Flyers Creek Wind Farm Pty Ltd

Flyers Creek WIND FARM

Environmental Assessment

CHAPTER 9
Visual Assessment

9. Visual Assessment

This chapter of the Environmental Assessment addresses the Director-Generals' requirements relating to visual impact assessment. It includes a landscape analysis, a detailed description of the assessment methodology and results of the visual impact assessment together with supporting material and photomontages which are provided in Appendix C of this document.

9.1 Introduction

Wind turbines, by their nature, are usually located in elevated exposed positions and as large structures, can be highly visible. The proposed development is no exception in this regard and the wind turbines will be clearly visible from a range of viewing points. Additionally, community consultation for wind farm projects often identifies a portion of the local community that dislikes the appearance of the wind turbines or prefers the landscape to remain unchanged. Accordingly, visual issues are recognised as being a key aspect of the environmental assessment process.

9.2 Summary of Visual Characteristics

The key characteristics affecting visual amenity that need to be considered in the planning stages of a wind power development are as follows (National Research Council, 2007, EPHC, 2010):

- Scale
- Number of turbines in the view
- Visual clutter
- Visibility of project infrastructure
- Noise
- Lighting
- Landscape elevation

Section 9.2 reviews the physical aspects of the wind farm, the landscape character and the visual elements that may affect the community's opinion of the development's visual impact.

9.2.1 Wind farm visual characteristics

The wind farm involves the turbines, electrical connection works and access tracks. Of these, the wind turbines will be the most visible facilities. Elements of the wind farm that contribute to the visual impact to varying degrees are shown in Table 9.1. Wind turbine structures will have the general form shown in Figure 1.3.

The actual wind turbine model will be confirmed by a tender process. Typical turbines that could be selected for the project will likely have a hub height of between 80 -100 metres and a blade length of 44 – 55 metres. In any case, the total height of the wind turbine to the top of the blade tip will be no more than 150 metres. The indicative wind turbine for this Environmental Assessment, the GE 2.5 MWxl, has a hub height of 85 metres and a blade length of 50 metres for a total height of 135 metres. However, for this visual assessment, the dimensions of the wind turbine were assumed to be a hub height of 100 metres and a blade length of 50 metres. Therefore, this assessment is a 'worst case' based on the maximum height of the wind turbine being 150 metres above ground level.

The turbines will have three blades. The literature suggests that this number of blades is more visually balanced than turbines with only two blades. It is proposed that the turbines be finished in a matte white or similar light neutral colour. Documented experience of wind farms also suggests that finishing the turbines in a pale unobtrusive colour gives the most acceptable result (National Research Council, 2007; EPHC, 2010). Surface finishes will have low reflectivity to minimise an effect referred to as 'Glint' (See Section 9.13).

The substation component elements will mostly have a height less than 10 metres and can be effectively screened by the combination of siting, topography and by trees. Additional screening through planting of trees could be undertaken if required, subject to adequate clearances being

maintained. One or two pole structures may be required adjacent to the substation as part of the grid connection.

Access tracks are at ground level and most will not be visible from surrounding viewpoints as the tracks themselves are higher than the viewpoints. Where necessary, their visibility can mostly be mitigated by positioning of the tracks, suitable earthwork formation and revegetation to minimise visibility.

Table 9.1 – Wind farm components and key visual characteristics

Wind Farm component	Visual characteristic
Tower and hub	Tapered steel tower, fitted with an internal ladder or lift, 80 to 100 metres in height with an approximate diameter of five metres at the base and 2.5 metres at the top
Turbine	Three bladed with rotor diameter of between 88 and 112 metres (up to 55 metre blades) and Nacelle
Turbine rotation (rpm)	14 to 18 revolutions per minute
Colour	Matte off-white colour or similar light neutral colour
Generator transformer	Located within the nacelle (not visible) or near the base of each turbine – suitable shade of green (depending on turbine model)
33 kV underground cables	Underground power and control cables will connect the wind turbines within each group
33 kV/132 kV Substation	About 120 by 80 metres with a number of small buildings, height of structures mostly less than 10 metres but with busbars and supporting structures up to 25 metres high
33 kV overhead line	One to two metres wide by 10.5 kilometres with several wood or concrete poles could be used to support the conductors
132 kV overhead line	The connection requires a 15 kilometre section of overhead 132 kV volt power line between the substation and the existing overhead line on the Cadia Mine Site
Site entry points	Various signposted, gates. Preliminary discussions on the locations for entrances have been undertaken with the Blayney Shire Council. Still to be finalised
Site access tracks	38 kilometres of access tracks of 8 to 10 metres width. These will be unsealed and predominantly between the turbines with several access tracks leading up onto the ridges where the turbines will be located. This includes both upgraded and new tracks

9.2.2 Wind farm layout

The placement of the turbines has been designed to utilise sites that maximise the energy produced from the wind farm; however, significant consideration was also given to the following aspects:

- Provision of sufficient distance to existing residences to ensure the noise criteria is not exceeded
- Visual amenity considerations
- Reducing the occurrence of shadow flicker at neighbouring residences
- Site suitability for the type of turbines to be installed and for accessibility
- Spacing of turbines so that the disturbance of air flow has minimal affect on adjacent turbines
- Capacity of the existing transmission infrastructure to which the wind farm can connect

Some turbine sites offering high electricity generation potential have been excluded from the wind farm due to ecological considerations, proximity to residences and/or community concerns.

The exact details of the layout will be finalised after planning consent has been obtained, contracts for equipment supply and construction have been awarded and geo-technical surveys have been completed. As previously discussed in Chapter 6, turbine sites 1 and 2 were deleted from the project and Turbine 31 was moved further from the closest neighbouring residence following community consultation.

For the purposes of the assessment, the turbines have been grouped by location on a common topographic feature or where they have common access routes (Table 9.2). Ancillary components of the wind farm include the substation, access tracks, electrical collections circuits and the grid connection arrangement.

Table 9.2 – Wind farm turbine groupings

Wind farm component	Number of Turbines	Turbine numbers	General Location
Calvert Group (northern)	10	3 – 12	Northern end of the project area southwest of Beneree. Sites 1 and 2 omitted following community consultation.
Fern Hill Group (central eastern)	8	13 – 20	Small group of turbines about 1 – 2 kilometres west of Beneree Road and north and west of Fern Hill
Hopkins Group (south-western)	17	21 – 37	South-western group located on ridges and hilltops southwest of Errowanbang – Carcoar Road
Halls Gap Group (south-eastern)	9	38 – 46	South-eastern group located on ridges and hilltops east of Errowanbang – Carcoar Road and southeast of Halls Road
Total	**44**		

9.2.3 Visual aspects of the wind farm

The 150 metres maximum height of wind turbines, which is the basis of this assessment, is the height measured to the highest point of the area swept by the turbine rotor. With such heights, some people may compare the turbine structures to tall buildings. However, the wind turbines differ from bulky structures such as buildings in that the supporting towers are only 2.5 to five metres wide. Also, the turbine blades are relatively slender structures that have a maximum width of 3.5 metres near the hub and taper to the tip. When viewed from the side the blades have a very thin profile and present very little of the blade surface. Due to their height, the turbine structures will nevertheless be visible from a considerable distance.

It is likely that many viewpoints will only provide partial views of the wind farm with other parts of it being concealed by topography and/or trees. At other locations, the viewing aspect could be away from the wind farm and at such locations the development may be associated with a minor visual impact.

In general, the moderate size of the properties where the wind farm is located and the low settlement density of most of the surrounding areas, means that the bulk of public views of the wind farm will be distant views.

Neighbouring residences will all be at least one kilometre from the nearest turbine and most at considerably greater distances. It is worth noting the wind turbines have been granted planning approval as close as 500 metres to a neighbouring residence in other states. Given the size of the turbines, their scale in the landscape can be significant for the closest residences. There will be filtered views to the wind farm site from the Mid Western Highway which passes Carcoar about five kilometres southeast of the wind farm site.

The distribution of turbines is irregular, and based on the location of suitable sites, the effect of turbines trailing out of sight along a ridge line or being partially screened by topography can introduce an element of ‘depth’ to some views. Visual impact studies indicate this to be a preferred visual outcome. The spacing of the turbines can also affect the visual impact. The great majority of the turbines are 300-500 metres from the nearest neighbouring turbine.

The rotation of the turbine blades will add an element of movement in the view and could invoke varying responses including visual attraction or annoyance. It may also increase visibility. The three bladed wind turbines will rotate in random phase rather than synchronised rotation and this avoids introducing unnecessary geometry into the rural landscape. The relatively slow rotation speed of the turbines of 14 to 18 revolutions per minute is unlikely to be disturbing to most people. Observers at other wind farm sites have expressed surprise at the slow rotation speed of wind turbines.

Development of the wind farm will introduce large wind turbine structures to the generally rural landscape that will be a new noticeable element in the existing scenes. However, operation of the Blayney Wind Farm in the district for ten years will reduce the sense of novelty and change of the Flyers Creek project, even though the Flyers Creek project is considerably larger. Due to the turbines being located on top of the ridgelines, they will have the potential to attract attention, but they will not obscure views of the existing rural landscape features. Viewers' opinions of the visual impact of the turbines in the landscape will vary widely and are very likely to be influenced by subjective factors that are difficult to quantify. In addition, opinions can change; the Blayney wind farm attracted some opposition when originally proposed, but now it has strong community support.

Compared to the wind turbines, the visual impact of ancillary works will be minor and appropriate design and siting will further reduce their impact. The location of the substation, the grid connection to the Country Energy 132 kV overhead transmission line and the location and design of access tracks as described in Chapter 3 have all been selected with the objective of minimising their visual impact.

