Kyoto energypark

Appendix G

Assessment of Environmental Issues
Shadow Flicker and Blade Glint
Garrad Hassan
(28 August 2008)

pamada

ASSESSMENT OF ENVIRONMENTAL ISSUES FOR THE PROPOSED KYOTO ENERGY PARK - SHADOW FLICKER & BLADE GLINT

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C	28 Aug 2008	Minor revisions following client feedback. Layout revised to 42 wind turbines.

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1 EXECUTIVE SUMMARY

Pamada Pty Ltd. (Pamada) is developing the Kyoto Energy Park near Scone, New South Wales. Garrad Hassan Pacific (GH) has been requested by Pamada to carry out a variety of environmental studies relating to the installation of wind turbines across two sites within the Kyoto Energy Park project. The key findings in the report are:

Shadow Flicker

Shadow flicker from wind turbines can occur when the sun is low in the sky and moving shadows are cast by the rotating blades on to the area around them. When viewed from a stationary position this can appear as a flicker. To carry out their assessment, GH has drawn on various other guidelines most notably that of the Victorian wind farm guidelines [1]. Shadow flicker calculated in this manner overestimates the number of annual hours of shadow flicker experienced at a specified location [2, 3] due to several reasons, outlined later in the report.

- The modelling of shadow flicker conducted here has been done using simple geometric analyses where the wind turbine has been modelled assuming all wind turbines are disc objects positioned in the worst case with respect to shadow flicker, and the sun has been assumed to be a point light source.

- GH has adopted the more conservative approach and has used a limit to the length that a shadow can be cast of 1 km [4].

Analysis of duration of shadow flicker has been conducted for the area around the proposed Kyoto Energy Park, with approximation of shadow diffusion with distance. A map has been produced for regions immediately around the proposed development showing the predicted hours per annum of shadow flicker.

- Based on supplied house locations [5], no nearby house has modelled shadow flicker of greater than 30 hours per annum and therefore shadow flicker is not expected to be a constraint to this development.

Blade Glint

- Blade glint is the regular reflection of sun off rotating turbine blades. Its occurrence depends on a combination of circumstances arising from the orientation of the nacelle, angle of the blade, and the angle of the sun [6]. The reflectiveness of the surface of the blades is also important, and this is to some extent influenced by colour and age of the blade. Matt surface finishes can be specified to minimise blade glint. Blade glint is an aspect which can be a potential distraction to drivers if roads are aligned towards turbines. The effect can be noticed over considerable distances, but is usually very minor.

- Blade glint can be effectively and cost effectively managed through the use of matt coatings on the turbine blades.

2 DESCRIPTION OF THE WIND FARM SITE

There are two areas proposed for wind farms, Mountain Station and Middlebrook Station. The Mountain Station and Middlebrook Station sites areis located approximately 9 km and 7.5 km respectively west of Scone in New South Wales, as shown in Figure 1.

The Mountain Station site is an area of escarpments and ridges on the western side of the Hunter Valley. The proposed wind farm lies on a prominent escarpment called Mount Moobi and nearby ridgelines. Mount Moobi is of elevation between 600m and 640m which runs approximately north-south. Terrain slopes around the Main Ridge can be described as moderate to the west and complex in all other directions, as there are steep slopes present, particularly to the east.

Various configurations of turbine sizes are under consideration. The proposed maximum blade tip height is 150m agl..

3 SHADOW FLICKER

At present there are no formal regulations or guidelines in NSW pertaining to Shadow Flicker. To carry out their assessment, GH has drawn on various guidelines which are referenced in the section below.

3.1 Shadow Flicker Assessment Methodology

Due to their height wind turbines can cast shadows on the areas around them. Coupled with this, the moving blades create moving shadows. When viewed from a stationary position the moving shadows appear as a flicker giving rise to the phenomenon of 'shadow flicker'. When the sun is low in the sky the length of the shadows increases, increasing the shadow flicker affected area around the wind turbine.

