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Landscape and Visual Impact

6. Landscape and Visual Impact

The Landscape and Visual Impact Assessment (LVIA) of the Proposal has been prepared by Green Bean Design Landscape Architects (GBD) and included in this EA as **Appendix C**. The LVIA involved a comprehensive evaluation of the landscape character of the project site, and an assessment of the potential landscape and visual impacts that may result from the construction and operation of the Proposal, taking into account appropriate mitigation measures. This chapter presents a summary of the LVIA methodology as well as the key results and findings arising from the assessment.

6.1. Methodology

The LVIA methodology included the following key activities:

- desktop study addressing visual character and identification of view locations surrounding the wind farm;
- fieldwork and photography;
- preparation of Zone of Visual Influence (ZVI) diagrams;
- assessment and determination of landscape sensitivity;
- assessment and determination of visual impact;
- preparation of photomontages and illustrative figures;
- describing the potential impact of night time lighting; and
- determining the potential for cumulative visual impact of the wind farm against other approved and proposed wind farms in the area.

The LVIA methodology adheres to the general assessment framework outlined in the Australian Wind Energy Association and Australian Council of National Trust's publication *Wind Farms and Landscape Values National Assessment Framework* (June 2007). The LVIA also includes a review of the *Draft National Wind Farm Development Guidelines* (EPHC, 2010).

The LVIA addresses the DGR's for the assessment of potential landscape and visual impacts of the Proposal. It has also considered the relevant provisions of the Upper Lachlan Shire Council's DCP for Wind Farms (2010).

The assessment of shadow flicker was carried out by the Proponent and the results of this assessment are summarised in **Section 11.4.3**.

6.2. Visual Elements of the Proposal

6.2.1. Existing environment

The project site is located on several low undulating ridgelines and hills trending north-south along the Cullerin Range, and toward the northern point of the Lake George escarpment.

The landscape surrounding the project site is predominantly rural in character and occupied by medium size landholdings as well as larger commercial pastoral operations. Areas of cultivated farmland and livestock pasture are interspersed with occasional rural homesteads surrounded by cultural planting and windbreaks. Stands of remnant woodland occur within the wider context of a modified landscape which continues to be managed through a variety of farming activities.

Human modifications within the broader landscape are consistent with common adaptations to rural life and include roads (sealed and unsealed), drainage structures, agricultural buildings, and electrical transmission and communication structures.

A series of annotated panoramic photographs illustrating existing views from various locations in and around the project site are shown in **Appendix C**.

6.2.2. Wind Farm Infrastructure

The key components of the Proposal that are likely to be visible from surrounding areas include the following:

- wind turbine generators (WTGs);
- on-site access roads; and
- electrical substation and maintenance facilities.

Temporary work areas associated with the construction of the wind farm that may be visible during the construction phase include the construction compound and laydown areas.

The WTGs would be the most visible element of the Proposal. For purposes of the LVIA, the WTG model with the largest dimensions was considered to represent the worst-case visual impact. The design parameters of the example WTG are summarised in **Table 9**.

Table 9 Wind Turbine Parameters (Vestas V112)

Element	Dimension
Tower height	94m
Blade length	56m
Overall height from ground level to tip of blade	150m
Proposed number of wind turbines	68

6.3. Perception and Community Consultation

Individual perception is an important issue to consider in any visual impact assessment, as the attitude or opinion of an individual receptor adds significant weight to the level of potential visual impact. These attitudes or opinions of individual receptors toward wind farms can be shaped and formed through a multitude of complex social and cultural values.

It is unlikely that wind farms will ever conform, or be acceptable, to all points of view. Some people accept and support wind farm development in response to global or local environmental issues, whilst others support the environmental ideals of wind farm development as part of a broader renewable energy strategy, but do not consider them appropriate for their regional or local area. Some people believe that the wind farm development is unacceptable in any situation.

Feedback from community consultation indicates that there are a range of views regarding wind farms and landscape values; however, survey results (see **Section 4.9**) indicate that the majority would appear to be in favour of wind farm developments and accepting of the visual impact. Hence, while subjectivity arises in terms of individual perceptions of the visual impact of wind farm developments, there is strong support for this renewable energy technology, suggesting that other factors (e.g. support for renewable energy development in general, and concern about potential impacts of climate change) may come into consideration.

6.4. Viewshed, Visibility and Zone of Visual Influence

A key component of the LVIA is defined by the description, assessment and determination of the viewshed, zone of visual influence and visibility associated with the wind farm. The combination of these issues sets out the framework for assessing the significance and scale of potential visual impact of the wind farm. The relationship between viewshed, zone of visual influence (ZVI) and visibility is outlined in **Table 10** and detailed in **Appendix C**.

Table 10 Relationship of Viewshed, ZVI and Visibility

Term	Definition	Relationship
Viewshed	An area of land surrounding and beyond the project area which may be potentially affected by the wind farm.	Identifies the majority of the LVIA study area that incorporates view locations that may be subject to a degree of visual impact.
Zone of Visual Influence (ZVI)	A theoretical area of landscape from which the wind farm structures may be visible.	Determines areas within a viewshed from which the wind turbines may be visible.
Visibility	A relative determination at which a wind turbine or group of turbines can be clearly discerned and described.	Describes the likely number and relative scale of wind turbines visible from a view location.

6.4.1. Viewshed

The viewshed defines the study area for the LVIA. This viewshed is illustrated as a series of concentric bands at 2km, 5km and 10km distance offsets from the wind turbine clusters. While wind turbines may be visible from

some areas beyond the nominated viewshed, a wind turbine at a maximum height of 150m to the tip of the rotor blade would occupy only a small proportion of a person's field of view at distances beyond 10km.

The viewshed is used as a framework and guide for visibility assessment, as the degree of visual impacts would tend to be graduated with distance. The viewshed assumptions applied to the LVIA for the Proposal are outlined in **Table 11**.

Table 11 Viewshed Descriptors

Distance from Turbine	Potential Viewshed Descriptors
>20km	Wind turbines become indistinct with increasing distance. Rotor movement may be visible but rotor structures are usually not discernible.
10 - 20km	Wind turbines noticeable but tending to become less distinct with increasing distance. Blade movement may be visible but becomes less discernible with increasing distance.
5 – 10km	Wind turbines visible but tending to become less distinct depending on the overall extent of view available from the potential view location. Movement of blades discernible where visible against the skyline.
3 – 5km	Wind turbines clearly visible in the landscape but tending to become less dominant with increasing distance. Movement of blades discernible.
1 – 3km	Wind turbines would generally dominate the landscape in which the wind turbine is situated. Potential for high visibility depending on the category of view location, sensitivity and subject to other visibility factors.
<1 km	Wind turbines would dominate the landscape in which they are situated due to large scale, movement and proximity.

6.4.2. Zone of Visual Influence

The Zone of Visual Influence (ZVI) diagrams are used to identify theoretical areas of the landscape from which a defined number of wind turbines, or portions of turbines, could be visible within the viewshed. They are useful for providing an overview as to the extent to which the Proposal could be visible from surrounding areas.

Two ZVI diagrams (Figures 3 and 4 of **Appendix C**) have been prepared for the LVIA:

- Diagram 1 - ZVI from any part of the wind turbines (tip of blade); and
- Diagram 2 - ZVI from half the swept path of rotor (hub height).

The ZVI diagrams show the areas of landscape which are likely to provide a view toward a greater number of wind turbines are those that generally occur within private property and across tracts of unoccupied rural

landscape, including land belonging to associated landowners. The diagrams also illustrate the influence of surrounding hills and ridgelines that begin to interrupt visibility toward the Proposal from areas of the landscape beyond 3km of the wind turbines. There are elevated locations where views of a large number of turbines exist within this portion of the viewshed, including areas east of the project site along the Collector Road. However, these are moderately distant and generally uninhabited. It should be noted that the wind turbines, when viewed from distances of around, or greater than 15km, will generally be less distinct from other distant elements within the same field of view, and that the majority of land within the viewshed comprises rural agricultural land.

The ZVI methodology is assumed to be conservative as the screening effects of any structures and vegetation above ground level are not considered in any way. The methodology only takes into account the physical form of the landscape. Therefore the wind farm may not be visible at many of the locations indicated on the ZVI diagrams due to the presence of trees or other screening elements. A summary of the ZVI analysis is included in **Appendix C**.

6.4.3. Visibility

The extent of wind turbine visibility within the viewshed is influenced by a number of factors including the following:

- distance between a view location and the wind farm, and the associated atmospheric effects from dust and moisture;
- static or dynamic view locations (e.g. residents or motorists); and
- the relative position of the view location to the wind turbines, which affects the level of visual contrast.

Whilst the distance between a view location and the wind turbine is a primary factor to consider when determining potential visibility, there are other issues, for example the level of tree cover, which may also affect the degree of visibility.

6.5. Landscape Character Areas and Sensitivity

6.5.1. Landscape Character Areas

Landscape character is defined as *the distinct and recognisable pattern of elements that occur consistently in a particular type of landscape* (The Countryside Agency and Scottish Natural Heritage, 2002 cited in **Appendix C**). The LVIA identified five Landscape Character Areas (LCAs), which occur within the landscape surrounding the project site:

- LCA 1 – Undulating grasslands;
- LCA 2 – Wetland and drainage lines;
- LCA 3 – Slope and ridgeline areas;
- LCA 4 – Timbered areas (cultural and remnant native);and
- LCA 5 – Settlements and Homesteads.

The LCAs represent areas that are relatively consistent and recognisable in terms of their respective key visual elements and physical attributes, which include a combination of topography/landform, vegetation/landcover, land use and built structures (including settlements and local road corridors). The above LCAs have not been assessed, described or illustrated as singular *landscape units*. They do not occur as discrete areas, and characteristics within one LCA may occur in adjoining LCAs.

6.5.2. Landscape Sensitivity Assessment

The LVIA defines landscape sensitivity as the degree to which a particular LCA can accommodate change arising from a particular development, without detrimental effects on its character (British Landscape Institute, cited in **Appendix C**).

Landscape sensitivity is a relative term, and the intrinsic landscape values of the surrounding landscape could be considered of a higher or lower sensitivity than other areas in the NSW Southern Tablelands region. Whilst the assessment of landscape sensitivity is largely based on a systematic description and analysis of landscape characteristics, the LVIA acknowledges that some individuals and members of the local community would place higher values on the local landscape. These values could transcend preferences (likes and dislikes) and include personal, cultural as well as other parameters.

The LCAs were assessed for landscape sensitivity through an evaluation of their respective physical attributes that give rise to the landscape's overall robustness and capacity to accommodate the Proposal. The criteria applied by the LVIA for the landscape sensitivity assessment are shown in **Table 12**. These criteria were applied to the LCA using a graduated scoring to represent levels of sensitivity from low to high. Details of the analysis are shown in Section 7.3 of **Appendix C**. The results are summarised in **Table 13**.

In terms of overall landscape sensitivity, the LVIA determined the landscape within the Proposal viewshed has a medium sensitivity to accommodate change, and represents a landscape that is reasonably typical of landscape types found in surrounding areas of the NSW Southern Tablelands.

With a medium sensitivity to accommodate change, some characteristics of the landscape are likely to be altered by the Proposal; however, the landscape will have some capability to accommodate change. This capability is largely derived from the presence of predominantly large-scale and open landscapes across the majority of the project site, together with the relatively low settlement density within the viewshed.

In the context of landscape sensitivity, the LVIA determined the wind farm would not be an unacceptable development within the viewshed, which in a broader context also contains built elements such as roads, agricultural industry, aircraft landing strips, communication and transmitter towers and power lines, as well as approved wind farms in the vicinity of the project site.

It should be noted that despite being 'naturalistic' in appearance large portions of the NSW Southern Tablelands landscape have been heavily modified since European settlement. Physical change to the landscape from human and environmental influences is an ongoing process and can result in both positive and negative effects. It would not be appropriate to assume that the landscape surrounding the project site should be any less valued as a result of modification.

Table 12 Criteria for the Assessment of Landscape Sensitivity

Characteristic	Aspects indicating lower sensitivity to the wind farm development	Aspects indicating higher sensitivity to the wind farm development
Landform and scale: patterns, complexity and consistency	<ul style="list-style-type: none"> • Large scale landform • Simple • Featureless • Absence of strong topographical variety 	<ul style="list-style-type: none"> • Small scale landform • Distinctive and complex • Human scale indicators • Presence of strong topographical variety
Landcover: patterns, complexity and consistency	<ul style="list-style-type: none"> • Simple • Predictable • Smooth, regular and uniform 	<ul style="list-style-type: none"> • Complex • Unpredictable • Rugged and irregular
Settlement and human influence	<ul style="list-style-type: none"> • Concentrated settlement pattern • Presence of contemporary structures (e.g. utility, infrastructure or industrial elements) 	<ul style="list-style-type: none"> • Dispersed settlement pattern • Absence of modern development, presence of small scale, historic or vernacular settlement
Movement	<ul style="list-style-type: none"> • Prominent movement, busy 	<ul style="list-style-type: none"> • No evident movement, still
Rarity	<ul style="list-style-type: none"> • Common or widely distributed example of landscape character area within a regional context 	<ul style="list-style-type: none"> • Unique or limited example of landscape character area within a regional context
Intervisibility with adjacent landscapes	<ul style="list-style-type: none"> • Limited views into or out of landscape • Neighbouring landscapes of low sensitivity • Weak connections, self-contained area and views • Simple large scale backdrops 	<ul style="list-style-type: none"> • Prospects into and out from high ground or open landscape • Neighbouring landscapes of high sensitivity • Contributes to wider landscape • Complex or distinctive backdrops

Table 13 Landscape Character Areas and Sensitivity

Landscape Character Area	Description	Sensitivity
LCA 1	Undulating grasslands	Medium
LCA 2	Wetland and drainage lines	Medium
LCA 3	Slope and ridgeline areas	Medium to High
LCA 4	Timbered areas	Medium
LCA 5	Settlements and Homesteads	Medium

6.6. Potential Impacts

6.6.1. Criteria and Assessment Method

The potential significance of visual impact resulting from the construction and operation of the Proposal would result primarily from the combination of the following factors:

- the visibility or extent to which the wind farm structures would be visible from surrounding areas;
- the degree of visual contrast between the wind farm and surrounding landscape, and the capability of the landscape to visually accommodate the wind farm;
- the category and type of situation from which people could view the wind farm (e.g. residents or motorists);
- the distance between the view location and the wind farm;
- the potential number of people with a view toward the Proposal from any one location;
- the duration of time people could view the wind farm from any static or dynamic view location; and
- the visual sensitivity of view location surrounding the wind farm.