9.3 Visual impact assessment methodology

The methodology adopted for the visual impact assessment included the following steps:

- review of local landscape elements (Section 9.4)
- identification of the approximate visual catchment of the wind farm (Section 9.5)
- compilation of a list of assessment sites and photography at each of the sites (Section 9.6)
- computer modelling to generate simulated perspective views of the wind farm (Section 9.8)
- photomontage compilation for selected viewpoints (Section 9.8)
- development of visibility assessment criteria (Section 9.9)
- review of photomontages using visibility assessment criteria (Section 9.10)
  - review of indicative visibility for a range of other viewpoints, mostly residences surrounding the wind farm (Appendix C1)
- review of visual aspects of ancillary works (Section 9.11)
- shadow flicker analysis (Section 9.12)
- review of blade glint issues (Section 9.13)
- consideration of lighting for aviation safety (Section 9.14)
- review of options to mitigate the visual impact of the project (Section 9.15)

A summary of the assessment process and the resultant findings is provided in the following sections. The assessment delivers many of the elements described in the *"Wind Farms and Landscape Values – National Assessment Framework (NAF)"* developed jointly by the Australian Wind Energy Association and Australian Council of National Trusts. Each wind farm site will have its individual characteristics and visual amenity significance and assessment methodologies vary from site to site.

Because visual impact is rather subjective, it is desirable that potentially affected landowners and the Approval Authority have access to realistic representations of the proposed wind farm from a range of vantage points to allow an appreciation of the wind farm's visibility within the landscape. A series of photomontages presenting simulated views of the installed wind farm from eight representative viewing points has been produced and is provided in Appendix C1.

Photomontages of views of the wind farm from representative nearby residences were prepared, subject to landowner consent, and have also been provided in Appendix C1.

9.4 Review of local landscape elements

The proposed wind farm site and much of the landscape surrounding it comprises rural land that has been subject to extensive clearing. It is predominantly used for grazing and has scattered rural residences, farm buildings and associated cultural features including roads, fencing and power lines.

In addition, there are a few areas of remnant woodland vegetation throughout the area. Pine forest plantations occur in places, with the nearest being near the Cadia Mine and located to the north west of the wind farm site. While Cadia's mining activity occurs below ground level there is a large out of pit spoil pile that is visible from parts of the countryside to the west of the Flyers Creek Wind Farm site. There are also two large tailings dams that have limited visibility from a few elevated locations as at lower elevations, the tailings dams are effectively screened by topography and trees.

The topography of the wind farm locality varies from the elevated plateau land in the northeast in the vicinity of Beneree-Forest Reefs area with levels above 900 metres to more dissected land comprising ridges and intervening creeks draining to the south to the Belubula River Valley at levels below 700 metres in the south. The turbine sites are located on elevated ridges and slopes at levels between 750 and 950 metres. A substation will be located in a valley at the north-west of the wind farm site.

In general, the site exhibits a reasonable degree of relief and its ridges are most prominent from viewpoints to the south in the subdued Belubula Valley. There will be filtered views to the wind farm site from the Mid Western Highway and parts of Carcoar. Most roads within a few kilometres of the project area are local roads with low volumes of local traffic and offer intermittent views to parts of the wind farm. Orange, Millthorpe and Blayney are setback from the wind farm site and have intervening topography that is likely to screen any potential for distant views of the wind farm from many viewpoints at these locations.

Elevated topographic features in the broader area surrounding the site include Mt Canobolas (elevation 1,397 metres) located about 18 kilometres to the northwest of the site, Mt Macquarie (elevation 1,200 metres) located some 10 kilometres to the south-east. The Blayney Wind Farm (15 turbines) is located southeast of the Mid Western Highway on the northern slopes of Mt Macquarie around eight kilometres distant.

Roads in the vicinity of the wind farm include:

- sealed Mid Western Highway which passes south-east of the wind farm about four kilometres away at its closest point
- sealed Carcoar Tallwood Mill Road and Blayney to Browns Creek Road located to the east of the site
- sealed Beneree to Errowanbang Road to the north-west of the site
- unsealed Errowanbang to Carcoar Road to the west of the site
- unsealed Gap Road to the east
- sealed Mandurama Burnt Yards to Errowanbang Road to the south-west

Representative views of selected landscape elements in the vicinity of the wind farm are provided in Plates 9.1 to 9.10. Some of the landscape elements reflect particular physiographic features. All of the landscape elements have been influenced by human activities, particularly clearing, farming and settlement of the land. Despite the clearing and settlement activities having occurred relatively recently, many people viewing the landscape scenes might regard them as the natural visual state of the locality.

Plate 9.1 – Tallwood-Beneree landscape viewed from Platform Road (view to the west)

Plate 9.2 – Slattery's Creek Valley landscape (view to the south)

Plate 9.3 – Gooley's Creek landscape (view to the south)

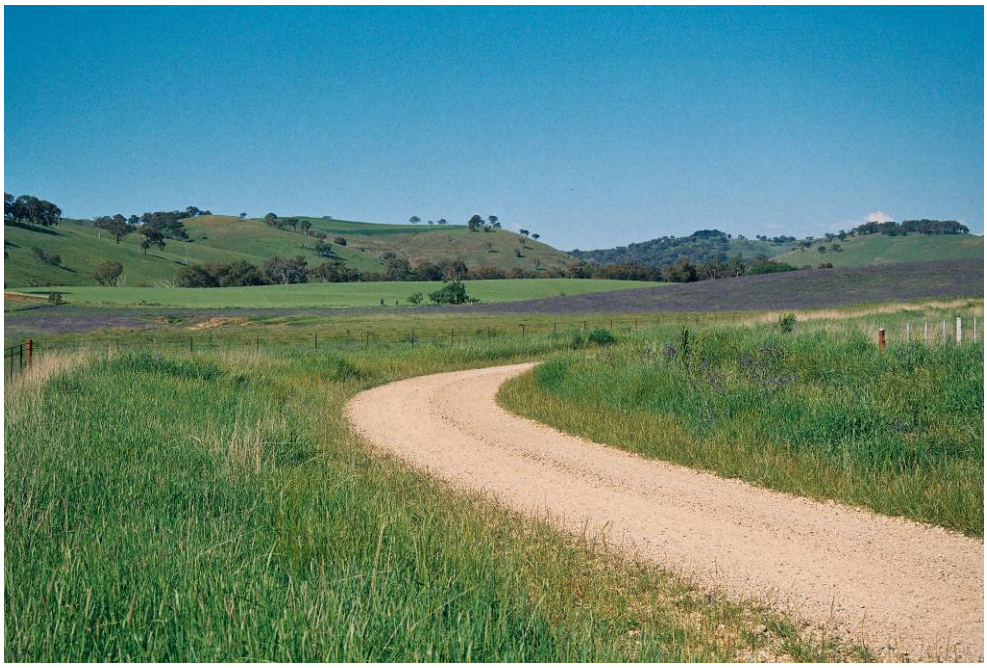


Plate 9.4 – Errowanbang valley landscape viewed from Old Errowanbang Road (view to the east)

Plate 9.5 – Burnt Yards landscape view towards the east and the wind farm site

Plate 9.6 – Gap Road landscape viewed from elevated location near turbine sites and showing a larger area of remnant woodland (view to the south)

Plate 9.7 – Dirt Hole valley landscape - View from Hopkins Trig Reserve towards Fern Hill (view to northeast)

Plate 9.8 – Dunstaffage Lane landscape (view to the south)

Plate 9.9 – Carcoar Village landscape - View of Carcoar Township looking in the east direction from historic railway station

The installation of wind turbines on the ridges at the wind farm locality will add a new element to the landscape scenes. A viewer's perception of this addition to the landscape as either a positive or negative attribute of a scene will vary according to circumstances and opinions. This will depend on a range of factors which are discussed further in Section 9.6.

An existing visible feature of the local landscape is the 15 turbine Blayney wind farm located eight kilometres south of the Flyers Creek wind farm site. The Blayney Wind Farm has strong support within the local community and is featured on the Blayney Shire logo. The wind farm's existence in the local landscape for ten years, and its popularity, indicates that the community is comfortable with the visual presence of wind turbines in the district. The presence of this smaller wind farm was a factor in the decision to proceed with the feasibility stage of the Flyers Creek project.

9.5 Visual catchment of the Wind Farm

The visual catchment of a wind farm is the area of surrounding land from which the wind farm may be wholly or partly visible. For the proposed development, a conservative visual catchment to a distance of up to ten kilometres and beyond was analysed using a Geographic Information System (GIS) that developed a representation of the landform from available topographic data and considered the wind farm details (turbine location and height) in order to map the areas from which the wind farm will be either partially or fully visible (Figure 9.1).

The effect of screening by trees cannot be included in the computation of the visual catchment as data is not readily available for the height and extent of tree cover across the area assessed. The degree of screening by trees may also vary in time depending on the stage of growth of the trees and the extent of any clearing. In addition, the presence of sheds or other buildings are also not included in the GIS analysis. However, trees and sheds can provide substantial screening of elements of the wind farm including blocking views of wind turbines completely. As screening by trees and buildings has not been taken into account, the computed visual catchment shown in this Environmental Assessment will significantly over estimate the extent of the wind farm's visual catchment within the assessed area. Nevertheless, the viewfield figures provide a guide to the extent of the wind farm visibility including

areas where topography will limit views of the wind farm. However, its conservative representation is a 'worst case' scenario.

An inspection of areas surrounding the wind farm was also used to gain further understanding of the visual catchment. Roads, which surround the project area, were travelled and the areas from which the wind farm site could potentially be seen were noted. A range of neighbouring properties were also visited to verify the visual catchment. It was found that the wind farm will be visible over a large area but local topography and vegetation will limit visibility from many locations. In some locations, screening by vegetation is significant. For some residences located to take advantage of district views, views of the wind turbines will be more prevalent.

