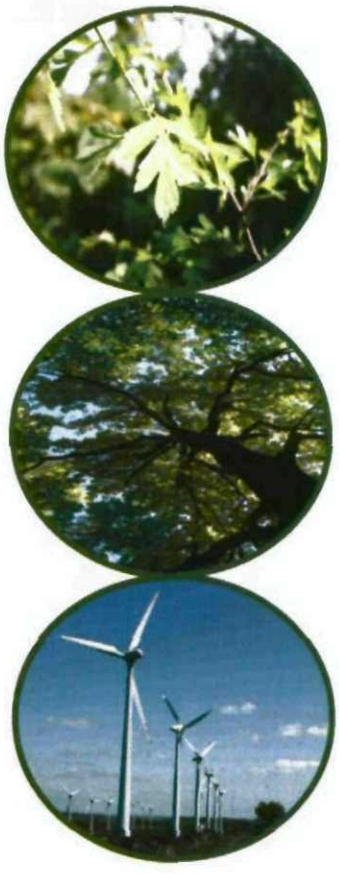
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Ringstone Hill Farm Wind Turbine

Shadow Flicker Assessment



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SITE INFORMATION

Shadow Flicker Assessment

Project:	Ringstone Hill Farm Wind Turbine
Ref:	SHF.309.001.R.002
For:	Empirica Investments
Status:	Final
Date:	December 2011
Author:	John Meehan – Senior Landscape Architect
Reviewer:	Paul Beswick – Technical Director

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FIGURES

Figure 1	Shadow Flicker Plan

1.0 INTRODUCTION

1.1 The Brief

1.1.1 This chapter describes and assesses the potential Shadow Flicker effects of the proposed individual wind turbine at Ringstone Hill Farm in South Yorkshire.

1.2 Background

1.2.1 Shadow flicker is the effect that occurs when the shadow of a moving wind turbine blade passes over a small building opening [i.e. window], briefly reducing the intensity of light within the room causing a flickering sensation.

1.2.2 The possibility and duration of this flickering depends upon the combination of; the suns position, the turbine and window locations, turbine orientation, the time of day, the day of the year and ambient weather conditions.

1.2.3 This flickering has the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a residence. Persons with photosensitive epilepsy are usually sensitive to flickering light between 16-25 hertz [Hz], although some people may be sensitive to rates as low as 3 Hz and as high as 60 Hz[1]. However the frequencies of flicker caused by modern wind turbines [less than 1.5 Hertz][2,3] are well below the 3 Hz frequency known to trigger photosensitive epilepsy.

1.3 The Site and Proposal

1.3.1 The site is located at Ringstone Hill Farm, close to Ringstone Hill in Brierley, a town and civil parish located in the Metropolitan Borough of Barnsley, South Yorkshire. The preliminary turbine location is: 442551, 410378 (SE 42551 10378).

1.3.2 The turbine would be an Enercon E-44 model and would be a maximum of 67m in height to blade tip, comprising a maximum 45m high tower to turbine hub with 44m diameter rotors (three bladed).

[1] Epilepsy Action (2007), 'Photo-sensitive Epilepsy' (http://www.epilepsy.org.uk/info/photo.html)
[2] Epilepsy Action (2007), 'Other Possible Epilepsy Triggers' (http://www.epilepsy.org.uk/info/photo_other.html)
[3] ODPM, (2004) 'Planning for Renewable Energy: A Companion Guide to PPS22', pp. 17

2.0 GUIDANCE AND ASSESSMENT METHODOLOGY

2.1 Relevant Guidance

2.1.1 Information specific to shadow flicker considered as part of this assessment may be found in 'Planning for Renewable Energy: A Companion Guide to Planning Policy Statement [PPS22] Renewable Energy. The Companion Guide states:

"Although problems caused by shadow flicker are rare, for sites where existing development may be subject to this problem, applicants for planning permission for wind turbine installations should provide an analysis to quantify the effect."

2.1.2 Within the UK there is no standard for the assessment of shadow flicker, nor are there any guidelines which quantify what exposure levels [to flicker] would be acceptable.

