Yass Valley Wind Farm – Shadow Flicker Addendum Report

Introduction

The original shadow flicker assessment was undertaken by Epuron for the Yass Valley Wind Farm (YVWF) Coppabella Hills and Marilba Hills Precincts in May 2009 as part of the Environmental Assessment. Since the completion of the original assessment, YVWF has revised the location of the wind turbine layout. This addendum report updates the results of the original assessment based on the current turbine layout of 144 turbines.

Guidelines

In NSW there are no guidelines on which to assess shadow flicker generated by wind turbines. To carry out the shadow flicker assessment we have drawn on the Victorian Planning Guidelines that limit the duration of shadow flicker to 30 hours a year (DCPD, 2012).

Consideration has also been made in this assessment to the Draft NSW Planning guidelines, which require that:

> *"The impact of 'shadow flicker' from wind turbines on neighbour's houses within 2km of a proposed wind turbine should be assessed. The shadow flicker experienced at any dwelling should not exceed 30 hours per year as a result of the operation of the wind farm. Specialist modelling software should be used to model shadow flicker impacts prior to finalisation of the turbine layout"*

Methodology

The methodology carried out is consistent with the original assessment. GL-GH Windfarmer software is used to conduct the modelling based on a wind turbine with a maximum tip height of 150m. This consists of a 100m diameter blade on a 100m tower.

The shadow flicker assessment for YVWF considers dwellings within 2km (as per consideration of Draft NSW Planning guidelines (DP&I, 2011)). The following dwellings are within 2km of a turbine: G11, G12, G13, G14, M20, M24, M32, M48, G15, G31, G16, M18, C27, C03, C02, C05, M21, C68, C56, C55, M41, G38 and M42. Table 1 lists all dwellings and the distance to the nearest turbine.

Due to a revision in the turbine layout dwelling C25 which was assessed in the original assessment is no longer located within 2km from a turbine and thus has not been assessed in this report.

Table 1 Dwelling location and distance to nearest turbine

Dwelling ID	Easting	Northing	Distance to nearest turbine (km)	Nearest turbine
G11	661209	6147630	1.71	143
G12*	660201	6149381	1.76	143
G13*	660057	6151077	1.98	136
G14	659607	6150702	1.42	136
M20	658743	6154508	1.88	100
M24	658623	6154599	1.90	100
M32*	652110	6146643	1.86	95
M48*	655766	6149602	1.53	93
G15*	655374	6149637	1.16	93
G31*	651691	6149344	1.52	84
G16	655016	6147518	1.15	96
M18*	652314	6149832	0.91	84
C27*	651322	6154526	1.10	111
C03*	637337	6151337	1.40	41

Dwelling ID	Easting	Northing	Distance to nearest turbine (km)	Nearest turbine
C02*	636019	6153226	1.66	44
C05*	644196	6148247	1.95	77
M21*	651854	6155574	1.37	111
C68*	651108	6154402	1.30	111
C56*	637828	6151304	1.38	41
C55*	636410	6151623	1.68	41
M41*	651736	6155517	1.37	111
G38*	659982	6150849	1.82	136
M42	653648	6155444	1.15	114

**denotes project involved landowner*

The South Australian Planning Bulletin suggests that shadow flicker is insignificant once a separation of 500m between the turbine and house is exceeded (Planning SA, 2002). The UK wind industry and UK government recommends 10 rotor diameters as the maximum shadow length from a wind turbine that will cause annoyance due to shadow flicker, this equates to 1000m for the proposed 100m blade diameter (ODPMUK, 2004). The EPHC Draft National Wind Farm Development Guidelines suggest a distance equivalent to 265 maximum blade chords as an appropriate limit which corresponds to 1060m for a 4m maximum blade chord (modern turbines typically have lengths of 3 to 4m) (EPHC, 2010). This issue is discussed in the EPHC Draft National Wind Farm Guidelines which states:

> *Shadow flicker can theoretically extend many kilometres from a wind turbine. However the intensity of the shadows decreases with distance. While acknowledging that different individuals have different levels of sensitivity and may be annoyed by different levels of shadow intensity, these guidelines limit assessment to moderate levels of intensity (i.e., well above the minimum theoretically detectable threshold) commensurate with the nature of the impact and the environment in which it is experienced.*

As a conservative measure a maximum shadow distance of 1060m is used as an input to the model for the expected case which more accurately reflects the operation of the wind farm.

