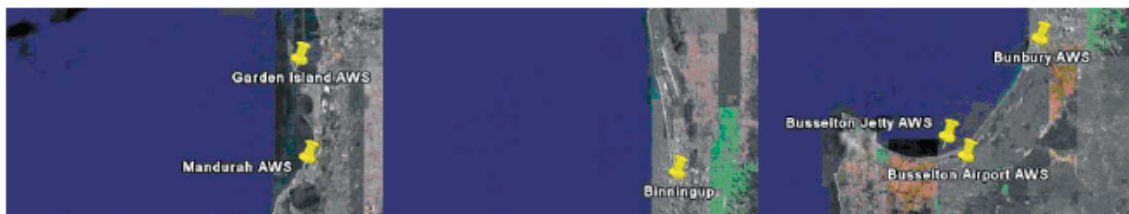




Australian Government  
Bureau of Meteorology  
Special Services Unit

# Report on an Estimated Offshore Binningup Wind Data Set

Prepared for KBR



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## **Background:**

This work has been undertaken (with instruction from KBR) for use within the marine investigation modelling for the Southern Seawater Desalination Plant (SSDP) and will form part of the KBR modelling report.

## **Task:**

Generate representative five years of hourly wind observations (10m above sea level, 10 minute mean wind) for a site approximately 800m offshore from Binningup, Western Australia [33.15s, 115.69e].

## **Strategy:**

Use the nearest land based Automatic Weather Station (Bunbury AWS, approximately 23km to the south of Binningup), and modify the wind speeds to be more representative of an offshore site. To generate the modification algorithm, winds at other land based/offshore pairs (namely Busselton Airport/Busselton Jetty and Mandurah City and Garden Island) are compared.

## **Site Selection:**

The Busselton Airport/Busselton Jetty pairing, and the Mandurah City/Garden Island pairing were both assessed, with the following points considered:

- Busselton Airport [33.68s 115.40e] is 6km inland, and the Busselton Jetty AWS [33.63s 115.34e] is 1.5km offshore, the anemometer masts in both cases are at about 10 metres. The inland site is well exposed.
- Mandurah AWS [32.52s 115.71e] is on the coast, whilst Garden Island AWS [32.24s 115.68e] is very well exposed to the south and SW, is between 2.5 and 5km of the coast, and has the anemometer about 20 metres above sea level.
- Bunbury AWS [33.36s 115.64e], is 2.5km inland and is well exposed.

To correct the Bunbury AWS, the first consideration is to match the AWS with a site that has similar weather exposure and weather regime characteristics. In this case, the Busselton Airport AWS site is considered more appropriate, given that it is a similar distance inland from the coast.

The next consideration is the offshore site, and again the Busselton Jetty AWS site is considered superior, as the elevation of the anemometer head (10 metres) is better than Garden Island AWS (estimated 20 metres above sea level), as is the degree of exposure.

Climatology speaking, Busselton is in a weaker summertime sea breeze regime than Mandurah, with Binningup being in the middle ground. It could reasonably be expected that the Busselton wind corrections may slightly underestimate the strength of the sea breeze at Binningup.

After assessing the above points, the siting of the Busselton pair was considered more representative of the Bunbury/Binningup scenario.

### **Process:**

Five years of hourly 10 minute mean wind data were extracted for Bunbury, Busselton Airport AWS and Busselton Jetty AWS. Where observations were taken close to, but not at the hour (i.e. within 15 minutes), they were corrected to the hourly time.

Observations were binned by season (summer, autumn, winter and spring), by observation time (3am to 8am, 9am to 2pm, 3pm to 8pm, 9pm to 2am) and by wind speed ( $\leq 3$  knots,  $> 3$  and  $\leq 6$  knots,  $> 6$  and  $\leq 9$  knots,  $> 9$  and  $\leq 12$  knots, and  $> 12$  knots).

The median of the ratio of wind speed at the offshore site (Busselton Jetty AWS) divided by the wind speed at the onshore site (Busselton Airport AWS) was calculated at matching observation times for each of the bins. Notably, there was a lack of data points for wind speeds  $\leq 3$  knots and some instability in the ratios were observed. To address this, the median of the ratios was then calculated for all cases where wind speeds were  $\leq 3$  knots, irrespective of season or time.

