Appendix 30

Mount Emerald Wind Farm Shadow Flicker Assessment

Prepared by Parsons Brinckerhoff Australia

RATCH-Australia Corporation

Mount Emerald Wind Farm Shadow Flicker Assessment

22 July 2013

PARSONS BRINCKERHOFF

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B	27/03/2013	Inclusion of shadow flicker and receptor map, and operational hours per direction sector
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22 July 2013

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By email
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Dear Terry

Mount Emerald Wind Farm Shadow Flicker Assessment

Please find enclosed the Mount Emerald shadow flicker assessment as per the scope agreed upon by Parsons Brinckerhoff and RATCH Australia Corporation Limited (RATCH). This assessment was based on the wind farm layout provided by RATCH, wind data collected from the Mount Emerald wind farm and the Walkamin BoM long-term reference site. The methodologies and results are detailed herein.

Should you have any questions, please contact me at your convenience.

Yours sincerely

Ben Inkster
Wind Engineer
Parsons Brinckerhoff

Contents

Glossary

Bureau of Meteorology	Australia's national weather, climate and water agency
Shadow flicker	The fluctuating light levels caused by intermittent (moving or changing) shadows casted by the turbine blade

Abbreviations

BoM	Bureau of Meteorology
d	day
h	hour
kW, MW, GW	Kilowatt, Megawatt, Gigawatt
m/s	Metres per second
mAGL	Metres above ground level
mASL	Metres above sea level
MEWF	Mount Emerald Wind Farm
MWh	Megawatt hour
RATCH	RATCH Australia Corporation Limited
WTG	Wind Turbine Generator
y	year

Executive summary

RATCH Australia Corporation Limited (RATCH) has requested Parsons Brinckerhoff Australia Pty Ltd (Parsons Brinckerhoff) perform a shadow flicker assessment for the proposed Mount Emerald Wind Farm (MEWF). This report is a shadow flicker assessment of a single turbine layout at a nominal hub-height of 80 m and the location of 123 receptors, as specified by RATCH.

The shadow flicker assessment has been conducted using on-site monitored data from the 9530 monitoring tower as it records closest to the nominated hub height of 80 m. Parsons Brinckerhoff has used the sheared and long-term adjusted dataset from an energy yield assessment previously undertaken for this site as an input to determine the WTG orientation and operational hours.

The shadow flicker assessment conducted by Parsons Brinckerhoff consisted of a worst case and a realistic case for shadow flicker impact on each receptor. The realistic case was performed using conservative assumptions using monitored data from the Bureau of Meteorology to represent average sunlight hours per day; however, a number of parameters were still set at what are considered conservative values. Several sites were considered for realistic data, but the Walkamin Research Station was selected as the most appropriate reference site to use in the realistic shadow flicker calculation due to its proximity to the MEWF site, geographic similarity and duration of recorded data.

However, the worst case assessment uses conservative model parameters that are very unlikely to occur in combination over annual timescales. The results show that for most residences, even under these conservative conditions, shadow flicker is below recommended levels of both aggregate annual hours and maximum daily hours of shadow flicker time.

Of the 123 receptors assessed, four have been predicted to experience levels of shadow flicker due to MEWF. No receptors are expected to experience more than 5 hours of shadow flicker in the realistic case and for the worst case, no receptors are expected to experience over 10 hours of shadow flicker per year, as seen in the table below.

No.	GPS Coordinates		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R05	325,084	8,099,119	4:24	0:13	2:22
R26	327,385	8,104,239	5:27	0:15	2:43
R49	331,555	8,100,953	8:39	0:13	4:53
R78	327,662	8,103,902	9:49	0:14	5:00

The shadow hours per day provide an estimate of the maximum shadow experienced by a receptor on a single day of the year. There is no realistic and worst case scenarios associated with this parameter since, unlike shadow hours per year where the actual occurrence is cumulated over an entire year (and hence a range of environmental conditions), the shadow hours per day may well occur on a day that is conducive to the worst case for shadow flicker (i.e. assuming no cloud cover is present on the given day that this occurs).

Based on these results, the calculated levels of shadow flicker caused by MEWF on the receptors listed is substantially less than the limits prescribed by the appropriate guidelines for wind farm developments in Australia.



1. Introduction

RATCH has requested Parsons Brinckerhoff conduct a shadow flicker assessment for the Mount Emerald Wind Farm (MEWF), located in Northern Queensland, southwest of Cairns. RATCH has nominated a layout consisting of 70 WTGs with a nominal hub height of 80 m for evaluation and prediction of the shadow flicker at MEWF, using the Siemens 101-3.0 WTG.