Figure 9.1 provides a graphic representation of the visual catchment of the wind farm with the shaded areas representing the locations where the wind farm may be fully or partially visible. As can be seen in Figure 9.1, there will be distant views of parts of the wind farm from higher locations such as in Carcoar as can be seen in photomontage 5 in Appendix C1, However the great majority of the viewpoints within Carcoar township are at lower levels and will have no views, or at most partial views, of the wind farm due to screening by topography, aspect, buildings or trees. Contours in Figure 9.1 represent the distance from the wind farm (distance to the nearest wind turbine) with a contour interval of five kilometres.

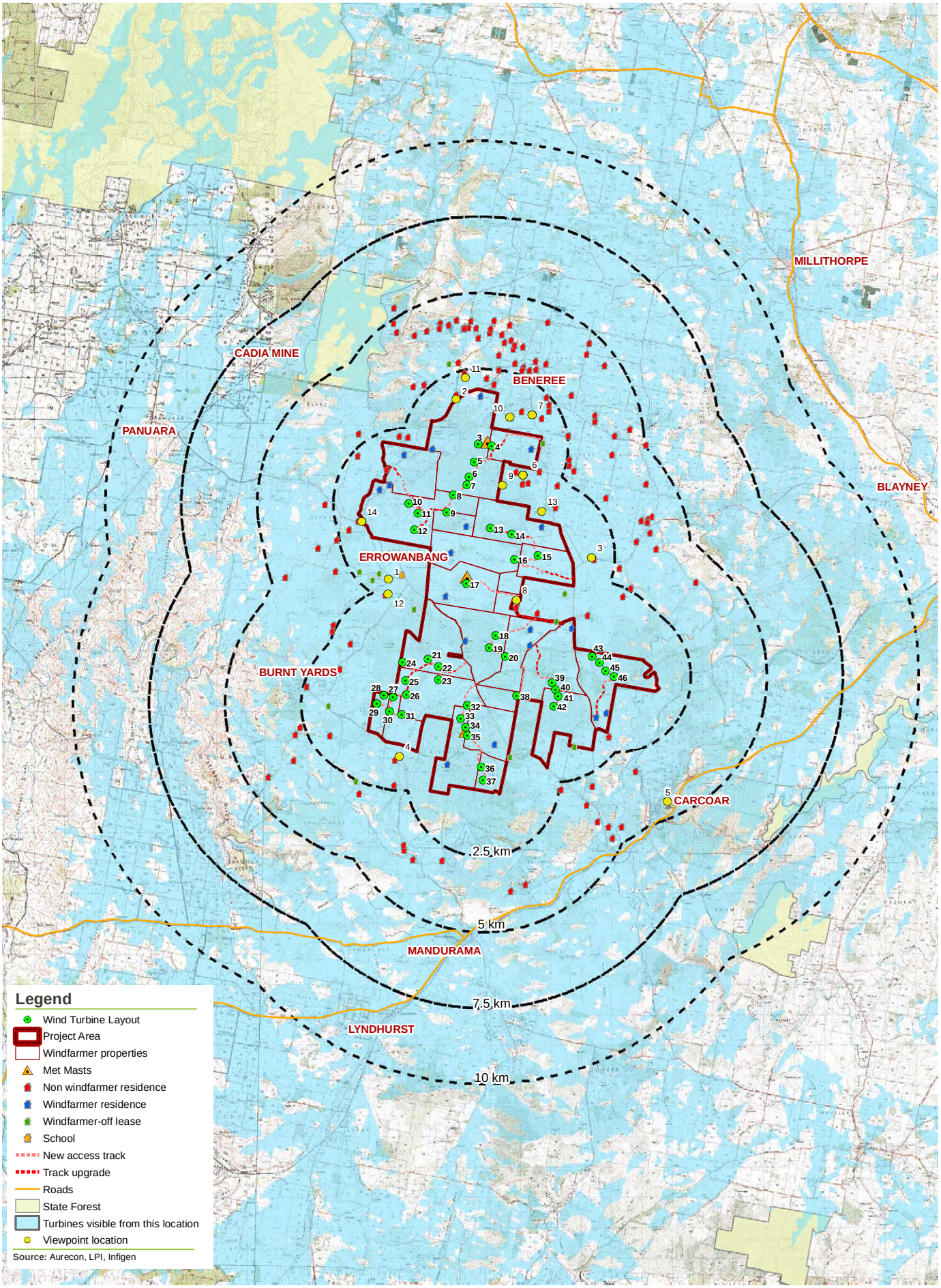
Figure 9.2 provides more detail of the visual catchment in the area closer to the wind farm (five kilometres). As mentioned above, additional screening provided by trees in some locations will reduce the actual visual catchment from that shown in Figure 9.2.

On clear days, the wind farm will be visible at distances greater than 10 kilometres in some directions, particularly to the south, southeast and southwest and from elevated distant points such as Mt Canobolas. However, at a distance of over 18 kilometres, the turbines will have a negligible visual amenity impact on views from Mount Canobolas and on a clear day might become a distant feature of interest.

However, due to the small apparent size of the turbines at greater distances, the effects of screening by vegetation from many locations and its absorption within the landscape, the visual impact of the Flyers Creek Wind Farm beyond even five kilometres, even where it is visible, is considered low.

Accordingly, the assessment focused on viewpoints with greater visual impact and, in particular, viewpoints less than five kilometres from the site. The visual catchment of each of the turbines varies and many views to the wind farm will have only partial views of the full wind farm due to topographic and/or vegetation screening.

To demonstrate the variation in visibility of different parts of the wind farm from different viewpoints a series of visual catchments was prepared using only selected turbines for sub-parts of the wind farm. The series of figures is provided in Appendix C1 (Figures C.2 to C.5).



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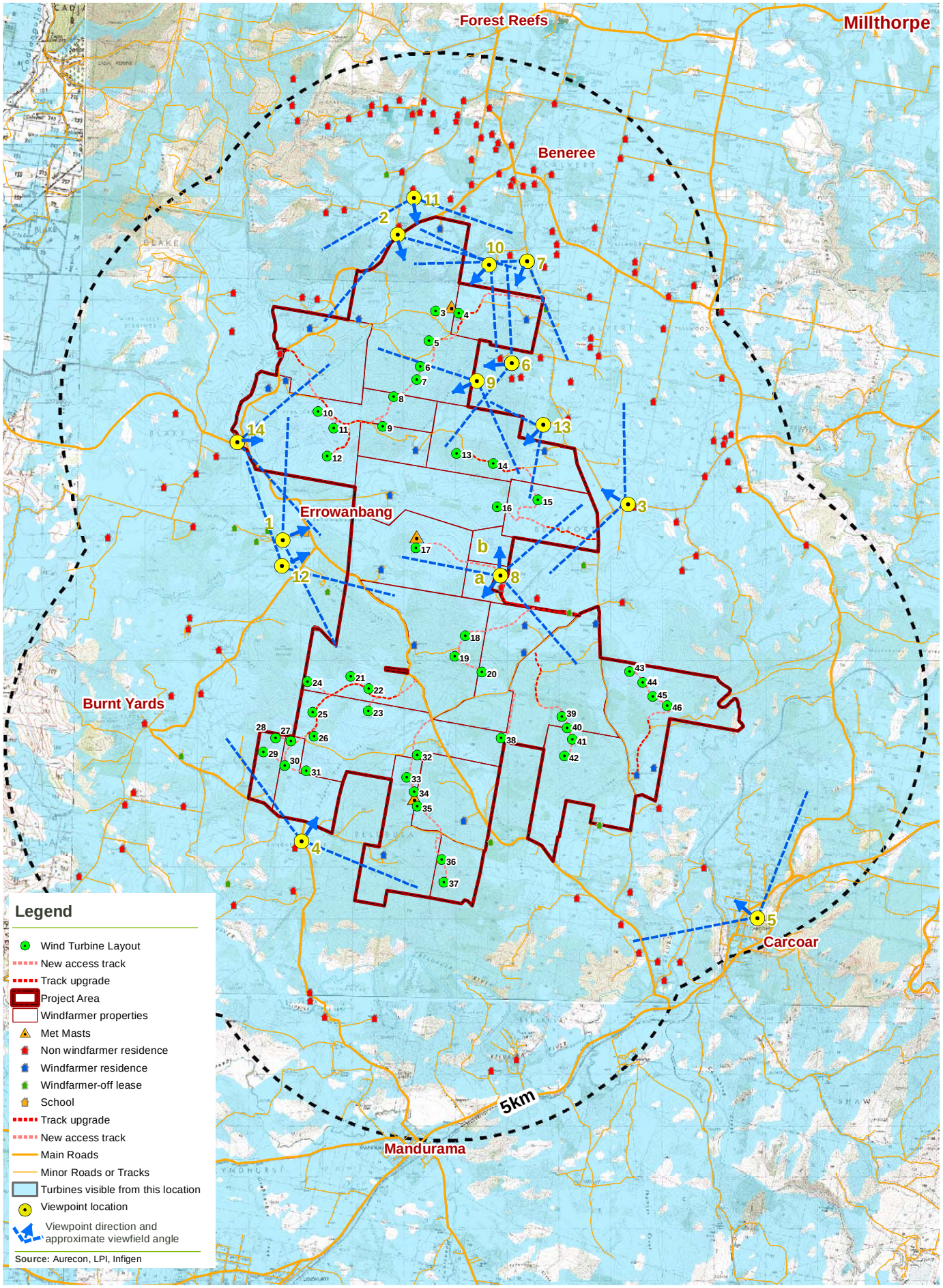
Flyers Creek Wind Farm **Environmental Assessment**

Projection: GDA 1994 MGA Zone 55

Notes: Visual analysis is based on a DTM built from a combination of best available contours. The analysis is created from top of blade (150m) and attempts to show an indicative worst case and over states the visibility of the turbines.
No allowance is made for the screening of vegetation or other structures