These ratios were then applied to the observed wind speeds at Bunbury (by season and time), to generate corrected wind speeds.

Given the relative closeness of the Bunbury AWS to the coast, and proximity to the Binningup site, there was no adjustment made to wind direction. To confirm this approach, an assessment was made of wind speed direction biases during late spring, summer and early autumn for sea breezes regimes (180 to 270 degrees), where impacts due to coriolis turning, and frictional effects may be at its strongest. However there was only a very small (less than 1 degree) bias evident between Mandurah AWS and Garden Island AWS sites.

## Outputs:

From the available data, five years of hourly observations were generated (01/07/2002 till 30/06/2007). The ratios used to correct (multiply) the raw observed wind speed are shown below in Table 1.

**Table 1 - Ratios used to correct raw observed wind speed**

### Summer:

UTC Time	0 to 2.99 knots	3 to 5.99 knots	6 to 8.99 knots	9 to 11.99 knots	gt 12 knots
0100 to 0600	2.4	1.385	1.109	1.088	1.075
0700 to 1200	2.4	1.769	1.457	1.351	1.149
1300 to 1800	2.4	1.714	1.390	1.314	1.224
1900 to 2400	2.4	1.714	1.348	1.263	1.161

### Autumn:

UTC Time	0 to 2.99 knots	3 to 5.99 knots	6 to 8.99 knots	9 to 11.99 knots	gt 12 knots
0100 to 0600	2.4	1.476	1.122	1.088	1.126
0700 to 1200	2.4	1.577	1.278	1.24	1.161
1300 to 1800	2.4	1.577	1.323	1.314	1.242
1900 to 2400	2.4	1.577	1.390	1.263	1.296

### Winter:

UTC Time	0 to 2.99 knots	3 to 5.99 knots	6 to 8.99 knots	9 to 11.99 knots	gt 12 knots
0100 to 0600	2.4	1.476	1.278	1.314	1.274
0700 to 1200	2.4	1.577	1.457	1.412	1.317
1300 to 1800	2.4	1.714	1.565	1.608	1.439
1900 to 2400	2.4	1.714	1.634	1.706	1.463

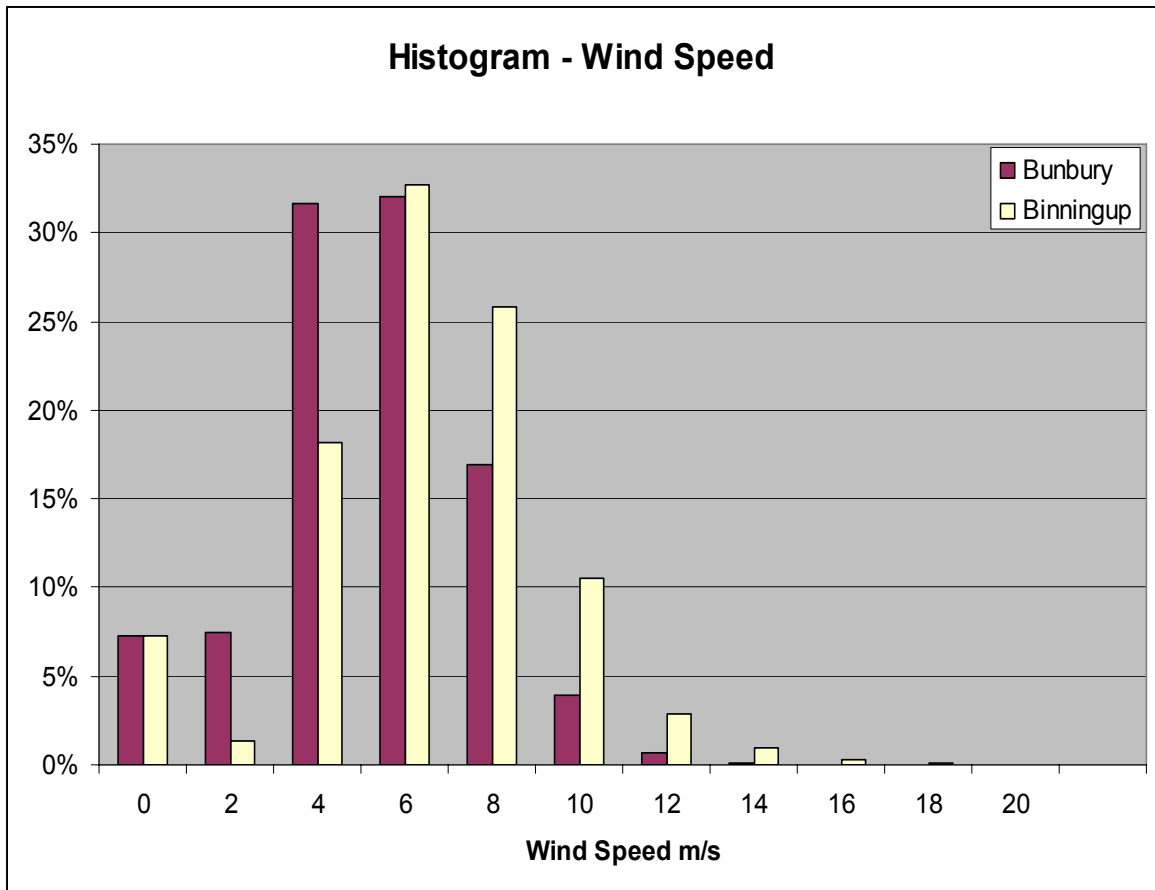
### Spring:

UTC Time	0 to 2.99 knots	3 to 5.99 knots	6 to 8.99 knots	9 to 11.99 knots	gt 12 knots
0100 to 0600	2.4	1.476	1.122	1.175	1.184
0700 to 1200	2.4	1.952	1.484	1.351	1.224
1300 to 1800	2.4	1.714	1.457	1.351	1.323
1900 to 2400	2.4	1.714	1.417	1.412	1.316

\* UTC time is used

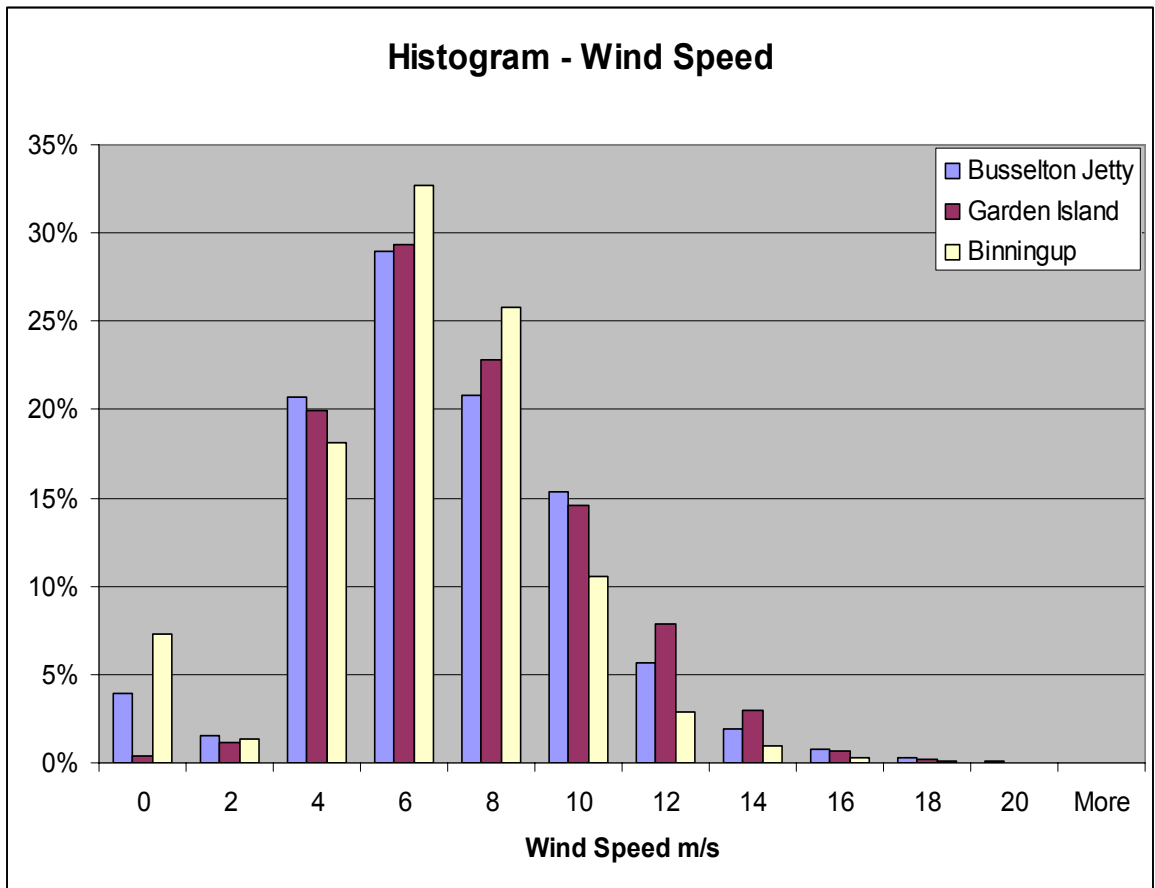
**Discussion of results:**

As is typically expected in these types of onshore/offshore regimes, the multipliers act to increase the offshore wind speeds. The shift in wind speeds is illustrated in a comparative histogram between Bunbury AWS (Bunbury) and the estimated Offshore Binningup (Binningup) wind speeds, as shown in Figure 1.



**Figure 1 - Histogram of wind speeds (m/s) for Bunbury AWS and estimated Offshore Binningup**

The estimated Offshore Binningup wind speeds can also be compared with the other offshore sites (Busselton Jetty AWS and Garden Island), as shown in Figure 2.



