

OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Wallowa



Prepared By:
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1.0 INTRODUCTION

The Oregon anemometer loan program was established in the fall of 2002 in order to assist landowners in the state evaluate the wind energy potential of their property. The program is funded by a grant from the Energy Trust of Oregon and is administered by the Energy Resources Research Laboratory at Oregon State University. The program involves several steps, beginning with a preliminary evaluation of the site. If estimates of the site show promise then a monitoring system is installed for a fixed duration (typically one year). The site is monitored regularly and the data processed and checked at regular intervals. Upon completion of the first year, the collected wind data is summarized and a report is prepared evaluating the wind data and the wind resource of the location.

This report represents the final portion of the project and is designed to give the landowner the information necessary to make an informed choice about the role wind energy might play in their property. The report is separated into sections with section 2.0 devoted to a description of the site, its location and the type of terrain found there. Section 3.0 includes a summary of the wind data collected during the study period including data quality checks and a characterization of the measured winds. In section 4.0 the wind data is analyzed to determine the amount of power production that might be expected from the site and to examine characteristics that might influence these estimates. This is followed in section 5.0 in which wind data from a nearby site is summarized and used to place the current study period in climatological context. A discussion and summary is then presented in section 6.0

2.0 SITE DESCRIPTION

Site Name:	Wallowa
Latitude:	45-36-27
Longitude:	117-31-53
Elevation:	3293 ft.
County:	Wallowa
Sensor Height:	67 ft.
Types of Sensors:	NRG Maximum #40 wind speed NRG 200 series2 wind vane
Types of Data:	10 min. average wind speed (mph) 10 min. std. dev. wind speed (mph) 10 min. wind direction (16 categories)
Installation Date:	August 13, 2003 @ 1117 PST
Removal Date:	September 15, 2004 @ 0640 PST

Site Location: Wallowa is a small town in the Wallowa Valley located in north-east Oregon. The anemometer site was located approximately two miles north of the town on a bluff overlooking the valley. The location of the tower site is marked on the map included in Appendix A. Access to the site is by an unimproved road running through and to the east of the landowner's property.

Site Description: The anemometer site is situated on a bluff about 400 feet above the valley floor on the north-east side. The site has good exposure in the immediate vicinity except to the south-east where there are several hills of slightly higher elevation. The area is open with few trees or structures that might influence the wind flow at the site. Most of the valley is used as farmland while the surrounding hills consist of grass and scattered trees. In a broader sense, the Wallowa Valley is dwarfed by the Wallowa Mountain to the south-west. A gap in the mountains exists directly west of the anemometer site.

Project Description: This site was installed after a request was made by the owner to evaluate the potential for installation of a wind turbine to help off-set high energy costs associated with farming and ranching activities. In a preliminary evaluation prepared prior to acceptance of this site, the annual mean wind was estimated to be in a range between 5.0 mph to 8.0 mph. While this is considered extremely low, no credible public wind data exists in the area and there was an interest in verifying the evaluation. There was also some speculation that the gap located to the west of the site might provide a corridor through which winds might be channeled.

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at this site in Wallowa are examined and discussed. The goals are to evaluate the characteristics that can help explain the physical processes at work at the site and to highlight the properties that are important to assessing the wind energy potential. These evaluations are done using hourly averaged means that have been constructed using the 10 minute means recorded at the site. This is done so that existing analysis programs can be used and is not expected to have any appreciable influence on the interpretation of data.

Data Recovery: The amount of data recovered during an observation period is important to characterize and should be examined to determine the confidence of other characteristics.

Data were plotted and scanned manually to identify any problems with the site. Data collection from the site was complete for the entire reporting period and there were no apparent problems or periods of missing data. However, data for several periods were removed from the records because the effects of icing were detected. This was only done for periods with a clear presence of icing and it is possible that other periods with a more limited influence occurred. Much of the data for the winter months showed possible signs of icing. However, only the prolonged periods were removed and it is difficult to determine the full extent and the influence for shorter duration periods. A table of site visits and the actions taken has been included in Appendix A.

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ann
Rec (%)	100	100	100	79.8	94.9	100	100	100	100	100	100	100	97.9

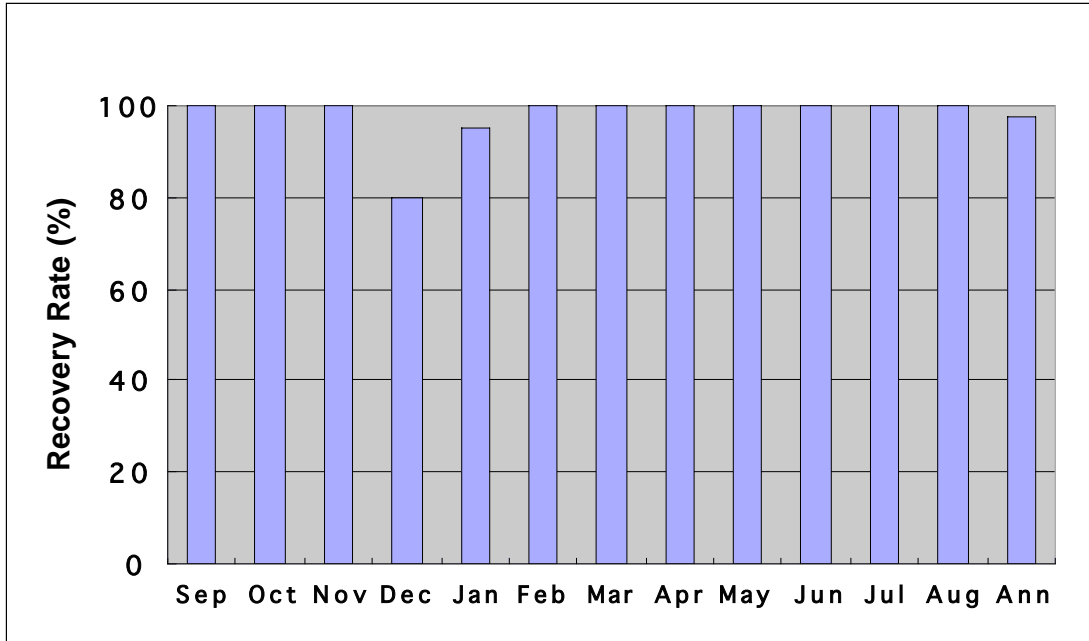


Figure 3.1: Data recovery by month for the ALP site in Wallowa.

Monthly Means: Monthly means are often constructed and used to determine the overall strength of the winds during different periods of the year.