Shadow flicker occurs when the sun passes behind the blades of a WTG casting an intermittent shadow. This affect is known to cause annoyance when this shadow is received at a dwelling. The severity and frequency of shadow flicker will decay with the distance from a WTG and if the location of a dwelling is within 2 km of a WTG, there is potential for this intermittent shadow to be frequent enough to cause annoyance.

This assessment has evaluated shadow flicker on nearby receptors to MEWF in accordance with the draft National Wind Farm Development Guidelines – July 2010, which includes a worst case and realistic evaluation of shadow flicker to a distance of 265 times the maximum chord length from all WTGs.

This assessment has been conducted using a layout consisting of 70 WTGs, and the location of 123 shadow receptors (including surrounding dwellings), as specified by RATCH. It was found that no receptors are expected to exceed the recommended shadow flicker limits of the guidelines.

1.1 Description of shadow flicker

Shadow flicker is the fluctuating light levels caused by intermittent (moving or changing) shadows. If a location is in the shadow of a moving object, then there will be a momentary reduction in light intensity as the shadow passes by. This is most noticeable in an enclosed room that is lit by the sun, when the shadow falls across the window that is providing the light. Wind turbines can cause shadow flicker from the moving shadow of the wind turbine blades. Shadow flicker can also be caused by any moving objects that cast a shadow, such as vehicles or aeroplanes.

The rate of flicker for a three bladed, horizontal axis wind turbine is 3 times the rotational speed of the wind turbine rotor. For example a three bladed wind turbine with a rotor speed of 20 revolutions per minute (rpm) results in a flicker frequency of 1 Hertz (once per second). If the alternating light levels caused by the shadow flicker are of significant intensity and affect the whole light source of a room (i.e. the whole window is shadowed), it can disturb reading and other light-sensitive tasks, thus causing annoyance.

In order for a wind turbine to cause shadow flicker at a given location, the following conditions have to be satisfied. If any one of these conditions is not met, then shadow flicker will not occur, or will have a diminished impact, at that location.

- The sun must be in the correct position in the sky to cast a shadow of the turbine onto the location. This will only occur for certain times of day and days of the year.

- Wind direction will have an impact on shadow flicker impact, as the area of the shadow cast by the wind turbine will depend on which direction the wind turbine is pointing (yaw), which in turn is dependent on the wind direction.
- There has to be unobstructed line of sight between the wind turbine and the location.
- The sun must not be significantly obscured by cloud or diffused by the atmosphere (significant diffusion typically occurs for angles of less than 3° above the horizon).
- The wind turbine has to be operating (i.e. the blades rotating).
- The dimension of the part of the blade causing the shadow has to be large enough to cast significant shadow. The largest dimension of blades is the chord near the root, which may be up to 3.5 m on large turbines, and the smallest is the depth of the blade near the tip, which may be 0.3 m or less. The latter is not sufficient to cast any noticeable shadow. If the blade is edge-on to the sun, then the shadow will be very small.
- The shadow must fall over most of a room's natural light source, i.e. window or skylight. If the windows are large (compared to the size of the shadow), or do not face the wind turbine, then the room's light levels will not vary significantly.

The sun's position varies with the time of day and the time of year. This means that the locations affected by shadow flicker from wind turbines vary with the time of day and time of the year.

The shadow flicker usually occurs to the east and west of the turbines or to the south if there is a large height difference between the turbines and the observer location.

Flicker effects will be strongest closest to the WTGs, as the shadows cast by the rotating blades will be strongest. As the distance from the WTGs increases, the shadows cast by the rotor blades will become less distinct, reducing the impact of the flicker. At about 10 times the rotor diameter (1 km for a 100 m rotor diameter) the effect is reduced, and at a distance of 2 kilometres the proportion of light blocked by the WTG blades becomes so small that flicker is not discernible. Therefore, Parsons Brinckerhoff has not evaluated shadow flicker beyond 2 km from any WTG at MEWF.

1.2 Scope of work

The scope undertaken in this assessment has been agreed between Parsons Brinckerhoff and RATCH in the email *MEWF – Shadow Flicker Assessment* on 6 March 2013, and is as follows:

- Parsons Brinckerhoff will perform a shadow flicker assessment based on:
  - A single turbine layout with a single hub height and rotor diameter, as specified by RATCH;
  - Daily sunshine data from the closest or most applicable BoM site;
  - A list of coordinates of residences that RATCH wishes to be included in the assessment.
- Parsons Brinckerhoff will detail the results of this assessment in a single report, which will include:
  - A discussion of methodology and best practices;
  - A discussion on calculation inputs;
  - Documentation of the results for each residence for Worst Case Shadow Flicker per day and per year, and Realistic Shadow Flicker hours per year.

1.3 Input data

The following has been supplied by RATCH to produce the shadow flicker model:

- List of shadow receptors
- 70-WTG layout

From Parsons Brinckerhoff's previous involvement in the MEWF, additional inputs such as valid wind data and digital contours have been incorporated in the shadow flicker assessment.



