 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.

**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

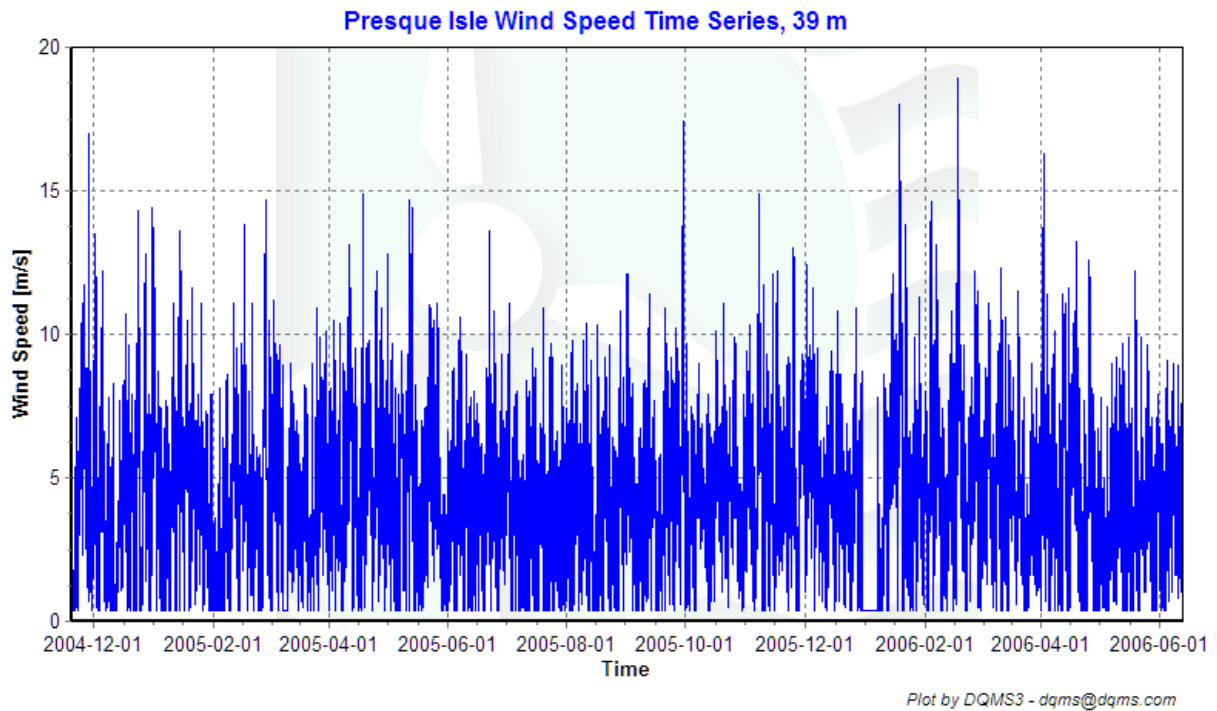
This report contains several types of wind data graphs. Unless otherwise noted, each graph represents data for the complete period of data collection. The following graphs are included:

- Time Series – 10-minute average wind speeds are plotted against time for all data starting on November 21<sup>st</sup> 2004 in Figure 3. This plot presents data at 39 meters. Immediately obvious is the missing data is a long sensor-icing event at the end of December 2005/beginning of January 2006.
- Wind Speed Distribution – A histogram plot giving the percentage of time that the wind is at a given wind speed. Figure 4 shows that the wind speeds ranged between 4 and 5 m/s (8.9 and 11.2 mph) approximately 17% of the time. This plot presents data at 39 meters and is drawn from the entire dataset.
- Monthly Average Wind Speeds – This plot shows the trends in the mean monthly wind speed at a height of 39 m. This graph shows the trends in the wind speed over the year. The monthly average wind speed plot is shown in Figure 5. Accurate averages for December 2005 and January 2006 could not be calculated due to sensor icing.
- Diurnal – A plot of the average wind speed for each hour of the day. Figure 6 shows that the hourly average varied between approximately 4 and 6 m/s (8.9 and 13.42 mph), with the highest average speeds near noon. This plot presents data at 39 meters and is drawn from the entire dataset.
- 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. In general, turbulence intensities range from 0.1 to 0.4; for Presque Isle, the average turbulence intensity was 0.21. In Figure 7, the turbulence intensity flattens out between 7 and 8 m/s (15.7 and 17.9 mph). This plot presents data at 39 meters and is drawn from the entire dataset.
- Wind Rose – A plot, by compass direction showing the percentage of time that the wind comes from a given direction and the average wind speed in that direction. Figure 8 shows the prevailing direction from the northwest. The wind blew from the north approximately 11% of the time with a mean wind speed of approximately 4.5 m/s (10.07 mph). This plot presents data at 39 meters and is drawn from the entire dataset.

## 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 3 – Wind Speed Time Series, November 21, 2004 through July 7, 2006**