2.1.3 The guide does however, provide technical information on a range of renewable energy technologies, including onshore wind power, which is universally applicable and describes the conditions under which flicker may occur. The guide states that the flicker effect diminishes with distance, and that *"flicker effects have been proven to occur only within ten rotor diameters of a turbine."* It also confirms that effects only occur within 130° either side of north relative to the turbines.

2.2 Assessment Methodology

Study Area

2.2.1 Properties with the potential to be affected by shadow flicker have been identified using Ordnance Survey 1:10,000 scale digital mapping to identify the area around the proposed turbine location within a distance of ten rotor diameters (i.e. 44m x 10 = 440m) and 130° either side of north (the 'shadow flicker study area'). The properties identified in this way, which was confirmed during a site visit, are shown on **Figure 1**.

Analysis Parameters

2.2.2 A wind farm computer modelling package[4] has been used to calculate theoretical specific times and durations of flicker effects for each property. Details of the assumptions made about the properties are given in the Baseline Description above.

2.2.3 *The software creates a model of the turbine and adjacent properties, based on:*

- The turbine locations, hub height and rotor diameter;
- Topography [obtained from OS elevation data on a 50 m horizontal grid]; and
- The latitude and longitude of the Development site [used in calculating the position of the sun in relation to time of day and year].

[4] WindFarm by ReSoft, Release 4.2

2.2.4 A cut-off distance of 440m [10 rotor diameters] from each turbine was employed during this calculation.

2.2.5 Certain worst-case assumptions are made in the calculation, which are that:

- Weather conditions are such that shadows are always cast during each of 365 days of the year [i.e. *bright sunshine* every day];
- The turbine rotor will always be facing directly towards a given window, maximising the size of the shadow and duration of the effect;
- The turbines will always be rotating; and
- There are no intervening structures or vegetation [other than topography] that may restrict the visibility of a turbine, preventing or reducing the effect.

2.2.6 When the sun is visible close to the horizon, at dawn and dusk, the intensity of the sun's rays are reduced and are less likely to cast distinct shadows. It is generally considered that when the sun is lower than 2° above the horizon shadow flicker is unlikely to occur to any significant extent. This parameter has also been included in the calculations.

2.2.7 These calculations provide the theoretical, maximum, potential duration of the effects and an approximation of the times of day and year when the effects will be felt. This is considered sufficient for the purposes of this assessment, although a more detailed assessment can be carried out for the purposes of developing detailed mitigation measures, if required.

2.2.8 In the United Kingdom *bright weather* conditions that would give rise to flicker effects typically occur for around 30% of daylight hours per annum. This means that the computer model calculation almost certainly overestimates the duration of effects by as much as three times. Other factors such as screening by vegetation or intervening structures and the orientation of the turbine, due to varying wind direction, also reduces or prevents flicker incidence when compared to the theoretical maximum suggested by the calculation.

2.2.9 As discussed above there is no UK guidance available in respect to shadow flicker, which might be considered acceptable in the UK, so this assessment assumes that any shadow flicker effects predicted will be significant.

3.0 BASELINE DESCRIPTION

3.1 Assessment

3.1.1 The immediate area surrounding the site is predominantly rural with scattered dwellings surrounding the site. A desk based study identified a small number of residential buildings which would be theoretically susceptible to shadow flicker. The nearest settlements of Brierely Hemsworth, South Kirby, Grimethorpe, Cudworth and Shafton all lie outside the 440m radius from the turbine within which receptors are susceptible to shadow flicker. The desktop study and site surveys identified three buildings within the 440m study area.

3.1.2 The orientations of the side(s) of the buildings which would be orientated to face the wind turbine were recorded, and a window was added to each of these facades within the computer model.

3.1.3 Details of the three buildings are provided in **Table 1** below, and are illustrated on **Figure 1**.

Table 1: Assessment Locations

Ref.	Description/Name	Location		Distance to the turbine
		Easting	Northing	
1	The Lodge, Common Road, Brierely	442839	410430	290m
2	Robin Hood Public House, Brierely	442828	410367	275m
3	Burntwood Court Hotel, Brierely	442405	410762	390m

3.1.4 The following assumptions have been made for all potential receptors:

- All windows have been assumed to measure 1m by 1m and are situated 3m above ground level, to the window's centre [this represents an average of ground and first floor levels] and located at the grid references given in Table 1 above;
- Each property is assumed to have one window on each façade that faces towards the proposed turbine location. The orientations assumed are detailed in Table 2; and
- The orientation of the properties' façades has been estimated using the OS 1:10,000 scale digital mapping, to the nearest 15°.