Worst case theoretical shadow flicker and expected shadow flicker has been calculated for the site. The expected shadow flicker at site uses a maximum shadow distance of 1060m as supported above and further considers actual on site conditions by accounting for cloud cover as per the original assessment, using Bureau of Meteorology cloud cover data at Yass[1]. The worst case theoretical shadow flicker calculated overestimates the annual number of hours of shadow flicker experienced at a specific location as detailed in the original assessment. Additional features of actual site conditions will prevail that are not considered here such as: turbine orientation, screening and low wind speed which will further reduce shadow flicker. As such the expected shadow flicker calculated in this assessment is thus considered conservative.

Results of worst case theoretical shadow flicker

As requested by the Department of Planning shadow flicker has been modelling for dwellings within 2km of a wind turbine. Worst case theoretical shadow flicker has been modelling based on the assumptions shown in Table 2. The numerical results as produced by the software are shown in Table 3. The results show that 4 dwellings receiver greater than 30 hours per year of shadow flicker under a theoretical worst case scenario with 3 of these landowner being project involved and 1 being project non-involved. Worst case theoretical shadow flicker overestimates the shadow flicker that will result from the operation of the wind farm. The expected shadow flicker results detailed below is a more accurate prediction of shadow flicker that will result due to the operation of the wind farm. Further detailed turbine by turbine results are reported by the software but require 15 pages per dwelling as the

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[1] Cloud cover data is based on the Burea of Meteorology station number 070091. The mean number of cloudy days over 46 years spanning 1965 to 2010 is 109 days per year. This corresponds to a reduction in shadow flicker of 30% per year, which is applied to the software produced results to calculate the expected shadow flicker for the expected case.

impact of each individual turbine on each individual dwelling is generated. This results in 345 pages of reporting which have not been included here due to the extensive volume.

Table 2 Worst case theoretical modeling assumptions

Assumption	
Software	GL-GH Windfarmer 4.2
Calculate shadow flicker distances	2km
Year	2020
Min elevation angle	3deg
Calculation time interval	1minute
True North	Yes
Model sun as a disc	Yes
Height above ground for mapping	1.5m
Turbine orientation	Rotor plane facing azimuth +180
Terrain and visibility	Use terrain to calculate turbine and sun visibility
Cloud cover assessment	No

Table 3 Worst case theoretical shadow flicker results

Dwelling ID	Worst case theoretical shadow flicker (hrs/yr)
G11	7
G12*	3
G13*	0
G14	21
M20	0
M24	0
M32*	8
M48*	35
G15*	59
G31*	15
G16	38
M18*	71
C27*	10
C03*	0
C02*	19
C05*	0
M21*	0
C68*	25
C56*	0
C55*	0

Dwelling ID	*Worst case theoretical shadow flicker (hrs/yr)*
M41*	0
G38*	10
M42	0

**denotes project involved landowner*

Results of expected case

The calculation of expected shadow flicker at site more accurately reflects shadow flicker due to the operation of the wind farm then the worst case theoretical case. The assumptions used for expected shadow flicker is shown Table 4. The results of the shadow flicker assessment are shown in Figure 1 & Figure 2. The expected shadow flicker for each dwelling is shown in Table 5, this is derived from the software produced results with the impact of cloud cover treated externally due to software functionality. Table 5 shows both software output and expected shadow flicker once cloud cover is accounted for. No dwellings receive an expected shadow flicker of greater than 30 hours per year. As with worst case theoretical shadow flicker the large volume of software generated reporting has not allowed those results to be included here.

The original assessment assessed compliance against the Victorian guidelines at the time which had additional compliance criteria of a maximum shadow flicker of 30 minutes per day. The current 2012 Victorian Planning Guidelines do not stipulate this criterion. For comparison this information has been included. All dwellings receive less than 30 minutes per day of shadow flicker.

Table 4 Expected case modeling assumptions

Assumption	
Software	GL-GH Windfarmer 4.2
Calculate shadow flicker distances	1.06km
Year	2020
Min elevation angle	3deg
Calculation time interval	1minute
True North	Yes
Model sun as a disc	Yes
Consider distance between rotor and tower	No
Height above ground for mapping	1.5m
Turbine orientation	Rotor plane facing azimuth +180
Terrain and visibility	Use terrain to calculate turbine and sun visibility
Cloud cover assessment	Yes, conducted externally