The number of annual hours of shadow flicker at a given location can be calculated using simple geometrical models incorporating data such as the sun path, the topographic variation and wind turbine details such as rotor diameter and hub height. In such models, the wind turbine rotor is modelled as a disc and assumed to be in the worst case (i.e. perpendicular) to sun-turbine vector. Further, the sun is assumed to be a point light source.

Shadow flicker calculated in this manner overestimates the number of annual hours of shadow flicker experienced at a specified location [2, 3] due to several reasons.

1. The occurrence of cloud cover has the potential to significantly reduce the number of hours of shadow flicker.

2. The probability of wind turbines consistently yawing to the 'worst case' scenario where the wind turbine is facing into or away from the sun- wind turbine vector is less than 1 (i.e. less than 100% of the time).

3. The amount of aerosols in the atmosphere has the ability to influence shadows cast.

   Firstly, the distance away from a wind turbine that shadows can be cast is dependent on the degree that direct sunlight is diffused, which is in turn dependent on the amount of dispersants (humidity, smoke and other aerosols) in the path of light between the light source (sun) and the receiver [2].

   Secondly, the quantity of aerosols in the air is known to vary with time and it has the potential to vary the air density, thereby affecting the refraction of light. This in turn affects the intensity of direct light to cause shadows.

4. The modelling of the wind turbine blades as discs to determine shadow path overestimates the shadow flicker effect.

   The blades are of non-uniform width with the thickest viewable blade width (maximum chord) occurring closer to the hub and the thinnest being located at the tip of the blade. As outlined in point 3 above, the direct sunlight is diffused resulting in a maximum distance from the wind turbine that a shadow can be cast. This maximum distance is dependent on the human threshold which variation in light intensity can be perceived [2]. When the blade tip causes shadow, the diffusion of direct sunlight means that the light variation threshold occurs closer to the wind turbine than when a shadow is caused by the maximum chord. That is, the maximum shadow length cast by the blade tip is less than by the maximum chord.

5. Modelling the sun as a point light source rather than a disc has an effect similar to that of point 4 above.

   Firstly, situations arise where the light rays from different portions of the sun disc superimpose around a shadow resulting in light intensity variations less than human perception.

   Secondly, when the sun is positioned directly behind the wind turbine hub, there is no variation in light intensity at the receiver location and therefore no shadow flicker. However, when the sun is modelled as a point source, shadow flicker still arises.

6. The presence of vegetation shields incidences of shadow flicker.

7. Periods where the wind turbine is not in operation due to low winds, high winds or operational and maintenance reasons.

Taking the above issues into account, the modelling of shadow flicker has been conducted using simple geometric analyses. The wind turbine has been modelled assuming all wind turbines are disc objects positioned in the worst case with respect to shadow flicker. The sun has been assumed to be a point light source.

Due to points 3 and 4 above, an approximation for the maximum length of shadow flicker cast has been used. Guidance from the South Australian Government indicates that this distance is 500 m [7]. GH has adopted a more conservative approach and has used a limit to the length that a shadow can be cast of 1 km [4].

Therefore, with the exception of the 1 km limit on shadow length, the modelling conducted here represents a very conservative scenario and is believed to overestimate the actual annual hours of shadow flicker experienced at a location.

Analysis of duration of shadow flicker has been conducted for the area around the proposed Kyoto Energy Park, with approximation of shadow diffusion with distance. A map has been produced showing the predicted hours per annum of shadow flicker, and this is provided in Figure 2 and Figure 3 for the Middlebrook and Mountain Station sites respectively.

3.2 Shadow Flicker Compliance Assessment

GH has adopted the guidelines for the development of wind farms in Victoria [1]. The issue of shadow flicker is addressed where it is stated that:

> *"The shadow flicker experienced at any dwelling in the surrounding area must not exceed 30 hours per year as a result of the operation of the wind energy facility."*

3.3 Shadow Flicker Assessment Results

Annual shadow flicker durations have been modelled for the area around the proposed Kyoto Energy Park. Modelling of the annual hours of shadow flicker is a good design principle to minimise the effect of wind farms on neighbouring properties.