3.1.5 The foregoing assumptions provide a level of accuracy consistent with the assumptions discussed the Assessment Methodology above.

4.0 ASSESSMENT OF POTENTIAL EFFECTS

4.1 Summary of Predicted Occurrence of Shadow Flicker

4.1.1. **Table 2**, below, details the results of the calculations carried out of the theoretical maximum shadow flicker effects at the identified receptors, and the likely duration (assuming 30% per annum bright sunshine).

Table 2: Potential Shadow Flicker Effects

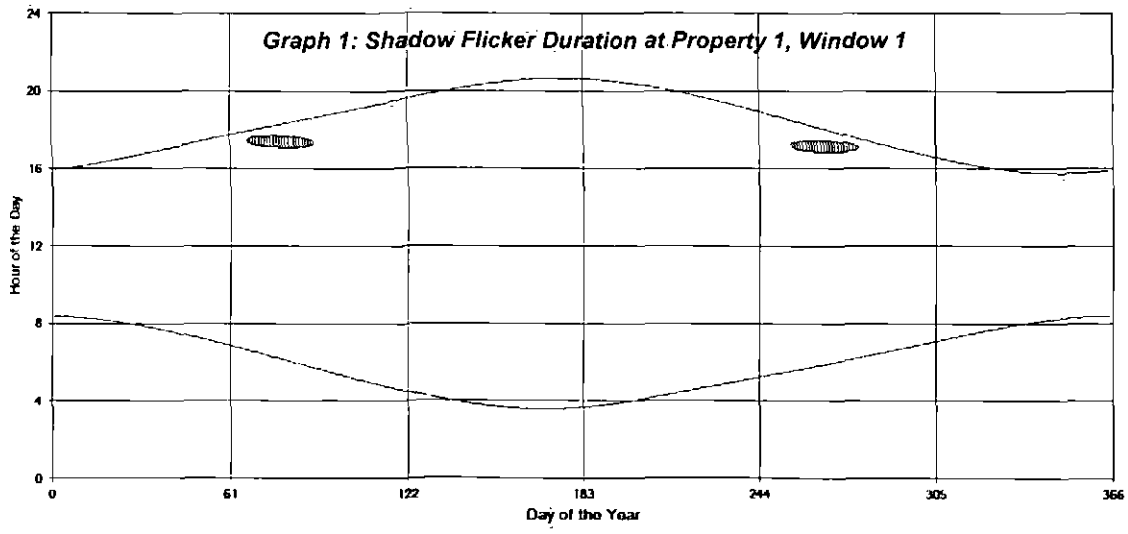
Ref Property	Window	Orientation[5]	Days per Annum	Hours per Day		Total Hours per Annum	
				Max	Mean	Max	Mean
1 The Lodge	1	180°	48	0.61	0.47	29.3	22.6
	2	270°	48	0.61	0.48	29.3	23.0
2 Robin Hood Pub	1	212°	53	0.65	0.51	34.5	27.0
	2	302°	53	0.65	0.51	34.5	27.0
3 Burntwood Court	1	164°	0	0.00	0.00	0.0	0.0

4.1.2. It should be noted that in practice the effects are likely to be far less than those predicted above as a result of the factors previously identified [para 2.2.8].

