EPURON
POWER FOR PORTFOLIOS

Biodiversity Addendum Report

LIVERPOOL RANGE WIND FARM AND TRANSMISSION LINE PROJECT

MAY 2017

www.nghenvironmental.com.au

Document Verification

Project Title: Liverpool Range Wind Farm and Transmission Line Project

Project Number: 16-176

Project File Name: Liverpool Addendum report v2. 170517docx.docx

Revision	Date	Prepared by (name)	Reviewed by (name)	Approved by (name)
Working Draft	23/12/16	Freya Gordon Brenton von Takach Dukai Bianca Heinze, Calia Jones, Ryan Simms, Brooke Marshall	Brooke Marshall	Brooke Marshall
Final V1	27/01/17	Bianca Heinze Calia Jones Brooke Marshall	Brooke Marshall Dave Maynard (Offset Strategy)	Brooke Marshall
Final V2	18/05/17	Bianca Heinze	Brooke Marshall	Brooke Marshall

nghenvironmental is a registered trading name of NGH Environmental Pty Ltd; ACN: 124 444 622.
ABN: 31 124 444 622

suite 1, 216 carp st (po box 470) bega nsw 2550 australia t (02) 6492 8333

www.nghenvironmental.com.au e ngh@nghenvironmental.com.au

unit 18, level 3, 21 mary st
surry hills nsw 2010 australia
t (02) 8202 8333

suite 1, 39 fitzmaurice st (po box 5464)
wagga wagga nsw 2650 australia
t (02) 6971 9696

unit 17, 27 yallourn st (po box 62)
fyshwick act 2609 australia
t (02) 6280 5053

35 morrisset st (po box 434)
bathurst nsw 2795 australia
0488 820 748

Contents

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

AoS	Assessment of Significance
BA	Biodiversity Assessment
BOM	Australian Bureau of Meteorology
CEEC	Critically Endangered Ecological Community
CRA	Collision Risk Assessment
Cwth	Commonwealth
DECCW	Refer to OEH
DoE	DoE
DPE	(NSW) Department of Planning and Environment
EEC	Endangered Ecological Community
EIA	Environmental impact assessment
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Cwth)
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
ha	hectares
HQS	Habitat Quality Scores
km	kilometres
KTP	Key Threatening Process
LGA	Local Government Area
LRWF project	The Liverpool Range Wind Farm and Transmission Line project
m	Metres
NES	Matters of National environmental significance under the EPBC Act (*c.f.*)
NPWS	National Parks and Wildlife Services
NSW	New South Wales
OEH	(NSW) Office of Environment and Heritage, formerly Department of Environment, Climate Change and Water
SCA	State Conservation Area
SEPP	State Environmental Planning Policy (NSW)
SF	State Forest
sp/spp	Species/multiple species
TLSA	Transmission line study area
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
WFSA	Wind Farm Study area

1 INTRODUCTION AND BACKGROUND

1.1 PROJECT OVERVIEW

In July 2014 Epuron submitted an Environmental Assessment under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the Liverpool Range Wind Farm and its associated transmission line (the LRWF project). The project would have an operational capacity of up to 1015 MW. The project is considered a State Significant Development under the EP&A Act.

1.1.1 Infrastructure components

Including electricity transmission infrastructure, the Project Area is approximately 20 km (east-west) by 65 km (north-south).

The project includes the following infrastructure components:

- Up to 282 wind turbine generators including associated electrical generators (three blades mounted on a tubular tower (165 m to highest blade tip);
- Up to 43 km of high voltage 330 kV transmission line and easement located between Ulan and Cassilis (maximum easement width of 60m);
- Construction of one connection substation and up to 4 collection substations and maintenance facilities;
- Creation of up to 274 km of new access tracks and widening of existing tracks (4-5 metres wide) that would connect all of the wind turbines and associated infrastructure;
- Upgrades to existing public roads.

1.1.2 Location of the activity

The project is located to the east of Coolah and the northwest of Cassilis, with the transmission line running south from Cassilis to Ulan. The proposal is approximately 325 km northwest of Sydney, in Central Western NSW. The Project Area for the LRWF project would be located across the Warrumbungles, Upper Hunter and Mid-Western Regional Local Government Areas (LGAs). The wind turbines would be located in the Warrumbungles and Upper Hunter Regional LGAs. Refer Map set, Appendix A.1.

1.2 ASSESSMENT CONTEXT AND SCOPE OF THIS REPORT

In 2013, NGH Environmental completed the assessment of the potential biodiversity impacts associated with the development of the LRWF project in two parts:

- NGH Environmental (2013a): Biodiversity Assessment, Liverpool Range Wind Farm – Wind Farm Study Area.
- NGH Environmental (2013b): Biodiversity Assessment, Liverpool Range Wind Farm – Transmission Line Study Area.