The criteria used to establish visibility and the significance of visual impact are detailed in **Appendix C**.

6.6.2. Visual Impact at Residential View Locations

The LVIA identified a total of 114 residential view locations within 10km of the wind farm (see Figure 15 in **Appendix C**). Seven view locations were chosen as representative of the range of view perspectives from residences within Collector village. An assessment of each residential view location for the proposed turbine layout showed the following:

- 6 (5.2%) locations were determined to have a High visual impact.
- 4 (3.5%) locations were determined to have a Moderate to High visual impact
- 10 (8.8%) locations were determined to have a Moderate visual impact;
- 8 (7.1%) locations were determined to have a Low to Moderate visual impact;
- 36 (31.5%) locations were determined to have a Low visual impact; and

- 50 (43.9%) locations were determined to have a Nil visual impact.

Three of the residential dwellings determined to have a high visual impact are project-involved residences. Of the non-involved residences within 2km of a proposed turbine, two are expected to experience a high visual impact and the third a low to moderate impact, given the screening vegetation within the residential curtilage.

The LVIA determined that residential view locations beyond 10km of the wind farm would be unlikely to experience a visual impact greater than 'low' and would more than likely be screened by a combination of undulating landform and tree cover.

6.6.3. Visual Impact at Public View Locations

Nine public view locations were identified as part of the visual assessment process (see Figure 16 in **Appendix C**). An assessment of the visual impact for each location indicated that all would experience only a low visual impact mainly due to the indirect views available and the very short-term period of view (e.g. motorists driving along the Hume Highway).

It should be noted that the term 'visual impact' may not necessarily always imply or represent an individual's negative response toward the visibility of wind turbines, and that perceptions of wind farms among individuals within a community can be positive, negative or neutral.

6.7. Photomontages

Photomontages have been prepared to illustrate the general appearance of the Proposal during the operational phase. The photomontages presented here have been prepared by Truescape Visual Communication, with the methodology detailed in Appendix B of the LVIA (**Appendix C** of this document). The view fields of the photomontages simulate the Primary Human Field of View; that is, 124 degrees in the horizontal and 55 degrees in the vertical. The photomontages represent the view that would be experienced when standing 500mm behind the actual viewpoint position at the same time of day and under the same climatic conditions as those experienced on the day the photograph was taken.

To accurately assess the potential visual impact of the Proposal using the photomontages, the images must be viewed in accordance with a specific methodology. The images must be reproduced at the correct size, and be viewed at the correct height and distance and from the correct perspective (see Appendix B of the LVIA). The photomontages will be displayed at the main public exhibition location in Collector village during the first half of the public exhibition period and thereafter will be available for viewing at Gunning Library and Upper Lachlan Shire Council offices at Crookwell. Reduced scale photomontages are included in **Appendix E**.

The photomontages were prepared from five selected public view locations and from two of the three private residences within 2km of the nearest turbine, as required by the NSW Guidelines (2011). The third private resident declined permission for the necessary photographs to be obtained from the property; hence photomontages were unable to be prepared.

The locations for the photomontages are shown in Figure 19 in **Appendix C**. Each photomontage location was selected following a desktop review of preliminary ZVI diagrams, together with a site inspection to identify representative viewpoints.

While a photomontage can provide an image that illustrates an accurate representation of a wind turbine - both in relation to its proposed location and its scale relative to the surrounding landscape - it is recognised that it is only a simulation of the real life situation. This is partly due to the fact that a flat image does not allow the viewer to perceive certain information relating to depth or distance. The LVIA quotes the British Landscape Institute as follows:

It is also important to recognise that two-dimensional photographic images and photomontages alone cannot capture or reflect the complexity underlying the visual experience and should therefore be considered an approximate of the three-dimensional visual experiences that an observer would receive in the field.

6.8. Aviation Obstacle Lighting

Aviation obstacle lighting is not proposed for the Collector Wind Farm. The following assessment of night-time lighting impacts is provided in order to ensure that a full assessment was carried out in accordance with the DGR's.

A small number of existing night time light sources are present in the vicinity of the wind farm, including lights within and surrounding settlements, dispersed homesteads, vehicles travelling along local roads and communication towers. While night-time lighting from the Proposal has the potential to be visible from distant view locations, the level of impact will diminish when viewed from more distant view locations or when contained by surrounding landform. Should obstacle lighting be required to be installed, visual impact can be minimised through the use of shielding below the horizontal plane.

The cumulative impact of installed night-time lighting by the Proposal will be minimal as there are very few existing structures in the area that have similar hazard lighting. The only night-time illumination in the vicinity of the project area would originate from residential properties. It should also be noted that the night-time lighting installed on the Cullerin Range Wind Farm (as illustrated in **Appendix D**) has been decommissioned by Origin Energy following a risk based aviation assessment. A number of recent wind farm developments in New South Wales have been approved without requirement for night-time lighting, including the Gullen Range and Glen Innes wind farms.

The impact of obstacle lighting on motorists would also be minimal due to the limited duration of visibility and partial screening by undulating landform along some sections of the road corridors.

6.9. Cumulative Visual Impacts

An assessment of cumulative environmental impacts considers the potential impact of a proposal in the context of existing developments and future developments to ensure that any potential environmental impacts are not considered in isolation.

Direct cumulative visual impacts may occur where two or more wind farms have been constructed within the same locality, and may overlap and are simultaneously viewed from the same view location.

Indirect cumulative visual impacts may also arise as a result of multiple wind farms being observed from the same view location, but do not overlap or occur within a single field of view.

Sequential cumulative visual impacts may also arise as a result of multiple wind farms being observed at different locations during the course of a journey (e.g. from a vehicle travelling along a highway or from a network of local roads), which may form an impression of greater magnitude within the construct of short-term memory.

Existing wind farms within the regional location of the Proposal are identified in **Table 14**.

Table 14 Wind Farm Developments in the Region

Wind Farms (within 25km radius)	Total number of turbines	Status
Gunning	32	Operational
Capital I	67	Operational
Capital II	Up to 53	Under construction
Woodlawn	25	Operational
*Cullerin Range	15	Operational

* Wind farm within Collector Wind Farm 10km viewshed

The majority of wind farms within NSW, currently constructed, approved or under consideration by DoPI, are located within the general regional area of the NSW Southern Tablelands, including sites in the localities of Crookwell, Goulburn and Yass.

There would be opportunities for direct and indirect views toward the Proposal and Cullerin Range Wind Farm from surrounding residential dwellings and public view locations including local roads and highways. However, visibility toward both wind farms would be restricted in some locations due to tree cover and undulating landform. The relatively small size of the Cullerin Range Wind Farm would minimise potential for significant cumulative visual impact.

There would be a limited number of residential view locations with the Proposal viewshed with direct or indirect views toward the Proposal and the Gunning wind farm, largely due to tree cover and undulating landform as well as the distance between the two developments.

A sequential view would occur for motorists travelling along the Hume Highway and sections of local roads who could take in views toward Cullerin, Gunning and the Proposal. Due to the undulating landscape, the motorist would have a range of views extending over regional areas from highpoints or contained by landform and vegetation.

Direct and indirect intervisibility between the Proposal and the Capital/Woodlawn wind farms would be limited by topographical features including the Lake George escarpment and low timbered hills.

A sequential view would occur for motorists travelling along the Federal Highway, passing the Capital, Woodlawn and the Proposal wind farms. Notwithstanding high traffic volumes, the potential for cumulative impact is considered to be low as the view distance toward the Capital and Woodlawn wind turbines is around 10km from the Federal Highway and travel time is short when passing through the wind farms. This LVIA determined the Proposal is unlikely to result in any significant 'direct', 'indirect' or 'sequential' cumulative visual impact resulting from associated views toward existing wind farm developments within a 10km viewshed, including the Cullerin Range, Gunning and Capital/Woodlawn wind farms.

6.10. Pre-Construction and Construction

The key pre-construction and construction activities that may be visible from areas surrounding the project site include:

- various civil works to upgrade local roads and access tracks;
- construction facilities, including portable structures and laydown areas;
- various construction and directional signage;
- mobilisation of rock crushing and concrete batching plant (if required);
- excavation and earthworks; and
- various construction activities including erection of wind turbines, monitoring masts and substation with associated electrical infrastructure works.

The majority of pre-construction and construction activities, some of which would result in physical changes to the landscape, are generally temporary in nature and for the most part restricted to various discrete areas within or beyond the immediate wind farm area. The majority of pre-construction and construction activities would be unlikely to result in an unacceptable level of visual impact for their duration and temporary nature.

6.11. Management and Mitigation

The degree to which the Proposal would be visually mitigated is constrained by the scale and position within the landscape relative to surrounding view locations of wind turbines. In general, mitigation measures could reduce the potential visual impact of the Proposal in one of two ways:

- reducing the visual prominence of the wind turbines and associated structures by minimising the visual contrast between the wind turbines and the landscape in which they are viewed; and
- screening views toward the wind turbines from specific view locations.

The latter measure is likely to be the most effective at the majority of view locations.

While the physical dimensions of WTGs are dictated by efficient design and generating capacity requirements, the choice of colour provides an opportunity to reduce visual contrast between the turbines and the background against which they are viewed. This can be achieved through the use of an appropriate off white or grey colour for the turbines where the visual contrast would be reduced when portions of the turbine were viewed against the sky as well as for those portions viewed against a background of landscape. The final colour selection would, however, be subject to the availability of turbine models on the market at the time of ordering.

The potential visual impact of the Proposal from specific view locations could be mitigated by planting vegetation close to the view locations. For instance, tree or large shrub planting close to a residence can screen potential views to individual or groups of turbines. Similarly roadside tree planting can screen potential views of turbines from particular carriageways.

The location and design of screen planting used as a mitigation measure is very site specific and requires detailed analysis of potential views and consultation with surrounding landowners. Planting vegetation would not provide effective mitigation in all circumstances and can reduce the extent of existing views available from residences or other view locations.

Subject to any condition of approval, the Proponent would consider implementing landscape treatments to screen and mitigate the potential visual impact of the wind farm for individual neighbouring properties (including those determined to have a high visual impact) within an appropriate and agreed distance from the wind farm project area. The extent and nature of appropriate mitigation measures would be subject to consultation and agreement with individual property owners.

There is greater potential to mitigate the visual prominence for some of the ancillary structures and built elements associated with the wind farm through the appropriate siting, selection of materials and colours, together with consideration of their reflective properties.

Furthermore, a number of mitigation measures would be implemented during the construction phase of the Proposal with the aim of minimising visual impact. These include:

- minimising cut and fill for access roads by following contour lines and using existing roads as much as possible, which will also minimise the potential for landscape scarring;
- minimising activities that may require night time lighting and, if necessary, using low intensity lighting designed to be mounted with the light pointed towards the site to minimise glare;
- enforcing safeguards to control and minimise dust emissions during construction;
- restricting the height of stockpiles to minimise visibility from outside the site;
- reinstating disturbed soil areas following construction; and
- maximising the revegetation of disturbed areas to ensure effective cover is achieved.

7

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Noise Assessment

7. Noise Assessment

A noise impact assessment was prepared by Marshall Day Acoustics for the construction, operation and decommissioning phases of the Proposal, with the report presented in **Appendix F**. This chapter describes the various noise sources associated with the Proposal, the applicable guidelines for noise compliance, the methodology for predicting noise levels at nearby residences, and the predicted noise levels and potential impacts from the Proposal at these residences.

7.1. Wind Farm Noise

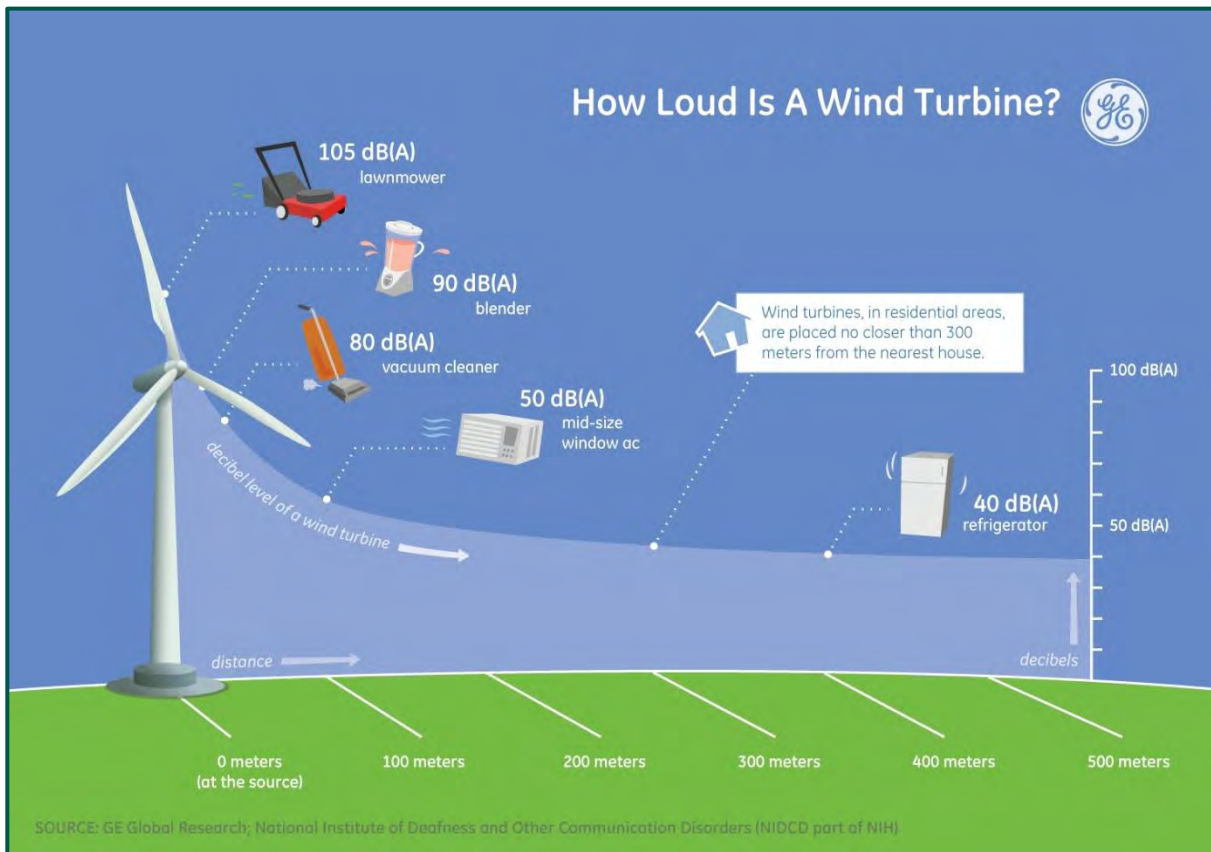
Noise can be considered as sound that causes annoyance for an individual. Within this basic definition there is complexity not only in terms of an individual's perception of what constitutes noise, but also the characteristics of different noise sources such as tonality, modulation and frequency. For the purposes of assessing the impact of noise sources on humans, noise emissions are measured in 'A-weighted' decibels (dBA). The A-weighting is applied to the noise spectrum emitted from a particular source to select the frequencies that fall within the range of human hearing. These frequencies are within the range of 500 to 4,000 hertz (Hz). The decibel scale is logarithmic, meaning that a 10dBA increase in noise emission represents a doubling in loudness. **Table 15** shows the typical noise levels in dBA from various sources as a means of comparison.