GH has been supplied with house locations [5], and these have been used to review the modelled shadow flicker at nearby houses. From Figure 2 and Figure 3 it can be seen that there is only one residence that falls within 1 km of the proposed development. This residence is owned by the landholder of the proposed Middlebrook section of the development, and is situated east of the proposed Energy Park as shown in Figure 2. Based on the methodology outlined here, this house has 7 hours per annum of modelled shadow flicker. The falls well within the *Victorian Wind Energy Development Guidelines* [1] of 30 hours per annum.

4 BLADE GLINT

An issue sometimes raised with respect to wind projects is blade glint. This refers to the potential for the movement of the blades to catch the light and produce glint which may be seen from surrounding areas. The paint used on modern blades and tower of the wind turbines helps to significantly reduce any occurrence of glinting. Due to the atmospheric variations raised in Section 3 above, and the complex geometry of the wind turbines and the surrounding terrain, it is almost impossible to estimate where and when glinting may occur. If it were to occur, as with shadow flicker, it would only occur for a short period as the sun moves in the sky.

At present there are no formal regulations or guidelines in NSW pertaining to Blade Glint. To carry out their assessment, GH has drawn on the Victorian wind farm guidelines [1].

> *Blade Glint*
>
> > *Blade glint can result from reflection of the sun from the turbine blades.*
>
> *Evaluation*
>
> > *Blades should be finished with a surface treatment of low reflectivity to ensure that glint is minimised.*

Blade glint can be effectively and cost effectively managed through the use of matt coatings on the turbine blades and, if so done, is not considered to be a visual impact.

5 CONCLUSIONS AND RECOMMENDATIONS

Shadow Flicker

At present there are no formal regulations or guidelines in NSW pertaining to Shadow Flicker. To carry out their assessment, GH has drawn on various other guidelines most notably that of the Victorian wind farm guidelines [1].

The modelling of shadow flicker conducted here has been using simple geometric analyses. The wind turbine has been modelled assuming all wind turbines are disc objects positioned in the worst case with respect to shadow flicker. The sun has been assumed to be a point light source.

An approximation for the maximum length of shadow flicker cast has been used. GH has adopted a more conservative approach and has used a limit to the length that a shadow can be cast of 1 km [4].

Analysis of duration of shadow flicker has been conducted for the area around the proposed Kyoto Energy Park, with approximation of shadow diffusion with distance. A map has been produced for regions immediately around the proposed development showing the predicted hours per annum of shadow flicker.

House locations have been supplied to GH [5], and shadow flicker durations have been modelled at these locations. No house has modelled shadow flicker duration of greater than 30 hours, and therefore shadow flicker is not expected to be an issue at nearby houses.

Blade Glint

At present there are no formal regulations or guidelines in NSW pertaining to Blade Glint. To carry out their assessment, GH has drawn on various other guidelines most notably that of the Victorian wind farm guidelines [1]:

> *Blade Glint*
> *Blade glint can result from reflection of the sun from the turbine blades.*
> *Evaluation*
> *Blades should be finished with a surface treatment of low reflectivity to ensure that glint is minimised.*

Blade glint can be effectively and cost effectively managed through the use of matt coatings on the turbine blades and, if so done, is not considered to be a visual impact.

6 REFERENCES

1 "Policy and planning guidelines for development of wind energy facilities in Victoria", Sustainable Energy Authority Victoria, 2003.

2 Freund H-D., Kiel F.H., "Influences of the opaqueness of the atmosphere, the extension of the sun and the rotor blade profile on the shadow impact of wind turbines", DEWI Magazin 20, Feb 2002.

3 Osten, T. & Pahlke T., "Shadow Impact on the surrounding of Wind Turbines", DEWI Magazin 13., Aug 1998.

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6 Energy-Wise Renewables "Guidelines for Renewable Energy Developments - Wind Energy", Energy Efficiency and Conservation Authority New Zealand, June 1995.