**Figure 2 - Histogram of wind speeds (m/s) for Offshore Binningup, Busselton Jetty AWS and Garden Island AWS**

No direct estimate of the directional error generated by using the onshore site can be made. However, comparing wind offshore and onshore sites at Busselton (see Table 2) indicates that winds are within 45 degrees on more than 95% of occasions, when the wind is greater than 4 m/s. At lighter wind regimes (less than 4m/s), this decreases to about 70% (see Table 3).

**Table 2 - Directional error comparison between offshore and onshore sites at Busselton when winds are > 4m/s**

Month	Greater than 45 degree error	45 Degree or less error
1	194	2928
2	145	2535
3	146	2159
4	76	1731
5	72	1614
6	49	1670
7	53	1671
8	46	1701
9	46	1868
10	51	1884
11	84	1908
12	89	2131
<b>Total</b>	<b>1051</b>	<b>23800</b>

**Table 3 - Directional error comparison between offshore and onshore sites at Busselton when winds are <= 4m/s**

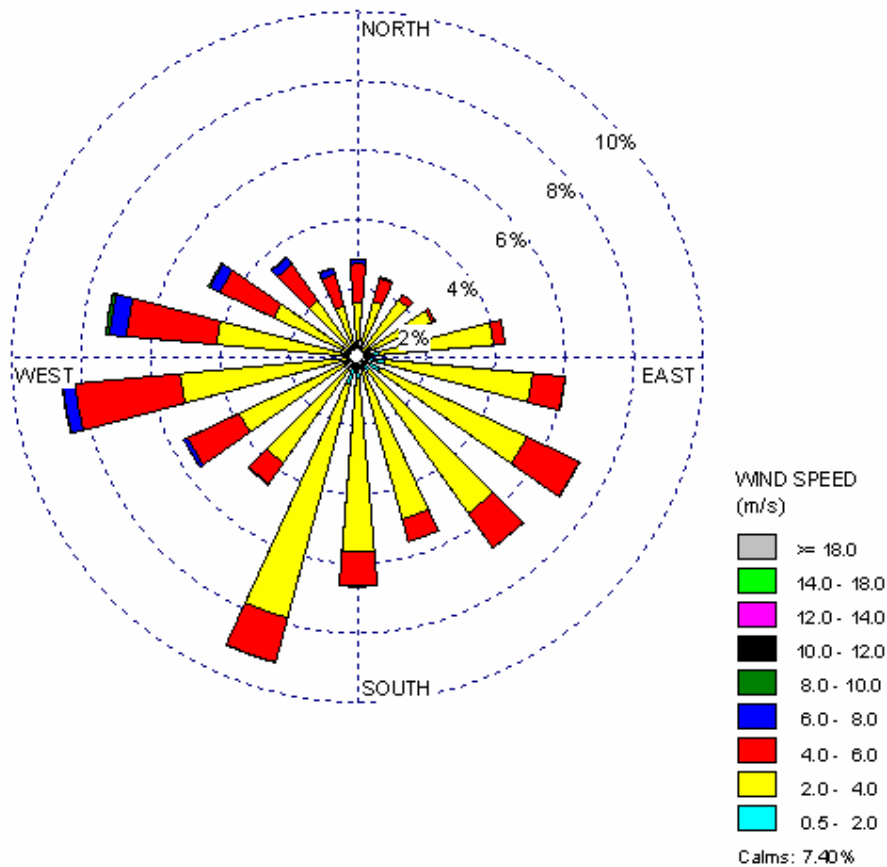
Month	Greater than 45 degree error	45 Degree or less error
1	263	837
2	277	834
3	432	1119
4	612	1587
5	736	1822
6	666	1707
7	713	1656
8	760	1574
9	694	1401
10	485	1139
11	315	871
12	358	794
<b>Total</b>	<b>6311</b>	<b>15341</b>