The annual mean wind speed at this site in Wallowa for this reporting period was 5.36 mph. This is near the lower end of the estimated range provided in an initial evaluation of the site and confirms that a large energy resource is not available from this site. In general, there is no clear seasonal pattern and all of the months have means in the same general range. The monthly mean values range from a low of 2.8 mph in February to a high of 7.0 mph in March. However, in terms of wind energy, these means are very low. The low wind speed values during the winter are somewhat surprising. This site was expected to have higher winds during the winter when winter storms pass through this region. One explanation for the low means is that the valley or basin nature of this location produces an inversion that traps cold air close to the surface and inhibits wind flow in the lower levels. This would also contribute to a high occurrence of icing at the site.

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ann
Mean (mph)	5.1	5.8	5.7	3.7	4.0	2.8	7.0	5.8	6.9	6.2	5.7	5.0	5.36

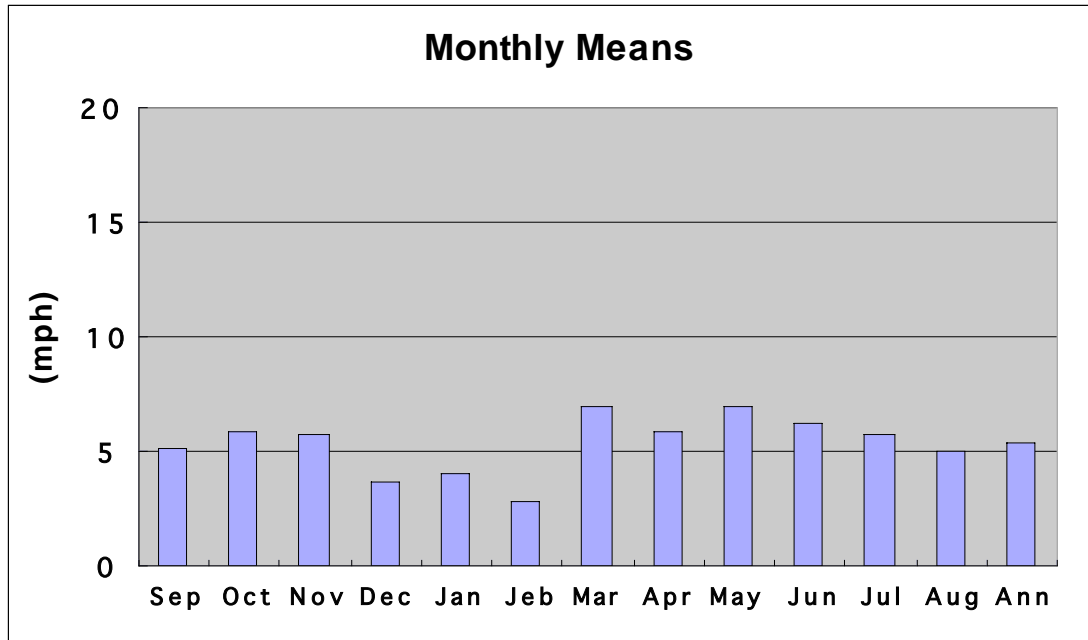


Figure 3.2: Monthly Mean Wind Speed Values for the ALP site at Wallowa.

Diurnal Means: The diurnal pattern of winds is an important characteristic for many wind sites and helps illuminate the mechanisms responsible for the winds. In general, a diurnal pattern is associated with a site at which strong thermal influences play a role. These are normally accentuated during the summer months when the daily heating cycle is at its greatest. Diurnal variations can also provide an indication of dependable and predictable winds at a site.

In Figure 3.3 the mean diurnal patterns are shown for the individual months of January, March and July and for the entire period as a whole. While the site has extremely low monthly mean wind speed values, it does exhibit a fairly strong diurnal variation for most of these periods. The peak for January is fairly weak but for the other months and the period as a whole the peak is pronounced and continues for several hours through the afternoons. This peak is strongest in March where the means exceed 12.0 mph. Overall, however, the magnitude of these peaks is still relatively small.

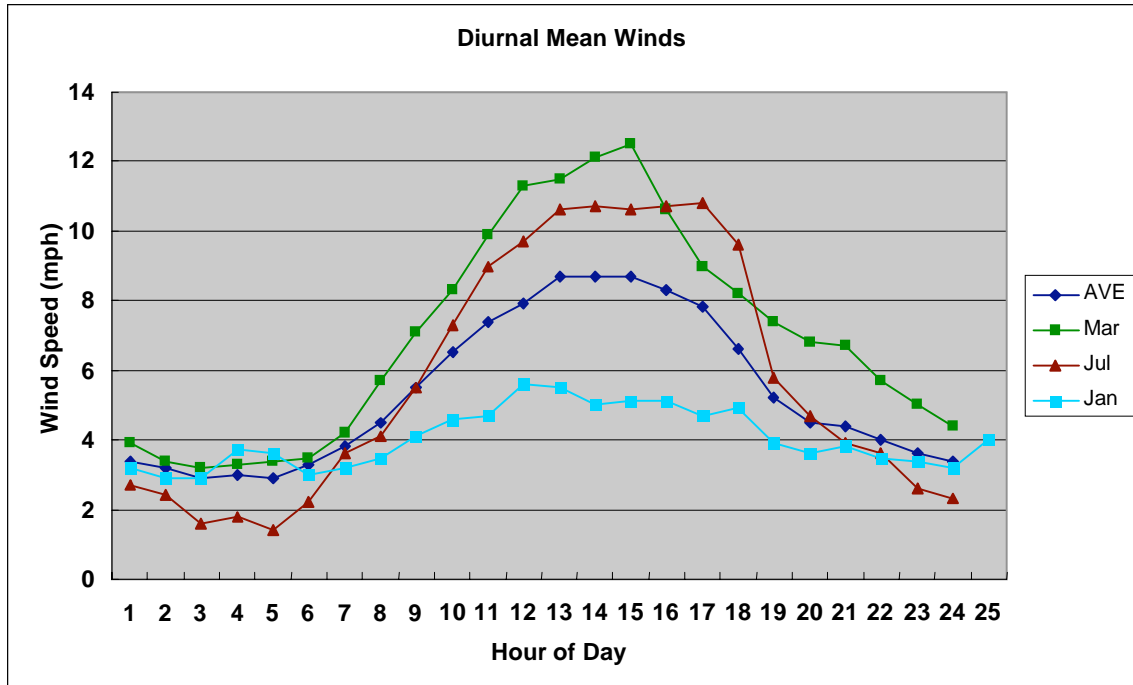


Figure 3.3: Diurnal mean wind speed values for the ALP site at Wallowa.

Frequency Distribution: How the wind speed at a site is distributed over various wind speed categories is an important indication of the wind resource potential of a site. An ideal site would have winds that blow at a high rate for long periods. This is not normally the case, however, and wind records from a site show a skewed distribution with a higher frequency of winds at lower speeds.