## Wind Speed Distributions

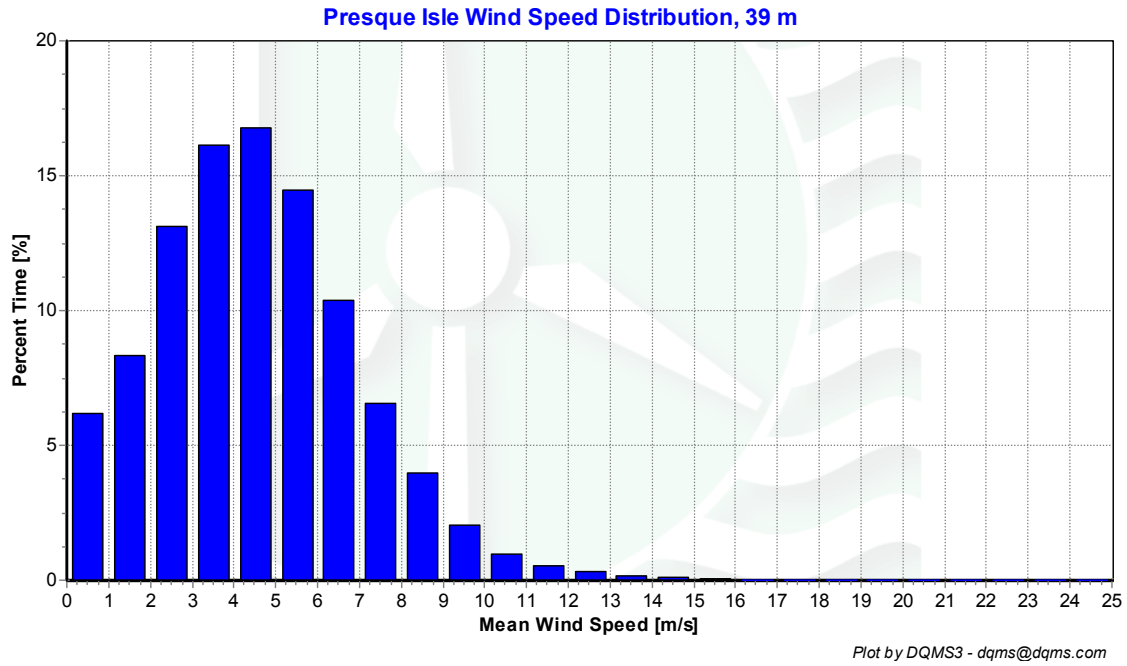


Figure 4 – Wind Speed Distribution, November 21, 2004 through July 7, 2006