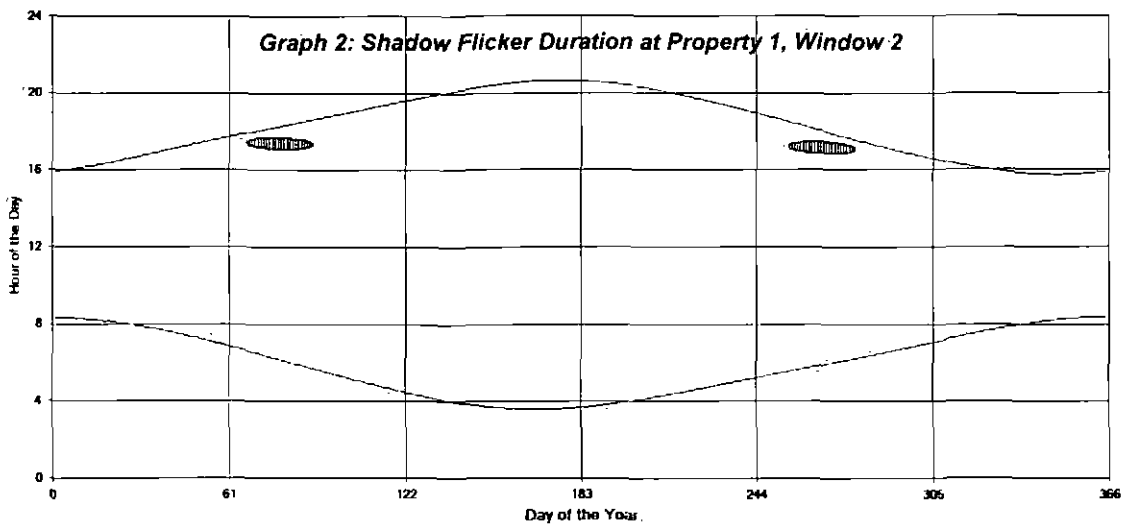
4.1.3. Charts showing the times of day and year when effects are predicted to occur [for the worst affected window in each case] and a discussion of the results for each property are presented below.

4.2 Evaluation of Effects

Property 1: The Lodge



[5] Degrees from North.