However, given the nature of the coastline and topography of the two locations (Busselton and Bunbury), and the fact that Bunbury AWS is closer to the coastline, it is suggested that the directional error should be significantly better in the lighter wind regimes.

The wind rose for the estimated Offshore Binningup winds (presented in Table 4 and Figure 3) shows a weak maxima at 100 degrees and 2 to 4 m/s associated with the wintertime regime of cold air drainage, with another maxima at 140 degrees and 4 to 6 m/s associated with the summertime SE'ly winds. A stronger maximum appears at 190 degrees and 4 to 6 m/s. This is associated with summertime sea breezes, and is possibly underestimated in intensity. By comparison, the Mandurah AWS coastal site sea breeze maximum occurs in the 6 to 8 m/s range. The strongest maxima occurs at 250 degrees and 6 to 8 m/s, and is associated with wintertime westerly flow.

**Table 4 - Wind rose for the estimated Offshore Binningup winds (m/s)**

Dirn	0 m/s	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Total
0	3177												3177
10		2	84	194	177	96	22	4	4				583
20		2	107	150	98	55	19	2					433
30		7	127	203	63	29	7						436
40		13	167	254	54	19	2	1					510
50		12	216	235	46	10	3	1					523
60		22	259	203	59	15	2						560
70		25	362	235	90	16	2						730
80		27	426	369	261	56	5						1144
90		39	437	429	317	112	10	1					1345
100		44	485	395	273	129	18	2					1346
110		47	458	423	403	182	26	1					1540
120		38	373	497	465	232	49	6					1660
130		18	300	618	483	162	25	1					1607
140		26	265	632	401	103	11						1438
150		33	199	574	383	62	1						1252
160		15	233	591	355	68	3						1265
170		29	247	618	369	76	2						1341
180		40	377	685	413	138	9	2	1				1665
190		31	555	934	491	191	26	3					2231
200		31	546	833	342	123	21						1896
210		19	319	445	249	73	15	1	1				1122
220		13	191	306	247	78	27	9	3				874
230		8	126	348	359	152	35	10	5	1			1044
240		7	134	412	561	188	57	13	1	2			1375
250		3	144	488	777	309	89	31	11	3	1		1856
260		4	133	473	725	341	120	37	8	2		1	1844
270		2	114	444	644	342	115	48	29	5		1	1744
280		3	135	366	449	235	95	50	18	8	4	1	1364
290		4	110	280	343	182	73	33	11	7	1		1044
300			94	259	269	176	72	41	9	5			925
310		5	78	195	222	151	62	21	9	4	3		750
320		3	80	205	195	124	73	26	7	4		1	718
330		5	84	179	146	93	52	16	10	1	1		587
340		3	61	143	140	98	52	16	9	1	1		524
350		1	71	123	137	110	45	22	5	1			515
360		7	82	197	221	134	39	10	1	1			692
<b>Total</b>		<b>588</b>	<b>8179</b>	<b>13935</b>	<b>11227</b>	<b>4660</b>	<b>1284</b>	<b>408</b>	<b>142</b>	<b>45</b>	<b>11</b>	<b>4</b>	<b>43660</b>