2. Methodology

Parsons Brinckerhoff has used WindPRO to assess shadow flicker on supplied receptors at the MEWF. The model used for the calculation of flicker effects contains a mathematical model of the sun's position in the sky for a given location and time of year. Also contained in the model is information relating to the three-dimensional positions and sizes of the turbines and the locations where the flicker is to be calculated. This information is combined to calculate the times for which the turbine rotors will cast shadows over the locations of interest. Shadow flicker is assumed to occur when the centre of the sun passes behind any part of a turbine rotor.

A comparison between the realistic and worst case assessment assumptions are summarised in Table 2-1.

Table 2-1 Comparison of realistic and worst case scenario assumptions

Assessment assumptions		
	Realistic scenario	**Worst case scenario**
Sunlight cover	Data obtained from Walkamin Research Station.	Direct sunlight during all daylight hours (i.e. no clouds are ever experienced over the wind farm site).
WTG operational hours	Operational hours based on power curve and 9530 mast data; as a conservative measure, Parsons Brinckerhoff has not modified the power curve to account for hysteresis.	The wind turbines are always operating (i.e. it is always windy, and the turbines are never inoperable due to maintenance or faults).
WTG orientation	WTG orientation based on 9530 mast data.	The wind turbines are always turned in the horizontal plane to face the sun (i.e. the turbine rotor casts the maximum possible shadow).
WTG visibility	All the WTGs are visible except those screened by the topography.	
Maximum distance for influence	2 km	
Minimum sun height over horizon for influence	3°	
Dimensions of receptor window	Represented by a vertical rectangle facing each turbine; termed as a "Greenhouse" configuration, 10 m wide and 2 m high, centred 1.5 m off the ground (any shadow on any part of this rectangle is included in the count).	

In addition to the above assumptions, these calculations are based on the following WTG parameters:

- WTG rotor diameter 101 m
- WTG hub height 80 m (as requested by RATCH)
- WTG blade chord of 3.4 m

Parsons Brinckerhoff has considered a conservatively large receptor window of 10 m in width and 2 m in height to adequately include borderline situations where a receptor is just marginally exempt from

experiencing the effects of shadow flicker. The Draft National Wind Farm Development Guidelines – July 2010 suggest that the effects of shadow flicker are dependent on the blade dimensions and recommend an assessment distance of 265 times the maximum blade chord. Based on the maximum blade chord of the Siemens 101-3.0 WTG of 3.4 m, the assessment distance is 901 m; however, Parsons Brinckerhoff has used a more conservative assumption of 2 km in this assessment to account for the varying levels of human sensitivity to the intensity of shadow flicker.

The worst case assessment for each receptor results in the number of shadow flicker hours that the dwelling could potentially experience in a year. However, the occurrence of all these assumptions at one time is considered highly unlikely as cloud cover will occur over the project site, for example. Therefore, the worst case shadow flicker results serve as a starting point from which a more realistic situation is derived using measured data from reference sites recording sunlight information.

Parsons Brinckerhoff has applied a reduction factor to account for cloud cover at the MEWF to convert the worst case shadow flicker results to a more realistic annual estimate. This is based on recorded information on sunlight and cloud cover by the Bureau of Meteorology (BoM). The closest reference site is the Walkamin Research Station, located 6 km northeast of MEWF. This information is applied to the worst case shadow flicker assessment on a monthly average basis, measured using a Campbell-Stokes device. The average daily sunshine hours for Walkamin Research Station are shown in Table 2-2.

Table 2-2: Average daylight hours per day on a monthly mean basis (Bureau of Meteorology)

Average daylight hours per day												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Walkamin Research Station	6.8	6.0	6.6	7.2	7.2	7.4	7.7	8.5	9.2	9.6	8.9	7.9

The cloud cover reduction factor is applied to the worst case results for the annual aggregate value only. The worst case shadow hours experienced in a day remains a realistic assumption as a dwelling may experience no cloud cover on the day of the year that has the maximum shadow flicker.

The location of the Walkamin Research Station relative to the MEWF site is shown in Figure 2-A.