FIGURE 9.1: Wind Farm Viewfield



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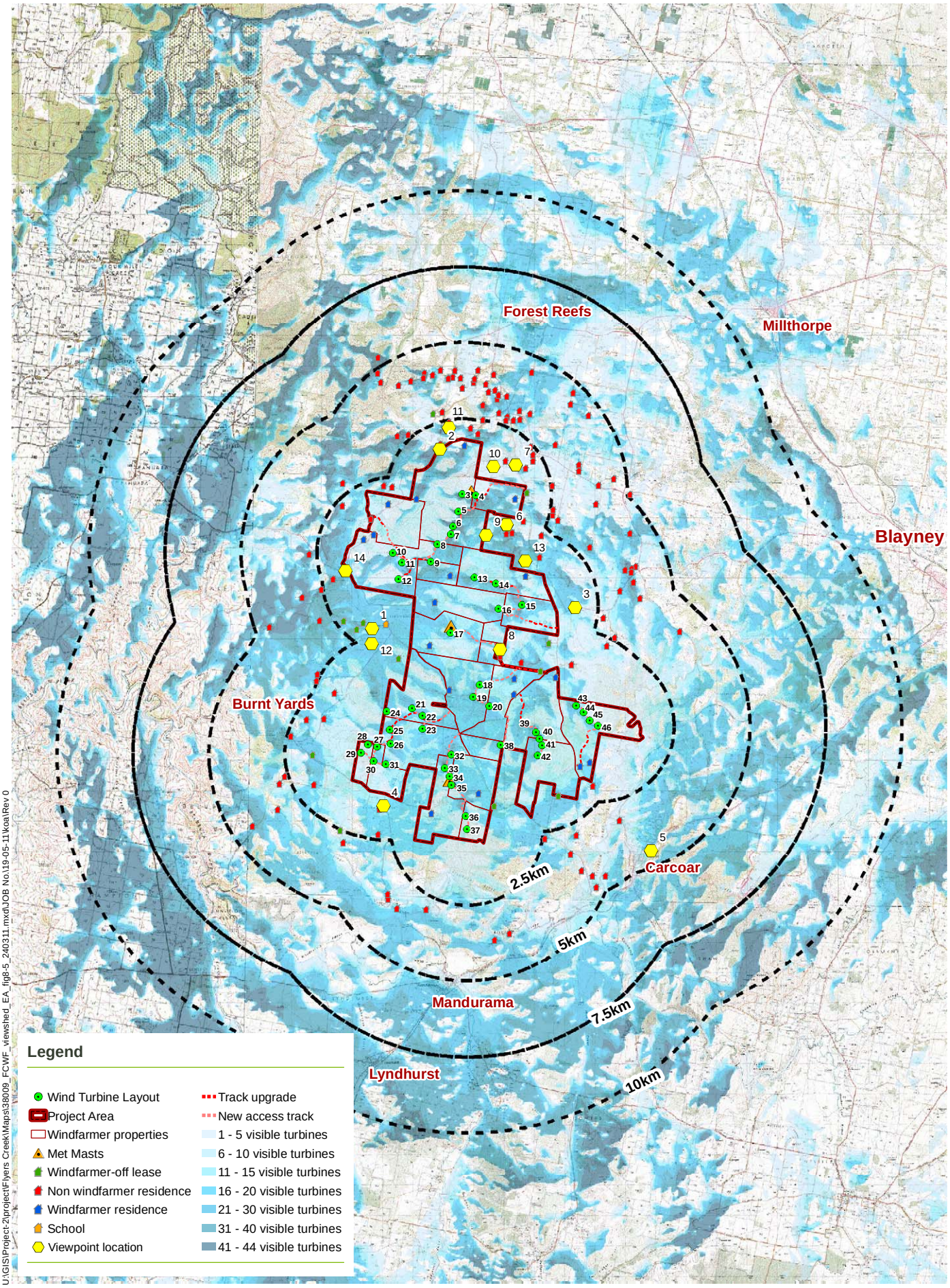
Flyers Creek Wind Farm **Environmental Assessment**

Projection: GDA 1994 MGA Zone 55

Notes: Visual analysis is based on a DTM built from a combination of best available contours.
The analysis is created from top of blade (150m) and attempts to show an indicative worst case and over states the visibility of the turbines.
No allowance is made for the screening of vegetation or other structures

FIGURE 9.2: Wind Farm viewshed with fourteen representative viewpoint locations



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Flyers Creek Wind Farm **Environmental Assessment**

Projection: GDA 1994 MGA Zone 55

FIGURE 9.3: Zone of Visual Influence

Notes: Viewfield analysis is based on a DTM built from a combination of best available contours.
The analysis is created from turbine hub (100m) and attempts to show an indicative worst case and over states the visibility of the turbines.
No allowance is made for the screening of vegetation or other structures

In addition to the series of viewpoints described above, a map depicting the wind farm's zone of visual influence has been prepared and shown in Figure 9.3 on the previous page. This figure demonstrates the number of turbines for which at least the tips of the rotors are visible in the area surrounding the wind farm. The presentation does not provide details of the proportion of each turbine visible at each possible viewpoint and in some cases where a turbine has been included as being visible, only the tips of the turbine rotor may be visible.

As indicated above, the computation of the zone of visual influence and its illustration in Figure 9.3 does not take into account the screening effects of trees and structures surrounding residences. Consequently, it overstates the potential visibility of the wind turbines and is a conservative expression of the actual viewfield. In practice the actual viewfield from a given location is likely to have a lesser extent and some locations indicated as being within the viewfield may have no views to the wind farm.

9.5.1 Distribution of residences

Table 9.3 provides a distribution of residences within five kilometres of the wind farm that were included in the visual assessment provided in Appendix C1.

Table 9.3 – Distribution of residences within five kilometres of Flyers Creek Wind Farm

Distance of residence from nearest turbine	Total number of residences	Wind farmer [1]	Neighbours (non-Windfarmer)
0 to 1 kilometres	7	7	0
1 to 2 kilometres	43	19	23 [2]
2 to 3 kilometres	50	4	46
3 to 4 kilometres	34	0	34
4 to 5 kilometres	23	0	23
Total	**157**	**30**	**127**

Note: [1] A wind-farmer residence is one where the owner has leased part or all of their land for the wind farm development. Some neighbouring residences are owned by wind farmers and are included here as wind farmer residences.

[2] Includes school – "Residence 57"

9.6 Visual Absorption Capability

The ability of the Flyers Creek landscape to visually absorb the proposed wind farm project has been examined based on consideration of visual factors such as distance from the project, viewer exposure, angle of view, panorama versus narrow view, scenic quality of view, focal point within view, number of observers, viewer expectations, documented scenic resources and visibility (National Research Council, 2007, EPHC, 2010)

Based on the topographic variations at the wind farm locality and the available landscape views, the 'visual absorption capability' of the individual landscapes appears to vary from place to place. Many of the neighbouring residences or viewpoints that are close to the wind farm may have clear views to the turbines that are relatively close to the residence while those turbines that are further distant in the hilly terrain may be progressively obscured with distance by topography and woodland.

The wind speeds in NSW are generally less than in South Australia, Victoria and Tasmania which are exposed to the "Roaring 40's" enabling some wind farms to be located on relatively flat land near the coast. Wind farm developments in NSW are by their nature most likely to be located in rural areas on elevated ridges where they will be prominent features in otherwise pastoral landscapes as is the case for this proposal. To a large extent the turbines add a new element in the landscape without significantly obscuring existing elements. For some observers of the landscape the turbines will represent a new point of interest and at other wind farm localities various observers have described the turbines as having aesthetic appeal. For such observers, visual absorption is less important and

the turbines may be regarded as complementing the pastoral scenes and both the wind farm views and pastoral scenes may be appreciated.

The Flyers Creek Wind Farm landscapes have not been recognised under any planning scheme or heritage register as a zone of special visual significance. Nevertheless the project area and its surrounds have scenic merit which is enjoyed by the local community and people travelling through the area.

9.7 Representative viewpoints for visibility assessment

For the purposes of visual impact assessment, eight representative viewpoints within the five kilometre envelope that are within the visual catchment were selected to assess the wind farm's visual impact. Figure 9.2 shows the locations of the selected viewpoints.

The chosen viewpoint locations are predominantly on public roads surrounding the wind farm site and are sometimes close to residence locations. Viewpoints that provided direct views to the wind farm were selected in preference to viewpoints that had filtered views through vegetation or where no views were available due to obstructions in the landscape. Accordingly, the viewpoints are not representative of viewpoints with restricted views to the wind farm site but tend to be those locations with better visibility of the wind farm. For example, a viewpoint from within the central area of Carcoar would not show any wind turbines. Instead, an elevated viewpoint on the outskirts of Carcoar was selected to provide a "worst case" of the visual impact. Details of the selected viewpoints are provided in Table 9.4.

In addition to the views from representative locations with views of the wind farm, owners from nearby non-windfarmer residential locations were approached regarding their interest in having a photomontage of the view from their residences prepared. A total of 12 adjacent land owners were approached with six agreeing to have images taken from their residences with the resultant photomontages included in the Environmental Assessment (see Appendix C1). It is also worth noting that some residents who were approached did not desire a photomontage, because they were supportive of the wind farm and did not consider that the visual impact needed to be assessed from their residence.

Table 9.4 includes details of the representative viewpoints assessed in this section as well as the residential viewpoints assessed in Appendix C1.