Table 15 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Sources	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3m	Very noisy
90	Construction site with jackhammer	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to Quiet
50	General office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Unoccupied recording studio	Almost silent

Source: *Wind Prospect CWP (2009)*

Figure 8 provides a graphical illustration of the relative noise levels from a wind turbine at various distances, overlaid with some common household noise sources.



Source: <http://www.gereports.com/how-loud-is-a-wind-turbine> (accessed 6 June 2012)

Figure 8 Wind Turbine Noise

When assessing the noise impact from a particular source, the measured or predicted noise levels are compared with the background noise. Also referred to as ambient noise, background noise is the average noise level experienced in a particular environment. For the purposes of noise modelling, the background noise is considered to be the noise level exceeded for 90% of the time, represented by the L_{A90} descriptor.

Noise emissions from operating wind farms come from two main sources: turbines and the substation. Other noise sources can include corona (buzzing or crackling) and aeolian (wind) noise associated with transmission lines.

7.1.1. Wind Turbine Noise

Noise from wind turbines is either aerodynamic or mechanical. Aerodynamic noise is generated by the movement of the blades through the air; this type of noise is often referred to as a 'swooshing' sound. The aerodynamic noise levels of a wind turbine increases with wind speed up to a maximum level. In this respect,

aerodynamic noise resembles background noise, which also increases with increased wind speeds. An example of such background noise is the noise from trees on a windy day.

Mechanical noise is associated with the operating components of the wind turbine. Modern wind turbines emit relatively low levels of mechanical noise as the operating components are housed within the nacelle, which provides insulation that minimises sound emissions to the environment.

7.1.2. Substation Noise

The Proposal includes a single high voltage substation with two 130 megavolt ampere (MVA) transformers to step up the incoming electricity current from the WTGs at 33 kilovolts (kV) to match the 330kV of the transmission grid. Noise from substation transformers can be characterised as a 'hum'. The noise impact assessment considered the strong tonality at 100Hz displayed by transformers and a correction factor has been applied to the predicted results.

7.1.3. Other Noise Sources

Other noise sources covered by the noise assessment included aeolian and corona noise, construction noise, and construction and operation phase traffic noise. In addition, vibration levels during the construction phase were assessed.

Aeolian noise (caused by winds passing across transmission lines generating tonal noise) and corona noise (caused by the voltage difference applied across a volume of air and emitted as a hiss or crackle) are both associated with the proposed turn-in connection to the TransGrid transmission line.

7.2. Noise Guidelines

7.2.1. Wind Farm Guidelines

The noise assessment was undertaken in accordance with the South Australia Environment Protection Authority *Wind Farms – Environmental Noise Guidelines* (2003) (SA EPA Guidelines). The DGRs require that these guidelines be used to assess the noise impacts of the Proposal.

The SA EPA Guidelines were established to protect the amenity of residents near wind farms, with guidance on acceptable levels of noise for neighbouring landowners who do not have an agreement with the wind farm developer. Within the guidelines, these residents are referred to as 'relevant receivers'. The SA EPA Guidelines specify wind farm noise criteria as follows:

The predicted equivalent noise level ($L_{Aeq,10 min}$), adjusted for tonality in accordance with [the] guidelines, should not exceed:

- 35dB(A), or
- the background noise by more than 5dB(A)

whichever is the greater, at all relevant receivers for wind speeds from cut-in to rated power of the WTG.

The SA EPA Guidelines also contain specifications for particular noise characteristics such as tonality, for which the predicted noise level should be adjusted by adding 5dBA.

The noise assessment also accounted for the draft *NSW Wind Farm Noise Guidelines*, issued by DoPI as part of the *Draft NSW Planning Guidelines: Wind Farms* (DoPI, 2011). The draft guidelines are currently being finalised following a public exhibition period. In the interim, and in advance of any final guidelines, the noise assessment has taken account of the proposed noise criteria contained in the draft NSW guidelines, which state:

For a new wind farm development the predicted equivalent noise level (Leq, 10 minute), adjusted for any excessive levels of tonality, amplitude modulation or low frequency, but including all other normal wind farm characteristics, should not exceed:

35dB(A) or the background noise (L90) by more than 5dB(A), whichever is the greater, at all relevant receivers not associated with the wind farm, for wind speed from cut-in to rated power of the WTG and each integer wind speed in between.

Further discussion on the application of the NSW Guidelines is included in **Appendix F**.

7.2.2. Other Applicable Guidelines

There are other relevant noise guidelines which are applicable to and have been used in the assessment of noise from sources associated with other aspects of the Proposal. These are the following:

- project-involved receivers– the European Working Group on Noise from Wind Turbines document *ETSU R-97 the Assessment and Rating of Noise from Wind Farms* recognises that where landowners have a financial involvement with the wind farm, higher noise levels are acceptable. The noise assessment for the Proposal adopts the recommended criteria of 45dBA for involved receivers, which is in agreement with the World Health Organisation (WHO) criterion for protection of amenity and avoidance of sleep disturbance as published in the document *Guidelines for Community Noise* (1999).
- electrical substation - the *NSW Industrial Noise Policy* (INP) (EPA 2000) was used to assess noise from the wind farm substation. The INP specifies noise amenity criteria at nearby receivers for different times of the day as follows:
 - day (7:00am to 6:00pm) = 50dBA;
 - evening (6:00 to 10:00pm) = 45dBA; and
 - night (10:00pm to 7:00am) = 40dBA.
- traffic noise – noise from construction and operational traffic was assessed in accordance with the NSW EPA *Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA 1999);
- site establishment and construction – construction noise was assessed in accordance with the *Interim Construction Noise Guidelines* (DECC 2009); and
- vibration – construction-phase vibration was assessed in accordance with *Vibration Assessment: A Technical Guideline* (DEC, 2006).

Blasting will not be undertaken during the site establishment and construction and therefore blasting noise and vibration impacts have not been covered in the noise impact assessment.

7.3. Existing Environment

Eight residences are situated within 2km of the nearest wind turbine; five of these are project-involved landowners. The location of residences in the vicinity of the project site is shown on **Figure 4**. Residences located greater than 2km from turbines are unlikely to experience adverse noise emissions from turbines, nevertheless an additional 26 dwellings have been included in the noise assessment.

The project site is adjacent to the existing Cullerin Range Wind Farm, which is immediately to the north across the Hume Highway. Given the proximity to the Proposal, the cumulative noise impacts associated with this facility were included in the noise assessment.

7.4. Methodology

7.4.1. Wind Turbine Noise

Assessment of wind turbine noise was undertaken in accordance with the SA EPA Guidelines which involved a four-stage methodology:

Determination of Relevant Receivers

Relevant receiver locations are selected among residential premises where the preliminary wind farm noise level predictions exceed 35dBA. The Proponent identified 34 dwellings as potential relevant receivers for inclusion in the noise assessment.

Establishment of Noise Limits

Background noise monitoring data obtained for the four locations during the second monitoring episode exhibit a persistent and recurring increase in noise levels during the evening. The nature of the increase suggested a potential temporary or seasonal phenomenon such as frog or insect noise. This trend was not seen in the results from the first episode of background noise monitoring.

Because of the uncharacteristic night time background noise levels measured at four of the eight monitoring locations, the entire background noise data set was discarded. Instead, a conservative approach was taken with respect to noise limits by adopting the SA EPA Guidelines base noise level of 35dBA as the limit for all non-involved receivers.

Assessment of the Acceptability of Wind Farm Noise

Noise predictions were undertaken for each receiver identified in stage one using the SoundPLAN computer model and in accordance with the ISO9613 standard. As the final wind turbine model for the Proposal has not been chosen, three turbine models were used in the noise prediction to represent the range of noise levels: the Suzlon S88-2.1MW, the REPower 2.4M104 and the Siemens SWT-2.3-101. The predicted noise levels were compared to the noise criteria adopted for the Proposal. The results are described in **Section 7.6**.

Low frequency noise was assessed against the *NSW Wind Farm Noise Guidelines* and involved predictions of the C-weighted noise levels at the three non-involved residences within 2km of proposed WTG locations.

7.4.2. Other Noise Sources

Noise emissions from other noise sources associated with the wind farm were assessed using the methodologies described below:

- **Substation Noise.** Potential noise impacts from the substation were predicted using the CONCAWE noise model. Background noise levels were predicted using the methodologies specified in the NSW INP to establish the Rating Background Level (RBL).
- **Construction Noise.** A noise model was established for the construction phase using the assumption that all mobile equipment would be operating simultaneously at full load. Noise predictions were made in accordance with AS2436 – 1981: *Guide to noise control on construction, maintenance and demolition sites* at the closest turbine location to each residence.
- **Traffic Noise.** The traffic noise assessment was undertaken in accordance with the methodology described in the ECRTN, using traffic data derived from the traffic and transport assessment (**Appendix H**). The assessment considered sections of the projected route for overland trucking of turbine components to the site, and Lerida Road South which is the main public road access to the site.

7.5. Impact Assessment – Construction and Decommissioning

7.5.1. Construction Noise

The *Interim Construction Noise Guidelines* (OEH, 2009) sets out noise management levels and defines two thresholds: the noise affected level and the highly noise affected level. The noise affected level applicable to residential dwellings is equal to the Rating Background Level, determined in accordance with the NSW INP, and adding 10dB. Where the RBL was found to be less than 30dBA, the RBL was set to 30dBA. Since the RBLs at all assessed residences were found to be less than 30dBA under calm wind conditions, the management levels were set at $L_{eq, 15min} = 40dBA$. The highly affected noise level for residential dwellings is 75dBA. It represents the point above which there may be strong community reaction to noise.

Construction activities modelled in the noise assessment included:

- access road and crane pad construction;
- turbine tower foundation excavation and construction;
- trench excavation for laying underground cabling; and
- assembly and erection of turbine tower, nacelle and rotor blades.

Table 16 shows the predicted noise levels for each of the construction activities listed above compared with the management levels adopted for the assessment. Because more specific equipment and work methodologies will be selected during the construction phase and associated noise would vary, the predicted construction noise levels are provided as indicative ranges of levels which may occur in practice.

The predicted noise levels at non-involved residences during the construction phase would comply with the noise management levels. Noise levels would exceed the noise affected level at project-involved residences (excluding residence N) by up to 10dBA but remain more than 20dBA below the threshold of highly affected noise level defined by the Interim Construction Noise Guidelines,

Table 16 Construction Noise Level Predictions

Receiver	Management level (Leq, 15 minute)	Indicative Predicted Noise Level (dBA)					Comply (Y/N)
		Access Road Construction	Turbine Foundation Preparation	Cable Trench Digging	WTG Assembly	Concrete Pouring	
G*	40	40-45	40-45	40-45	<30	30-35	N
M*	40	35-40	35-40	35-40	<30	<30	Y
N*	40	55-60	55-60	55-60	40-45	45-50	N
T*	40	45-50	45-50	40-45	30-35	35-40	N
L	40	30-35	30-35	30-35	<30	<30	Y
Q	40	30-35	30-35	30-35	<30	<30	Y
Z	40	35-40	30-40	35-40	<30	<30	Y
FF	40	35-40	30-40	35-40	<30	<30	Y

*Project-involved residence

7.5.2. Traffic Noise

Construction traffic noise was predicted based on the projected transport route to the site of turbine components from Port Kembla via Picton Road, the Hume Highway and Lerida Road South, and of the construction workforce who will most probably be travelling from accommodations in Goulburn via Hume Highway. The predicted construction traffic volumes were compared with the existing volumes along these routes.

The noise criteria applied to the various receivers were adopted from ECRTN as follows:

- Receiver N and Z (located near Lerida Road South) – Land use developments with potential to create additional traffic on local roads: $L_{Aeq(1hr)}55$ daytime (7:00am-10:00pm), with traffic arising from the development not to increase existing noise levels by more than 2dB where the criteria are already exceeded;

- Receiver CC, Picton Road and Hume Highway (S of Illawarra Highway) – Land use developments with potential to create additional traffic on existing freeways/arterials: $L_{Aeq(1hr)}$ 60 daytime (7:00am-10:00pm), with traffic arising from the development not to increase existing noise levels by more than 2dB where the criteria are already exceeded.

Traffic noise at potentially affected residences in and near the project site near the transport routes (represented by Receivers N, Z and CC) are predicted to comply with ECRTN criteria (**Table 17**).

The assessment also shows that receivers along Picton Road and Hume Highway (within the setback adopted in the assessment) already receive traffic noise emissions above the ECRTN criteria. The predicted construction traffic noise from the Proposal will not cause any significant increase in existing noise levels on either road.