The wind speed frequency distribution for Wallowa is shown in Figure 3.4. This distribution is somewhat atypical. Generally the distribution shows a low frequency of winds at the lowest range and a peak centered somewhere up the scale. In this case the peak is at the very lowest categories and drops off quickly with higher wind speed values. This indicates that winds at this site have a much higher frequency of winds in the 0.0 and 1.0 mph category than most sites. These low winds could be a result of ice or possible caused by a persistent and frequent inversion. At any rate, this helps explain the extremely low mean winds observed at the site.

This distribution also shows that winds in the higher wind speed categories are infrequent. In this case, the observed winds are below 10.0 mph about 80 % of the time and below 20.0 mph about 97 % of the time. In addition, the upper end is relatively low and the highest hourly wind value observed was 44 mph. This is relatively low for a good wind site and suggests that there is a low frequency of winds at the upper end of the range. This is significant because it is at higher wind speeds where most of the power could potentially be produced.

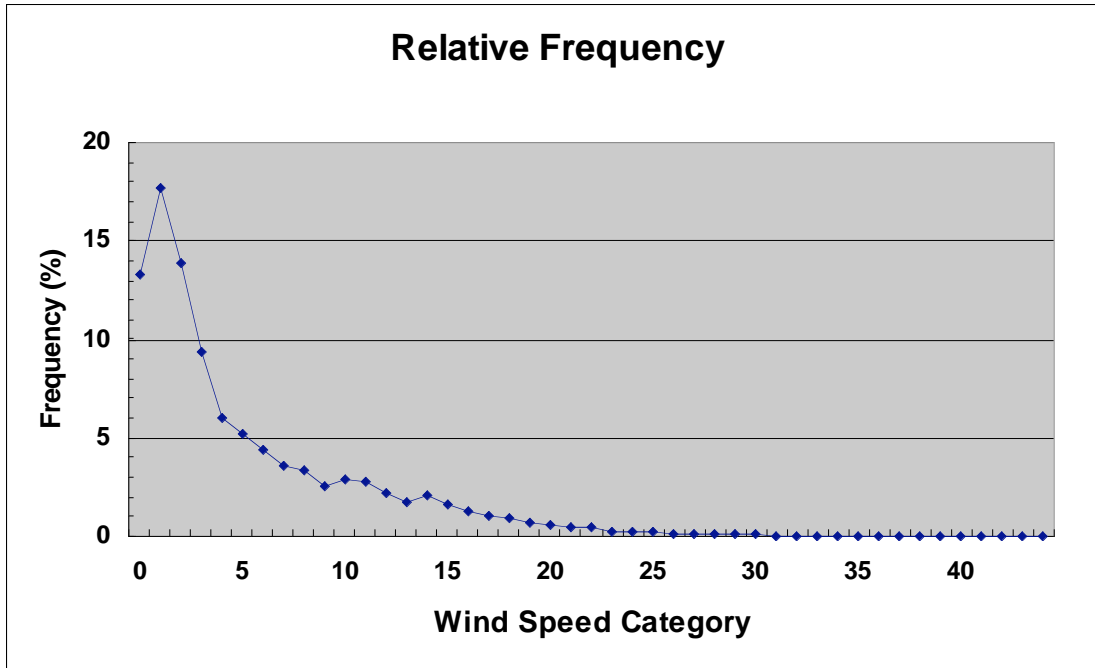


Figure 3.4: Wind speed frequency distribution for the ALP site at Wallowa.

Wind Rose: How the wind varies with direction is also important to understanding the physical processes that contribute to the local winds at a site and eventually in designing a wind facility. A wind rose is often used to display this information and show the frequency with which the wind occurs in different direction categories. A similar plot can be used to show the strength of the wind from each of the direction categories.

For this site in Wallowa (Figure 3.5), it is apparent that the winds come primarily from one general direction but that wind from nearly all directions is possible. Nearly 35 % of the time (34.2 %), winds are observed coming from one of two categories (W and WNW). These categories also have the highest mean wind speeds (9.6 mph and 9.4 mph). This suggests that the best winds come from the gap in the mountains located due west of the site (see Section 2.0). Mean speeds for the direction categories outside of these four are below 5.0 mph with the exception of the NW category (6.0 mph). All of this suggests that while strong winds are possible and come from the most frequent directions much of the time the winds are light and can come from nearly every direction.

The wind rose also indicates that this site has a high frequency of calm winds. While this might be attributed to the influence of ice during the winter months the observations indicate that calm wind occur at high frequencies during other periods as well. To illustrate this, the frequency of observed calm winds is shown in Figure 3.6. The high frequency for January may be periods of icing that were not removed, but it is clear that other periods have high frequencies as well including those during the summer. Together with the diurnal plots this suggests that the site is prone to very stable conditions in which light winds prevail.

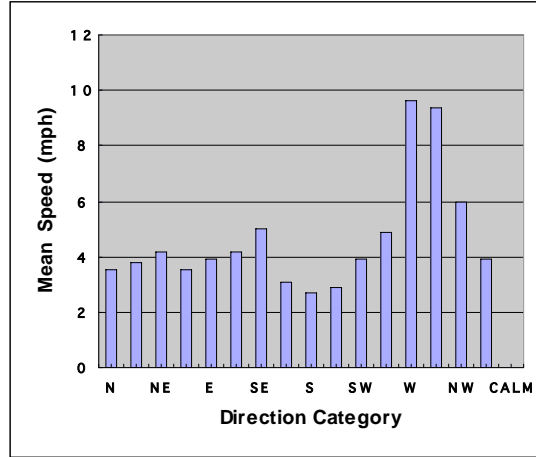
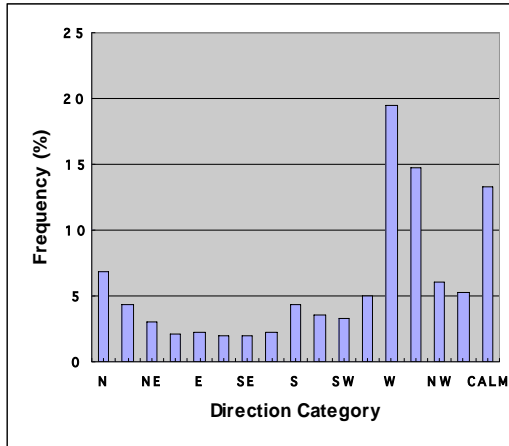


Figure 3.5: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories from the ALP site at Wallowa.