7 Planning SA, Planning Bulletin "Wind Farms, Draft for Consultation", South Australian Government, 2002.

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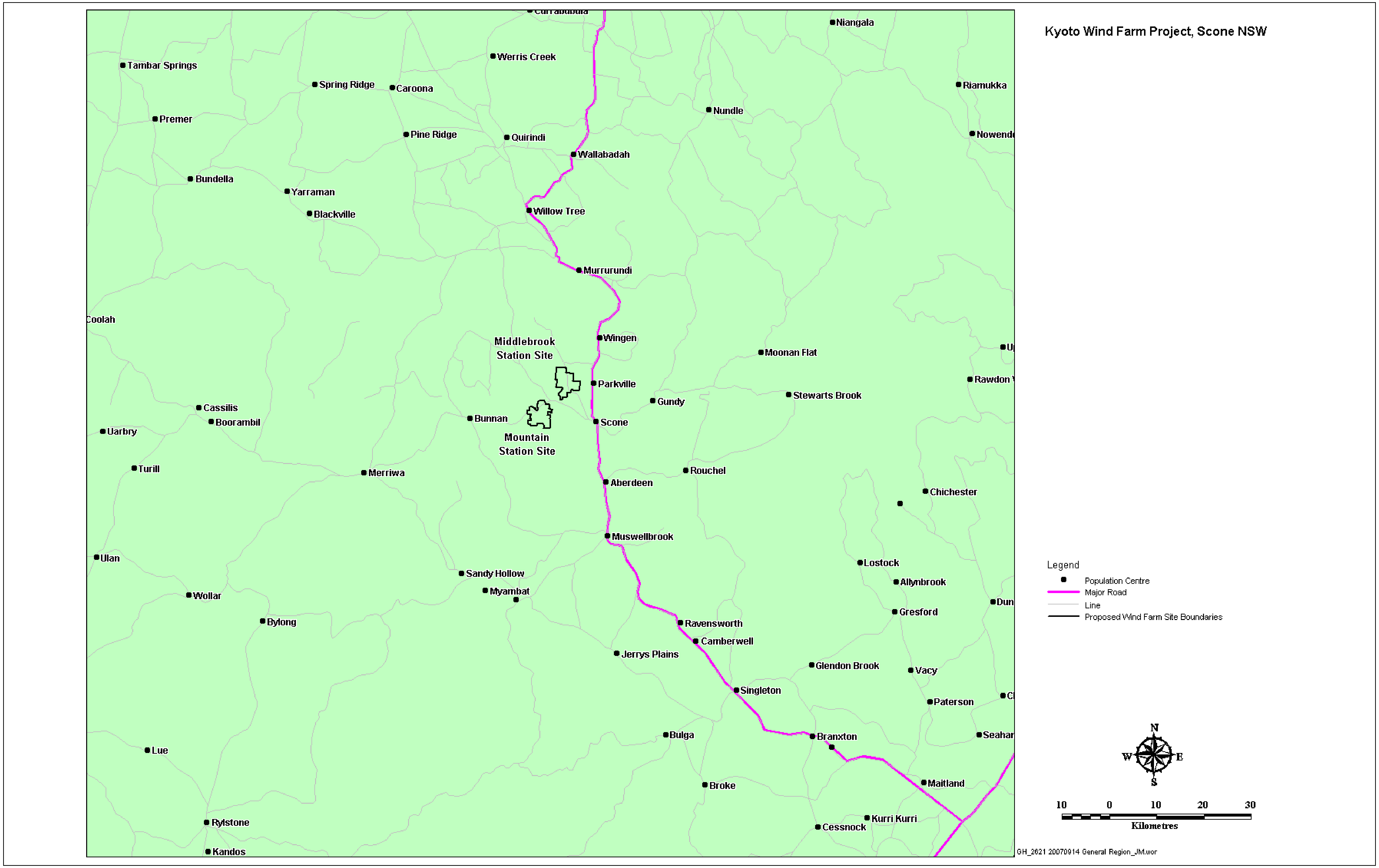