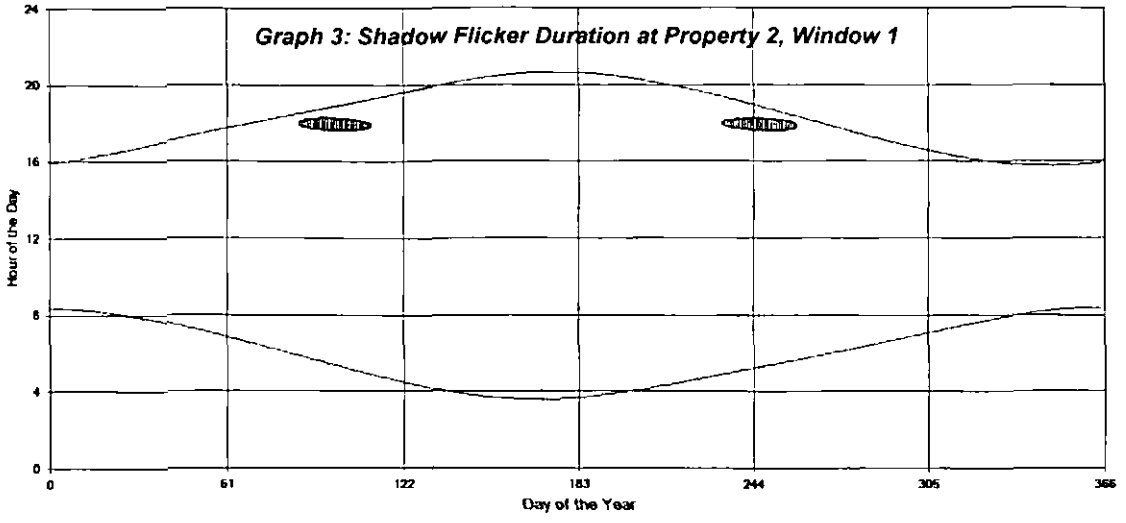


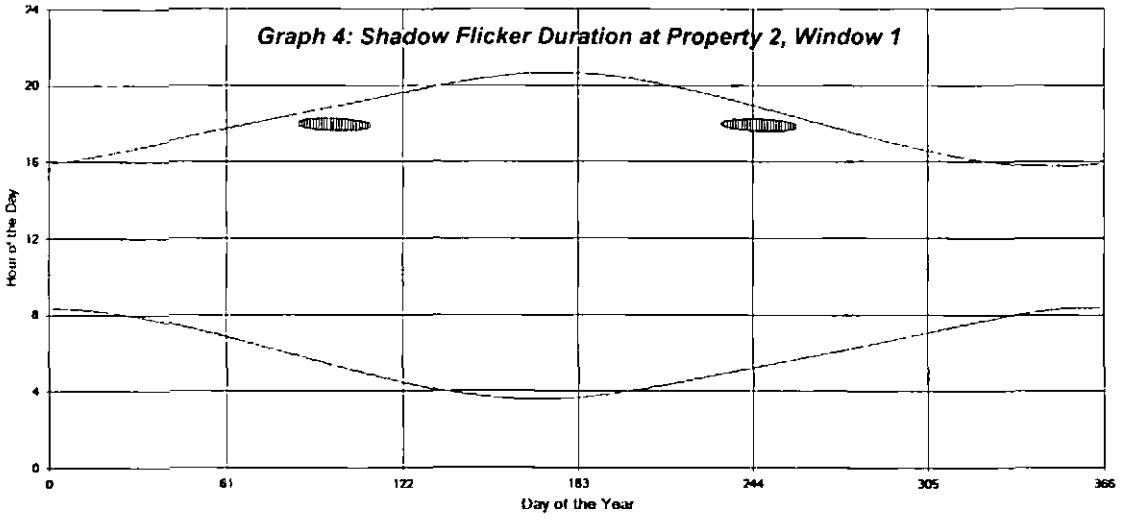
4.2.1 The graphs here [Graphs 1 and 2] illustrate the period during the day that shadow flicker has been predicted to occur at The Lodge on both windows 1 and 2, which would face the turbine either fully or partly.

4.2.2 The data demonstrates that at The Lodge, the shadow flicker effects would be experienced during the months of March and September on a maximum of 48 days (or 24 days in each of March and September). The data also demonstrates that the shadow flicker effect would be experienced for an average of 29mins on each of the 48 days and would occur at approximately 5.30pm (prior to dusk). The maximum duration of shadow flicker (the peak effect) on one day during March and one day during September would be 37mins. There is a negligible difference identified in the data between Windows 1 and 2.

4.2.3 It should be noted that to the west of this property, in the intervening landscape to the turbine, is a cluster of mature trees which is expected to greatly assist in mitigating any shadow flicker impacts on the property.

Property 2: Robin Hood Public House





4.2.4 The graphs here [Graphs 3 and 4] illustrate the period during the day that shadow flicker has been predicted to occur at the Robin Hood Public House on both windows 1 and 2, which would face the turbine either fully or partly.

4.2.5 The data demonstrates that at the Robin Hood Public House, the shadow flicker effects would be experienced during the periods of late March, early April and late August, early September on a maximum of 53 days (or 26.5 days in each of the late March, early April and late August, early September periods). The data also demonstrates that the shadow flicker effect would be experienced for an average of 31mins on each of the 53 days and would occur at approximately 6.00pm (prior to dusk). The maximum duration of shadow flicker (the peak effect) on one day during each of the late March, early April and late August, early September periods would be 39mins. There is no difference identified in the data between Windows 1 and 2.

4.2.6 It should be noted that to the west of this property, in the intervening landscape to the turbine, is a cluster of mature trees which is expected to greatly assist in mitigating any shadow flicker impacts on the property.

Property 3: Parkwater Farm and Vittlefields Offices

4.2.7 The data confirms that Property 3: Burntwood Court would not be affected by shadow flicker.

4.3 Other Potential Effects

4.3.1 The assessment undertaken only addresses the effects of shadows within buildings. However, moving shadows are also apparent out of doors, although these do not result in flicker in the same manner or to the same extent. The intensity of effect is amplified indoors due to the periodic interruption of light entering windows.

4.3.2 Flicker effects will only occur during the operational phase of the turbine and there will be no effects during the construction or decommissioning.

5.0 MITIGATION

5.1.1 Although there are no UK guidelines which quantify the shadow flicker exposure levels which would be acceptable, the theoretical annual duration of shadow flicker at the only property identified is relatively low. Therefore, even where particular combinations of circumstances arise that result in nuisance, mitigation to counteract the potential exposure to acceptable levels can easily be incorporated.

5.1.2 These mitigation measures range from planting tree belts [or indeed improving existing tree belts], between the affected window and the turbines, to shutting down the turbines using turbine control systems during periods when shadow flicker could theoretically occur.