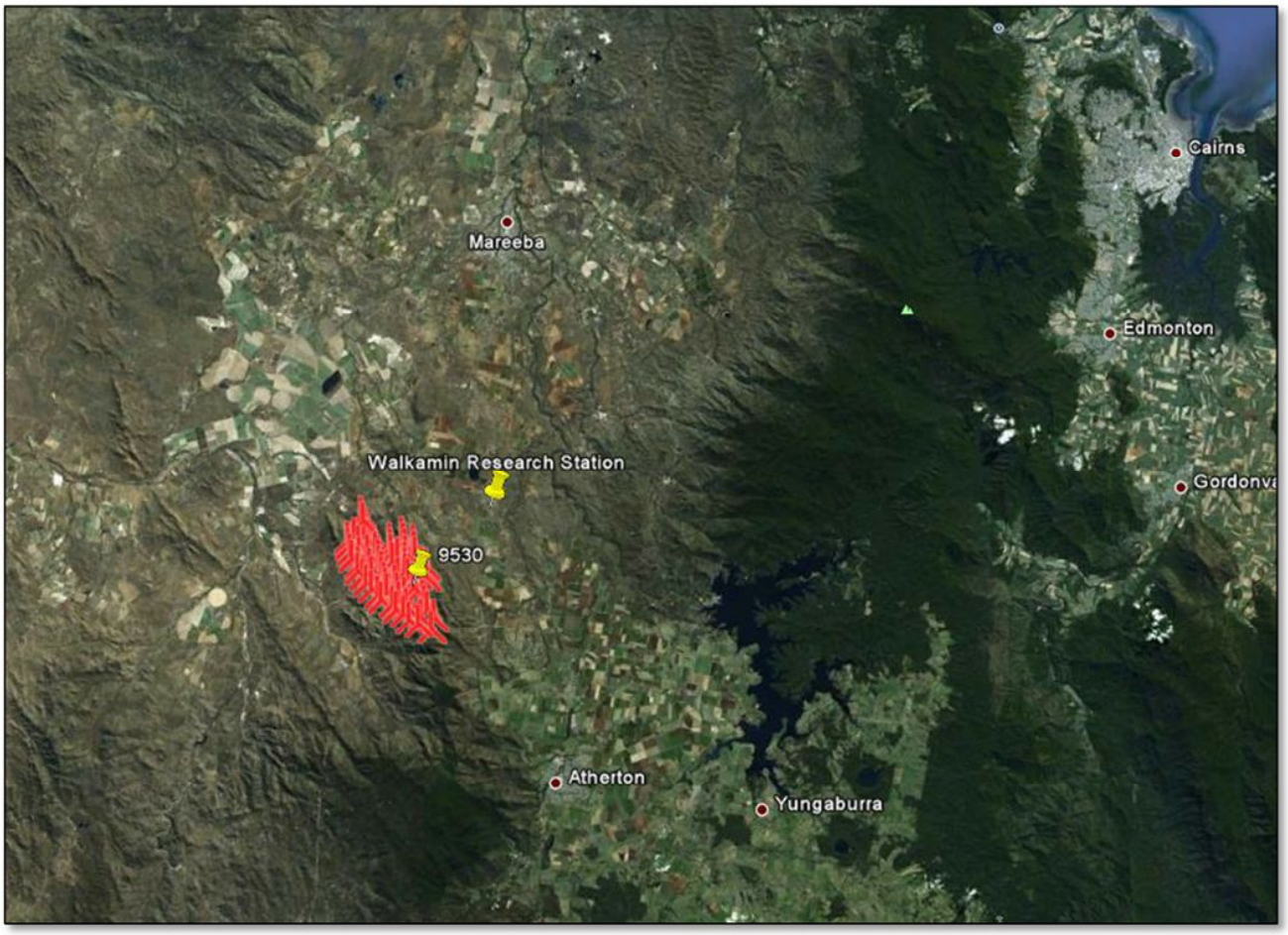


Figure 2-A Location of Walkamin Research Station (Image source: ©2010 Google, Image ©DigitalGlobe, ©2013 Google, ©2013 Whereis® Sensis Pty Ltd)

As discussed above, wind speed and direction data recorded at the 9530 mast has been used as an input to this study. The operational hours have been determined by applying the power curve to the wind speed data at 80 m, and the availability is estimated to be 97%. The operational hours per direction sector have been calculated by grouping the operational hours in 30 degree direction sectors.

The WTG power curve and operational hours per direction sector are presented in the tables below.

Table 2-3 WTG power curve

Siemens SWT3.0-101 WTG power curve		
Wind Speed	Power	Thrust Coefficient
m/s	kW	Ct
0	0	0
1	0	0
2	0	0
3	48	0.887
4	128	0.890
5	263	0.885
6	469	0.888
7	757	0.884
8	1138	0.887
9	1620	0.885
10	2189	0.872

Siemens SWT3.0-101 WTG power curve		
Wind Speed	**Power**	**Thrust Coefficient**
11	2697	0.801
12	2933	0.532
13	2991	0.391
14	2999	0.303
15	3000	0.242
16	3000	0.198
17	3000	0.165
18	3000	0.140
19	3000	0.119
20	3000	0.103
21	3000	0.090
22	3000	0.079
23	3000	0.070
24	3000	0.063
25	3000	0.056