Table 17 Current and Construction Traffic Noise Levels (dB)

Receiver	Distance to Road (m)	Current Noise Level	Predicted Construction-Phase Level	ECRTN Criterion 7am-10pm (Leq,1hr)	Within ECRTN Criteria?
N*	45	41	53	55 or less than 2dBA increase	Yes
Z	625	28	40	55 or less than 2dBA increase	Yes
CC	700	49	50	60 or less than 2dBA increase	Yes
Picton Road	20	66	67	60 or less than 2dBA increase	Yes
Hume Highway	45	68	68	60 or less than 2dBA increase	Yes

* *Project-involved receiver*

7.5.3. Vibration

The predicted vibration levels at a distance of 250m for typical construction plant were compared with the relevant criteria for building conservation and human exposure (Table 15 in **Appendix F**). The maximum predicted peak particle velocity (pp.) for a piling machine at 10m distance is 30 millimetres per second (mm/s) (1.37mm/s at 250m). While it is unlikely that a piling machine would be required, the assessment considered this plant item as a theoretical worst case. The representative case for the Proposal would involve a 15 tonne roller, which has a predicted maximum pp. of 8mm/s at 10m (0.37mm/s at 250m). The building conservation and human exposure limits for vibration are 15-50mm/s and 8.6-17mm/s, respectively.

The nearest receiver to the construction activities is located approximately 300m away from the nearest WTG. As the vibration limits for building conservation and human exposure at 250m distance are predicted to be an order of magnitude less than the respective limits, the vibration impacts at 300m would likewise fall below the vibration criteria.

7.5.4. Decommissioning

Decommissioning activities, equipment, machinery and traffic movements will be consistent with that of construction phase. Therefore, for the purpose of this EA, noise impacts associated with decommissioning phase are based on construction phase estimates.

Decommissioning of the wind farm will involve the removal of mechanical turbine infrastructure along with excavation of turbine footings and rehabilitation of road corridors not required for agricultural or fire control activities. Similar to the construction phase, decommissioning works will entail the use of pneumatic equipment and machinery (e.g., jack hammer). Such equipment/machinery has the potential to emit noise above background levels.

The impacts for use of ground breaking machinery and equipment has been considered in accordance with the *Interim Construction Noise Guidelines* (DECC, 2009) and *Assessing Vibration: A Technical Guide* (DEC, 2006) by Marshall Day, 2011 (**Appendix F**). Given the straight line distance from sensitive receptors (non-involved), and the anticipated relatively limited duration and intermittent nature of works, it is considered unlikely that significant noise and vibration impacts will result from the decommissioning of the wind farm.

At the time of preparation of this EA, the noise impacts associated with the decommissioning of wind farm infrastructure had not been quantified in consideration of the following factors:

- no turbine manufacturer or contractor had been engaged;
- no detailed design of footings, access roads and turbine infrastructure had been finalised;
- the potential for background noise profile of the region to change over the duration of the operation phase (approximately 30 years);
- the potential for local and regional sensitive receptors to change over the duration of the project; and
- the potential for advancements in technology and industry best practice (i.e. plant, equipment, machinery and sound mitigation measurements).

Whilst it is considered unlikely that noise and vibration impacts will significantly impact current sensitive receptors (based on construction phase predictions) it is anticipated that the Proponent will be required to prepare an updated noise impact assessment prior to the commencement of decommissioning works.

7.6. Impact Assessment – Operation

7.6.1. Wind Turbine Noise

Noise levels from the wind farm operation were predicted for three turbine models under consideration: the Siemens SWT-2.3-101 which has the highest sound power level (SPL) of 106dBA; the REpower 3.4M104 turbine, with an SPL of 105dBA; and the Suzlon S88 turbine which has the lowest SPL of 103.6dBA. In terms of noise criteria for non-involved receivers, a conservative approach has been adopted for the Proposal, with the 35dBA base criterion adopted.

Noise predictions applied to the 68 WTG layout indicate that compliance with the adopted 35dBA noise criteria level at nearby non-involved residences is achievable for the three wind turbine models listed above, except at

residence FF, where only the Suzlon S88 achieves compliance (**Figure 9**). To achieve compliance with the 35dBA criterion at residence FF, a reduction in number of WTGs for the remaining two models would be required as follows:

- REpower 3.4M – omit one WTG to the north-east of receiver FF giving a 67 WTG layout (**Figure 10**); and
- Siemens SWT-2.3 – omit three WTGs to the north-west and one to the south-west of receiver FF giving a 64 WTG layout (**Figure 11**).

The predicted receiver noise levels for the reduced layout for three turbine models are shown in **Table 18**. Predicted noise levels below 20dBA cannot be practically measured in the conditions in which turbines operate, and therefore the numerical value of the predicted noise level at locations below 20dBA is not reported. The noise criterion for involved residences is 45 dBA (WHO, 1999). **Table 18** indicates that the noise predictions for the involved residences for the three turbine models at their respective reduced layouts are compliant with the 45 dB limit, with the exception of residence N.

Table 18 Maximum Predicted Noise Level at Residential Receivers

House	Maximum Predicted Noise Level L_{eq} dB			Minimum Noise Limit
	68 x Suzlon S88-2.1MW	67 x REpower 3.4M 104	64 x Siemens SWT-2.3-101	
A	<20	<20	<20	35
AA	31	31	32	35
B	<20	<20	<20	35
BB	31	31	31	35
C	<20	<20	<20	35
CC	26	27	27	35
D	21	21	21	35
DD	28	28	29	35
E	21	21	22	35
EE	25	25	25	35
F	25	25	26	35
FF	35	35	35	35
G*	34	34	36	45
GG	27	27	28	35
H	28	28	30	35
HH	29	29	30	35

House	Maximum Predicted Noise Level L_{eq} dB			Minimum Noise Limit
	68 x Suzlon S88-2.1MW	67 x REpower 3.4M 104	64 x Siemens SWT-2.3-101	
I	26	26	27	35
J	30	30	32	35
K	30	31	32	35
L	30	30	31	35
M*	35	35	36	45
N*	46	47	49	45
O	30	30	31	35
P	24	24	25	35
Q	27	27	28	35
R	28	28	29	35
S*	37	38	39	45
T*	38	38	40	45
U	22	22	23	35
V	30	30	31	35
W	27	27	28	35
X	27	27	28	35
Y	27	27	28	35
Z	33	34	35	35

* Involved residence

7.6.2. Meteorological Conditions and Noise Propagation

The noise impact assessment considered the potential effect of meteorological conditions, including atmospheric stability and the van den Berg effect, on noise propagation (Appendix E in **Appendix F**). The van den Berg effect relates to potential increases in noise levels from wind farms due to stable air conditions.

The wind velocity above the ground surface generally varies with altitude, with minimum speeds at ground level increasing with height above the ground. Wind velocity is primarily determined by topography; however local atmospheric conditions can also have an impact. Atmospheric stability relates to the daily thermal exchange that occurs due to solar activity causing thermal mixing, vertical air movement and turbulence. As a result of this turbulence, the atmosphere is unstable, preventing significant changes in the wind velocity profile over short distances. On clear nights, more stable atmospheric conditions can occur such that there is a