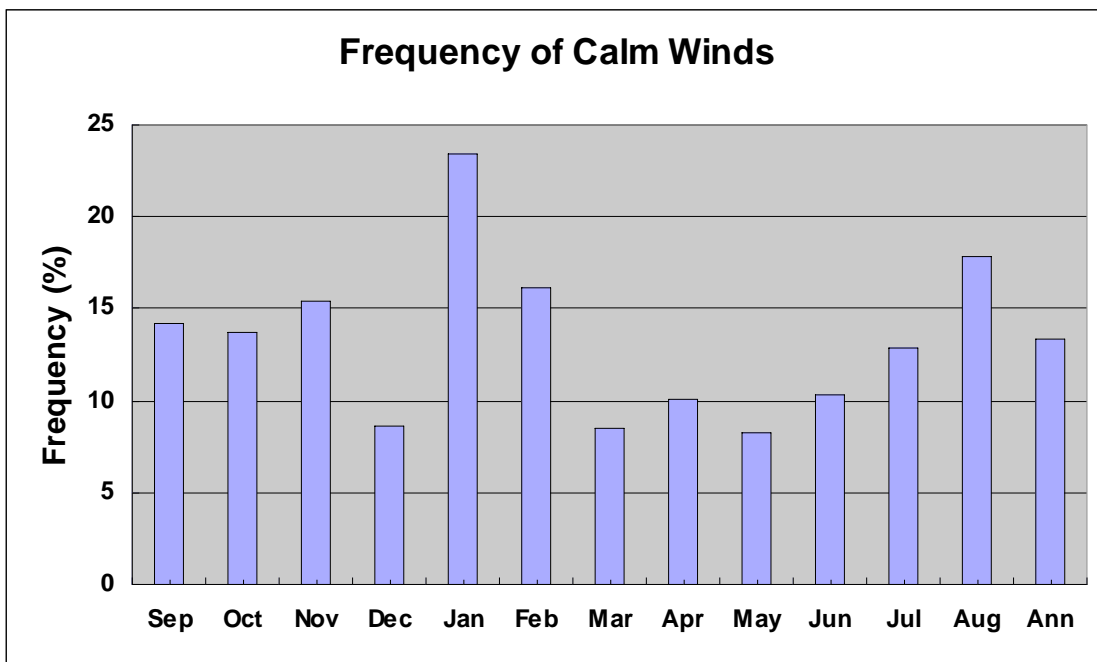


Figure 3.6: Frequency (%) of calm winds from at ALP site at Wallowa.

4.0 SITE POWER CHARACTERISTICS

In order to evaluate the wind power potential at this site a number of quantities were computed using the collected wind data. As with the wind characteristics, hourly wind data was used to complete this work. The power density calculation requires air density. This is estimated assuming a standard atmosphere and the site elevation. The computed quantities include the mean and standard deviation of the hourly values, the wind speed data recovery rate, the maximum one hour average, the wind power density and the frequency that the wind was observed within a wind speed range (12 mph to 60 mph). These quantities are shown in Table 4.1 and reveal a number of things about the potential for generating energy the site. Shape and scale factors have been included in the event that Weibul statistics are of interest.

First, the quantities in Table 4.1 confirm what was observed in the previous section and show that the overall power characteristics at this site in Wallowa are very low. No single month or period shows any indication that a reasonable energy resource exists at this site. No month has a mean wind speed above 8.0 mph and the highest percentage of time a turbine might operate for any month was only 22.6 % (March 2004). In addition, these values show a high level of variability from month to month and clearly indicates that the site is not well suited to capture winds during the winter months. As mentioned in Section 3.0, this may be because of the higher terrain to the south and southwest or to the characteristics of the site that may be conducive to the formation of an inversion.

To examine the overall amount of energy contained in the wind, the power density is very useful. It represents the amount of energy that would be available to a unit area each hour. The monthly mean values are shown in figure 4.1 and highlight the low wind resource potential for this site. The highest power densities can be found in October (87 W/m**2) and November (89 W/m**2). These were not the months with the highest mean winds but did apparently have some of the strongest winds. Both months also had high 1-hour maximum values and show that wind in the higher ranges can produce much more power. Overall, however, these values are quite low and confirm that there is no period at this site in which a strong wind resource is observed.

Table 4.1: Observed and computed power quantities for the ALP wind site at Wallowa.

Month	Mean (mph)	Std. (mph)	Recovery Rate (%)	Max 1-Hr (mph)	Time in Range 12-60 mph(%)	Power Den. W/m**2	Shape Factor	Scale Factor
Sept	5.1	5.4	99.9	29.6	13.4	40	0.95	5.0
Oct	5.8	7.0	100.0	43.3	16.3	87	0.82	5.2
Nov	5.7	7.3	100.0	37.5	17.9	89	0.77	4.9
Dec	3.7	4.1	79.8	22.9	6.1	19	0.90	3.5
Jan	4.0	6.2	94.9	34.4	10.6	55	0.62	2.8
Feb	2.8	3.4	100.0	21.5	3.0	10	0.82	2.5
Mar	7.0	7.4	100.0	38.1	22.6	56	0.94	6.8
Apr	5.8	5.9	100.0	34.9	13.2	53	0.98	5.7
May	6.9	5.5	100.0	24.8	20.2	33	1.28	7.5
Jun	6.2	5.2	100.0	24.8	17.5	43	1.21	6.6
Jul	5.7	5.2	100.0	24.8	13.8	39	1.11	5.9
Aug	5.0	4.8	100.0	25.6	8.5	30	1.05	5.1
ANN	5.4	5.9	98.1	43.3	13.8	53	0.90	5.1