**Figure 3 - Rose of Wind direction versus Wind Speed in m/s (1 July 2002 to 30 June 2007) Binningup**

### ***Conclusions:***

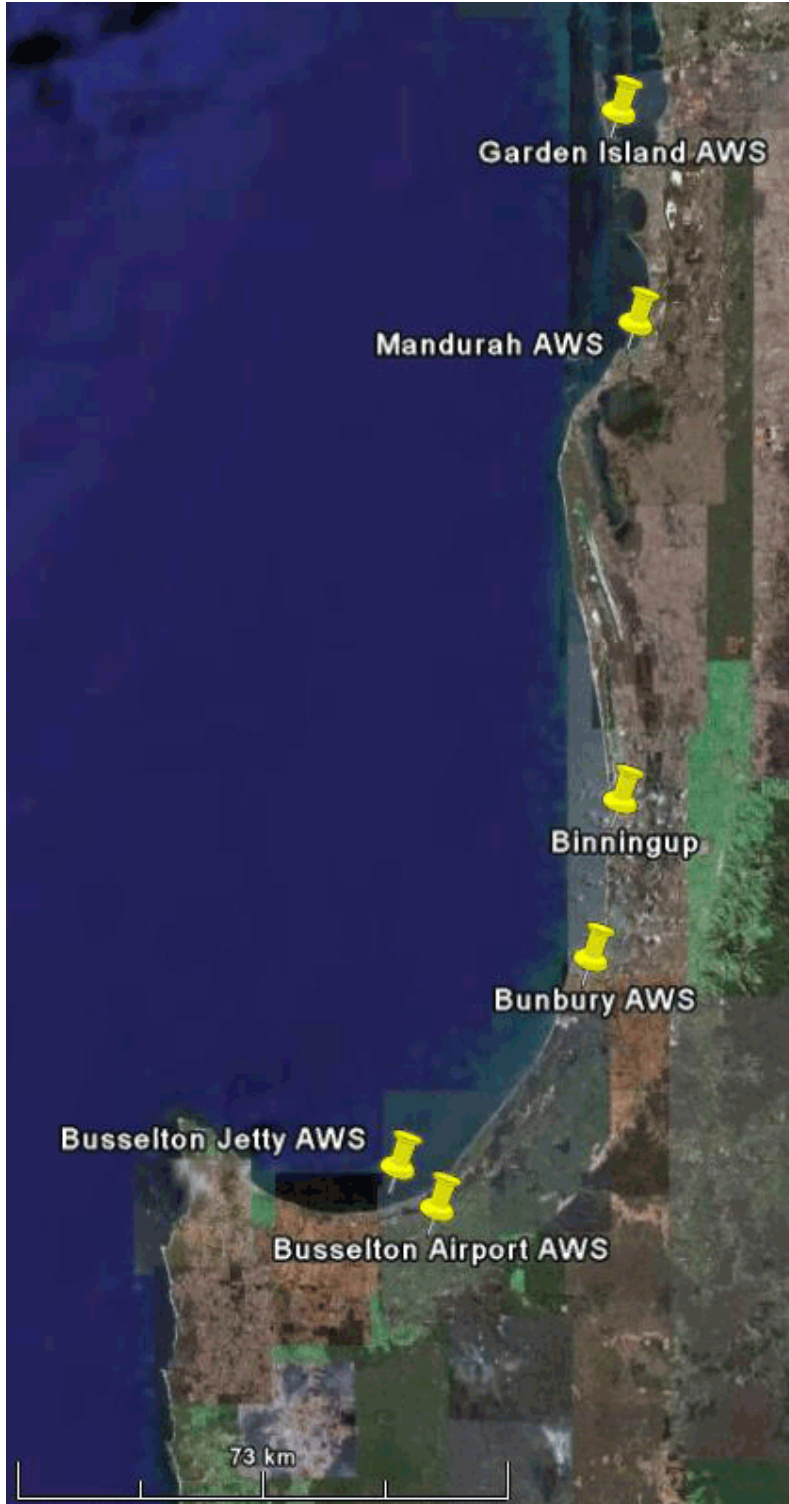
The estimated Offshore Binningup wind data should reasonably approximate the hourly 10 minute mean winds at 10 metres above sea level for a site 800m offshore from Binningup.

Comparison with other coastal sites suggests that the strength of the summertime sea breeze is underestimated; perhaps on the order of 2 m/s. It should be borne in mind, however, that the west coast sea breeze circulation is weaker towards Bunbury, and a true relation could only be determined by direct measurement.