Table 9.4 – Details of viewpoint assessment sites

Ref	Viewpoint Location			View Details						
	Easting	Northing	Description of Location	Nearest turbine (no and distance in km)		Direction of view	Turbine Group in view (see Note 1 below) Y = 'Yes'			
	(m)	(m)		no	km		A	B	C	D
1	689784	6286517	Old Errowanbang Road facing the school	12	1.8	East	Y	Y	Y	
2	692010	6292436	Watersons Lane intersection near residence 27	3	1.7	South	Y	Y	Y	Y
3	696469	6287214	Browns Creek Road near residence 45	15	1.7	NW	Y	Y	Y	
4	690147	6280681	Mandurama – Burnt Yards Road near residence 95	31	1.3	NE		Y	Y	
5	698977	6279193	View from Carcoar near the water tower (highest point in Carcoar)	46	4.5	NW		Y	Y	Y
6	694215	6289944	Dickinson Lane	4	1.4	West	Y			
7	694513	6291918	Beneree Road	4	1.7	SW	Y	Y		
8a	694000	6285829	Dunstaffage Lane (near residences 77/78)	18	1.3	SW		Y	Y	Y
8b	694000	6285829	Dunstaffage Lane (near residences 77/78)	16	1.3	NE	Y	Y		
9	693536	6289596	Residence 89 [2]	6	1.1	W	Y			
10	693781	6291846	Residence 25 [2]	4	1.1	SW	Y			
11	692311	6293151	Residence 94 [2]	3	2.2	S	Y			
12	689759	6286016	Residence 12 [2]	12	2.3	NE	Y			
13	694816	6288790	Near Residence 44 [3]	14	1.3	SW	Y	Y		
14	688899	6288414	Residence 17 [2]	10	1.7	NE	Y	Y		

Note 1: Turbine group A: Calvert Group (northern) – Turbines 3-12
Turbine group B: Fern Hill Group (central-eastern) – Turbines 13-20
Turbine group C: Hopkins Group (south-western) – Turbines 21-37
Turbine group D: Halls Gap Group (south-eastern) – Turbines 38-46

Note 2: Denotes view from residence

Note 3: Denotes view from utility shed near residence, since turbines are not visible from homestead

9.8 Production of photomontages for selected viewpoints

To assist the assessment of visibility at each of the representative viewpoints, photographic simulations of the installed wind turbines in the existing landscape (photomontages) were prepared and are included in Appendix C1. The objective of the photomontages is to provide realistic representations of the appearance and scale of the installed wind farm in the landscape using photography obtained before the wind farm is constructed.

The process for production of photomontages involved three primary stages as follows:

- Colour photographs were taken at about 30 locations surrounding the wind farm. Of these, eight viewpoints were selected to provide representative views of the wind farm site. The photographs were taken to achieve a perspective of sizes as realistic to the eye as possible. Photographs were taken at each of the visual impact assessment sites, with a 35 mm single lens reflex camera with its lens set to 50 mm focal length for Viewpoints 4 and 6, and 65 mm focal length for all other viewpoints. A focal length of 65 mm has been previously recommended for photography to be used for photomontage preparation and in previous applications has been suitable for the purpose. In two cases, a focal length of 50 mm was used for viewpoints 4 and 6 because of the relative elevation of the viewpoint and of the closest turbines. It is worth noting that the human eye has a focal length of about 50 mm and such imagery is equally suitable for photomontage preparation. The film was scanned at high resolution to provide images for the photomontage.

  The additional photographs used to prepare photomontages from nearby residences were taken later during the project assessment with a high resolution Digital SLR camera with a fixed focus lens with an equivalent SLR focal length of 56 mm.

  Due to the focal length used and narrow field of view for a single photograph, it was necessary, for all of the viewpoints, to join several photographs to produce a panoramic view of the wind farm. As far as practical the photography was taken with fine weather and with blue sky as the preferred sky colour, but this was not possible for all viewpoints.

- Sophisticated computer modelling software 'WindFarmer' was used to produce perspective diagrams of the wind farm from each viewpoint for the purpose of providing accurate representations of the proposed turbines in relation to the topography.

- To illustrate the appearance of the wind farm from specific locations the photographs and computer generated perspective views of the wind farm were combined with panorama photographs to create photomontages. Production of the resultant photomontages provides an accurate simulation of the appearance and scale of the wind farm on the existing landscape. While considerable effort has been made to ensure the photomontages are realistic representations for the respective viewpoints, the process incorporates a number of steps that may each slightly reduce the precision of the final result. In addition, some 'manual' effort is required to accurately display the turbine in front of, or behind, trees or topography in the photographs as the computer software cannot do this automatically. The appearance of the turbines has generally been enhanced in the photomontages to improve the contrast of the turbine against the background. Typically the background for the turbines is the sky due to the elevated positions of the turbines relative to the viewpoints.

The photomontages from the representative viewpoints form a key reference by which the Approval Authority and the community can gain an appreciation of the visibility of the wind farm at various locations in the landscape. Photomontages showing simulated wind farm views from all eight assessment sites and the six residences are provided in Appendix C1.

The orientation of each wind turbine will vary with the wind direction at the turbine site and, for most of the time, the turbines are likely to be facing east or west into the prevailing wind directions. The views of the wind turbines will look different, depending on the orientation of the turbine relative to the viewpoint. To maximise the visual impact of the turbines in the individual photomontages the turbines have been shown generally facing the viewpoint.

9.9 Visibility Assessment Criteria

The visibility of the proposed development from the eight representative viewpoints was reviewed against assessment criteria that assist with relative ratings of visibility. The key criteria against which the visibility of the proposed development was assessed are described below.

- **Distance from the viewpoint to the nearest wind turbine:** Distance from the project is an important determinant of visual impact. For the purposes of assessing visual impact, position in the landscape is classified as foreground, mid-ground and background.

  In foreground areas, details can be seen and objects appear large and often occupy a large part of an overall view. Landscape patterns in the mid-ground can be perceived as can individual wind turbines, although they will appear smaller and part of a larger context than turbines in a foreground view. Large landforms tend to dominate background views. Under optimal atmospheric conditions wind turbines may be seen up to 25 kilometres away, but appear very small at such distances and occupy very small portions of a large panorama (National Research Council, 2007; EPHC, 2010).

  The distance of each viewpoint from the closest turbine was used as a principal factor to rate proximity of views. The classification of foreground, mid-ground and background was based on the visibility assumptions discussed in Section 9.9.1.

  - foreground (0 – 3 kilometres)
  - mid-ground (3 – 5 kilometres)
  - background (more than 5 kilometres)

  The Flyers Creek Wind Farm development extends approximately 11 kilometres from north to south, and is up to nine kilometres wide toward the southern end, and about six kilometres wide toward the northern end. Where there are many turbines in a view, a significant proportion are likely to be in the mid-ground and background. It is the closest turbines that are regarded as having the most visual impact. In some cases, topography and/or trees may obscure the views of some turbines particularly more distant turbines.

  The assessment of viewpoints, with the exception of viewpoint 5, includes turbines within the foreground range. Viewpoint 5 (Plate C.5 in Appendix C1), the viewpoint from Carcoar, is classified as mid-ground as the closest wind turbine is located 4.5 kilometres distant.

- **View field angle:** This angle can be described as the angle subtended by the visible wind farm at the observer's location. This angle varies for different viewpoints and is influenced by the distance from the wind farm, the number of turbines, the layout and its orientation relative to the viewer and the effect of intervening topography. In some cases, only part of the wind farm will be visible. The angle between the left and right hand edge of the view field of the visible wind farm defines the affected proportion of the viewpoint. The extent of the human viewfield is 124° horizontal and 55° vertical (EPHC, 2010). A broader field will be seen, of course, by scanning one's eyes (or head) from side to side.

  As noted above, the angle subtended by the wind farm is, in part, dependent on distance in that, as the distance from the wind farm increases the view field angle for the same width of wind farm will decrease. The greatest angular decrease in the view field with distance occurs up to one kilometre. Beyond about three kilometres there is a lesser decrease in the view angle as distance increases.

  The view field angle in Appendix C1 overstates the actual extent of the viewfield in some cases as the view of turbines at either side of the viewfield angle may be blocked by vegetation and/or structures. In some cases a wide view angle may be derived by the grouping together of several narrow sections of visible turbines that when combined form a wider arc.

- **Number of visible turbines:** the number of turbines located in the foreground, mid-ground and background was determined for each assessment site from inspection of photomontages (Viewpoints 1 to 8) and review of layouts relevant to the viewpoints (See Table 9.6).

9.9.1 Wind turbine visibility rating

An indication of the effect of distance on visibility of the wind turbines is obtained by considering the reduction in view angle with distance. The following table provides an analysis of the angle of view on the basis of the worst case wind turbine height assumed for the visual assessment (150 metres). It is noted that the vertical primary field of view by the human eye is around 55° (EPHC, 2010).

Table 9.5 – Visibility Assumptions for Flyers Creek Wind Farm (Adapted from EPHC, 2010)

Distance from Observer to Nearest Wind Turbine (kilometres)	Line of Sight Vertical Angle of View (degrees)	Impact on Viewer
10	0.5	Insignificant
5 – 10	1 – 0.5	Discernable - the wind turbines will not dominate the landscape while noticeable depending on local conditions and affected by landscape and viewer sensitivity.
3 – 5	2.5 – 1.5	Visually apparent – can be prominent in the landscape depending on the landscape aspects and sensitivity of the viewer
1 – 3	8.5 – 2.5	Highly visible – wind turbines are generally highly visible and can dominate the landscape when visible. Degree of intrusion is affected by placement in the landscape and viewer sensitivity.

These criteria have been used to assign a simple relative rating of the visibility of the turbines into three classes, high, moderate and low. For the purpose of this assessment the following descriptors were adopted based on the assumed visibility.

- **High Visibility:** Scenes having high visibility include viewpoints within one kilometre and up to three kilometres from the nearest turbine depending on the wind farm view field angle.
- **Moderate Visibility:** This applies to viewpoints intermediate between three and five kilometres
- **Low Visibility:** Low visibility is assigned to all viewpoints beyond five kilometres and viewpoints between three and five kilometres, depending on the wind farm view field angle. It should be noted, however, that low visibility does not necessarily correspond to low visual impact. The visibility of turbines beyond 10 km will generally be insignificant, however for the purpose of the assessment they are included in the low visibility category.