Figure 1 Location of proposed Kyoto Wind Park

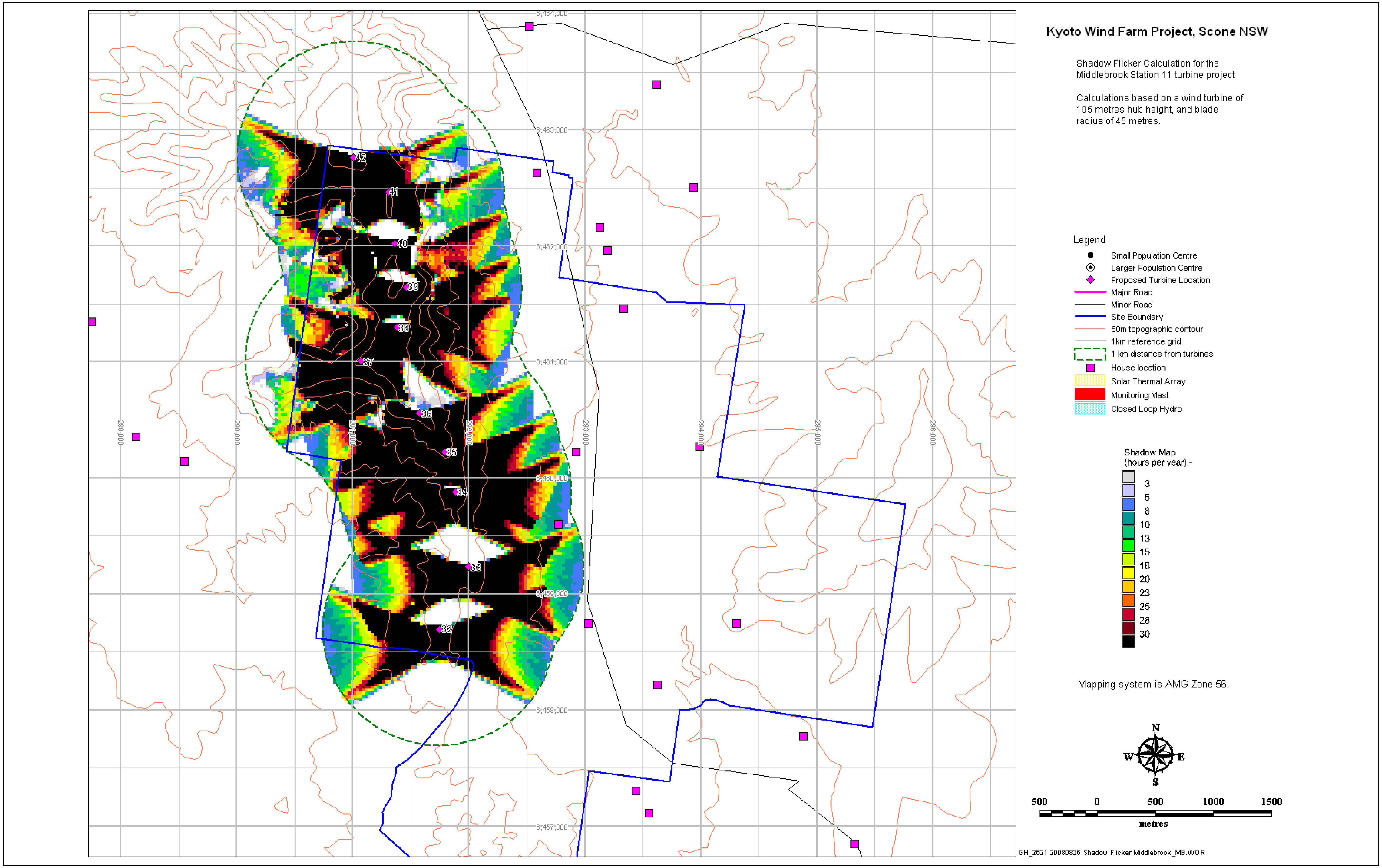

Figure 2 **Modelled number of shadow flicker hours for the region proximate to the Middlebrook section of the proposed Kyoto Energy Park.**