## Monthly Average Wind Speeds

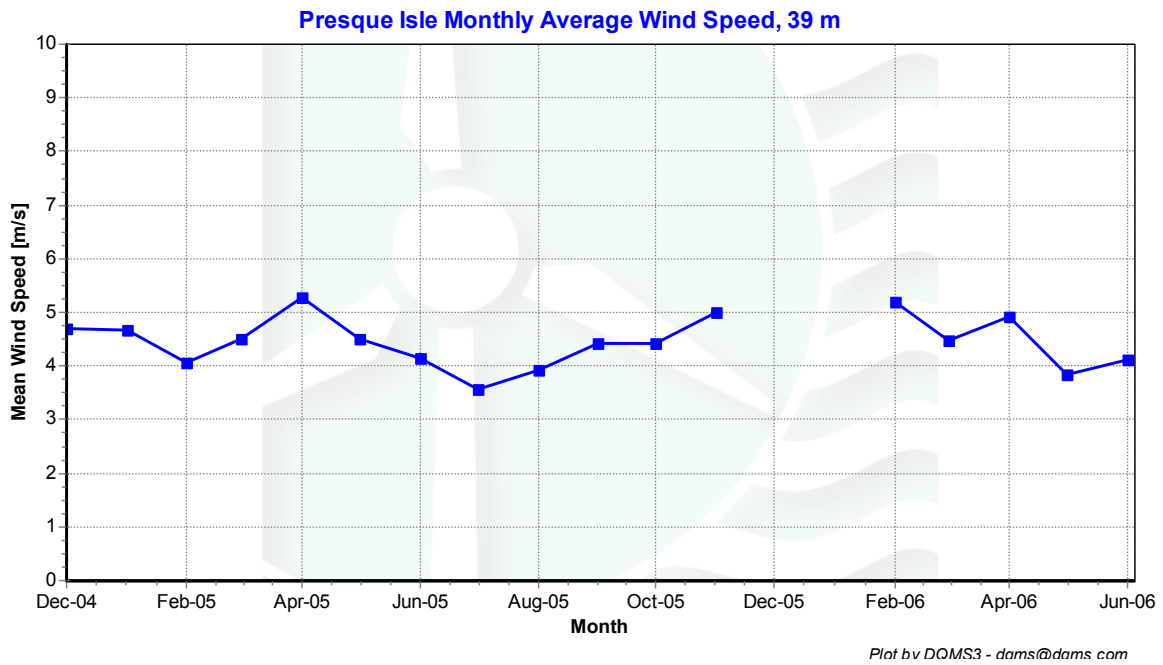
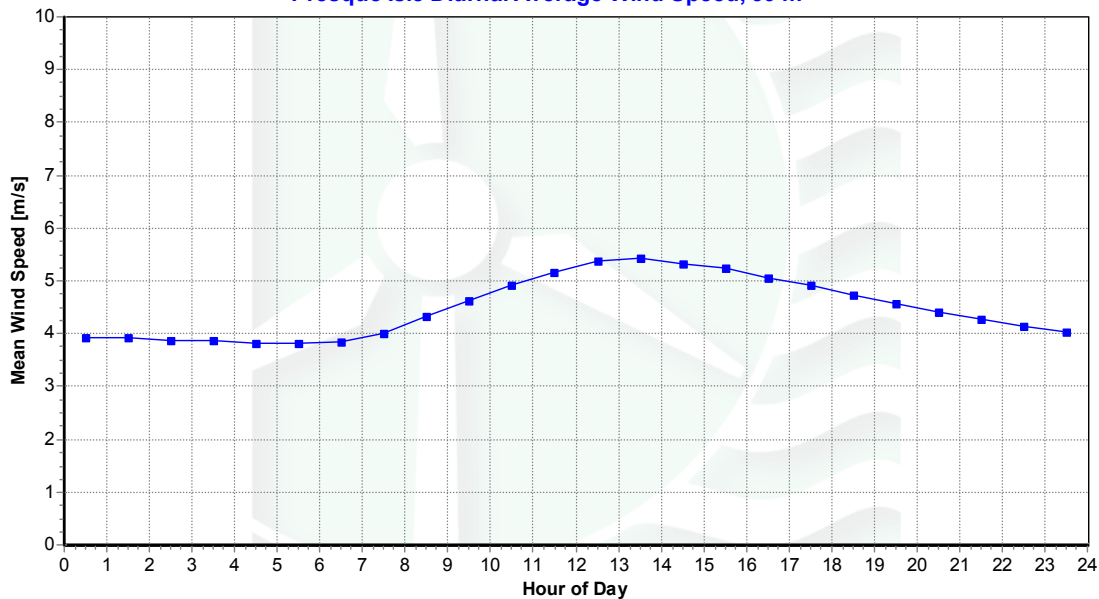