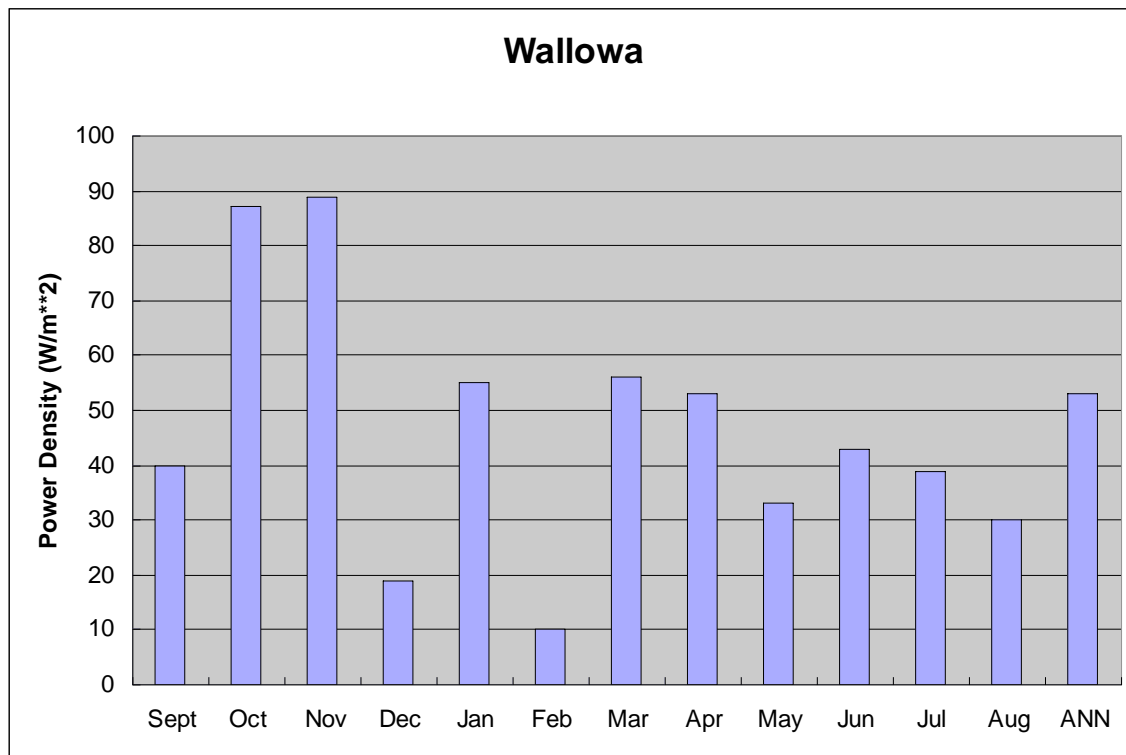


Figure 4.1: Monthly power density for the ALP wind site at Wallowa.

In addition to evaluating these basic power characteristics it is possible to estimate how specific wind turbines might interact with the winds at a particular site. Using the collected wind data and the characteristics of a particular wind turbine it is possible to estimate the amount of power it could produce. This is done by comparing the wind data with a power curve for a specific wind turbine. A power curve is simply the curve that shows the relationship between the wind speed and the amount of power a turbine can produce. An example is provided in Figure 4.2. There are several portions of the curve that are important. At low wind speeds, below the cut-in speed, no energy is produced. Any turbine has a lower threshold below which it won't operate. This is in part because there is little energy available at these levels. In the middle is a ramp up zone where even a small increase in wind speed results in a larger increase in power. At some point, depending on the type of turbine, the amount of power hits its rated capacity as the blades are pitched to spill energy and protect the turbine. At the upper end, energy production will stop if the winds reach a cut-out speed. This is the speed at which a turbine is shut down.

In Table 4.2, energy capacity factors are shown for eight different types of turbines. The capacity factor is the ratio of the amount of energy produce to the amount of energy that could be produced if a turbine ran at its rated capacity all the time. The rated capacity is effectively a theoretical maximum and capacity factors generally range from 0.0 to 0.40. It's difficult to compare these because of the different turbine characteristics but they are

given to provide a range of values that might be expected from this site. In computing these values, it is necessary to adjust the observed data which is measured at 67 feet to the hub height of the particular turbine. In this case this is done using a standard assumption that the wind follows a typical power law profile with a coefficient of 0.143.

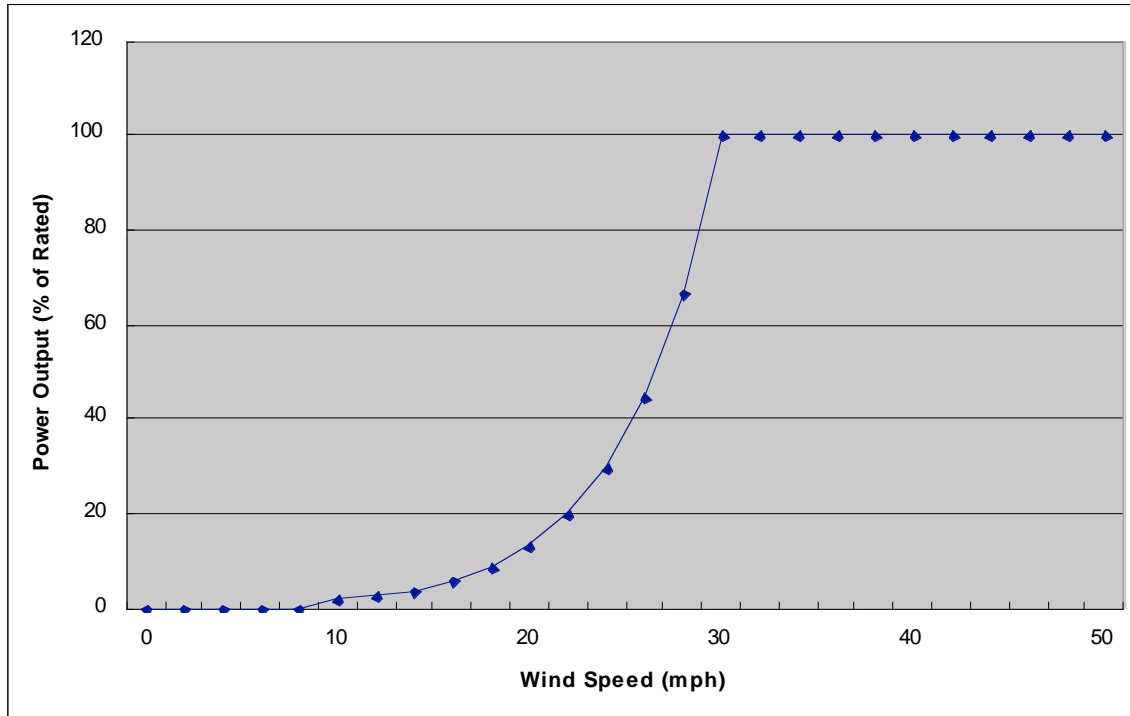


Figure 4.2: Sample power curve for a theoretical turbine

The capacity factors in Table 4.2 support the conclusions of the previous sections and indicate that there is not a significant energy resource at this site. Capacity values for each of the turbine types are extremely small and vary greatly from one month to the next. The highest capacity factors for each turbine type occur in March with the largest 0.132 (Vestas 80). This shows that, at best, a turbine would capture only about 13 % of its rated capacity. For the annual period as a whole, all of the values are below 0.071. For a good wind site this value would ideally be closer to 0.300 or higher.

Table 4.2: Capacity factors computed for the ALP site at Wallowa using observed wind data and characteristics of eight different wind turbines.