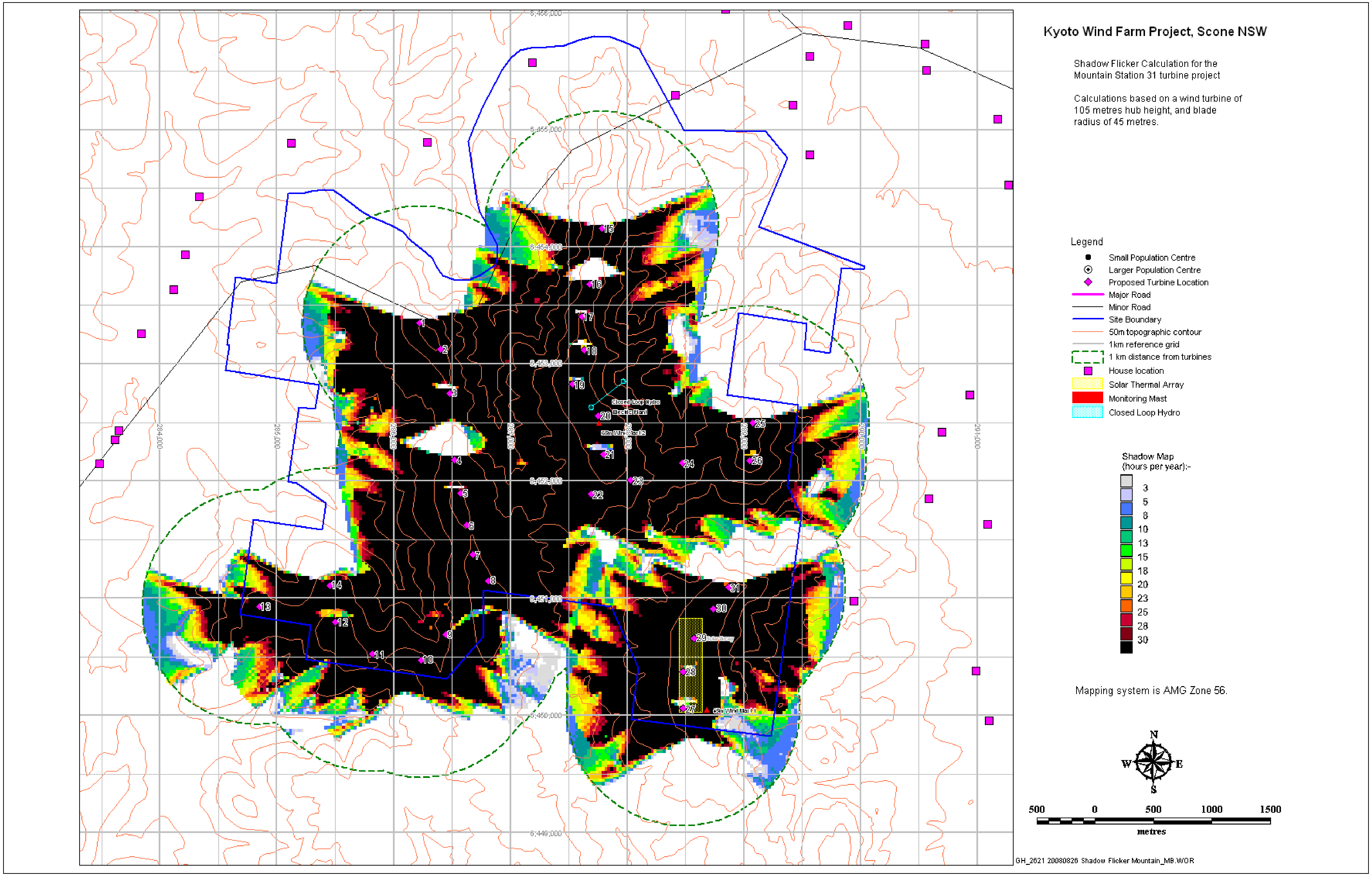

Figure 3 Modelled number of shadow flicker hours for the region proximate to the Mountain Station section of the proposed Kyoto Energy Park.