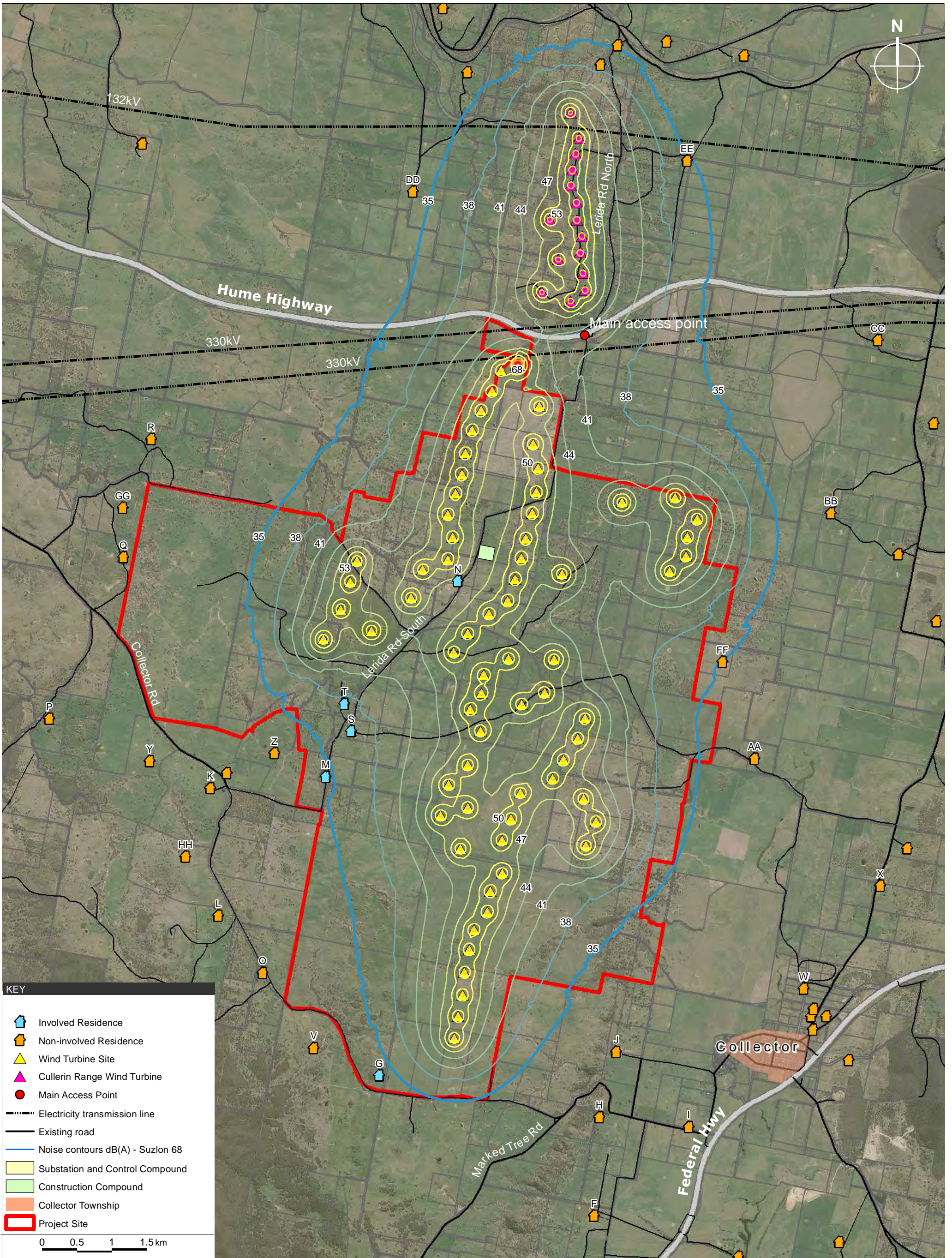


Figure 9: Noise Contours – Suzlon S88

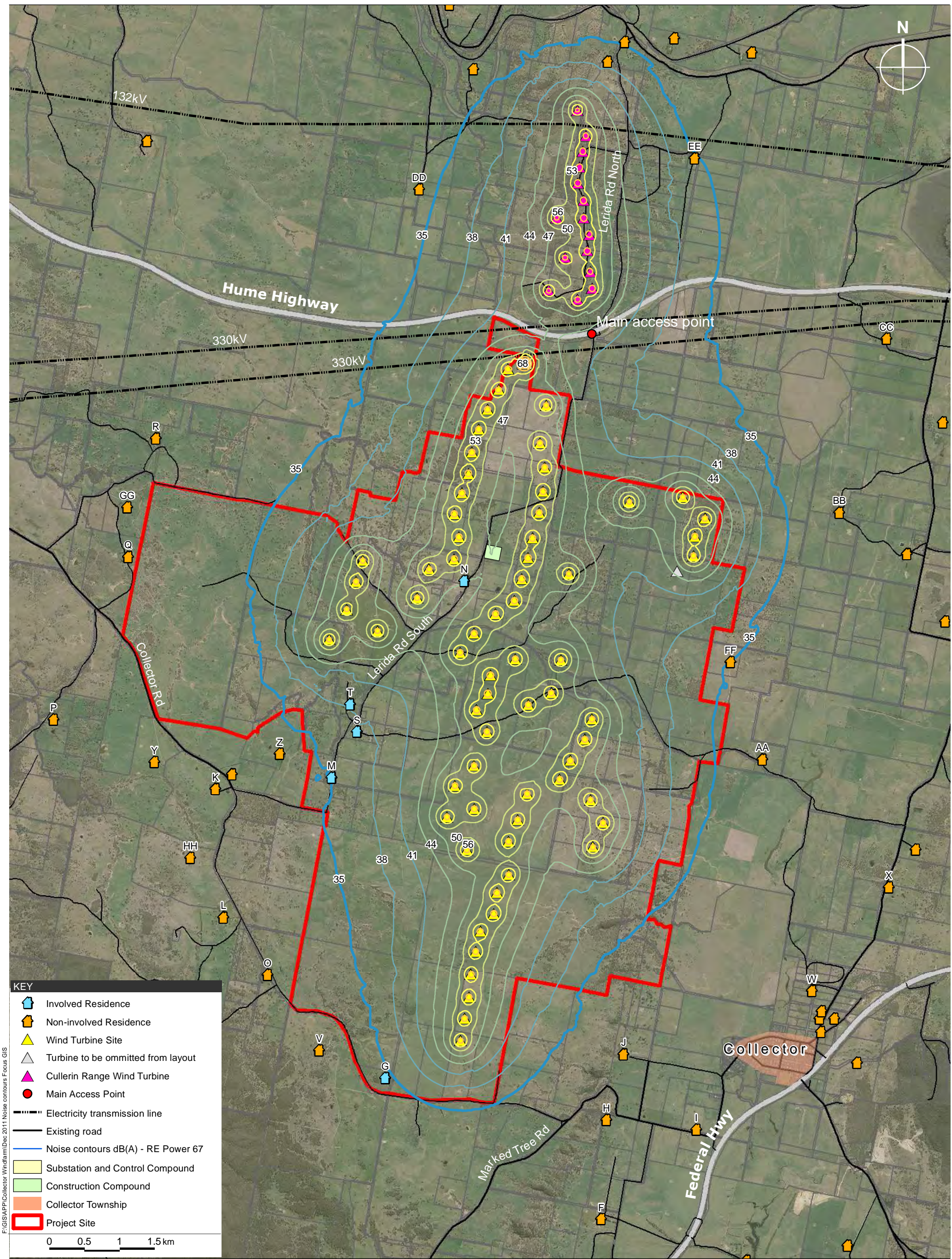


Figure 10: Noise Contours - Repower 3.4m

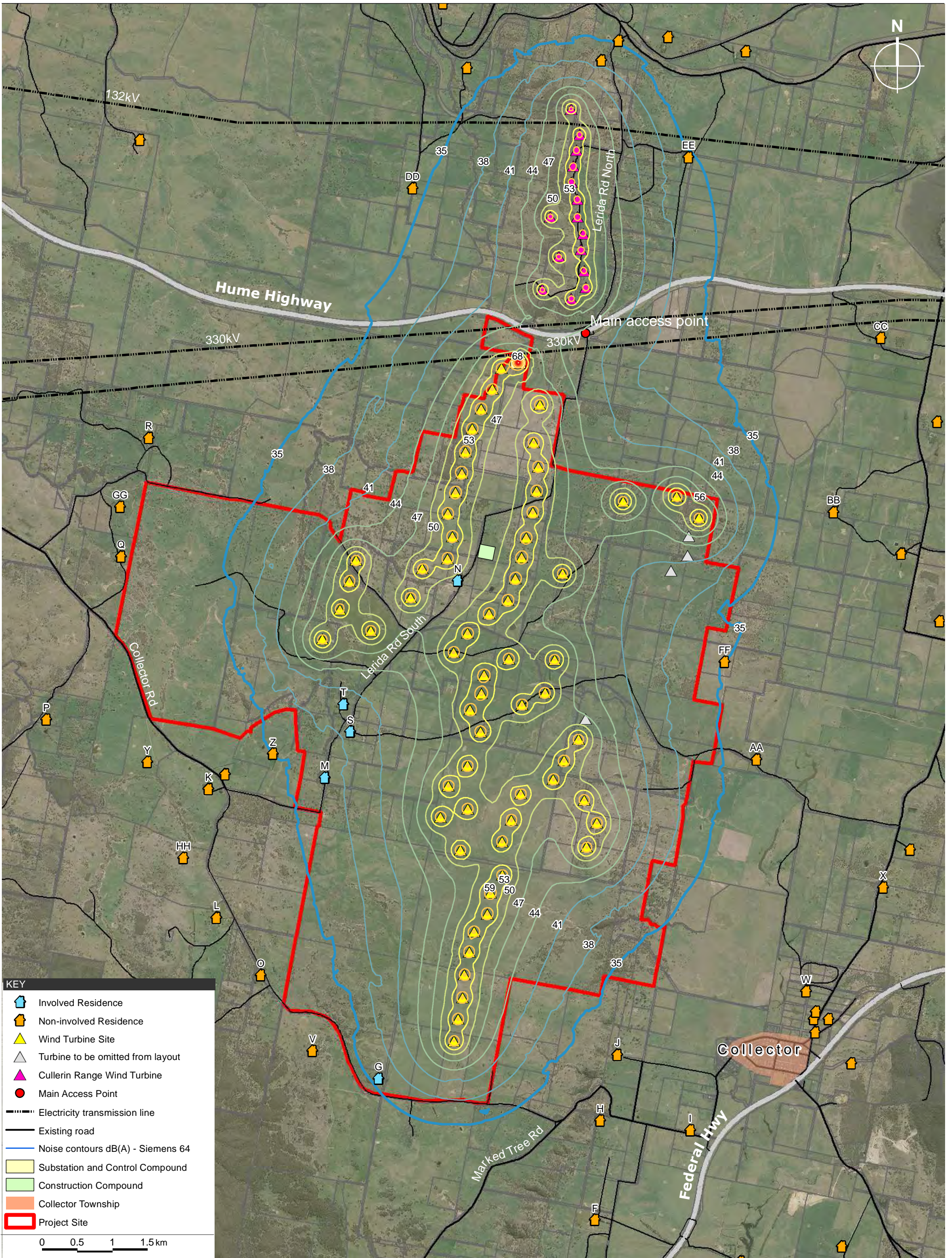


Figure 11: Noise Contours – Siemens SWT – 2-3

higher wind velocity gradient between the ground surface and higher elevations. The noise assessment methodology, using the SA EPA Guidelines (2003), takes into account the wind profile conditions in the local area and the wind speed measurements made during the background noise monitoring period would be expected to cover all atmospheric stability conditions.

Marshall Day Acoustics notes that it has not observed the van den Berg effect in Australia, nor is it aware of the phenomenon being reported at any operational wind farm.

7.6.3. Tonal and Low Frequency Noise

An assessment of the potential for tonal noise associated with the WTGs was undertaken as part of the noise impact assessment, which concluded that a tonal correction was not required.

Low frequency noise was a more common problem with the older wind turbine designs where the rotating blades were located downwind of the tower. The blades cutting through the turbulence created by the tower resulted in increased low frequency noise. Modern turbine designs which place blades upwind of the tower, have exhibited significantly lower low frequency noise.

Research cited in the noise impact assessment (**Appendix F**) notes that measurements of low frequency noise from modern wind turbines have been below thresholds of human detection. The subject of low frequency noise and health is discussed further in **Section 11.4.1**.

7.6.4. Noise from Substation Transformers

The sound power level for each transformer in the wind farm substation was estimated as 103.5dBA based on Australian Standard AS2374.6-1994 *Power transformers – Determination of transformer and reactor sound levels*. As the type of transformer proposed can also exhibit strong tonality, a penalty of 5dB was added to the predicted results. Combined noise levels from the transformers were predicted at the two nearest receivers, DD and N, which are 2.9km and 3.2km from the substation, respectively. Predicted noise levels were more than 10dB below the relevant night-time criteria.

7.6.5. Corona and Aeolian Noise from Transmission Line

The noise impact assessment considered transmission line aeolian and corona noise effects arising from the 250m long turn-in line to connect to the 330kV transmission grid. This connection will occur around 3km from the nearest existing residence. The existing 330kV transmission line running across the northern end of the project site may give rise to Corona and Aeolian noise at existing dwellings in the area. The Proposal's turn-in transmission line is not expected to alter the level or regularity of this Corona and Aeolian noise from the existing 330kV transmission line. It is therefore considered that the turn-in line will not give rise to Corona or Aeolian noise impacts on receivers in the vicinity of the project site.

7.6.6. Other noise sources

Another potential source of noise emissions during operation is traffic noise. Operation phase traffic will be mainly generated by on-site staff, whose numbers are not expected to exceed 25, occasional maintenance

crews or subcontractors, occasional supply deliveries, and site visitors. The daily volume of this traffic is much less than the traffic during the construction phase so it is not considered that operation phase traffic will exceed the relevant ECRTN criteria.

7.6.7. Cumulative impacts

An assessment of potential cumulative impacts associated with the operational Cullerin Range Wind Farm was undertaken as part of the noise assessment. The southern extent of the Cullerin Range Wind Farm is located approximately 4.2km north of the nearest receiver in the project site (receiver N). The cumulative noise impact assessment predicted operational noise levels from Cullerin Range Wind Farm (using the same ISO9613-2:1996 methodology applied to the Proposal) then overlaying the relative noise contribution from Cullerin Range Wind Farm and the Proposal. The highest predicted noise levels from the three candidate turbine models and the respective reduced layout were used. The predictions are conservative as it was assumed there was simultaneous downwind propagation from each WTG of each wind farm.

The predicted cumulative noise at the two most affected receivers near Cullerin Range Wind Farm show that there would be a marginal increase at house DD, and a negligible increase at House EE, with the projected contribution of each wind farm below the SA EPA guideline base limit of 35dBA. All other receptors relevant to Cullerin Range Wind Farm are located further from the Proposal and therefore it is considered that the Proposal would represent a marginal contribution to noise levels at these receivers.

The predicted increase in noise at receivers near the Proposal from the contribution of Cullerin Range Wind Farm is 0.6dBA or less and the combined predicted total noise levels are below the relevant minimum limits at each location. The noise contours, shown in **Figure 9**, **Figure 10** and **Figure 11**, account for the contribution of the Cullerin Range Wind Farm.

7.7. Mitigation Measures – Construction and Decommissioning

Noting that noise emissions from construction and decommissioning activities will be localised and temporary, the key mitigation measures to minimise the potential impacts are the following:

- adherence to accepted working hours: 7.00am to 6.00pm Monday to Friday; and 8.00am to 1.00pm on Saturdays, with no work or deliveries on Sundays or public holidays, except for some activities which may need to occur outside standard working hours such as delivery of oversize loads and the completion of concrete pouring past the standard hours of work due to climatic considerations;
- in accordance with the *Interim Construction Noise Guidelines* (DECC, 2009), all feasible and reasonable work practices would be employed to minimise construction noise impacts; and
- notification and ongoing consultation with potentially affected receivers in the vicinity of the project site will be maintained, especially where potentially noisy works are anticipated.

Mitigation measures for traffic noise impacts within the subject site would include:

- regulating the timing of deliveries; and
- notification to residents when deliveries of large loads are scheduled.

To reduce noise emission from construction plant, these will be:

- selected on the basis of low inherent potential to generate noise and vibration;
- fitted with noise control equipment (such as mufflers) and low-noise reversing alarms; and
- be regularly inspected and maintained to ensure noise emissions do not exceed typical levels.

Vibration from construction activities are expected to comply with building conservation and human exposure criteria and no adverse impacts are expected.

The Proponent will establish a complaints number to provide a mechanism for residents to register noise complaints. When noise complaints are received, the affected resident will be contacted to identify the source of noise and any remedial measures that may be required.

7.8. Mitigation Measures - Operation

The wind farm layout will be determined by the chosen turbine model. Turbine locations will be removed from the layout in the vicinity of residence FF to permit compliance with the SA EPA 35dBA base criterion.

Within the first twelve months of operation, monitoring of wind farm noise emissions would be undertaken at the four closest non-involved residences to assess compliance with noise criteria. Where it is determined that the operational wind farm exceeds noise limits set in the project approval conditions, the following noise mitigation measures will be implemented:

- using active noise control functions of turbines;
- rectify any manufacturing defects or control settings so that noise can be reduced to the in accordance with the contracted specifications; or
- if excesses still occur, acoustic treatment of receiver dwellings.

Should any of the above measures be adopted, their effectiveness will be verified through noise monitoring during the first 12 months of operation.

The results of the noise modelling indicate the predicted noise level at project-involved receiver N will not comply with the WHO noise criterion of 45dBA. Additional contingency measures will be included in recognition of the higher predicted noise levels expected to occur at this involved location. These additional measures would comprise options for landscaping measures around the dwelling to introduce additional sources of background masking noise (e.g. additional and taller foliage), and building insulation measures designed to achieve acceptable internal noise levels. The insulation measures would address ventilation treatments to enable windows to remain closed for a range of conditions, and potential upgrades to key facade elements such as windows. These arrangements are contemplated in the operational phase lease conditions for property N.

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Flora and Fauna Assessment

8. Flora and Fauna Assessment

A Biodiversity Assessment was undertaken by NGH Environmental (NGH) to assess the constraints, evaluate the potential impacts and to develop specific mitigation measures to minimise the potential impacts of the Proposal on biodiversity values. The results of this assessment are summarised in this chapter and the assessment report is attached as **Appendix G**.

8.1. Assessment Methodology

In order to understand the existing ecological environment and assess any potential impacts from the Proposal, NGH conducted a variety of investigations such as preliminary studies, desktop assessment, fieldwork and detailed surveys and mapping. The study area covered the project site and adjacent habitat types. More detailed assessment was undertaken within the development envelope.

8.1.1. Preliminary Studies

Two preliminary investigations were undertaken by NGH prior to the final Biodiversity Assessment:

- *Preliminary Ecological Investigation of the Proposed Collector Wind Farm*, February 2010 (PEI), prepared to identify potentially significant ecological issues on site; assess the level of risk to flora and fauna posed by the development and operation of a wind farm; and develop a targeted program for further ecological investigations; and
- *Biodiversity Study Collector Wind Farm*, July 2010, prepared to address the issues identified in the PEI. The report included a targeted flora and fauna survey program.

8.1.2. Assessment Approach and Objectives

The Biodiversity Assessment has been prepared in accordance with the following requirements and guidelines:

- Collector Wind Farm Director-General's Requirements;
- *Draft Guidelines for Threatened Species Assessment* (DEC, 2005);
- Biodiversity Offset Principles (OEH);
- *Threatened Biodiversity Survey and Assessment: Guidelines for Development and Activities - Working Draft* (DEC, 2004);
- *National Wind Farm Development Guidelines Draft* (EPHC, 2009); and
- *Draft NSW Planning Guidelines: Wind Farms* (DoPI, 2011)
- *Australian Wind Energy Association Best Practice Guidelines* (AusWind, 2006).

The primary objectives of the Biodiversity Assessment were to:

- draw on the existing information obtained from preliminary investigations as well as provide additional survey effort sufficient to assess the potential impact of the Proposal on biodiversity values;
- identify potential impacts to native vegetation;

- identify potential impacts of blade strike on birds and bats;
- assess potential cumulative impacts associated with Capital and Cullerin Range Wind Farms;
- develop management strategies for identified impacts; and
- identify measures to avoid, mitigate or offset impacts, consistent with 'improve or maintain' principles.

8.1.3. Desktop Assessment

Database searches of threatened and migratory species were conducted for the Murrumbateman, Monaro and Crookwell sub-catchments (study area related catchments) and in a 25km radius from the centre of the project site. Other searches conducted and sources consulted in order to identify known and potential values included:

- topographic maps;
- aerial photographs;
- previous surveys and records contained in national and state databases;
- predictive vegetation mapping;
- the Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands; and
- web-based databases including the OEH Wildlife Atlas and the Species Profile and Threats (SPRAT).

8.1.4. Fieldwork

Fieldwork consisted of three flora and fauna surveys undertaken across the study area during the periods 8-11 December 2009 (reported in the PEI), 22-26 March 2010 and 8-12 November 2010. An additional targeted survey for the Striped Legless Lizard and Pink-tailed Worm-lizard was conducted between 28 September and 21 November 2011. Survey periods were chosen to target threatened species in their most suitable survey periods, whilst also addressing seasonal variation, which is particularly relevant to vegetation condition.

The flora surveys were conducted under a three-tiered approach incorporating plot-based, traverse and general inspection and targeted search methods in order to ensure that vegetation could be characterised in detail, while providing the areal coverage required for the project.