Figure 5 – Monthly Average Wind Speed

## Diurnal Average Wind Speeds

Presque Isle Diurnal Average Wind Speed, 39 m

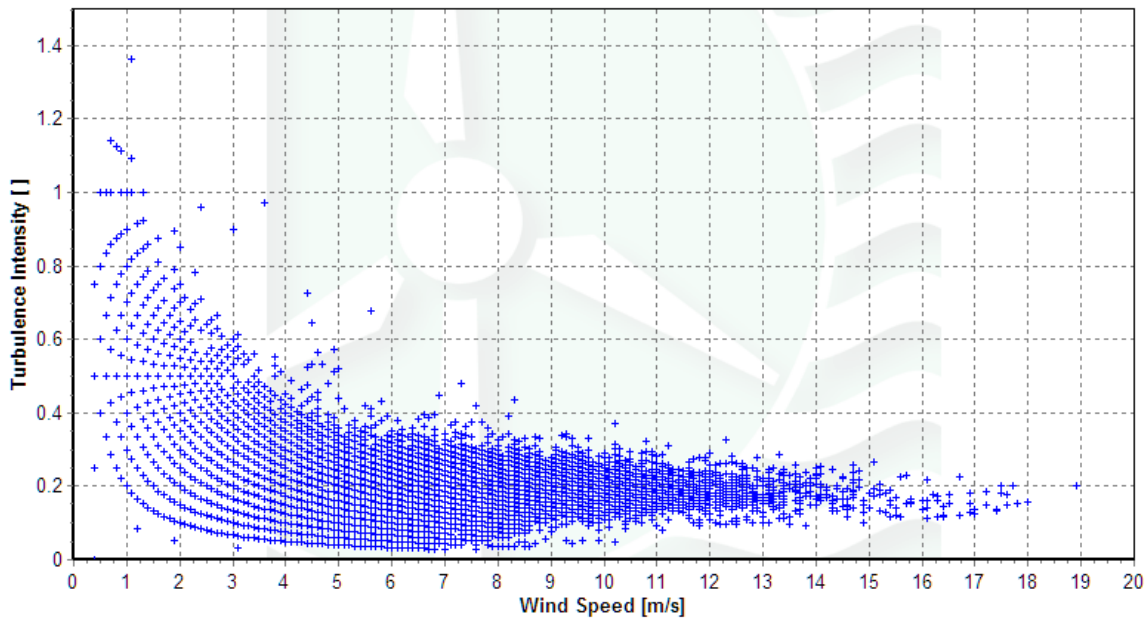


Plot by DQMS3 - dams@dams.com

Figure 6 – Diurnal Average Wind Speed, November 21, 2004 through July 7, 2006

## Turbulence Intensities

Presque Isle Turbulence Intensity, 39 m

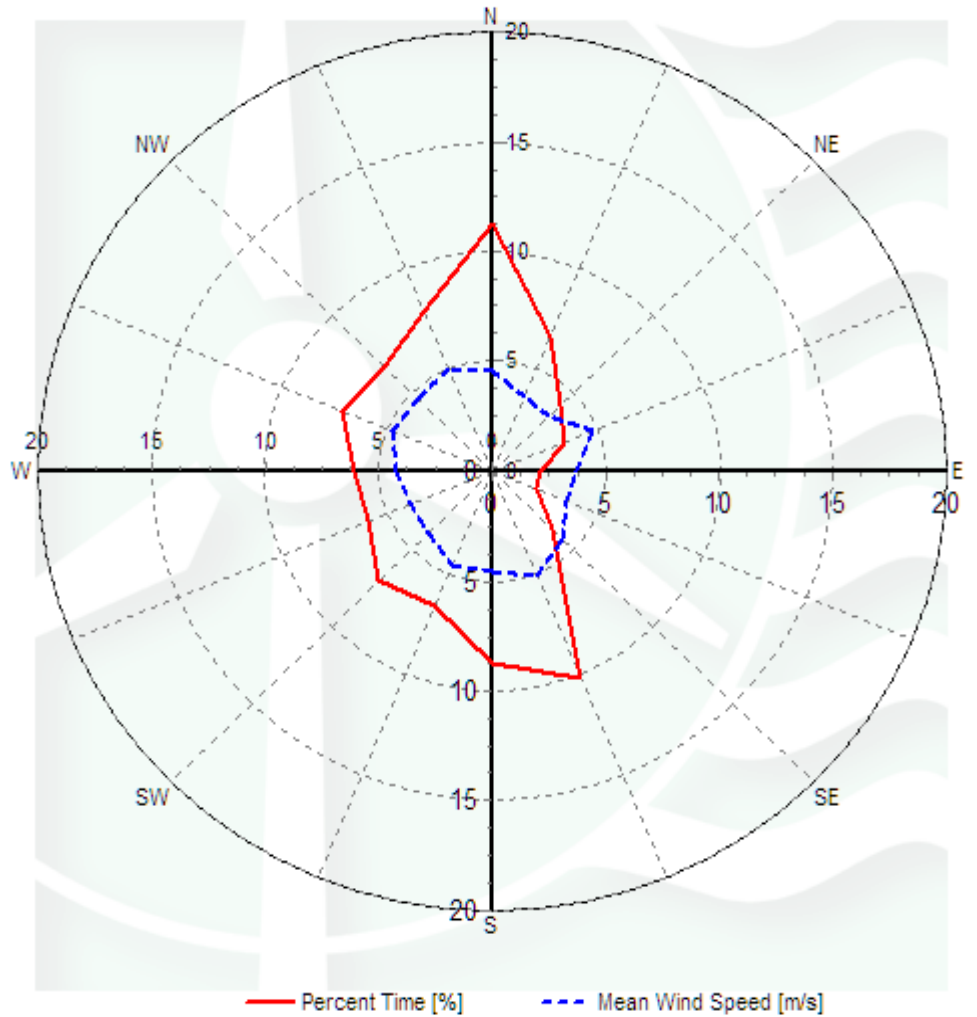


Plot by DQMS3 - dqms@dqms.com

Figure 7 – Turbulence Intensity, November 21, 2004 through July 7, 2006

## Wind Roses

### Presque Isle Wind Rose, 39 m



Plot by DQMS3 - dqms@dqms.com

Figure 8 – Wind Rose, November 21, 2004 through July 7, 2006

# APPENDIX A - Sensor Performance Report

## Test Definitions

Test Order	Test Field1	Test Field2	Test Field3	Calc Field1	Calc Field2	Calc Field3	Test Type	Factor 1	Factor 2	Factor 3	Factor 4
1							TimeTest Insert	0	0	0	0
2	Etmp2aDEGC						MinMax	-30	60	0	0
3	Etmx2aDEGC						MinMax	-30	60	0	0
4	Etmn2aDEGC						MinMax	-30	60	0	0
5	EtmpSD2aDEGC						MinMax	-30	60	0	0
10	Anem39aMS						MinMax	0	90	0	0
11	Anem39bMS						MinMax	0	90	0	0
12	Anem30aMS						MinMax	0	90	0	0
13	Anem30bMS						MinMax	0	90	0	0
14	Anem10aMS						MinMax	0	90	0	0
15	Anem39yMS						MinMax	0	90	0	0
16	Anem30yMS						MinMax	0	90	0	0
20	AnemSD39aMS						MinMax	0	4	0	0
21	AnemSD39bMS						MinMax	0	4	0	0
22	AnemSD30aMS						MinMax	0	4	0	0
23	AnemSD30bMS						MinMax	0	4	0	0
24	AnemSD10aMS						MinMax	0	4	0	0
25	AnemSD39yMS						MinMax	0	4	0	0