Table 2-4 Operational hours per direction sector

Operational hours per direction sector based on 9530 data												
N	**NNE**	**ENE**	**E**	**ESE**	**SSE**	**S**	**SSW**	**WSW**	**W**	**WNW**	**NNW**	**SUM**
78	334	381	2,026	4,689	275	51	63	172	261	110	52	**8492**



3. Results

The results of the shadow flicker assessment including worst case results and realistic results using average sunshine statistics are shown below in Table 3-1 and it can be observed that none of the receptors are expected to experience shadow flicker for more than 30 hours per year in both the worst and realistic case scenarios, or 30 minutes per day in the worst case scenario. Based on these results, the calculated levels of shadow flicker caused by MEWF on the receptors listed are substantially less than the limits prescribed by the Draft National Wind Farm Development Guidelines. The shadow flicker and receptor map is shown in Appendix A.

Table 3-1 MEWF Shadow Flicker Results

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R01	327,108	8,094,240	0:00	0:00	0:00
R02	323,399	8,101,041	0:00	0:00	0:00
R03	322,551	8,100,377	0:00	0:00	0:00
R04	322,401	8,100,614	0:00	0:00	0:00
R05	325,084	8,099,119	4:24	0:13	2:22
R06	324,402	8,099,053	0:00	0:00	0:00
R07	324,438	8,098,311	0:00	0:00	0:00
R08	324,461	8,097,943	0:00	0:00	0:00
R09	324,552	8,097,638	0:00	0:00	0:00
R10	324,741	8,097,351	0:00	0:00	0:00
R11	325,824	8,096,858	0:00	0:00	0:00
R12	326,812	8,094,840	0:00	0:00	0:00
R13	322,913	8,101,970	0:00	0:00	0:00
R14	323,526	8,098,996	0:00	0:00	0:00
R15	322,190	8,101,228	0:00	0:00	0:00
R16	323,417	8,099,332	0:00	0:00	0:00
R17	321,385	8,101,835	0:00	0:00	0:00
R18	322,861	8,105,817	0:00	0:00	0:00
R19	323,237	8,105,869	0:00	0:00	0:00
R20	324,011	8,106,789	0:00	0:00	0:00
R21	327,346	8,105,105	0:00	0:00	0:00
R22	327,532	8,105,458	0:00	0:00	0:00
R23	327,320	8,105,720	0:00	0:00	0:00
R24	327,836	8,105,651	0:00	0:00	0:00
R25	328,105	8,105,059	0:00	0:00	0:00
R26	327,385	8,104,239	5:27	0:15	2:43

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R27	328,640	8,104,706	0:00	0:00	0:00
R28	328,814	8,104,996	0:00	0:00	0:00
R29	329,227	8,104,783	0:00	0:00	0:00
R30	329,632	8,104,345	0:00	0:00	0:00
R31	329,738	8,105,254	0:00	0:00	0:00
R32	329,821	8,104,154	0:00	0:00	0:00
R33	329,870	8,104,536	0:00	0:00	0:00
R34	330,044	8,104,444	0:00	0:00	0:00
R35	330,166	8,103,957	0:00	0:00	0:00
R36	330,281	8,103,655	0:00	0:00	0:00
R37	330,744	8,104,165	0:00	0:00	0:00
R38	331,053	8,103,796	0:00	0:00	0:00
R39	331,012	8,103,431	0:00	0:00	0:00
R40	331,286	8,103,732	0:00	0:00	0:00
R41	331,610	8,103,457	0:00	0:00	0:00
R42	331,773	8,103,467	0:00	0:00	0:00
R43	331,900	8,103,216	0:00	0:00	0:00
R44	332,241	8,103,249	0:00	0:00	0:00
R45	332,142	8,103,035	0:00	0:00	0:00
R46	331,667	8,102,969	0:00	0:00	0:00
R47	331,836	8,102,949	0:00	0:00	0:00
R48	331,981	8,102,675	0:00	0:00	0:00
R49	331,555	8,100,953	8:39	0:13	4:53
R50	333,099	8,102,820	0:00	0:00	0:00
R51	333,372	8,102,564	0:00	0:00	0:00
R52	333,849	8,102,111	0:00	0:00	0:00
R53	333,977	8,101,981	0:00	0:00	0:00
R54	334,001	8,101,907	0:00	0:00	0:00
R55	334,143	8,101,119	0:00	0:00	0:00
R56	334,828	8,100,860	0:00	0:00	0:00
R57	332,290	8,102,160	0:00	0:00	0:00
R58	333,082	8,100,051	0:00	0:00	0:00
R59	332,424	8,099,580	0:00	0:00	0:00
R60	332,526	8,098,770	0:00	0:00	0:00
R61	333,441	8,099,268	0:00	0:00	0:00
R62	332,750	8,099,348	0:00	0:00	0:00
R63	333,180	8,098,115	0:00	0:00	0:00
R64	333,966	8,098,486	0:00	0:00	0:00
R65	334,769	8,098,473	0:00	0:00	0:00
R66	333,273	8,097,584	0:00	0:00	0:00
R67	333,769	8,097,741	0:00	0:00	0:00
R68	333,818	8,097,418	0:00	0:00	0:00
R69	333,759	8,097,284	0:00	0:00	0:00
R70	333,858	8,097,008	0:00	0:00	0:00
R71	333,837	8,096,819	0:00	0:00	0:00
R72	334,122	8,096,447	0:00	0:00	0:00
R73	334,300	8,097,467	0:00	0:00	0:00