The plot-based approach involved 0.04ha standard quadrats (approximately 20m x 20m) used to survey vegetation structure, floristic and site physical values. The traverse approach consisted of formal random meanders up to 30 minutes duration and covering up to one hectare in order to complement the quadrat data. Full details of the survey sites are provided in **Appendix G**. In addition to the traverse and plot-based survey sites, the majority of the project site was surveyed on foot or by slow-moving vehicle during the December 2009, March 2010 and November 2010 surveys in order to confirm vegetation types, map the distribution of Endangered Ecological Communities (EEC) and search for threatened species. EECs and good condition native vegetation were surveyed in more detail compared to highly modified areas with likely low conservation significance.

The flora surveyed under the techniques discussed above were rated according to a condition class, shown in **Table 19**, with a focus on floristic integrity in the understory.

Table 19 Rating Scale Applied to Flora Survey

Class	Description
Exotic	Ground layer dominated by exotics, no native overstorey
Poor	Ground layer dominated by one or two native grass species, less than 5 native non-grass species or native overstorey present and ground layer dominated by exotics.
Moderate	Ground layer dominated by native grasses, 5 to 11 native non-grass species present
Good	Ground layer dominated by native grasses with a diversity of native non-grass (at least 12 native non-grass species)

All of the above classes, excluding the 'exotic' class, would equate to the 'moderate to good' definition specified within the biometric guidelines.

The combined timing of the three surveys (December, March and November) is considered adequate for the identification of all species. Threatened species and communities declared under the TSC Act or the Commonwealth EPBC Act were specifically targeted in the assessment.

The fauna surveys were designed around fauna considered likely to occur based on the threatened species evaluation undertaken as part of the PEI. **Table 20** provides a summary of the fauna surveys undertaken.

Across the development envelope, surveys were stratified according to these habitat stratification units:

- pasture with scattered trees;
- woodland; and
- forest.

For reptiles, microhabitat units including rocky outcrops and native grassland were also assessed:

The biodiversity assessment focused on the development envelope, the area within which infrastructure may be located. The extent of the development envelope is estimated at 813ha, reflecting the spread of WTG locations within the project site; however, the actual infrastructure footprint will extend to about 75ha only, consisting of both permanent and temporary disturbance areas. As noted in **Chapter 2**, the extent of the development footprint and the development envelope is based on a 68-turbine layout and would therefore represent a worst-case impact scenario for the purposes of the assessment.

Table 20 Summary of Methodology of Fauna Surveys

Survey	Survey Details
Detailed habitat evaluation to assess the extent and condition of threatened species habitat	The detailed habitat evaluation involved an initial assessment of the vegetation structure and habitat components followed by a search for scats, signs, footprints and tracks to detect fauna. Habitat assessments were also undertaken.
Hollow-bearing tree survey, including number and size of hollows and density of hollow-bearing trees in forested areas	Hollow-bearing trees were surveyed using two methods: in 50m x 50m or 100m x 100m quadrats, depending on tree density, or in nested 25m x 25m quadrats within a 50m x 50m quadrat, in the case of forests. Both methods identified areas with high densities of hollow-bearing trees.
Diurnal bird censuses: bird surveys targeting threatened woodland and migratory birds.	The bird survey was generally conducted by area search method over 20 to 30 minutes using a species-time curve approach, whereby surveys cease when no additional species are identified after a set time period. Bird species recorded by sight and vocalisations. Species present within the search area, flying overhead and outside the search area were recorded, in addition to point count surveys undertaken in suitable habitats.
Reptile hand searches targeting threatened reptile species	Reptile hand searches varied between 15 and 45 minutes and targeted three main species, namely the Pink-tailed Worm-lizard (<i>Aprasia parapulchella</i>), Little Whip Snake (<i>Suta flagellum</i>) and Striped Legless Lizard (<i>Delam impar</i>), by rolling rocks, logs and other debris.
Microbat census	Microbats were surveyed using an Anabat detector. The detector was left in place overnight in locations chosen to maximise the potential for picking up multiple species of bats.
Nocturnal surveys	Nocturnal surveys included stagwatch (of trees bearing potential roost hollows), call playback and spotlighting for threatened owls
Bird utilisation surveys	In addition to bird census, bird utilisation surveys were carried out on sites representing different habitat types under a range of conditions.
Artificial shelter surveys	An artificial shelter survey was established to allow a presence-absence survey to be undertaken for the Striped Legless Lizard and the Pink-tailed Worm-lizard. The survey followed a methodology developed in consultation with OEH and involved installation of ten roof-tile arrays across the project site.

While the surveys also covered habitat areas outside the project site, including Lake George, given the large size of the development envelope the biodiversity assessment was not able to survey the entire area in detail.

In general, surveys were biased towards areas of better ecological quality as these were identified in preliminary studies as posing the highest level of constraint to the Proposal. In order to address potential deficiencies, the biodiversity assessment adopted the precautionary principle by assuming that a species may be present if suitable habitat occurs on site.

8.2. Existing Environment

8.2.1. Flora

The majority of the existing project site has been cleared, grazed by sheep and cattle and cultivated with exotic pasture species. Dry forest remnants exist and generally comprise mature regrowth and a few old growth trees. The shrub layer has been almost completely removed in both forest and woodland areas by clearing and grazing. Minor pasture weed species were common across the project site, and some noxious weeds were also observed.

The following vegetation communities were identified on the project site:

- Brittle Gum - Broad-leaved Peppermint Dry Forest;
- White Gum Dry Forest;
- Ribbon Gum - Snow Gum Forest;
- Snow Gum Snow Gum Grassy Woodland; and
- Box-Gum Woodland and Secondary Grassland.

Data from the Southern Region Comprehensive Regional Assessment (SCRA) vegetation mapping show there is a high level of depletion and poor conservation status of the woodland vegetation types in the region, with Box-Gum Woodland in particular being heavily impacted by clearing; grazing, cultivation and introduction of weed and pasture species. The impact of this depletion is compounded by fragmentation and continuing degradation of remaining stands. On a regional basis 60% of the remaining stands of vulnerable types and 100% of endangered types should be reserved or otherwise protected under the JANIS (Joint ANZECC-MCFFA National Forest Policy Statement Implementation Sub-Committee) criteria.

From the surveys, the occurrence of habitat for three threatened communities in the project site was confirmed:

- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (listed as an Endangered Ecological Community (EEC) under the TSC Act, and as a Critically Endangered Ecological Community (CEEC) under the EPBC Act);
- Tablelands Basalt Forest (listed as EEC under the TSC Act); and
- Tablelands Snow Gum Grassy Woodlands (listed as preliminary EEC under the TSC Act).

The Natural Temperate Grasslands EEC was assessed as having low to moderate occurrence and was not actually recorded during the field survey of the project site. Three areas of the Tablelands Snow Gum Grassy Woodlands EEC were identified within the project site. The Tablelands Basalt Forest EEC has been mapped as occurring outside the development footprint.

Table 21 shows in summary the occurrence and extent of the threatened vegetation communities within the project site.

Table 21 Summary of Occurrence of Threatened Vegetation Communities

Vegetation Type	Existing Situation
Box-Gum Woodland	Approximately 220ha of Box-Gum Woodland community occurs within the development envelope, together with approximately 430ha of Box-Gum Woodland Derived Grassland. Most examples of this community within the project area are in poor condition in terms of flora values, with extensive loss of diversity from the understorey.
Tablelands Snow Gum Grassy Woodland	Three areas of Snow Gum trees over a native grassy groundlayer within the development envelope belong to the Tablelands Snow Gum Grassy Woodland EEC. There are approximately 38ha of this community within the development envelope.

A threatened species evaluation concluded that seven threatened species have at least moderate potential to occur in the project area, based on site quality, disturbance history, known distribution ranges and survey findings. A targeted search of these species failed to locate individuals within the development envelope, although a population of Hoary Sunray (*Leucochrysum albicans var tricolor*, EPBC listed) was detected on the verges of Lerida Road South but outside the development envelope.

The assessment of the project site for areas of biodiversity conservation (*red flag* areas) under the OEH Biometric guidelines showed the Box-Gum trees occurred in small isolated patches on large areas of exotic pasture or crop land and therefore would not be considered as *red flag* areas.

8.2.2. Fauna

Fauna habitat in the project site can be broken into four main stratification units:

- pasture with scattered trees, important for a range of fauna for both habitat and connectivity within a wider habitat matrix;
- woodland, containing Box-gum Woodland and dry forest remnants;
- forest, similar to woodland but with additional understorey strata and/or a more closed canopy; and
- native pasture, which provides habitat for a range of reptiles and resources for many birds.

Exotic pastures, rocky outcrops and aquatic areas (dams, watercourses) are also present and were investigated.

Habitat quality at the project site was variable during the site surveys due to weather fluctuations at different times of the year. However, for the most part, habitat resources in the project site were considered to be

generally poor for threatened and migratory fauna species, due to fragmentation and simplification of habitat from past agricultural clearing and grazing. Habitat types in the development envelope are described in greater detail in Section 4.2 of **Appendix G** and shown in **Figure 12**.

Returns from database searches for threatened species were evaluated for the potential of these species to occur based on habitat quality on the project site. Among the species evaluated were the following:

- Squirrel Glider – areas identified as having potential to support Squirrel Gliders were mapped during preliminary investigation stages so that these could be avoided when planning the infrastructure layout, therefore the targeted trapping surveys was not considered warranted when assessing potential impacts on the development envelope which already avoided potential habitats;
- Pink-tailed Worm-lizard and Little whip Snake – surveys in November when the preceding period was mild and wet failed to detect either species and it is considered that habitat was unsuitable for Pink-tailed Worm-lizards;
- Striped Legless Lizard – reptile surveys were undertaken in suitable secondary grassland habitat; however, this species was considered unlikely to occur due to the absence of native temperate grassland, the high level of disturbance of grassland areas and the isolation of these areas from potential source populations;
- Spotted Harrier and Square-tailed Kite – these were considered to have the potential to occur and were therefore included in the assessments of significance;
- Other threatened species – other species have no or few local records and habitat was considered marginal. These were not considered likely to occur or to have potential to be impacted by the Proposal and were not considered further.

Field surveys and targeted searches detected a total of 129 fauna species within the study area, comprising:

- 7 amphibians;
- 85 birds, including raptors, waterbirds, passerines and non-passerines;
- 25 mammals, including common terrestrial mammals, microbats, and feral species; and
- 12 reptiles.

Full details are presented in Section 4.3 of **Appendix G**.

Ten species listed under the EPBC Act or TSC Act as threatened species were recorded in the study area. These consist of six vulnerable birds - Brown Treecreeper, Diamond Firetail, Gang-gang Cockatoo, Superb Parrot, Varied Sittella and White-fronted Chat - and five vulnerable microbats - East Coast Freetail Bat, Eastern Bentwing Bat, Large-footed Myotis and Yellow-bellied Sheathtail Bat. In addition, one species of migratory bird and eight species of marine birds listed under the EPBC Act were recorded in the project area.

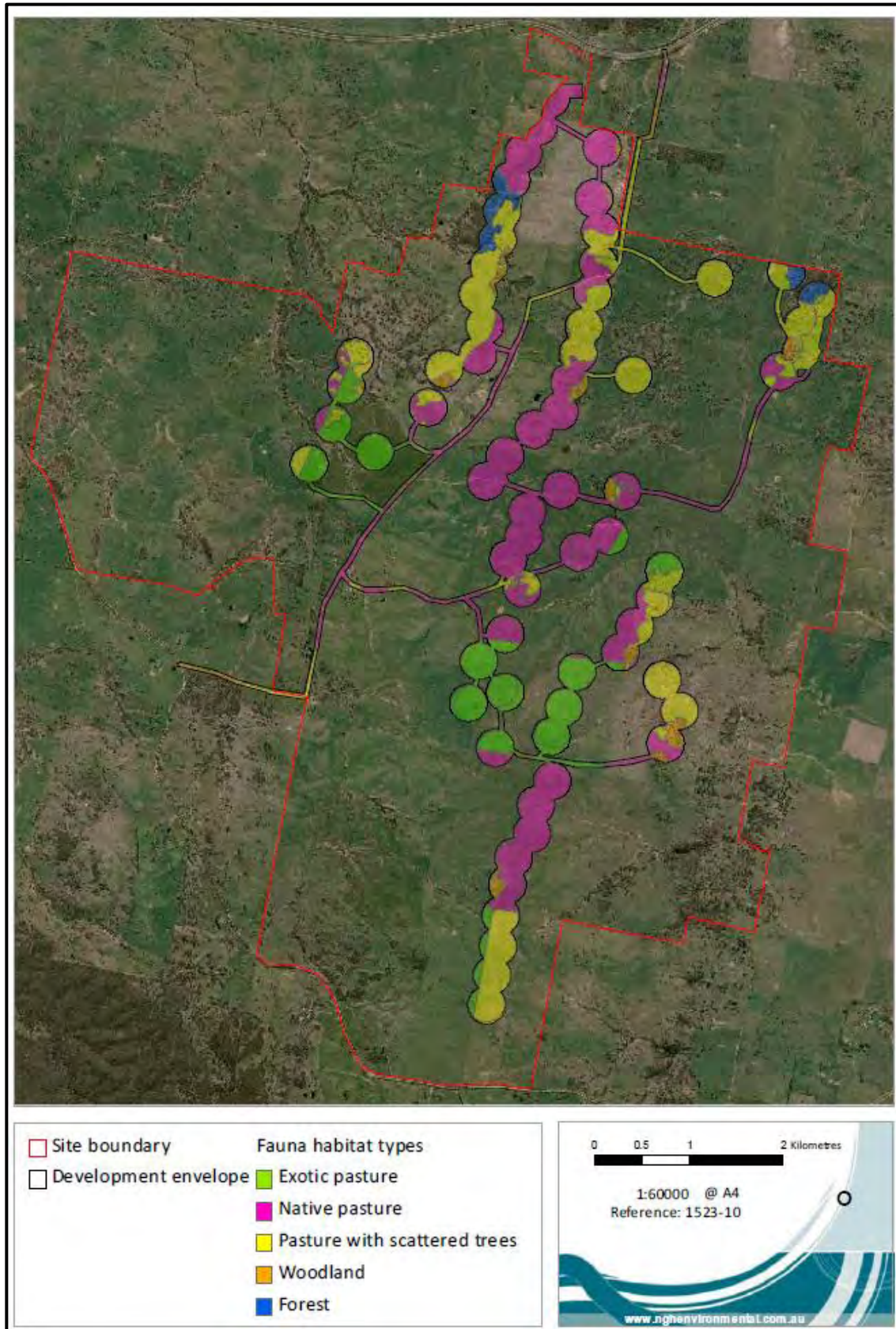


Figure 12 Fauna Habitat Types

8.3. Impact Assessment

8.3.1. Types of Impact

There are two main impact types associated with the Proposal:

- loss and degradation of habitat from direct impacts such as vegetation clearing, earth moving/landform reshaping, installation of infrastructure and associated sediment, erosion, weed and pollution risks; and
- collision with infrastructure causing injury or fatality.