While the above classification scheme is somewhat arbitrary, it does serve to rate visibility of turbines at respective viewpoints for consideration in the overall impact assessment. It is stressed that visibility rating does not represent the visual impact. Visual impacts are subject to a range of other considerations. Similarly, the visibility rating does not indicate whether the visibility is adverse or favourable.

Although not specifically taken into account in assessing the visual impact of the wind farm, the number of visible turbines is also likely to contribute to overall visibility. To some extent it can affect the viewfield angle and has indirectly affected the visibility rating described below. Visible turbines may also be only partly visible, tips only, part rotor and hub, or the full rotor and tower being visible.

9.10 Visual impact assessment

9.10.1 Assessment of the selected viewpoints

The assessment of the eight representative viewpoints was based on:

- a review of the photomontage for each location
- visits to each of the viewpoints to assess visibility of the wind farm site (ie assessment of the proportion of wind farm that may be visible from the viewpoint)
- observation of factors that may reduce the visibility (eg topographic features, tree screening)
- reference to GIS based view field analysis that takes into account the height of the turbines
- review of the visibility of turbines using 'Windfarmer' software

The distance to the nearest turbine and view angle of the visible turbines is shown in Table 9.6. In addition, the number of turbines in various distance ranges (1-3 kilometres, 3-5 kilometres and >5 kilometres) from the viewpoint are also shown.

None of the turbines within the representative viewpoints are located closer than one kilometre. All viewpoints, except viewpoint 5, have the closest turbine in the 1-3 kilometre range and therefore have a visibility rating of high based on the key visibility criteria discussed in Section 9.9,. The nearest turbine in viewpoint 5 is 4.5 kilometres which has a visibility rating of moderate.

Table 9.6 – Visibility assessment results – representative viewpoints

Note: It should be noted that the Windfarmer software estimates all turbines likely to be visible within a 360° view from the viewpoint location based on the available topographic information. A turbine is regarded as being visible even if it is only partially visible. The viewpoints shown in the photomontages are limited to a specific viewfield angle (eg 140° for viewpoint 1). Based on this, only the turbines visible from the particular viewpoint within the photomontage view angle have been taken into account in the table below.

Ref No.	Viewpoint Location (Figure 9.1)	No. of visible turbines (predicted by Windfarmer) (1)			Nearest turbine		Turbine View Angle
		1 – 3 km	3 – 5 km	> 5 km	No.	Dist – km	degrees
1	Old Errowanbang Road facing the school	5	13	3	12	1.8	140
2	Watersons Lane intersection near residence 27	6	7	25	2	1.3	68
3	Browns Creek Road near residence 45	3	7	9	15	1.7	90
4	Mandurama to Burnt Yards Road near residence 95	14	6	0	31	1.3	130
5	Elevated view from Carcoar near the water tower	0	4	14	46	4.5	65
6	Dickinson Lane	6	3	0	4	1.4	65
7	Beneree Road	4	5	0	4	1.6	70
8a	Dunstaffage Lane (near residences 77/78 looking SW)	3	3	0	16	1.3	150
8b	Dunstaffage Lane (near residences 77/78 looking NE)	5	8	2	18	1.3	98

Note: (1) 0-3 kilometres is considered foreground, 3-5 kilometres mid-ground and more than five kilometres background.

Taking into account the number of turbines visible in the mid-ground and background, the available screening of topography and vegetation, the representative views are assessed in the following sections. In order to assist the viewer locate the more visible turbines in the landscape, the nearest visible turbines in each photomontage, and selected more distant turbines, have their number

indicated at the top of the image. The turbine numbers are also shown in the viewpoint overview map provided below each photomontage in Appendix C1.

- View Point 1 – Old Errowanbang Road looking east towards the school (Appendix C1 Plate C.1) Views from this location are assessed as low to moderate visual impact. The majority of the 21 turbines within the view field are further than three kilometres away from the viewpoint with only five turbines between 1.8 and three kilometres of the viewpoint. While the turbines are a noticeable new 'man – made" vertical element within the landscape and the five turbines would be classed as highly visible, they add to the visual diversity of the landscape without dominating the view, being interspersed with scenic views including points of focus that do not contain turbines.

- View Point 2 – Watersons Lane Intersection looking south (Appendix C1 Plate C.2) is assessed as having a moderate to high visual impact, with six wind turbines located between 1.3 and three kilometres from the viewpoint which are highly visible, when the distribution of turbine within the landscape and the diversity within the landscape are considered. While the six closest turbines will be the dominant vertical element in the landscape that will attract the attention of the viewer at this location, this impact is lessened to some degree by other the existing vertical features in the landscape, such as fence posts and road signs in the near field and the patchwork of trees and cleared areas throughout the landscape. The remaining 32 turbines are further than three kilometres, with the great majority over five kilometres away, which reduces their visual impact.

- View Point 3 – Browns Creek Road looking north-west (Appendix C1 Plate C.3) has been assessed to have a low to moderate visual impact. As shown in Table 9.6, three of the 19 visible turbines are within three kilometres of the viewpoint and therefore classed as highly visible, the closest being 1.7 kilometres away. The available topography and vegetation within the view field reduces the visibility of one of these turbines such that only the top portion of the third turbine is visible behind some trees. The rural landscape is assessed to have a low to moderate scenic quality. The near field roadside vegetation also lessens the impact created by the three closest turbines. For the remaining visible turbines located further away, the views are limited to part of the rotor blades in most cases. Whilst being discernable, these turbines do not dominate the view.

- View Point 4 – Mandurama to Burnt Yards Road (Appendix C1 Plate C.4) has been assessed to have a moderate visual impact on the existing landscape. Based on the analysis in Table 9.6, twenty turbines have been indicated as being visible however, only sixteen are apparent in the photomontage presented in Appendix C1 as Plate C.4. The majority of the visible turbines are located two to three kilometres from the view point.

  While the turbines are primarily located on cleared ridges and there is not a lot of vegetation available to reduce the visual impact, significant portions of many of the turbines are obscured by the topography. Six turbines to the northeast, 2.5 to three kilometres away from the viewpoint, have a noticeably reduced visual impact compared to the five turbines directly north. The proponent has responded to a request from the nearest neighbour to set back the closest turbine to the far side of the hill.

- View Point 5 – An elevated location in Carcoar near the water tower (Appendix C1 Plate C.5) provides the photomontage for View Point 5. It can be seen that due to the effects of distance (4.5 kilometres for closest turbine) and diversity in the landscape, while the wind turbines are discernible within the landscape, the visual impact from Viewpoint 5 has been assessed as low.

- View Point 6 – Dickinson Lane (Appendix C1 Plate C.6). The visual impact from this location has been assessed as low to moderate. Six of the nine visible turbines from View Point 6 are located at a distance less than three kilometres (1.4 to three kilometres) and are therefore classed as highly visible. However, the significance of the impact of the wind turbines is diminished by low to moderate scenic quality of the view due to its low visual diversity and the contribution of other vertical elements (mainly tree trunks) in the foreground. The visibility of the more distant turbines is reduced due to vegetation and topography.

- View Point 7 – Beneree Road (Appendix C1 Plate C.7). The visual impact from View Point 7 has been assessed as being low. As shown in Table 9.6, nine turbines are visible from View Point 7. Of the four turbines visible in the one to three kilometre range, only two intrude into the landscape to a significant extent. Other turbines are obscured by the landform or vegetation. The scenic quality of the landscape is assessed as low to moderate with some contrast provided by the rolling terrain but with little variety in the direction of the wind farm.

- View Point 8a - Near residence 77 and 78 view to south-west (Appendix C1 Plate C.8a). The visual impact from this viewpoint is considered low to moderate. Of the six visible turbines in View Point 8a three are located less than three kilometres and are the only ones visible in the photomontage. The landscape depicted is assessed as having moderate scenic quality with a number of introduced features that provides some diversity. The effects of the additional elements in the landscape, whilst highly visible, are diminished by this diversity in the landscape. The turbines do not obscure the existing views of the landscape. The remaining turbines are screened by topography and vegetation.

- View Point 8b – Near residence 77 and 78 view to north (Appendix C1 Plate C.8b). The visual impact from View Point 8b has been assessed as being low to moderate. Based on the photomontage for View Point 8b and on the distribution of visible turbines indicated in Table 9.6, five turbines are within three kilometres of the view point (1.3 to three kilometres) and are therefore highly visible. A further ten turbines are located at distances greater than five kilometres. At these distances, the turbines are discernible in the distance. The scenic quality is assessed as Moderate with distant views of rolling hills and a patchwork of vegetated and cleared rural landscape. While adding a highly visible new element to the landscape the views include a combination of natural and introduced or modified elements. The distribution of turbines does not block the views of the existing landscape.

The visual impact assessments of Viewpoints 9 to 14 are included in Appendix C1.

9.10.2 Consideration of impacts at Residences within five kilometres of the wind farm

The potential visibility of the wind farm for all the residences within five kilometres of the wind farm was assessed in terms of the visibility criteria, key screening factors and visual impact assessment. Table C1 in Appendix C1 provides a listing of the indicative visibility parameters.

Overall, the development will be a prominent addition to the local landscape with its visual impact partly dependent on visibility factors indicated above (the distance of the viewpoint from the wind farm and also the proportion of the view field occupied by the wind farm) and subjective factors relating to viewer's perceptions and preferences. Changes to the landscape may initially seem significant, but over time, they may appear less so as is the case with the Blayney Wind Farm which is widely seen as a 'normal' part of the landscape of the district.

Even though the wind turbines are prominent features, they will not significantly mask the elements of the various scenes although they may be seen to change the scene's character to some extent. Furthermore, there will be large areas of the adjoining landscape that will remain unchanged by the development. In short, a significant part of the existing landscape will remain unchanged.

As discussed in Section 9.6, while the Flyers Creek Wind Farm landscapes are not unique and have not been recognised under any planning scheme or heritage register as a zone of special visual significance, the project area and its surrounds have scenic merit and are no doubt enjoyed by the local community and people travelling through the area. It is expected that the overall visual impact of the wind farm will be viewed as both positive and negative depending on the location in the landscape and sensitivity of the viewer towards wind farms in the landscape.