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R74	334,315	8,097,097	0:00	0:00	0:00
R75	334,312	8,096,814	0:00	0:00	0:00
R76	334,510	8,096,570	0:00	0:00	0:00
R77	333,420	8,095,349	0:00	0:00	0:00
R78	327,662	8,103,902	9:49	0:14	5:00
R79	326,084	8,095,615	0:00	0:00	0:00
R80	326,633	8,095,887	0:00	0:00	0:00
R81	322,227	8,102,228	0:00	0:00	0:00
R82	328,862	8,104,954	0:00	0:00	0:00
R83	331,064	8,103,659	0:00	0:00	0:00
R84	328,138	8,105,207	0:00	0:00	0:00
RANGEVIEW	335,269	8,097,070	0:00	0:00	0:00
WALKAMIN	332,711	8,105,470	0:00	0:00	0:00
R87	324,029	8,106,539	0:00	0:00	0:00
R88	325,804	8,107,243	0:00	0:00	0:00
R89	324,925	8,104,393	0:00	0:00	0:00
R90	323,839	8,105,103	0:00	0:00	0:00
R91	333,946	8,102,712	0:00	0:00	0:00
R92	334,049	8,103,397	0:00	0:00	0:00
R93	333,585	8,103,544	0:00	0:00	0:00
R94	333,738	8,103,749	0:00	0:00	0:00
R95	333,737	8,103,972	0:00	0:00	0:00
R96	333,543	8,104,296	0:00	0:00	0:00
R97	333,476	8,104,424	0:00	0:00	0:00
R98	333,652	8,104,597	0:00	0:00	0:00
R99	332,659	8,104,989	0:00	0:00	0:00
R100	332,380	8,105,473	0:00	0:00	0:00
R101	332,447	8,105,917	0:00	0:00	0:00
R102	333,013	8,104,126	0:00	0:00	0:00
R103	332,934	8,104,276	0:00	0:00	0:00
R104	332,397	8,104,339	0:00	0:00	0:00
R105	330,771	8,106,228	0:00	0:00	0:00
R106	330,687	8,106,366	0:00	0:00	0:00
R107	330,802	8,106,936	0:00	0:00	0:00
R108	331,175	8,107,484	0:00	0:00	0:00
R109	328,594	8,107,639	0:00	0:00	0:00
R110	328,212	8,107,130	0:00	0:00	0:00
R111	328,314	8,106,195	0:00	0:00	0:00
R112	327,666	8,106,205	0:00	0:00	0:00
R113	327,055	8,106,025	0:00	0:00	0:00
R114	327,675	8,108,169	0:00	0:00	0:00
R115	327,309	8,108,440	0:00	0:00	0:00
R116	324,316	8,109,076	0:00	0:00	0:00
R117	320,884	8,102,947	0:00	0:00	0:00
R118	321,231	8,101,117	0:00	0:00	0:00
R119	321,148	8,101,136	0:00	0:00	0:00
R120	321,240	8,101,684	0:00	0:00	0:00

Receptor No.	GPS Coordinates (UTM WGS 84, Zone 55)		Worst case shadow flicker hours per year	Maximum shadow hours per day	Realistic shadow flicker hours per year
	Easting	Northing	h/year	h/day	h/year
R121	319,947	8,100,527	0:00	0:00	0:00
R122	333,913	8,094,653	0:00	0:00	0:00
R123	334,862	8,095,248	0:00	0:00	0:00