Turbine	Vesta 47	Vestas 80	Vestas 66	Vestas 7.5	BWC EXCEL	GE Wind 70.5	Vestas 29	Mitsubishi
Size (kW)	660	2000	1650	55	10	1500	225	250
Hub Ht. (ft.)	131	262	197	59	79	210	103	100
Sept	0.051	0.062	0.044	0.041	0.029	0.059	0.052	0.036
Oct	0.074	0.087	0.067	0.063	0.049	0.083	0.076	0.058
Nov	0.093	0.106	0.084	0.082	0.063	0.104	0.095	0.074
Dec	0.024	0.029	0.020	0.019	0.013	0.027	0.024	0.012
Jan	0.057	0.066	0.052	0.050	0.039	0.066	0.059	0.046
Feb	0.012	0.016	0.010	0.009	0.007	0.014	0.013	0.008
Mar	0.113	0.132	0.101	0.097	0.072	0.129	0.115	0.086
Apr	0.060	0.072	0.054	0.050	0.039	0.069	0.063	0.046
May	0.073	0.090	0.063	0.057	0.040	0.084	0.075	0.051
Jun	0.059	0.073	0.051	0.046	0.033	0.068	0.061	0.042
Jul	0.050	0.063	0.044	0.040	0.028	0.059	0.052	0.036
Aug	0.036	0.046	0.031	0.029	0.021	0.043	0.039	0.026
ANN	0.059	0.071	0.052	0.049	0.037	0.068	0.061	0.044

5.0 CLIMATOLOGICAL ANALYSIS

Measurements taken over a single one-year period can provide a good estimation of the winds and wind energy potential of a site. However, this is a fairly limited period and is only meaningful if we can place the period into a larger climatological context. For this site in Wallowa there are not any good long-term monitoring sites. Most of the adequate sites are located some distance away or in an adjoining valley. There is one site that can provide a general indication. This includes a site the Bonneville Power Administration has maintained at a station at a microwave site south of Kennewick Washington since 1976.

The Kennewick BPA site is well exposed and should provide a good indication of conditions in the region. While the terrain is quite different and the site is located much further west it should provide an indication of conditions in the general area, particularly during the winter months. Wind data for Kennewick was obtained for the period 1987 to 2004. Information about the site and the monthly means and departures for this annual study period can be found in Table 5.1. First, the winds overall at Kennewick BPA were very close to normal for the observation period at Wallowa (September 2003-August 2004). A departure of +1.6 % is extremely small for an annual period and shows that conditions in the region were close to their climatological means. Secondly, the winds during certain key months show a similar variability to those at Wallowa. These include the below normal condition during December and February when the departures were -13.6 % and -31.9 % respectively. This confirms suspicions that conditions at Wallowa were below what would be expected. However, the positive departure for March at Kennewick (+15.8 %) also suggests that the high wind speed observed at Wallowa may also have been an anomaly.

Overall, the climatological analysis of wind data from Kennewick suggests that the observations collected at Wallowa are a fair assessment of overall conditions. While a few months may have been above or below normal, conditions for the period as a whole were close to normal.

Table 5.1: Monthly mean and departures for winds at the Kennewick BPA wind site.

KENNEWICK BPA			
Latitude: 46.10N		Elevation: 2200'	
Longitude 119.13W			
Month	Normal (mph) 1982-1997	Mean (mph) current	Departure (%)
Sept	14.7	15.7	6.8
Oct	16.5	19.9	20.6
Nov	19.8	23.7	19.7
Dec	19.1	16.5	-13.6
Jan	20.4	19.3	-5.4
Feb	18.8	12.8	-31.9
Mar	19	22.0	15.8
Apr	18	15.9	-11.7
May	17.6	19.1	8.5
Jun	17.6	17.3	-1.7
Jul	15.7	15.9	1.3
Aug	15.4	17.8	15.6
ANN	17.7	18.0	1.6

6.0 SUMMARY AND DISCUSSION

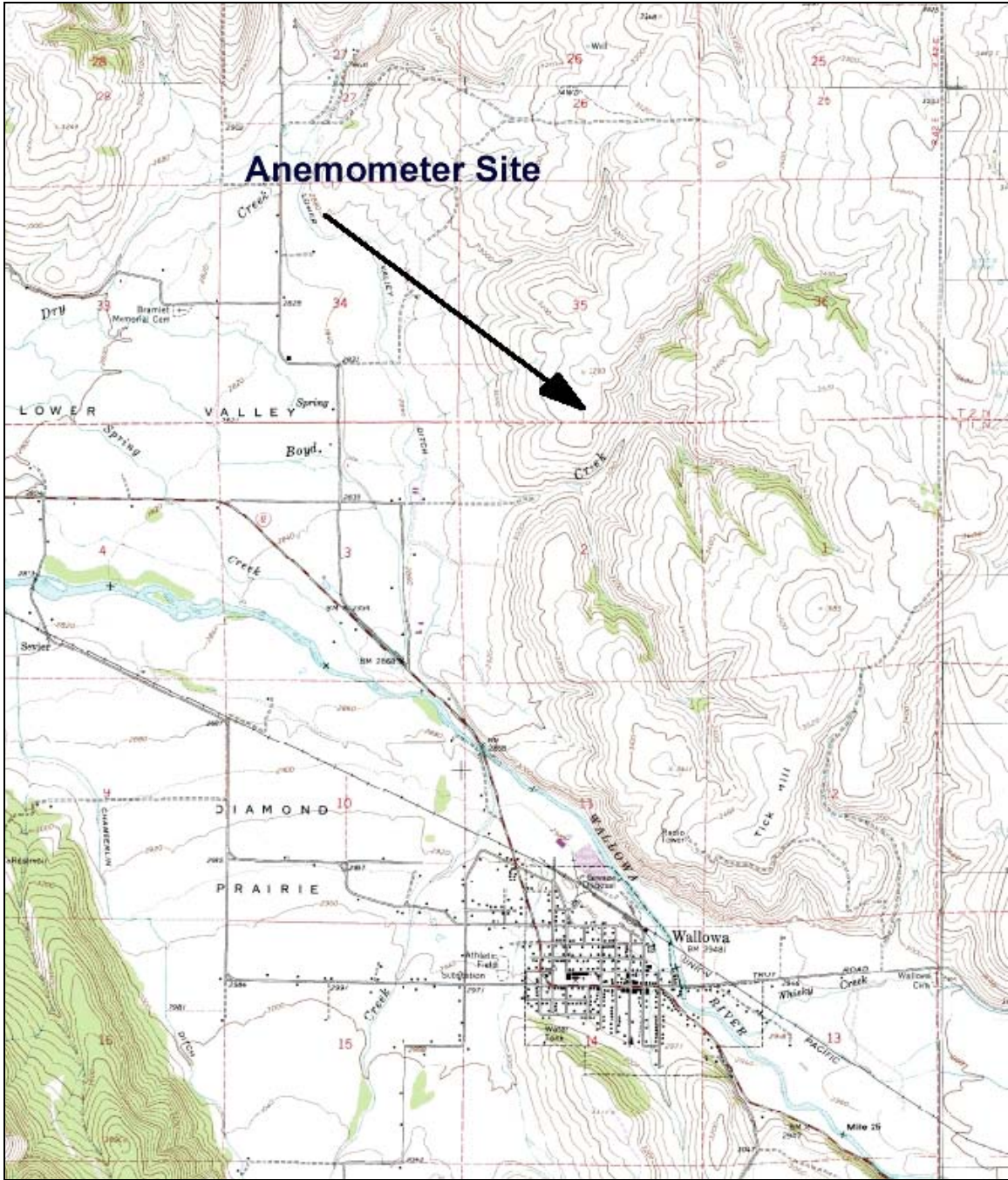
There are a number of factors that might have an influence on the interpretation of the winds observed over this annual study period at Wallowa. First, measurements were taken from only one tower and it is possible that other locations in the area might provide better exposure to the prevailing winds. The location of the tower was chosen because of land ownership issues but other well exposed sites in the area are not expected to show significant differences.