5.1.3 In this instance the mitigation proposed would be a 'Shadow Flicker Mitigation Protocol', which could be imposed as a planning condition, detailing that the wind turbines would be operated in accordance with a shadow flicker mitigation scheme which would be submitted to and approved by the Local Planning Authority prior to the operation of the turbine. BERR's 'Onshore Wind Energy Planning Conditions Guidance Note [2007][6]' suggests the following condition:

"The operation of the turbines shall take place in accordance with the approved shadow flicker mitigation protocol unless the Local Planning Authority gives its prior written consent to any variation."

5.1.4 Below is an example of a shadow flicker protocol that could be implemented for the proposed development:

1. *"Every turbine and the nearby buildings window sizes, elevations and orientations of potentially effected buildings are mapped;*
2. *A computer model is created of the Wind Farm layout together with the details of nearby buildings window sizes, elevations, orientations;*
3. *A shadow flicker assessment is undertaken in the computer model which details the days and periods in each day that each turbine may cause shadow flicker to the buildings;*
4. *The times of potential shadow flicker are inputted into the turbine control system and each turbine is fitted with a sunlight detector; and*
5. *When the control system detects that it is both sunny and is in a time of potential shadow flicker then the turbine will shut down until there is no sun or the time passes for potential shadow flicker."*

[6] Onshore Wind Energy Planning Conditions Guidance Note – A report for the Renewables Advisory Board and BERR, October 2007

6.0 SUMMARY OF KEY FINDINGS AND CONCLUSION

6.1.1 A shadow flicker assessment has been undertaken for three buildings within 440m of the proposed turbine location. The turbine modelled in this assessment is a 44m blade diameter turbine, which provides a worst case scenario in terms of the potential area susceptible to shadow flicker.

6.1.2 It has been shown that under worst case conditions, the maximum occurrence of shadow flicker amounts to 34.5 hours per year, experienced at the Robin Hood Public House. The time of day when shadow flicker is likely to occur is at approximately 5.30pm during the months of March, April, August and September and there would be a maximum duration of 39mins on a day in each of March and September. In addition, a residential property, The Lodge, would experience a maximum of 29.3 hours per year of shadow flicker. The time of day when shadow flicker would occur would be approximately 6.00pm during the months of March and September and there would be a maximum duration of 37mins on a day in each of March and September.

6.1.3 Full details of the potential shadow flicker are shown in **Table 2**.

6.1.4 It is important however to note that these are the theoretical maximum number of shadow hour figures per year and do not take the following into account:

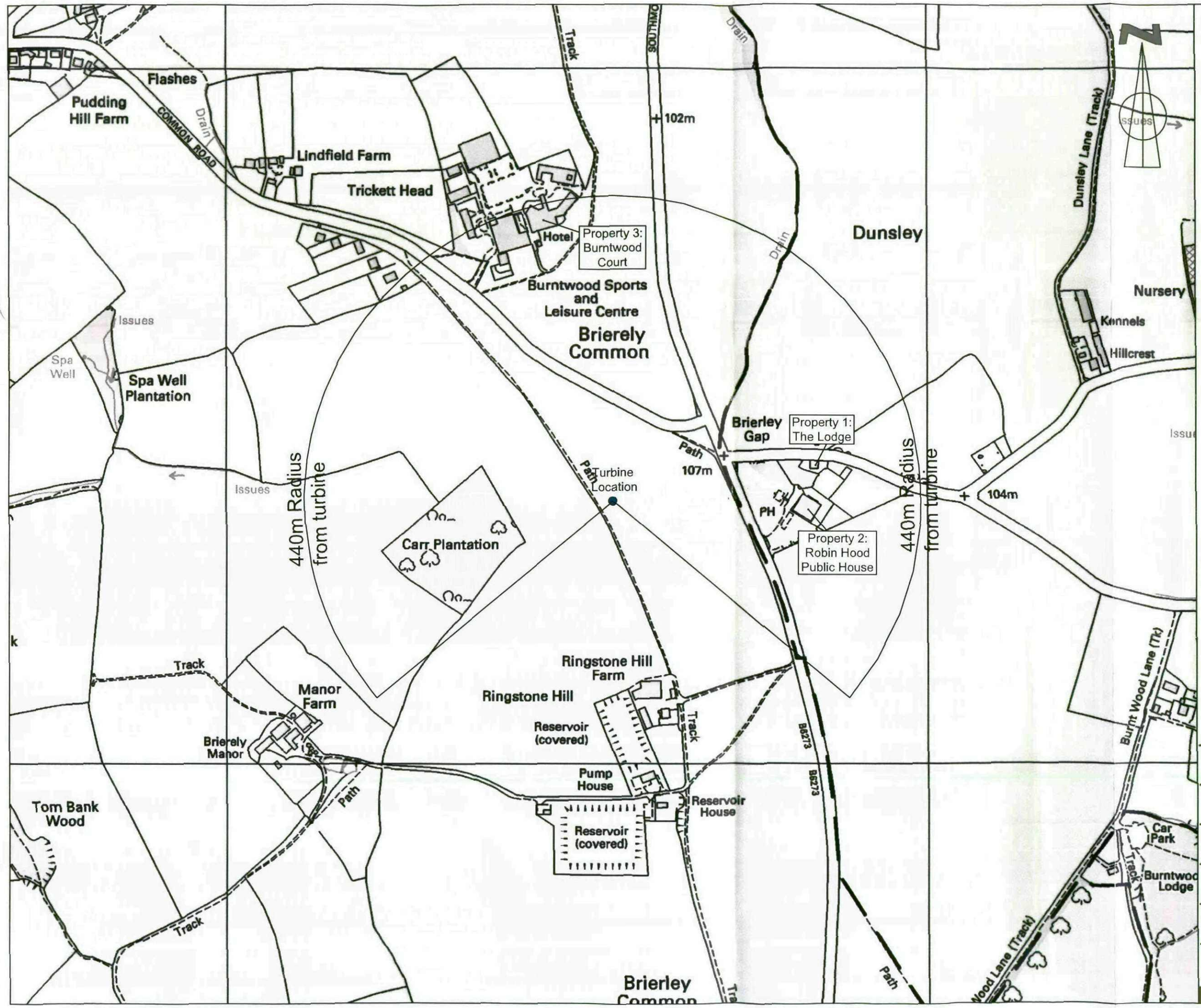
- The weather conditions [i.e. no sun or partially cloudy];
- Local visual obstructions [such as trees, hedges or other structures]; or
- The turbine orientation and turbine operation.

6.1.5 In real terms the length of time when shadow flicker occurs will be far less than has been predicted. Furthermore, it is also important to note that the affected windows may well be in rooms that are not in use at the times when effect are predicted to occur.

6.1.6 If shadow flicker is found to cause a nuisance, mitigation measures will be implemented in order to reduce and were possible remove the occurrence of shadow flicker. In this instance mitigation would be achieved by the imposition of a 'Shadow Flicker Mitigation Protocol' as a planning condition in agreement with the local authority.

7.0 REFERENCES

- National Society for Epilepsy (2007) Information on Epilepsy: Photosensitive Epilepsy;
- ODPM (2005) Planning for Renewable Energy A Companion Guide to Planning Policy Statement PPS22: Renewable Energy, HMSO;
- Clarke A.D (1991) A Case of Shadow Flicker/Flashing: Assessment and Solution, Open University; and
- Harding, G.F.A., Harding, P. and Wilkins A.J. (2008) Wind turbines, flicker and photosensitive epilepsy: Characterising the flashing that may precipitate seizures and optimising guidelines to prevent them. Epilepsia [Volume 49 Issue 6, Pages 1095 – 1098].



N.B. A 440m radius from the turbine has been taken as the maximum study area. A 130° angle has been taken from the northing on both sides of the 0° axis to refine the study area.

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CLIENT:	Empirica Investments
SCALE: 1:25,000@A3	PROJECT NO: SHF.309.001
DRAWN: JM / CHECKED: PT	DATE: Dec 2011
PROJECT:	Ringstone
TITLE:	Shadow Flicker Plan
FIGURE REF:	1

Environmental Co-ordination

EIA/ES GAP Analysis

Environmental Reviews

Environmental Planning

Landscape and Urban Design

Landscape Assessment

Visual Assessment

Historic Setting Assessment

Noise and Vibration Assessment

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