4. Bibliography

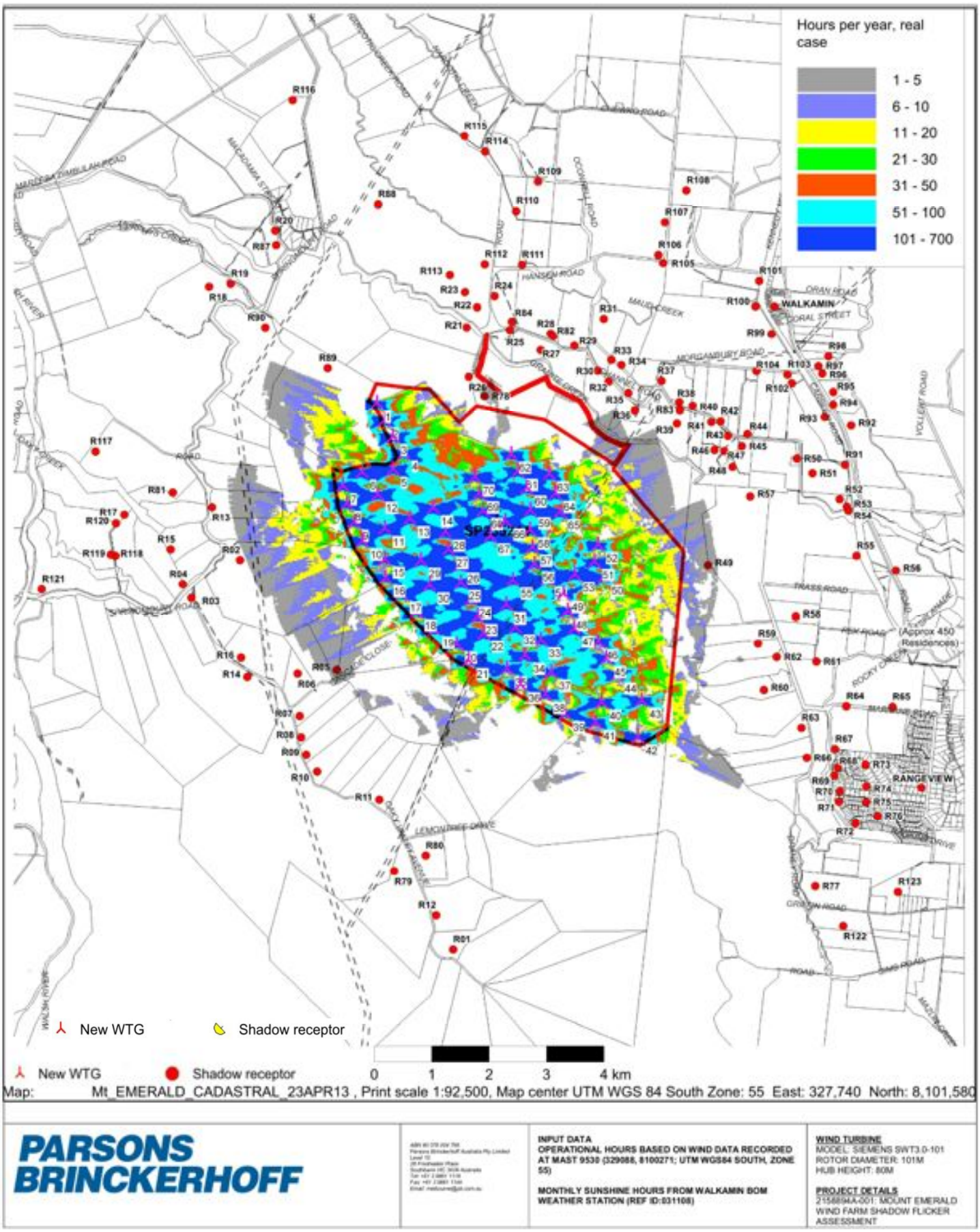
Bureau of Meteorology. (2013). *Climate statistics for Australian locations; Walkamin Research Station.* Retrieved 3 7, 2013, from http://www.bom.gov.au/climate/averages/tables/cw_031108.shtml

Environmental Protection and Heriatge Council. (2010). *Draft National Wind Farm Development Guidelines .*