9.11 Visual issues associated with ancillary works

Ancillary works will include:

- construction of new access tracks
- upgrading of existing tracks
- construction of a substation with facilities and auxiliary services buildings
- installation of underground cables
- installation of the overhead line for grid connection to the Country Energy 132 kV transmission line between Orange and the Cadia Mine.

The visual impact of most of the ancillary works will be insignificant compared to that of the wind turbines. In addition, the ancillary works will be designed and located so as to reduce their visual impact.

Access tracks

Upgrading of existing tracks and construction of new access tracks will be required. Any temporary tracks not required for ongoing operation and maintenance will be removed and re-sown after construction works have been completed. Permanent tracks will be located to achieve suitable grades on stable slopes and designed so that they will not exacerbate erosion at the site. As far as possible, the location of tracks will also be chosen to minimise visual impact from the surrounding countryside.

In most cases there will be limited visibility of tracks for the surrounding countryside. However, some access tracks may need to be located on slopes that could be visible from surrounding vantage points. It is possible with careful design to construct these tracks such that their visual impact is minimised. Earth batters on any tracks that are benched into slopes will be revegetated to prevent erosion and to reduce visibility of the constructed track.

Substation and associated buildings

The substation and associated buildings will be located at the north-western side of wind farm site in Slatterys Creek Valley, a part of Flyers Creek Catchment. There will be minimal visual impact by placing the substation in the valley but it will be close to the Beneree to Errowanbang Road that has low levels of traffic. The substation and associated buildings can be screened by vegetation as well as by topography. This will mean that the substation site will only have limited visibility from most neighbouring residences and the nearby public road. This can be achieved despite the short distance for direct vehicle access to the substation and wind farm control centre from Beneree to Errowanbang Road. Night lighting at the substation will be minimised as far as practicable and will be activated by security sensors and shut-off remotely once any security risk has been cleared.

Overhead lines

To reduce visual impact at the location of the turbines, the 33 kV cables linking the turbines within each group will be placed underground along the ridge tops as far as practical. The 33 kV underground cables will also link the turbines directly to the substation or for the southern turbine groupings, sets of cables are likely to be connected to a 33 kV overhead (double circuit) transmission line to facilitate connection to the substation. Plate 3.4 in Chapter 3 provides an example of a typical double circuit overhead line arrangement. Most parts of the 33 kV overhead line will be located away from the roads and within the project area. Some visibility of the line may occur to the west of residences 77 and 78, but the line will be located down slope and toward the western boundary of the neighbouring property which will reduce the visibility from these residence locations.

The 132 kV line route from the substation to the point of grid connection is about 15 kilometres long and is proposed to follow Panuara Road to the west and then head northward, west of the active mining area of the Cadia Mine. The proposed line route eliminates the need for any clearing of remnant woodland, avoids areas of archaeological significance, and importantly is well clear of any uninvolved residences. The main area of visibility of the 132 kV line will be where the line exits the

wind farm site and crosses over Beneree to Errowanbang Road. The wind farm power line will largely follow existing lower voltage distribution power line(s) and could be considered as an augmentation of the existing line.

Plates 3.8 and 3.9 in Chapter 3 show sections of the 132 kV line north of Cadia Mine including change in direction and a typical 132 kV pole with conductors. The overhead grid connection will be a minor visual feature of the development that will be located near the Cadia Mine site and beside Panuara Road and will not be visible from the great majority of neighbouring residences not involved in the project.

9.12 Shadow flicker

Flyers Creek Wind Farm Pty Ltd commissioned Parsons Brinckerhoff to undertake a shadow flicker assessment on the Flyers Creek Wind Farm. The full assessment has been provided in Appendix C2 and has been summarised in this section.

9.12.1 Introduction

Shadow flicker is a visual effect that occurs when rotating turbine blades cause intermittent shadowing at a viewpoint as the blades momentarily block the sun's path. To protect amenity at neighbouring residences surrounding wind farms, thresholds for the maximum period of the shadow flicker effect at any residence are generally assigned, typically less than 30 hours per year.

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.

- It is not a cloudy period.
- The sun must be in the correct position to cause shadowing by a turbine at a particular viewpoint. As the relative positions of the sun and the residence are continually changing the effect is limited in duration and variable in respect of when it occurs.
- Direction the wind turbine is pointing, (dependent on the wind direction) is similar to the direction of the sun to the residence (rotor approximately perpendicular to the suns rays).
- No obstructed line of sight between the wind turbine and the viewpoint location.
- There is no low cloud or diffusion by the atmosphere (significant diffusion typically occurs for angles of less than 3° above the horizon).
- The wind turbine must be operational and the wind must be blowing (ie the blades are rotating).
- The widest part of the blade causes the shadowing (largest dimension of the blade is the chord near the root of the blade and the smallest is near the tip).
- For indoor situations, the shadow must fall over most of a room's natural light source,

Shadows cast by the rotating blades will be strongest closest to the wind turbines and as the distance from the wind turbines increases, the shadows cast by the rotor blades will become less distinct, reducing the impact of the flicker effect. At about 10 times the rotor diameter (one kilometre for a 100 metre rotor diameter) the effect is significantly reduced, and at a distance of two kilometres the proportion of light blocked by the wind turbine blades becomes so small that flicker is not discernable or insignificant.

9.12.2 Methodology

The methodology for undertaking the shadow flicker assessment is provided in Section 2 of Appendix C2. In summary, the shadow flicker impact on each neighbouring residence was assessed using WindPro wind farm modelling software. The assessment was undertaken for a "realistic case" and for

a “worst case”, using the GE 2.5xl wind turbines with a 100 meter blade diameter and 85 metre hub height. The assumptions for each case are provided in Section 2 of Appendix C2.

The model produces the number of shadow flicker hours that a residence could potentially experience in a year as a “worst case.” However, the worst case annual shadow flicker impact could not occur as all of the following would need to happen for 365 days:

- The wind never stopped blowing
- No wind turbine was ever taken off line for maintenance or repairs
- Any wind turbine causing shadow flicker experienced wind in a direction directly towards or away from the residence affected
- Existing vegetative screening by trees does not diminish or block any shadow flicker
- No clouds were ever present during periods of potential shadow flicker (ie the sun was always shining when shadow flicker might occur).

The “worst case” shadow flicker results therefore serve as a starting point from which a more realistic situation is derived using measured data from reference sites recording sunlight information. Canberra airport was used as a reference site due to the geographic similarity, duration of recorded data and the higher level of experienced daylight at Canberra Airport (conservative choice). The first four conservative assumptions are all maintained in the realistic case making even this case very conservative.

9.12.3 Modelling results

The results of the shadow flicker assessment including worst case results and realistic results using average sunshine statistics for all residences are shown in Appendix C2.

Of the 157 residences assessed, only 25 have been predicted to experience any level of shadow flicker due to the wind farm project. Table 9.7 provides the shadow flicker and shadow results for the 25 affected residences. For the realistic case, no neighbouring residence is predicted to experience annual shadow flicker of more than 2½ hours. Even for the essentially impossible worst case, no neighbouring residence is estimated to experience more than 13 hours of shadow flicker.

The maximum shadow hours per day provide an estimate of the maximum amount of time a shadow from the tower and the rest of the wind turbine will be experienced by a residence on a single day of the year. There is no realistic and worse case scenarios associated with this parameter since, unlike shadow flicker, shadow periods are experienced by almost every house due to trees, hills and other structures and do not have the potential to cause annoyance or distraction.

Appendix A of the Shadow Flicker Assessment (prepared by Parsons Brinckerhoff and provided in Appendix C2 of this assessment) provides detail of shadow calculations and a map showing the extent of the effect from the turbine sites based on Bureau of Meteorology data for Canberra and representative turbine dimensions.

Table 9.7 – Shadow flicker and shadow results for affected residences only (wind farmers (shaded) and neighbours)

Ref No	Residence	Distance to closest turbine	Indicative screening by trees[1]	Type of residence[2]	Worst case shadow flicker	Realistic shadow flicker	Maximum shadow hours per day
		km	Y / N / P	WF/WFOL/N	hours/year	hours/year	hours/day
3	Glen Ayr	0.9	P	WF	34:36	8:58	0:26
4	Lochewen	1.1	P	WF	22:04	4:10	0:22
14	Willow Park	1.1	Y	WF	28:48	8:00	0:35
22	Wallaby	1.4	P	WF	14:03	1:47	0:21
24	Windella	1.3	P	WF	7:16	0:26	0:22
28	Hillview	1.7	P	WFOL	2:27	0:04	0:11
50	Nullawonga	0.9	N	WF	13:32	1:33	0:21
51	Beulah Park	1.2	N	WF	26:40	6:57	0:18
52	Carramar	0.8	N	WF	25:59	7:33	0:32
54	Hillcrest	0.8	P	WF	3:10	0:53	0:08
56	Cooramilla	1.0	Y	WF	5:34	0:53	0:13
71	House	1.0	P	WF	38:26	9:32	0:26
72	House	1.6	N	WFOL	7:05	0:28	0:16
74	House	1.6	P	WF	5:00	1:12	0:14
76	House	1.2	Y	WF	14:42	2:58	0:17
79	House	0.8	P	WF	41:25	9:22	0:32
88	House	1.1	Y	WF	3:50	1:02	0:14
11	Rhondda Villa	1.8	P	N	5:18	1:11	0:14
17	Triangle Park	1.8	Y	N	9:47	1:22	0:15
23	Towradgee	1.2	P	N	10:45	1:52	0:17
45	Castle Hill	1.9	P	N	1:36	0:04	0:09
89	House	1.2	N	N	12:43	1:08	0:20
90	House (empty)	1.6	P	N	0:30	0:07	0:03
100	House	1.8	P	N	4:21	1:06	0:12
158	House	2.2	P	N	11:45	2:08	0:15

Note: [1] Y – Yes, N – No, P – Partial

[2] WF – windfarmer, WFOL – windfarmer off lease and N – neighbour

9.12.4 Conclusion

Table 9.7 shows that no residences, including windfarmer residences, experienced more than 10 hours/year of shadow flicker in the Realistic Case, well below the typical limit of 30 hours per year. No neighbouring residences will experience even 10% of the 30 hours per year level. Even for the essentially impossible 'worst case', no neighbouring residences will experience over 30 hours of shadow flicker per year.