A second factor that is important to consider is that observations were collected at only one height. Flow over a valley or basin often occurs at a higher level above the ground. These types of flows are influenced by many factors including the density of the air, the exact shape of the valley or basin and the upper air wind characteristics. Observations taken at a different height above ground would most likely show some differences that might be important to a determination of economic feasibility. This is particularly true in areas where a strong inversion might be present.

In summary,

- 1) No problems were encountered with the site during the data collection period. Several extended periods of icing were detected and removed from the records but it is possible that more periods are present, especially during January.
- 2) The observed annual mean wind speed was 5.36 mph.
- 3) The strongest winds come from the west, a direction that is also the most frequent.
- 4) This Wallowa site has a fairly strong diurnal pattern with strong winds lasting for a few hours in the afternoons and extremely long periods of calm winds during late night and early morning hours. The peak winds during these periods are relatively low and would not be expected to produce substantial amounts of power.
- 5) A comparison with a nearby site where a longer history of observations are available suggests that this study period (September 2003-August 2004) was approximately 1.6% above normal and that observations over this period should provide a good indication of conditions overall.

Appendix A: Topographic Map showing the Wallowa ALP site.



Appendix B: Photographs of the Wallowa tower looking west at the tower site and looking towards the bluff from the valley bottom.





Appendix C: Site Visit Records and wind gust during period prior to visit.

Changes Made					
Date:	Plug	Battery	Time	Gust (mph)	Comment
8/13/2003					Site Installed
9/2/2003	Y			44	
10/3/2003	Y			48	
11/3/2003	Y			68	
12/9/2003	Y			56	
1/7/2004	Y			45	
2/14/2004	Y	Y		79	
3/7/2004	Y			59	
4/8/2004	Y			49	
5/6/2004	Y			58	
6/4/2004	Y			49	
7/21/2004	Y			41	
9/15/2004				45	Site removed

Appendix D: Miscellaneous analysis Tables.

STATION - WALLOWA					
WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY					
DATA PERIOD OF RECORD - 9/2003 - 8/2004					
NORMALIZATION PERIOD - ONE YEAR					
AVERAGE WIND SPEED FOR PERIOD: 5.4 MPH					
NORMALIZED AVAILABLE ENERGY: 461.5 KWH/M**2/YEAR					
TOTAL HOURS OBSERVED: 8595					
NORMALIZED			NORMALIZED		
SPD	HOURS/	REL FREQ	CUMHRS	CUMREL FREQ	AVAIL. ENERGY
MPH	PERIOD				KWH/M**2/YEAR
0	1144	13.31	8595	100.00	0.0
1	1517	17.65	7451	86.69	0.1
2	1196	13.92	5934	69.04	0.5
3	808	9.40	4738	55.13	1.1
4	512	5.96	3930	45.72	1.7
5	444	5.17	3418	39.77	2.8
6	381	4.43	2974	34.60	4.2
7	311	3.62	2593	30.17	5.4
8	288	3.35	2282	26.55	7.5
9	222	2.58	1994	23.20	8.2
10	247	2.87	1772	20.62	12.5
11	237	2.76	1525	17.74	16.0
12	193	2.25	1288	14.99	16.9
13	150	1.75	1095	12.74	16.7
14	179	2.08	945	10.99	24.8
15	143	1.66	766	8.91	24.4
16	112	1.30	623	7.25	23.2
17	92	1.07	511	5.95	22.9
18	80	0.93	419	4.87	23.6
19	64	0.74	339	3.94	22.2
20	54	0.63	275	3.20	21.9
21	40	0.47	221	2.57	18.7
22	40	0.47	181	2.11	21.5
23	18	0.21	141	1.64	11.1
24	24	0.28	123	1.43	16.8
25	22	0.26	99	1.15	17.4
26	15	0.17	77	0.90	13.3
27	9	0.10	62	0.72	9.0
28	9	0.10	53	0.62	10.0
29	8	0.09	44	0.51	9.9
30	6	0.07	36	0.42	8.2
31	3	0.03	30	0.35	4.5
32	4	0.05	27	0.31	6.6
33	4	0.05	23	0.27	7.3
34	3	0.03	19	0.22	6.0
35	3	0.03	16	0.19	6.5
36	2	0.02	13	0.15	4.7
37	2	0.02	11	0.13	5.1
38	2	0.02	9	0.10	5.6
39	2	0.02	7	0.08	6.0
40	4	0.05	5	0.06	12.9
41	0	0.00	1	0.01	0.0
42	0	0.00	1	0.01	0.0
43	1	0.01	1	0.01	4.0

STATION - WALLOWA
 MONTHLY WIND SPEEDS (MPH)
 DATA PERIOD OF RECORD - 8/2003 - 9/2004

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS	AVG
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	5.1	5.8	5.7	3.7	3223	5.20
# OBS	0	0	0	0	0	0	0	446	719	744	720	594		
2004	4.0	2.8	7.0	5.8	6.9	6.2	5.7	5.0	5.9	0.0	0.0	0.0	6160	5.48
# OBS	706	696	744	720	744	720	744	744	342	0	0	0		