The directional error estimate can only be inferred, however in all but light winds (< 4 m/s), it is expected to be greater than 95% accurate.

**Appendix 1**

**Location of proposed SSDP and BOM Sites**



## ***Appendix 2***

### ***Site Exposures***

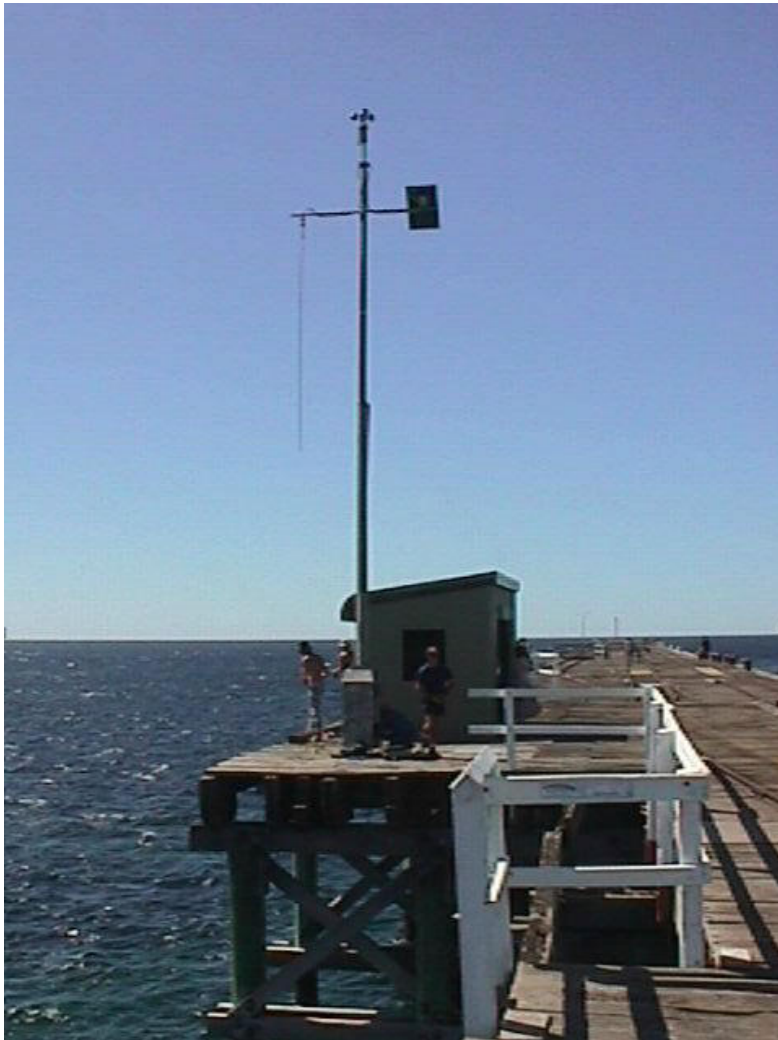
#### **Bunbury AWS – Plate 2.1**



#### **Busselton Airport AWS – Plate 2.2**



**Busselton Jetty AWS – Plate 2.3**



## **Appendix 3**

### **Original Specifications**

A. Metar data for years July 2002 - June 2007 for

1. Bunbury Airport AWS
2. Mandurah AWS
3. Garden Island AWS
4. Busselton Airport AWS
5. Busselton Jetty AWS

B. Convert data to hourly only information (excluding the observation not exactly on the hour), and replacing missing hourly observations with

1. The nearest time observation within 15 minutes of the hour
2. A null value otherwise

C. Compare

1. by onshore and offshore AWS location
  - Mandurah AWS wind speed with Garden Island AWS wind speed,
  - Busselton Airport AWS with Busselton Jetty AWS and

Generate a matrix of corrections:

2. by season
  - December-January-February
  - March-April-May
  - June-July-August
  - September-October-November
3. by observed wind speed
  - 0 to 7 knots
  - 7 knots to 15 knots
  - 15 knots to 22 knots
  - 22 knots and greater
4. by local time
  - 0000 to 0600
  - 0600 to 1200
  - 1200 to 1800
  - 1800 to 2400

The correction will be the median value of the multiplier that converts observed 10 minute mean wind speed at the onshore site to the observed 10 minute mean wind speed at the offshore site (in knots)