Therefore, the analysis demonstrates that occurrence of shadow flicker effect at sensitive receptors is well below recommended levels of both aggregate annual hours and maximum daily hours for the effect.

9.13 Blade glint

Blade glint refers to the regular reflection of sun from one or more rotating turbine blades. This can be a temporary effect at any particular location, though the majority of any glint occurs where the viewer is located above the altitude of the turbine hub and few such viewpoints occur around the wind farm. The occurrence of blade glint depends on a number of conditions including the orientation of the nacelle, angle of the blade, the angle of the sun and degree of cloud cover. The reflectivity of the surface of the blades is also very important and is influenced to some extent by the colour, surface finish and age of the blade.

Blade glint is an aspect that could be a potential distraction to drivers if roads are aligned towards turbines, particularly where the road is located at a higher altitude to the turbine hub and can be noticed over some distance, as much as 10 kilometres if high reflectivity paint were to be utilised. While the effect may be noticeable at distance its impact is regarded as very transient and therefore low.

Blade glint will not represent a significant issue for the Flyers Creek Wind Farm project due to the use of low reflectivity finish utilised in all modern turbine blade manufacture which minimises potential for glint. In addition, the Flyers Creek project benefits from the differing altitude of the turbines relative to potential view points, relatively low density of settlement in the surrounding areas and the low volumes of traffic on the local roads.

9.14 Lighting for aviation safety purpose

The Civil Aviation Safety Authority (CASA) has been provided with information with regards to the layout of the proposed wind farm and comments have been sought on any relevant air safety issues. To date, some Australian wind farms have been required to install lighting for aviation safety purposes, while others have not required obstacle lighting. This section reviews the impact of lighting, should it be required to be installed on some of the Flyers Creek wind farm turbines. Aviation issues have been addressed in Chapter 15 including a discussion on why it is unlikely CASA would require aviation lights to be installed.

If required by CASA or where significant risk is indicated without lighting, Flyers Creek Wind Farm Pty Ltd will install the required obstacle lighting. Mitigation measures such as shielding and focussing of the lights will significantly reduce the visual impact for surrounding residences if lighting is required. While some may think the obstacle lights have a negative amenity impact, some neighbours to Infigen Energy's Lake Bonney 2 wind farm, have indicated they do not want the lights turned off as they don't find them to be obtrusive and they have become useful for night time marine navigation.

The *Manual of Standards (MOS) Part 139 – Aerodromes* was prepared pursuant to Civil Aviation Safety Regulations (CASR) Part 139, which sets out the regulatory regime of aerodromes used by aeroplanes conducting air transport operations under CASR Part 121A and Part 121B. The MOS sets out the standards and operating procedures for certified, registered aerodromes and other aerodromes used in air transport operations. Obstacle lighting is addressed in Section 9.4 of the MOS. MOS 139 stipulates medium intensity lights would be utilised. Section 9.4.7 of the MOS provides the characteristics of medium intensity light. There is no requirement for the obstacle light to be seen above or below 1.5° from the horizontal. A light which minimises the intensity below 1.5°, to minimise the visual amenity impact on neighbours, while still meeting the 2000 candela (cd) at horizontal and 1000 cd at ±1.5° requirement for aircraft safety, will be selected. Therefore, the lighting intensity at ground level, which is typically well below -1.5° from horizontal at the turbine nacelle (at least 80 metres above the ground) will be significantly less.

There are aviation light models provided by a number of vendors which minimise the visual impact on neighbours, while still meeting the CASA standards, if lighting is required. Flyers Creek Wind Farm Pty

Ltd will select one of these aviation light models should CASA confirm that obstacle lighting is to be installed. Appendix C1 (Figure C.7) provides an analysis of the visibility of obstacle lighting if it is included in the project taking into account the performance of typical aviation lights which meet the standards specified by CASA. This figure demonstrates the possible visual catchment for obstacle lighting based on them being installed on about half of the turbines. The turbines selected for this analysis were those located on the highest points on the ridge and also the turbines that indicate the edges of the wind farm, ie turbines located at the northern and southern most points and those located at the most west and east points of the wind farm. Additionally, spacing of lights would generally not exceed 900 metres if obstacle lighting is required. As previously mentioned, the computation of the visual catchment of the obstacle lighting does not take into account the screening effects of trees and structures at surrounding residences and will therefore overstate the actual visibility of the lighting

Although the obstacle lighting would be visible, the impact of night lighting on the surrounding residences is considered to be low. This is due to the lights being only visible at night or in conditions of poor visibility, when most people are indoors with little or no view to the turbines or the lights. In addition, when the lights are on inside a residence, there is little or no visibility to the outdoor environment through the windows due to the reflective nature of glass.

9.15 Mitigation of visual impact

The proponent has developed a wind farm array with setbacks of at least one kilometre from all neighbouring residences. Adjustments to the array were undertaken following community information days, to remove two turbines at the northern part of the wind farm site as discussed in Section 6.4. While both sites had excellent wind energy potential the proponent has responded to concerns of several neighbours by removing Turbines 1 and 2. This change has resulted in significantly increasing the distance to the nearest turbine for neighbours to the north of the wind farm site, more than doubling the distance for some neighbours, resulting in a significant reduction in visual amenity impact of the project for these neighbouring residences. Turbine 31 was also relocated to the other side of the top of the hill after a specific request was made by a neighbour of the project.

Regardless of the model chosen, the turbines will be of the three bladed turbine design. The proposed matte white colour is generally accepted as being the most visually acceptable turbine arrangement and colour. Due to their size and required position on the top of ridges, the wind turbines will be prominent and difficult to screen at the site. Existing trees and other features at some surrounding locations will obstruct views of the wind farm to varying degrees.

Measures to further mitigate the visual impact that have, or will be, incorporated in the development will include:

- Earthworks will be restored as soon as possible after construction.
- Underground cables will be installed between turbines within each of the turbine groups as much as practical. Use of overhead lines internal to the wind farm will largely be limited to the connection of the southern collector groups to the substation. The proposed line route is set back from surrounding public roads and neighbouring properties.
- Cable trenches will be backfilled so that once restored they will have no visual impact. The choice of underground cables for the ridge top turbine locations instead of above ground transmission lines has been made to minimise the visual impact of the development.
- The colour of the turbines is that commonly chosen to minimise the visual impact of the turbines based on extensive studies and overseas experience.
- If necessary, and with agreement of the relevant neighbouring landowners, tree planting could be undertaken for some of the closer neighbouring properties (within three kilometres of the wind farm) to screen parts of the development. The preferred types of plants for screening are local native varieties but it may be necessary to plant non-natives that are fast growing where expediency is essential or where property owners would prefer non-natives.

- The design and location of ancillary works will incorporate measures to reduce their visual impact. Screening of certain ancillary works, if required, can utilise vegetation planting the location of the ancillary works.

- Access roads have been minimised and located to limit their visibility from neighbouring public areas and to minimise clearing of native vegetation. The construction methods will also aim to reduce the visibility of disturbed ground.

9.16 Conclusion

The layout of the proposed wind farm site has been based on achieving an acceptable energy output while addressing potential visual and noise impacts and comments received from the property owners and neighbours. The proponent has removed two high energy turbine sites to reduce the visual amenity impact of the array on neighbouring properties. While further minor micro-siting adjustments may be made to the locations of turbines within the site, such adjustments will not alter the overall visual impact.

The wind farm will be noticeable to various degrees from many points within the area surrounding the wind farm site but there are also many locations where views to the wind farm will be limited partially, or fully, by topography and / or trees or by the particular aspect of the viewpoint. As far as possible, all ancillary works will be implemented with due consideration to reducing their visual impact and in most cases they will have a minor contribution to the project's visual impact.

The perceived visual impact is likely to vary between individuals depending on a range of factors. For this reason a set of photomontages has been produced showing how the wind farm will appear when viewed from a selection of representative sites in the area. The photomontages provide representative views from each direction and at various distances from the wind farm. These photomontages, along with the visual impact assessment provided in Appendix C1, are intended to provide stakeholders with an accurate indication of the potential visual impact of the wind farm from representative locations surrounding the wind farm site.

Based on experience with the Blayney and Capital Wind Farms in NSW and larger wind farms of Lake Bonney near Mt Gambier in South Australia and Alinta Wind Farm near Geraldton in Western Australia, it is likely that a significant majority of the Blayney Shire community will regard the visual impact of the installed wind farm as being acceptable. All of the above-mentioned wind farm projects have been well received by the community after some initial concerns about the developments and their visual impacts.

Consultation to date with residents in the vicinity of the Flyers Creek Wind Farm has encountered a range of views including a considerable degree of support from the local community. However, some neighbours to the wind farm site have expressed concern as to the visual impact of the wind farm. Some of the concerns raised about visual impact may be linked to perceptions of the potential impact on land values. The proponent is able to offer tree planting at affected neighbouring residence locations to reduce the visual impact at the residence location, as described earlier in this Chapter.

It is generally not possible to locate wind turbines in locations where they are not visible, because such locations are almost uniformly not windy. To preclude ridgeline locations in NSW, such as Flyers Creek, from wind farm development would drastically reduce opportunities for the development of this form of renewable energy in NSW which appears contrary to expressed Federal and State Government objectives for expansion of renewable energy.