STATION - WALLOWA
 DIURNAL WIND SPEEDS (MPH)
 DATA PERIOD OF RECORD - 9/2003 - 8/2004

	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	AVG SPD
MON	3.2	2.9	2.9	3.7	3.6	3.0	3.2	3.5	4.1	4.6	4.7	5.6	5.5	5.0	5.1	5.1	4.7	4.9	3.9	3.6	3.8	3.5	3.4	3.2	4.0
JAN	3.3	2.7	2.3	2.7	2.4	2.4	2.4	2.0	1.9	2.2	2.4	2.7	3.5	3.7	4.2	4.1	3.3	2.9	3.2	2.9	2.8	2.6	2.0	2.2	2.8
FEB	3.9	3.4	3.2	3.3	3.4	3.5	4.2	5.7	7.1	8.3	9.9	11.3	11.5	12.1	12.5	10.6	9.0	8.2	7.4	6.8	6.7	5.7	5.0	4.4	7.0
MAR	2.5	2.4	1.7	1.8	1.8	2.3	3.4	4.9	6.8	7.6	9.4	9.9	11.3	10.8	10.8	10.2	9.6	7.4	5.8	4.7	3.9	3.6	3.3	2.9	5.8
APR	4.6	4.5	3.9	3.6	3.5	4.7	5.9	7.0	7.7	9.0	9.9	9.9	11.5	10.6	11.4	10.7	9.5	7.5	5.7	4.9	5.0	5.0	5.1	4.8	6.9
MAY	2.8	2.8	2.9	3.0	4.1	4.9	5.9	6.3	7.3	8.1	9.0	10.5	10.7	10.3	10.3	10.7	10.7	9.1	6.9	5.4	4.8	4.3	3.7	3.3	6.2
JUN	2.7	2.4	1.6	1.8	1.4	2.2	3.6	4.1	5.5	7.3	9.0	9.7	10.6	10.7	10.6	10.7	10.8	9.6	5.8	4.7	3.9	3.6	2.6	2.3	5.7
JUL	1.6	1.9	1.7	2.1	1.6	1.7	3.2	3.9	5.2	7.1	8.2	8.9	9.9	11.3	10.5	9.6	7.8	6.4	4.1	3.1	3.8	2.8	2.0	2.0	5.0
AUG	3.3	3.0	2.4	2.7	2.7	2.4	2.7	2.8	3.7	4.8	5.9	7.1	7.9	8.8	9.8	9.7	9.3	8.4	6.0	5.5	4.0	3.9	3.5	3.1	5.1
SEP	4.7	4.4	4.0	3.7	3.6	3.8	3.5	4.2	5.8	6.9	7.1	7.3	8.8	9.5	8.7	8.5	8.3	6.0	4.6	5.1	5.2	5.6	5.5	4.6	5.8
OCT	4.8	5.4	5.5	4.8	4.3	5.1	4.9	6.2	7.6	8.3	8.4	8.3	7.8	6.4	5.8	5.6	6.3	5.5	5.0	4.6	4.5	4.1	4.3	4.0	5.7
NOV	3.0	3.0	3.0	3.7	4.4	4.0	3.3	3.4	4.2	3.8	3.9	4.2	4.5	4.0	4.2	4.4	4.1	3.4	3.1	3.1	3.9	3.8	3.1	3.4	3.7
DEC	3.4	3.2	2.9	3.0	2.9	3.3	3.8	4.5	5.5	6.5	7.4	7.9	8.7	8.7	8.7	8.3	7.8	6.6	5.2	4.5	4.4	4.0	3.6	3.4	5.4
AVG																									

STATION - WALLAWA
WIND ROSE FOR ALL DATA - 8595 OBSERVATIONS
DATA PERIOD OF RECORD - 9/2003 - 8/2004

DIR	SPEED CATEGORIES (MPH)																TOTAL %	MEAN SPEED (MPH)
	0	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52		
TO	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55	55	6.8
N	6.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
NNE	4.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
NE	2.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2
ENE	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
E	2.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
ESE	1.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2
SE	1.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
SSE	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
S	4.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
SSW	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
SW	3.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
WSW	4.2	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
W	11.3	2.3	2.1	1.5	1.1	0.4	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	5.0
WNW	8.4	2.4	2.0	1.0	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5
NW	5.0	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7
NNW	5.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
CALM																		5.2
TOTAL	80.9	7.2	5.3	3.0	1.7	0.9	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	13.3
%																		100.0

NOTE: MEAN SPEED OF THE TOTAL IN A WIND ROSE MAY DIFFER FROM THE SPEED FREQUENCY DISTRIBUTION FOR A GIVEN PERIOD DUE TO DATA SELECTION. SPEED FREQUENCY DISTRIBUTIONS REQUIRE ONLY A WIND SPEED OBSERVATION BE PRESENT. WIND ROSES, ON THE OTHER HAND, REQUIRE BOTH SPEED AND DIRECTION BE PRESENT FOR EACH OBSERVATION.

4.6 2.7

STATION - WALLOWA
 ENERGY ROSE (TOTALS ARE NORMALIZED AVAILABLE ENERGY (KWH/M**2)
 DATA PERIOD OF RECORD - 9/2003 - 8/2004

MON	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	OBS.	
JAN	0.6	0.7	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.8	0.0	7.1	36.3	9.3	0.3	0.3	55.7	521	744
FEB	0.2	0.1	0.0	0.0	0.0	0.3	0.7	0.1	0.2	0.2	0.0	0.0	3.3	2.8	0.2	0.2	8.3	573	672
MAR	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	1.6	1.8	1.8	50.2	23.0	2.6	0.4	81.8	677	744
APR	0.4	0.7	0.8	0.2	0.7	0.9	0.3	0.7	0.9	0.3	1.5	2.1	18.8	15.6	1.0	0.4	45.3	645	720
MAY	0.3	0.0	0.1	0.0	0.4	0.1	0.1	0.0	0.2	0.3	0.3	0.5	21.2	17.0	2.7	0.8	44.0	677	744
JUN	0.3	0.9	1.4	0.5	1.0	3.1	2.1	0.9	0.1	0.1	0.1	0.6	6.8	14.7	2.2	0.4	34.9	643	720
JUL	0.6	0.2	0.2	0.4	0.2	0.1	2.4	0.1	0.1	0.1	0.0	0.3	8.8	15.8	3.6	0.7	33.6	642	744
AUG	0.7	0.3	0.9	0.1	0.4	0.7	0.6	0.1	0.4	0.0	0.1	1.0	10.0	8.8	2.7	0.7	27.6	602	744
SEP	0.1	0.3	0.2	0.1	0.1	0.2	0.3	0.1	0.4	0.0	0.3	2.6	11.9	15.3	1.6	0.2	33.7	614	720
OCT	0.6	0.6	1.1	0.6	0.7	0.0	0.0	0.0	0.2	0.2	0.2	1.7	56.4	11.7	1.4	0.1	75.6	639	744
NOV	0.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	6.9	1.6	60.6	6.0	0.4	0.1	76.4	604	720
DEC	0.6	0.3	0.3	0.0	0.0	0.1	0.2	0.0	1.0	0.8	0.1	0.9	8.0	2.5	0.5	0.2	15.5	537	744
TOT	4.5	4.6	5.4	2.0	3.5	5.4	6.8	2.3	3.6	4.5	11.2	20.2	292.2	142.4	19.2	4.4	532.3	7374	8760

NOTE: AVAILABLE ENERGY IN AN ENERGY ROSE MAY DIFFER FROM THE SPEED FREQUENCY DISTRIBUTION FOR A GIVEN PERIOD DUE TO DATA SELECTION. SPEED FREQUENCY DISTRIBUTIONS REQUIRE ONLY A WIND SPEED OBSERVATION BE PRESENT. ENERGY ROSES, ON THE OTHER HAND, REQUIRE BOTH SPEED AND DIRECTION BE PRESENT FOR EACH OBSERVATION.