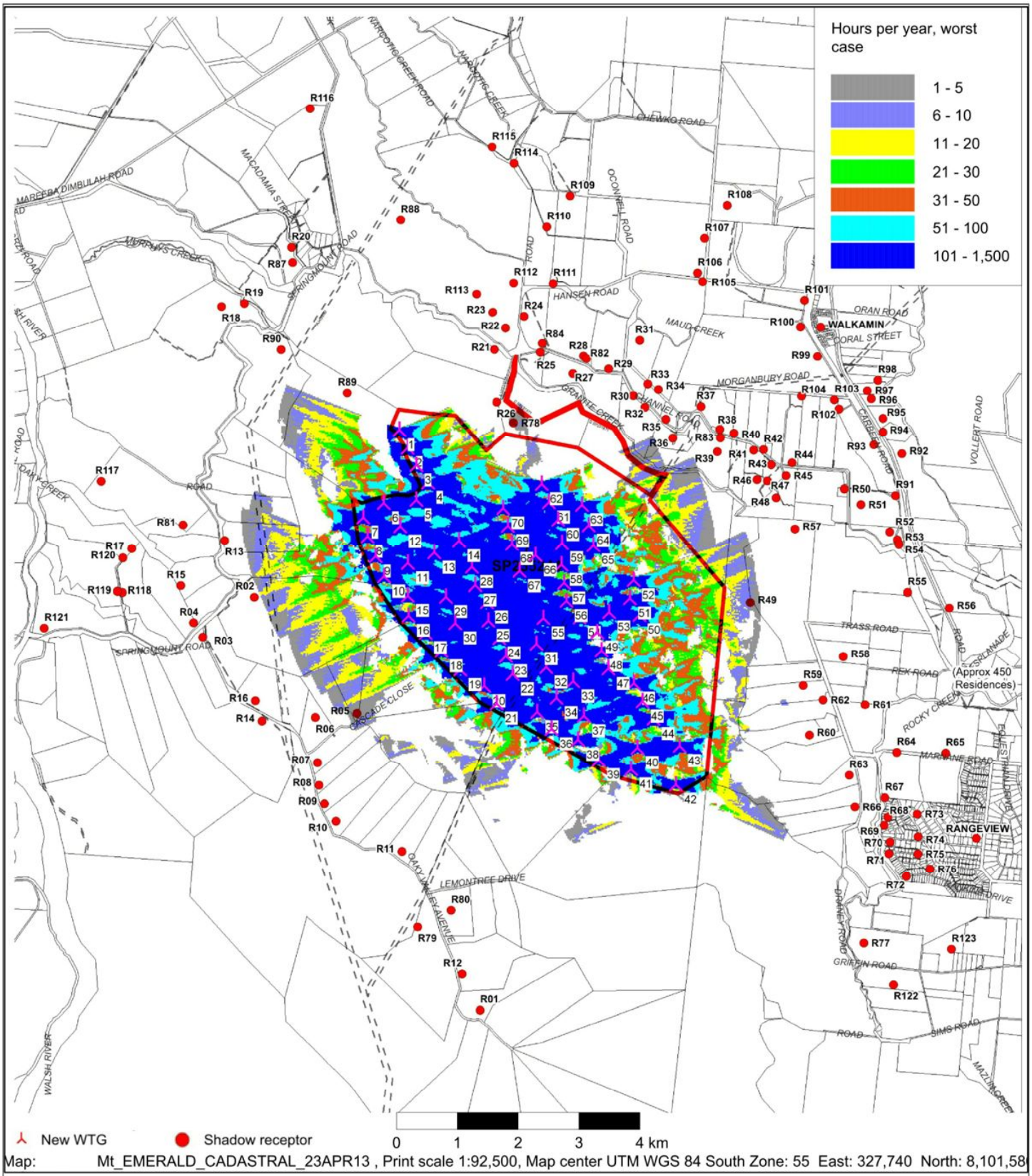
Appendix A

Shadow flicker maps

PARSONS BRINCKERHOFF



Appendix A.1: Mount Emerald shadow flicker map of realistic case shadow flicker hours with receptor locations.



Appendix A.2: Mount Emerald shadow flicker map of worst case shadow flicker hours with receptor locations.

Appendix B

WTG Layout (supplied by RATCH)

PARSONS BRINCKERHOFF

70 WTG Layout (supplied by RATCH)		
WTG number	Easting	Northing
	UTM WGS 84, Zone 55	
1	325792	8103791
2	325927	8103500
3	326071	8103211
4	326263	8102926
5	326071	8102642
6	325535	8102589
7	325197	8102351
8	325266	8102037
9	325402	8101713
10	325539	8101383
11	325930	8101603
12	325803	8102201
13	326364	8101775
14	326771	8101965
15	325931	8101065
16	325941	8100734
17	326222	8100448
18	326484	8100150
19	326793	8099845
20	327187	8099577
21	327392	8099290
22	327652	8099773
23	327542	8100066
24	327436	8100361
25	327254	8100649
26	327232	8100956
27	327039	8101238
28	326982	8101539
29	326556	8101046
30	326708	8100606
31	328045	8100267
32	328206	8099881
33	328648	8099655
34	328376	8099384
35	328058	8099149
36	328292	8098872
37	328824	8099088
38	328726	8098695
39	329067	8098362
40	329705	8098561
41	329600	8098212
42	330338	8097956
43	330401	8098594
44	329970	8099041
45	329790	8099328
46	329648	8099620
47	329228	8099859

70 WTG Layout (supplied by RATCH)		
WTG number	**Easting**	**Northing**
48	329113	8100157
49	329043	8100457
50	329738	8100745
51	329581	8101021
52	329644	8101320
53	329242	8100793
54	328753	8100703
55	328157	8100695
56	328537	8100981
57	328498	8101272
58	328458	8101575
59	328466	8101926
60	328402	8102310
61	328248	8102601
62	328130	8102902
63	328792	8102560
64	328903	8102219
65	328983	8101892
66	328031	8101732
67	327768	8101472
68	327640	8101915
69	327574	8102211
70	327496	8102505