26	AnemSD30yMS						MinMax	0	4	0	0
30	Vane39aDEG						MinMax	0	359.9	0	0
31	Vane30aDEG						MinMax	0	359.9	0	0
32	Vane10aDEG						MinMax	0	359.9	0	0
50	Turb39zNONE						MinMax	0	2	0	0
51	Turb30zNONE						MinMax	0	2	0	0
60	Wshr0zNONE						MinMax	-100	100	0	0
70	Pwr39zWMS						MinMax	0	5000	0	0
71	Pwr30zWMS						MinMax	0	5000	0	0
200	VaneSD39aDEG	Anem30yMS					MinMaxT	0	100	100	10
201	VaneSD30aDEG	Anem30yMS					MinMaxT	0	100	100	10
202	VaneSD10aDEG	Anem10aMS					MinMax	0	100	100	10
300	Anem39aMS	AnemSD39aMS	Vane39aDEG	VaneSD39aDEG	Etmp2aDEGC		Icing	1.1	1	2	10
301	Anem39bMS	AnemSD39bMS	Vane39aDEG	VaneSD39aDEG	Etmp2aDEGC		Icing	1.1	1	2	10
302	Anem30aMS	AnemSD30aMS	Vane30aDEG	VaneSD30aDEG	Etmp2aDEGC		Icing	1.1	1	2	10
303	Anem30bMS	AnemSD30bMS	Vane30aDEG	VaneSD30aDEG	Etmp2aDEGC		Icing	1.1	1	2	10
304	Anem10aMS	AnemSD10aMS	Vane10aDEG	VaneSD10aDEG	Etmp2aDEGC		Icing	1.1	1	2	10
400	Anem39aMS	Anem39bMS					CompareSensors	1	0.25	3	0
500	Anem30aMS	Anem30bMS					CompareSensors	1	0.25	3	0
501	Amin39aMS						MinMax	0	90	0	0
502	Amax39bMS						MinMax	0	90	0	0
503	Amax30aMS						MinMax	0	90	0	0
504	Amax30bMS						MinMax	0	90	0	0

510	Amax10aMS	MinMax	0	90	0	0
511	Amin39aMS	MinMax	0	90	0	0
512	Amin39bMS	MinMax	0	90	0	0
513	Amin30aMS	MinMax	0	90	0	0
514	Amin30bMS	MinMax	0	90	0	0
520	Amin10aMS	MinMax	0	90	0	0
521	Vmax39aDEG	MinMax	0	359.9	0	0
522	Vmax30aDEG	MinMax	0	359.9	0	0
530	Vmax10aDEG	MinMax	0	359.9	0	0
531	Vmin39aDEG	MinMax	0	359.9	0	0
532	Vmin30aDEG	MinMax	0	359.9	0	0

### Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Etmp2aDEGC	85572	85541	99.964	37.167	0	0	99.703
EtmpSD2aDEGC	85572	85541	99.964	0	0	0	99.964
Anem39aMS	85572	85548	99.972	0.333	833.667	118	93.297
AnemSD39aMS	85572	85548	99.972	0.333	833.667	118	93.297
Anem39bMS	85572	85548	99.972	0.167	926.333	28.667	93.275
AnemSD39bMS	85572	85548	99.972	0.167	926.333	28.667	93.275
Anem30aMS	85572	85550	99.974	0.333	1123	123.833	91.23
AnemSD30aMS	85572	85550	99.974	0.333	1123	123.833	91.23
Anem30bMS	85572	85552	99.977	0.167	1205.5	6.167	91.48
AnemSD30bMS	85572	85552	99.977	0.167	1205.5	6.167	91.48
Anem10aMS	85572	85548	99.972	0	720.5	0	94.92
AnemSD10aMS	85572	85548	99.972	0	720.5	0	94.92
Vane39aDEG	85572	85548	99.972	4.5	928.5	0	93.43
VaneSD39aDEG	85572	85548	99.972	4.5	928.5	0	93.43
Vane30aDEG	85572	85552	99.977	6	1218.833	0	91.389
VaneSD30aDEG	85572	85552	99.977	6	1218.833	0	91.389
Vane10aDEG	85572	85548	99.972	9.667	720.5	0	94.852
VaneSD10aDEG	85572	85548	99.972	9.667	720.5	0	94.852
<b>Total</b>	<b>1540296</b>	<b>1539870</b>	<b>99.972</b>	<b>79.5</b>	<b>15353.667</b>	<b>553.333</b>	<b>93.745</b>

## APPENDIX B - Plot Data

### Wind Speed Distribution Data

Bin Center Wind Speed [m/s]	Percent of Time [%]
0.5	6.17
1.5	8.31
2.5	13.11
3.5	16.15
4.5	16.78
5.5	14.45
6.5	10.39
7.5	6.54
8.5	3.95
9.5	2.03
10.5	0.97
11.5	0.52
12.5	0.31
13.5	0.18
14.5	0.08
15.5	0.03
16.5	0.03
17.5	0.02
18.5	0
19.5	0
20.5	0
21.5	0
22.5	0
23.5	0
24.5	0

Table 1 - Wind Speed Distribution

### Monthly Average Wind Speed Data

Date	10 min Mean [m/s]
Dec 2004	4.69
Jan 2005	4.66
Feb 2005	4.05
Mar 2005	4.49
Apr 2005	5.27
May 2005	4.5
Jun 2005	4.15
Jul 2005	3.56
Aug 2005	3.91
Sep 2005	4.42
Oct 2005	4.43

Nov 2005	5.00
Dec 2005	--
Jan 2006	--
Feb 2006	5.19
Mar 2006	4.48
Apr 2006	4.92
May 2006	3.85
Jun 2006	4.12

**Table 2 - Wind Speed Averages, 50m**

**Diurnal Average Wind Speed Data**

Hour of Day	Average Wind Speed [m/s]
0.5	3.94
1.5	3.93
2.5	3.88
3.5	3.88
4.5	3.83
5.5	3.83
6.5	3.84
7.5	4.01
8.5	4.34
9.5	4.63
10.5	4.92
11.5	5.16
12.5	5.37
13.5	5.42
14.5	5.31
15.5	5.24
16.5	5.06
17.5	4.92
18.5	4.73
19.5	4.57
20.5	4.42
21.5	4.27
22.5	4.15
23.5	4.03

**Table 3 - Diurnal Average Wind Speeds**

### Wind Rose Data

<b>Direction</b>	<b>Percent Time [%], 50 m</b>	<b>Mean Wind Speed [m/s], 50 m</b>
<b>N</b>	10.68	4.43
<b>NNE</b>	6.4	3.8
<b>NE</b>	4.19	3.63
<b>ENE</b>	3.33	4.22
<b>E</b>	2.31	3.64
<b>ESE</b>	2.17	3.82
<b>SE</b>	3.74	4.52
<b>SSE</b>	10.31	5.32
<b>S</b>	8.17	4.58
<b>SSW</b>	6.4	4.59
<b>SW</b>	6.74	4.07
<b>WSW</b>	5.87	3.94
<b>W</b>	7.01	4.59
<b>WNW</b>	7.85	4.98
<b>NW</b>	7.13	4.7
<b>NNW</b>	7.69	5.06

**Table 4 - Wind Rose, Time Percentage and Mean Wind Speed by Direction**