The first impact is mainly relevant to the construction and decommissioning phases. The second impact may include risks to stock and wildlife from construction traffic, but is most relevant during the operation phase of the wind farm.

Impacts to flora, ecological communities and ground dwelling animals will be mainly due to vegetation clearing and ground disturbance associated with the construction and installation of the various wind farm infrastructure, including the turbine tower sites and surrounding hardstand areas, substation and control building, and the electrical cabling and access roads.

Of the 813ha development envelope, the extent of permanently cleared vegetation resulting in permanent habitat loss corresponds to the development footprint is estimated to be 28.63ha. During the construction phase an additional 44.68ha of vegetation clearing will be required for the extra width of tracks, cable trench alignment, temporary crane hardstands and construction site compound. This area of temporary habitat loss will be rehabilitated post-construction.

Aside from direct clearing of the development footprint, vegetation surrounding the development footprint may be subject to peripheral impacts such as soil compaction and erosion due to vehicle movement, stockpiles and materials laydown. Construction activity has the potential to cause pollution associated with the use of concrete, fuels and lubricants, and other chemicals. Plant and construction vehicle movement may also introduce and spread weeds.

For fauna, the introduction of wind farm infrastructure may also result in habitat alienation, for example the alienation of hunting habitat for raptors. It should be noted, however, that fauna can also become habituated to wind turbines and other wind farm infrastructure, adapting to their new environment.

8.3.2. Threatened Flora

Based on the nearest records and the results of the targeted surveys the potential for threatened flora species to occur on the site is considered low. It is unlikely that these species were overlooked and exist in the development envelope and are therefore at risk of impact from the development. As such, assessment of significance pursuant to the TSC and EPBC Acts was not considered necessary.

8.3.3. Endangered Ecological Communities

While most of the area of permanent and temporary habitat loss due to vegetation clearing is within Derived Grassland, vegetation clearing will also affect the Box-Gum Woodland and Snow Gum Grassy Woodland

EECs in the project site. Aside from the direct loss of habitat, clearing of the EECs may result in the establishment and spread of weeds.

While not legally required for a Part 3A development, Assessments of Significance were carried out for the EECs which will be impacted by vegetation clearing. These assessments of significance provide a transparent and systematic characterisation of impact for the listed threatened species and EECs.

The assessment of significance of impacts on the EECs concluded that the impact of the removal of up to 21ha of Box-Gum Woodland EEC and derived grassland and up to 0.9ha of Tablelands Snow Gum Grassy Woodland EEC is not considered to be significant if the recommended management measures as outlined in this chapter and in **Chapter 16** are implemented.

The localised reduction in the Box-Gum Woodland CEEC (good condition Box-Gum Woodland) through the removal of 7.46ha of moderate to good condition Box-Gum Woodland EEC is not considered to significantly impact on the broader extent of the CEEC but would require the implementation of controls outlined in this section and in **Chapter 16** to minimise the impacts.

The extent of clearing within these EECs and a summary of the assessment of significance are shown in **Table 22**; the full assessments are included in **Appendix G**.

Table 22 Projected Extent of Clearing of EEC and Assessment of Significance

Vegetation Type	Extent of Clearing	Assessment of Significance
Box-Gum Woodland	<p>the following areas are to be permanently cleared:</p> <ul style="list-style-type: none"> 13.7ha of moderate constraint EEC / poor condition EEC; and 8.25ha of high constraint EEC / moderate to good condition EEC. 	<p>Considering the potential gains for this community through offsetting and the small amount of clearing proposed it is not likely that the Proposal would affect the extent or modify the community such that it would be placed at risk of extinction. The majority of suitable habitat likely to be removed by the Proposal is in poor condition and not considered important habitat. The extent of clearing is not anticipated to impact the long-term survival of this EEC in the locality. With implementation of an offset plan the Proposal has the potential to contribute to the Recovery Plan Objectives. Refer to Section 8.4 and Chapter 16 for details.</p>
Tablelands Snow Gum Grassy Woodland	Up to approximately 1.6ha is proposed for removal.	<p>Considering the ability to avoid understorey trees and the relatively small amount of clearing proposed, it is considered unlikely that the Proposal would impact upon the extent or modify the community to a degree such that it would place the local occurrence of the community at risk of extinction.</p>

8.3.4. Threatened Fauna and Migratory Birds

The Proposal could potentially impact directly on threatened fauna through collision with turbines, and on their habitats through the loss of hollow bearing trees and fallen timber, clearing of woodland and forest. Potential impacts would mainly be on birds and bats.

TSC Act-listed species with the potential to be impacted by the Proposal include raptors, woodland birds and microbats. EPBC Act-listed species with the potential to be impacted include the Vulnerable Superb Parrot and Migratory-listed White-bellied Sea Eagle. As in the EECs, assessment of significance for these species undertaken as part of the biodiversity assessment showed that the potential impacts from risk of collision and loss of habitat arising from the Proposal are not considered significant for all species, except for the Little Eagle and Eastern Bentwing Bat which have been identified as key *at risk* species to be covered by a proposed monitoring program during the operation phase. Elements of this bird and bat monitoring program are outlined in **Section 8.5**. A summary of the outcomes of the assessment of significance is shown in **Table 23**. The full assessments are provided in **Appendix G**.

8.3.5. Birds Using Lake George

The Proposal is located north-west of Lake George (**Figure 2**), which is a wetland about 15,000ha in size when full. Together with two other wetlands in the local area - Lake Bathurst and The Morass - Lake George provides waterbird habitat. While the Proposal is unlikely to directly impact the bird habitats within Lake George, WTGs located on or near the escarpment to the west may impact birds in the following ways:

- when birds are flying from or into the lake;
- when birds are using the escarpment as a navigational aid; and
- when birds are soaring in the updraughts along the escarpment.

The majority of water birds that use Lake George appear to be at low risk from wind turbines as these stay mostly on the lake shores and arrive in small groups. There are, however, key risk groups within transient bird populations due to factors such as large flocks, large body size and flight patterns. A more detailed discussion on the potential impacts of the Proposal on birds using Lake George is included in **Appendix G**.

8.3.6. Bat Risks

The most likely microbat group to be affected by the Proposal are migrating bats. There is a risk of collision and barotrauma impact on bats moving to and from staging caves during their migration to a maternity cave. A significant microbat migratory route lies to the south of the project site between Mt Fairy Cave, a known Eastern Bentwing Bat staging cave located about 35km to the south-east, and Church Cave, a maternity cave located about 60km to the south-west. Bats travelling from staging caves to the north are also at risk.

Bat deaths can also be caused by decompression or pulmonary barotrauma. This occurs as microbats come into contact with rapid air pressure change around the moving turbine blades, causing haemorrhaging of the lungs. Data from wind farms in Victoria, cited in the Biodiversity Assessment, show bat fatality rates of one to two bats per turbine per year, based on carcass monitoring.

Table 23 Assessment of Impact on Threatened or Migratory Species

Species	Collision Impacts	Loss of Habitat Impacts
Little Eagle*	Potentially significant - vulnerable travelling to and from the known nesting site on the escarpment, forage in the sweep zone.	Not significant - nesting habitat on the escarpment, south of the project site would not be impacted
Spotted Harrier	Not significant - fly below the sweep zone	Not significant - no nests were detected
Square-tailed Kite	Potentially significant - forage in the sweep zone.	Not significant - little evidence to suggest use of the project site
Brown Treecreeper	Not significant – pattern of flight and foraging/nesting movements are largely within the limits of the tree canopy	Not significant – extent of clearing and offsetting
Diamond Firetail	Not significant – pattern of flight and foraging/nesting movements are largely within the limits of the tree canopy	Not significant – extent of clearing and offsetting
Varied Sittella	Not significant – pattern of flight and foraging/nesting movements are largely within the limits of the tree canopy	Not significant – extent of clearing and offsetting
White Fronted Chat	Not significant – pattern of flight and foraging/nesting movements are largely within the limits of the tree canopy	Not significant – extent of clearing and offsetting
Gang-gang Cockatoo	Collision impact not covered in assessment of significance	Potentially significant – use hollow-bearing trees and stags
Superb Parrot	Collision impact not covered in assessment of significance	Potentially significant - use hollow-bearing trees and stags
Powerful Owl	Collision impact not covered in assessment of significance	Potentially significant - use hollow-bearing trees and stags
Eastern Bentwing Bat*	Potentially significant – fly in sweep zone, forage in the open and seasonally migrate to nearby staging cave	Potentially significant - Recorded across the project site however, there is no evidence to suggest the site is important to local populations.
Yellow-bellied Sheath-tail Bat	Potentially significant – fly in sweep zone, forage in the open and seasonally migrate	Not significant – occur in low numbers
Large-footed Myotis	Not significant	Not significant – occur in low numbers
East Coast Freetail-bat	Not significant	Not significant – occur in low numbers
White-bellied Sea-eagle	Potentially significant – may return to area to breed in the future	Potentially significant – have been recorded breeding on the escarpment 2km south of the project site

* A key species requiring operation-phase monitoring as part of the bird and bat monitoring program

It is considered that by removing WTG locations near the escarpment west of Lake George and along a wooded corridor more likely to be used by bats, the Proposal has addressed the risk to migrating Eastern Bentwing Bats. Operation-phase monitoring will be carried out to confirm this assessment.

8.4. Cumulative Impacts

Cumulative impacts resulting from the operation of the Cullerín Range and Capital Wind Farms have been assessed as part of the biodiversity assessment.

Capital Wind Farm is located approximately 22km south-east of the project site. It comprises 67 WTGs. It has been operational since October 2009. Cullerín Range Wind Farm is located immediately north of the project site; it has 15 WTGs. The WTGs in Capital and Cullerín Range Wind Farms are approximately the same size as the Proposal's.

8.4.1. Loss and Modification of Habitat

The siting of infrastructure on the three sites has avoided wooded areas which are of most value to large ranging species such as bats, birds and medium arboreal and ground dwelling mammals. It is considered that the cumulative impact in terms of loss and modification of habitat is low for any vegetation community or species of flora and fauna.

8.4.2. Collision and Alienation Impacts

The project site is unlikely to substantially increase any risk to birds that may congregate at Lake George, considering the location of Capitol Wind Farm which is closer to Lake George. The Proposal's infrastructure layout has been refined from the findings of early investigations which identified risks to birds and bats risks using the escarpment as a movement corridor from or to Lake George.

8.5. Mitigation Measures

Through iterative development of the final proposal, concurrent with biodiversity constraints assessment and other studies, the Proposal has been refined to:

- avoid many areas of high biodiversity conservation;
- exclude from the development envelope the areas near to the escarpment at the south of the preliminary site layout identified as high risk to birds and bats;
- minimise impacts in these areas, where avoidance is not possible;
- reduce the development envelope;
- include a suite of management measures to ensure that significant impacts are avoided;
- provide offsetting to ensure a positive net overall environmental outcome; and
- outline appropriate management measures to demonstrate that offsetting is feasible within the proposal site boundaries.

The Biodiversity Assessment identifies strategies for the mitigation and management of the potential impacts of the Proposal on the biodiversity of the project site. A full list of mitigation measures is included in **Appendix G** and summarised in **Table 24**.

Table 24 Flora and Fauna Impact Mitigation Measures

Project Phase	Mitigation and Management Measures
Design and Planning	<p>Infrastructure will be micro-sited with input from an ecologist.</p> <p>Location of infrastructure in areas of moderate to good condition EEC, forest, and woodland will be minimised.</p> <p>Clearing of overstorey and mature and native riparian vegetation will be minimised.</p> <p>Infrastructure will be preferentially sited in previously cleared and disturbed areas.</p> <p>Access track widths will be kept to a minimum when in CEEC areas</p> <p>Detailed hollow-bearing tree surveys will be undertaken in areas of woodland where hollow-bearing trees may be removed, with the results used in micro-siting infrastructure to avoid trees where possible and provide buffers around trees identified as having significance.</p> <p>A detailed management plan for the removal of hollow-bearing trees will be prepared by an ecologist to minimise impacts to resident fauna.</p> <p>Works would avoid rock outcrops where possible, especially in CEEC areas.</p> <p>An offset plan will be finalised (in accordance with the Draft Principles for the use of Biodiversity Offsets in NSW) based on the infrastructure design, prior to construction and in consultation with OEH.</p>
Construction	<p>Impact areas would be minimised through the following measures:</p> <ul style="list-style-type: none"> where possible, cabling would be laid within or adjacent to the road corridor to minimise additional impacts; where required, cabling in drainage lines would be underbored. If underboring is not feasible, rehabilitation works would be undertaken immediately following works within drainage lines; trenches would be back-filled as soon as possible; any trench left open overnight would be inspected at first light for any trapped fauna; erosion and sedimentation controls would be put in place prior to works, particularly when working in or near drainage lines; materials laydown and stockpiling would make use of existing areas of disturbance or other areas of low biodiversity value; all onsite staff are to undergo a site induction which covers the sensitivity of the surrounding flora and fauna.