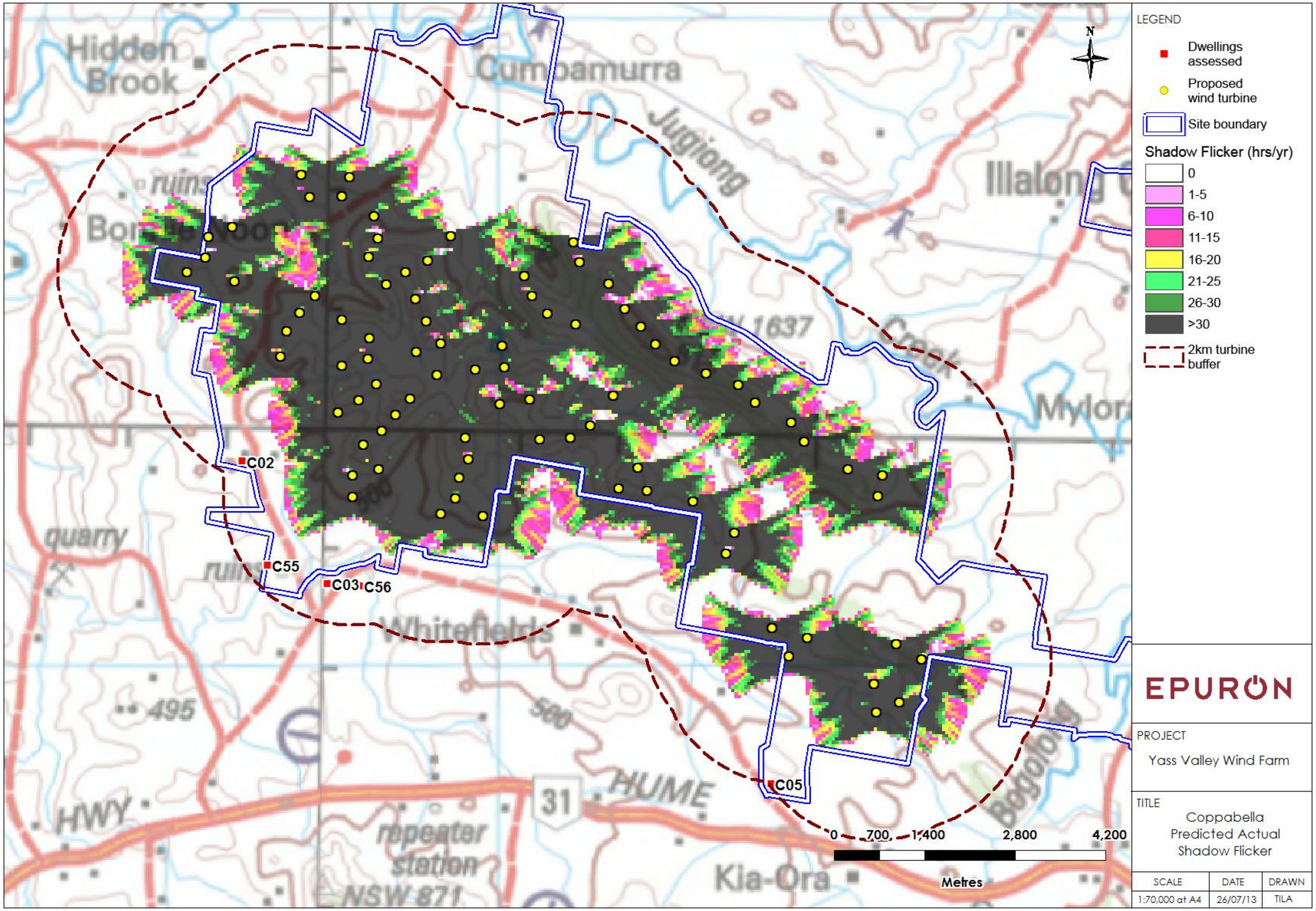

Figure 1 Results of expected shadow flicker assessment - Coppabella

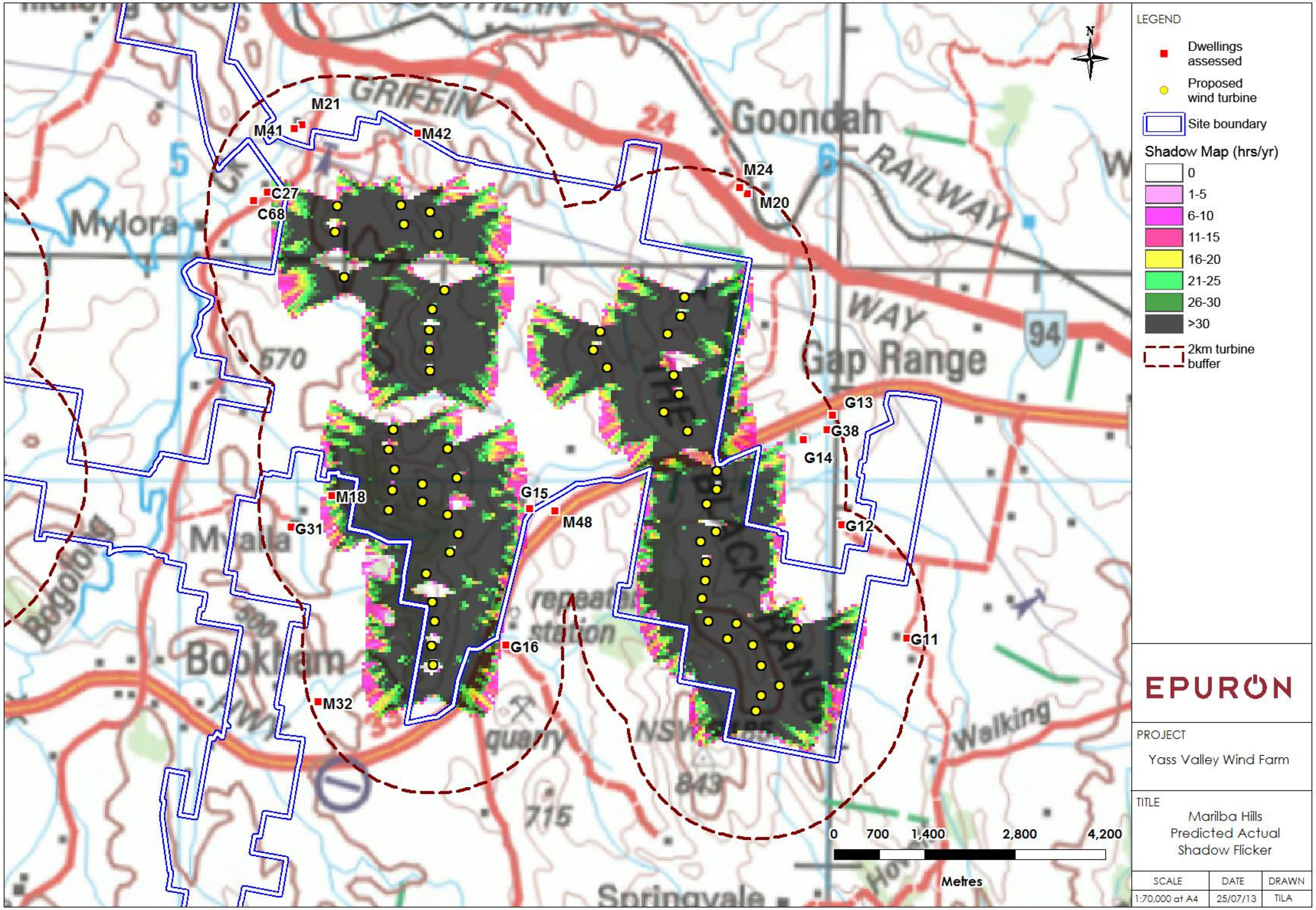

Figure 2 Results of expected shadow flicker assessment - Marilba

Table 5 Expected shadow flicker results

Dwelling ID	Expected shadow flicker - producted by software excluding cloud cover impact (hrs/yr)	Expected shadow flicker – includes cloud cover impact (hrs/yr)	Maximum shadow flicker (mins/day)
G11	0	0	0
G12*	0	0	0
G13*	0	0	0
G14	0	0	0
M20	0	0	0
M24	0	0	0
M32*	0	0	0
M48*	0	0	0
G15*	0	0	0
G31*	0	0	0
G16	0	0	0
M18*	32	23	29
C27*	0	0	0
C03*	0	0	0
C02*	0	0	0
C05*	0	0	0
M21*	0	0	0
C68*	0	0	0
C56*	0	0	0
C55*	0	0	0
M41*	0	0	0
G38*	0	0	0
M42	0	0	0

**denotes project involved landowner*

Conclusion

A detailed analysis of the potential for shadow flicker has been updated for Yass Valley Wind Farm. An initial investigation into the worst case theoretical scenario has been presented as well as an expected case. All residences receive less than 30 hours per annum of predicted actual shadow flicker. As such the project is compliant against the Victorian Planning Guidelines and the NSW Draft Planning Guidelines.