Project Phase	Mitigation and Management Measures
Construction	<p>Habitat elements and biodiversity will be retained through the following measures:</p> <ul style="list-style-type: none"> impacts to hollow-bearing trees that have not been specifically identified for removal would be avoided; fallen timber would be left in place or moved to a nearby area to retain fauna habitat; and where rocky outcrops could not be avoided, a preclearance survey would search and relocate captured reptiles and rocks would be placed in nearby areas, in consultation with an ecologist.
Construction	<p>Introduction and/or spread of noxious weeds would be controlled through the following measures:</p> <ul style="list-style-type: none"> noxious weeds within the development envelope would be controlled according to control plans and measures recommended by the Upper Lachlan Shire Council; where a specific weed risk has been identified, all machinery, equipment and vehicles are to be inspected and washed down as required before entering and leaving the project site; and onsite staff and contractors will be educated on noxious weeds occurring at the site and ways to prevent their spread.
Construction, Operation and Decommissioning	<p>A Threatened Species Management Plan (TSMP) will be prepared to describe measures that will minimise impacts on significant species throughout the area during all project phases. The TSMP will incorporate provisions for the following:</p> <ul style="list-style-type: none"> pre-clearance surveying and monitoring; handling and relocation of wildlife (if found); regular site inspections for injured species; and consultation with local government, OEH and other relevant stakeholders regarding the implementation of management strategies.
Operation	<p>An adaptive management monitoring program for birds and bats would be prepared and implemented. This would include:</p> <ul style="list-style-type: none"> A more intensive period of monitoring in the first six months of operation as birds and bats are in the process of habituating to the new development; Surveys will include regular carcass searches, bird utilisation surveys, observation of bird avoidance/diversion behaviour and targeted surveys for species of concern; Surveys will representatively sample the habitat and topography in which turbines are located; The monitoring program will include identification of key 'at risk' species including: <ul style="list-style-type: none"> ○ Little Eagle – searches for breeding activity and movements to the escarpment.

Project Phase	Mitigation and Management Measures
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- | | |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <ul style="list-style-type: none"> ○ Eastern Bentwing Bat – monitoring during ‘high risk’ periods, when this species may be moving through or foraging in the area. Reporting will be undertaken to identify any trends in the data and recommend management actions. These recommendations will include the intensity and duration of ongoing surveys as required. <p>The monitoring program will include a set of feasible management measures that can be implemented to reduce collision risks, if required.</p> |
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Decommissioning	Relevant mitigation measures implemented during the construction phase to contain impact would also be applied to decommissioning works.
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8.5.1. Biodiversity Offset Strategy

Permanent vegetation clearing for the Proposal’s development footprint will cover a combined 28.36ha, mainly in Derived Grassland (15.03ha), and a more limited extent in moderate to good condition Box-Gum Woodland EEC (7.46ha) and Frosty Hollow Grassy Woodland EEC (0.86ha). Aside from the direct impact on the affected EECs and the associated loss of habitat, the clearing, if not mitigated, may potentially result in habitat fragmentation and alienation, and increased salinity risk (**Chapter 13**). Among the key measures for managing the biodiversity risks from the Proposal, after avoidance of impacts through prevention and mitigation, is offsetting the residual loss of native vegetation and habitat.

Consistent with OEH guidelines, the Proponent will look into offset opportunities through the enhancement of existing habitat that have the same or similar ecological characteristics as the area affected by the Proposal. Such areas could be located inside or outside the project.

At this stage of the Proposal’s development, several areas of EECs in moderate to good condition within the site, which are not included in the vegetation clearing for the Proposal infrastructure, have been identified as suitable for offsets (**Appendix G**), subject to the requirements of landowners. These EECs include:

- 114 ha of Box-Gum Woodland EEC to the north of the site and up to 341 ha which may potentially occur in the central east of the site; and
- 65 ha of Snow Gum Grassy Woodland EEC in moderate to good condition, including a remnant area to the north of the site which adjoins more extensive areas of good quality Box-Gum Woodland.

If required, other target areas outside the project site will be assessed as part of the development of the offset strategy to identify land which may be suitable for offset, consistent with OEH’s selection criteria for conservation reserves in the region.

The Biodiversity Offset Strategy to be developed in consultation with OEH will explore the following:

- other options for offsets, such as funding third party biodiversity management actions and research;
- more detailed assessment of biodiversity impacts and determination of offset criteria;

- mechanisms to deliver the offset, including management arrangements with landowners, and coordination with statutory agencies and other offset agents in the area; and
- monitoring and evaluation, including provisions for reporting.

9

APP Corporation



Indigenous Heritage

9. Indigenous Heritage

This section provides an environmental assessment of the potential impact of the Proposal in respect to indigenous heritage values (archaeological and cultural). NSW Archaeology Pty Ltd has prepared an archaeological assessment of the project site (**Appendix H**).

9.1. Assessment Approach

9.1.1. Guidelines

NSW Archaeology Pty Ltd has undertaken an Indigenous Archaeological and Cultural Heritage Assessment to support this EA. This assessment was conducted in accordance with the following guidelines:

- *Draft Guidelines for Aboriginal Cultural Impact Assessment and Community Consultation* (DEC, 2005);
- *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW, 2010a); and
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b).

9.1.2. Objectives

The primary objectives of the indigenous heritage assessment were to:

- undertake background research;
- effectively consult with Indigenous stakeholders;
- identify and record Indigenous sites or objects;
- assess the archaeological potential of the landscape;
- complete a significance assessment; and
- formulate strategies to manage and mitigate potential impacts to Indigenous heritage.

9.1.3. Background Research and Field Survey

The background research undertaken as a component of the cultural heritage assessment included searches of heritage databases, registers and previous local and regional archaeological investigations. This provided an upfront analytical context to the assessment prior to beginning consultation with relevant stakeholders and completing field surveys. The background research included:

- search of the NSW OEH Aboriginal Heritage Information Management System;
- review of relevant archaeological reports held in the NSW OEH Cultural Heritage Unit;
- search of the Australian Heritage Database;
- analysis of topographic and Parish maps; and
- overlay of GIS data covering project site.

Based on the above, the field survey was designed to assess the archaeological sensitivity of the Proposal's entire impact area. For Indigenous surveys, the *non-site* approach of recording artefacts in different landforms was utilised, to best analyse archaeological variability across the landscape.

Field investigations were undertaken on October 2010 with the assistance of Luke Burgess of the Pejar Local Aboriginal Land Council (PLALC) and Wally Bell, representing Buru Ngunawal Aboriginal Corporation (BNAC). The remainder of this chapter provides a summary of the results and findings of this investigation in relation to potential impacts. These are presented in full in **Appendix H**.

9.1.4. Aboriginal Community Consultation

Consultation with the aboriginal community and stakeholders was undertaken by NSW Archaeology on behalf of the Proponent. This consultation was undertaken in accordance with the Aboriginal Cultural Heritage Consultation Requirements for Proponents (ACHCRP) which entail four primary stages:

Stage 1: Notification of Project Proposal and Registration of Interest

As a component of stakeholder consultation, the Proponent actively identified stakeholders and groups associated with the aboriginal community. Subsequently, these groups were invited to register their interest in the project. Written notification dated 14th September 2010, requesting a list of Aboriginal groups or persons who may have an interest in the Proposal, was forwarded to the following bodies:

- OEH LHPS Queanbeyan office;
- Pejar Local Aboriginal Land Council;
- Onerwal Local Aboriginal Land Council;
- Buru Ngunawal Aboriginal Corporation;
- the Office of the Registrar, Aboriginal Land Rights Act 1983;
- the National Native Title Tribunal, requesting a list of registered native title claimants, native title holders and registered Indigenous Land Use Agreements;
- Native Title Services Corporation Limited (NTSCORP Limited);
- Upper Lachlan Shire Council; and
- the Murrumbidgee Catchment Management Authority, requesting contact details for any established Aboriginal reference group.

In addition, an advertisement was placed in the 15th September 2010 edition of the *Goulburn Post*. The closing date for registration of interest was noted as 29th September 2010. In response to notifications received from various sources, additional letters of notification were sent to the following:

- Gundungurra Aboriginal Heritage Association Inc;
- Peter Falk;
- Registered Aboriginal Parties;
- Pejar Local Aboriginal Land Council; and
- Buru Ngunawal Aboriginal Corporation.

It is noted that the Onerwal Local Aboriginal Land Council could not be contacted regarding the Proposal despite repeated attempts to do so.

Stage 2 and 3: Presentation of Information and Gathering Information on Cultural Significance

An outline of the scope of the Proposal, the proposed cultural heritage assessment process and the heritage assessment methodology was forwarded to Pejar Local Aboriginal Land Council on the 23rd September 2010, Buru Ngunawal Aboriginal Corporation on the 28th September 2010, and to Gundungurra Aboriginal Heritage Association Inc. on the 11th October 2010. Luke Burgess of the PLALC and Wally Bell of BNAC assisted with the fieldwork conducted for the study and provided valuable information regarding the archaeological sensitivity and potential of the study area.

Stage 4: Reviewing the Report

For review and comment, a copy of the draft report was forwarded to the following:

- Pejar Local Aboriginal Land Council;
- Buru Ngunawal Aboriginal Corporation; and
- Gundungurra Aboriginal Heritage Association Inc.

A copy of the draft archaeological report was provided to the registered Aboriginal parties on 14 January 2011. The OEH ACHCRP requirements provide a period of 28 days for registered Aboriginal parties to comment on the draft report. As of the completion of this EA, a response has been received from the Buru Ngunawal Aboriginal Corporation which has expressed its agreement to the recommendations of the archaeological assessment and has asked to be fully consulted about construction arrangements so that it can provide input to any decision making that impacts its cultural heritage.

9.2. Existing Environment

The project site is located predominantly on a sparsely treed undulating plain which possesses relatively low biodiversity values. In an Aboriginal land use context, the project site is likely to have been utilised for a limited range of activities which may have included short stays, hunting, gathering and travel through country. These activities have likely resulted in low levels of artefact discard. The nature of stone artefacts discarded can be expected to have been correspondingly limited in terms of artefact diversity and complexity.

The earliest European reports present only fragmentary and incomplete accounts of the traditional culture of Indigenous groups which inhabited the area. Furthermore, as a result of European contact, much of the indigenous language and culture had altered before it could be accurately recorded. Consequently, reliable information is considered to be limited.

The local area has been utilised for stock grazing since the 1820s, the effects of which are apparent vegetation loss and subsequent erosion, primarily due to precipitation and wind, as well as soil compaction due to stock movements. Soils within the project site are generally highly eroded, which has significant ramifications in regard to the stability and integrity of artefacts.

A review of heritage databases and previous archaeological investigations was undertaken by NSW Archaeology Pty Ltd in order to provide an analytical context to the archaeological assessment of the project site. A search of the NSW OEH Aboriginal Heritage Management Information System conducted for this project (AHIMS # 32066 – 24 September 2010) revealed that there are three previously recorded Aboriginal objects located within the project site but outside of the development footprint.

For the field study conducted in October 2010 the study area was divided into 50 Survey Units according to landform morphological type. Survey Units are linear transects 100m wide. Surveying entailed walking parallel transects across the individual Survey Units, with each surveyor situated 20-30m apart. From the field survey a total of five Aboriginal object locales which contain stone artefacts were recorded. The five Aboriginal object locales were assessed to be of low archaeological significance. In addition, four trees were recorded as possible Aboriginal scarred trees.

9.3. Potential Impacts – Construction and Decommissioning

Potential impacts may occur during ground disturbance activities during the construction and decommissioning stages of the Proposal. **Table 25** provides an assessment of the potential impact for these stages.

The Proposal has the potential to disturb areas and items of Aboriginal cultural heritage through cut and fill processes. However given the sparse and relatively minor nature of known items of archaeological significance, it is considered highly unlikely that a significant impact will result from the construction and decommissioning of the wind farm. Furthermore, none of the Survey Units or Aboriginal object locales in the project site has been assessed to surpass archaeological significance thresholds which would act to entirely preclude proposed impacts. Nevertheless, steps will be taken to ensure that inadvertent impacts to these locales do not occur.

9.4. Potential Impacts – Operation

Given the nature of the Proposal it is considered highly unlikely any impacts will result to items or areas of Aboriginal cultural heritage during the operational phase of the wind farm. Whilst there is potential for the vista of the region to be modified through the erection of turbines (as discussed in **Chapter 6**), the area is not considered to be of Aboriginal cultural significance in this regard and therefore would not have a significant impact.

9.5. Mitigation Measures

The Archaeological Assessment included in **Appendix H** identifies strategies for the mitigation and management of the potential impacts of the Proposal on Aboriginal heritage items or places on the project site. A summary of these strategies is provided below:

- While the Aboriginal stone artefacts locales recorded very low density distributions of stone artefacts and the archaeological significance of these locales is assessed to be low, it is nevertheless recommended that a strategy of avoidance of impacts be adopted.

Table 25 Potential Impacts on Indigenous Heritage

Project Stage	Description	Potential Impact
Construction and Operation	The proposed wind farm construction program discussed in Section 2.5 entails the construction of road and the installation of cabling, hardstands, footings and foundations, turbines and ancillary infrastructure.	The projected extent of impact is approximately 74ha. Areas of excavation (i.e. turbine footings, access tracks) may have the potential to disturb areas or items of Aboriginal cultural heritage. A feasible strategy of avoidance of impacts can be adopted.
Decommissioning	Wind turbines and associated infrastructure would be dismantled, foundations would be cut back to below cultivation depth and access roads removed and rehabilitated.	Decommissioning will require ground disturbance and will therefore have the potential to cause impacts to any Aboriginal object which may be present within the site.

- A strategy of avoidance of impacts will be adopted in regards to the recorded trees with possible Aboriginal scars.
- In regard to the previously recorded Aboriginal objects listed on the NSW OEH AHIMS search which are located within the development envelope, but outside areas of proposed impact, these should be avoided during construction, operation and decommissioning of the wind farm. Steps should be taken to ensure that inadvertent impacts to these locales do not occur.
- Additional archaeological assessment will be conducted in any areas which are proposed for impacts that have not been surveyed during the assessment completed to date.
- A Cultural Heritage Management Plan, which documents the procedures to be followed for impact avoidance or mitigation, will be developed as a component of the Environmental Management Plan for the Proposal.
- If during the course of the construction works any items of aboriginal cultural heritage or significance (i.e. archaeological items) are uncovered, works shall cease (within vicinity to the item) and OEH notified of the findings. An appropriate assessment and salvage strategy will be determined and implemented prior to the recommencement of construction works within the area. Should human remains be found during the proposed earthworks works will cease and the police notified immediately.
- Personnel involved in the construction, operation and decommissioning phases of the project will be trained in procedures to implement the recommendations relating to cultural heritage.