These were publicly exhibited as part of the July 2014 Environmental Assessment submission. The content of the Biodiversity Assessments (BAs) were informed by the Director General's Requirements, issued by the Department of Planning and Environment (DPE). The assessment was placed on public exhibition in October 2014. Public and agency submissions were received in November 2014.

This addendum identifies and assesses changes to the project since the exhibition of the Environmental Assessment that affect the conclusions of the original biodiversity assessment (NGH Environmental 2013a and b).

It also includes additional information to address specific submissions received from:

- Department of Planning and Environment (DPE)
- NSW Office of Environment and Heritage (OEH)

Submissions addressed by this report are appended in full, Appendix E.1. A cross reference table is provided in Appendix E.2, showing where each item is addressed in this addendum.

1.3 REPORT STRUCTURE

This Biodiversity Addendum provides specific detailed information and a revised assessment of potential impacts of the project including:

- Key changes to the project since public exhibition of the Environmental Assessment and a justification for the changes. This includes ways the project has avoided and minimised impacts throughout the design refinements. — Section 2
- The methodology and effort expended for two additional surveys (March 2015 and October 2016) to assess alternate routes for the transmission line and other minor infrastructure changes. — Section 3
- The results for the two additional surveys (March 2015 and October 2016). — Section 4
- A revised impact assessment for the full project (2012-13, 2015 and 2016 survey areas) including: — Section 5
    - Updated project footprint impact on native vegetation and habitats.
    - Updated and additional Assessments of Significance summaries (included in full, Appendix C).
    - Updated collision risk assessment summaries (included in full, Appendix D).
- A summary of the revised offset strategy reflecting current OEH offset guidelines (FBA) for the updated project footprint (included in full, Appendix F). — Section 6
- Specific additional information to address agency submissions under the general headings of: — Section 7
    - Clarification of effort and methods undertaken in 2012-13
    - Expected impacts of the operational stage of the project
    - Analysis of migratory species (actual submission and cross reference table provided as Appendix E).
- An updated set of mitigation measures to manage the biodiversity impacts of the project. — Section 8.

- A series of map sets — Appendix A
    1. Proposed Development Layout
    2. Comparison of Current & EA July 2014 Infrastructure
    3. Survey effort: Coverage by date; 2012-13, 2015, 2016
    4. Results: Vegetation and Flora Survey Results
    5. Results: Conservation Significant Vegetation (EEC/CEEC Areas)
    6. Results: Fauna Habitat Types and Fauna Survey Results
    7. Result: Woodland Bird Habitat and Survey Results
    8. Results: Mammal Survey Results

- An updated Offset Strategy. Offset maps are including within the Offset Strategy (and not as part of this Biodiversity Assessment Addendum's Appendix A Map Set). — Appendix F

1.4 KEY RESOURCES IN THE PREPARATION OF THIS REPORT

To avoid duplication of information, where possible, this addendum report will refer to information contained in the original assessments:

- NGH Environmental (2013a): Biodiversity Assessment, Liverpool Range Wind Farm – Wind Farm Study Area.
- NGH Environmental (2013b): Biodiversity Assessment, Liverpool Range Wind Farm – Transmission Line Study Area.

It is noted that where comparisons are made to the original clearing area required and the revised area, this is done with reference to the clearing areas represented in the publicly exhibited Environmental Assessment (EA; Epuron 2014)[1]. This total impact area is less than assessed in the biodiversity assessment reports (NGH Environmental 2013a,b) but as the EA supersedes the BAs, it is the most relevant document to use for comparisons.

State and commonwealth policies and guidelines that have been consulted in the preparation of this report include:

- BioBanking Assessment Methodology (OEH 2014)
- EPBC Act Environmental Offsets Policy (SEWPaC 2012)
- Matters of National Environmental Significance: Significant Impact Guidelines 1.1 (DEWHA 2009)
- Threatened species assessment guidelines (DECC 2007)

[1] Different impact areas appeared in the BAs (NGH Environmental 2013a and b) due to different buffer widths being used for infrastructure components. For ease of interpretation, only the EA areas are cited in the comparison tables in this document.

2 CHANGES TO THE PROJECT

2.1 KEY CHANGES TO THE PROJECT AND THE BIODIVERSITY ASSESSMENT

The original project was divided into two assessments: the transmission line and the wind farm area. The transmission line considered three route options: the preferred route, alternative 1 and alternative 2. The wind farm consisted of up to 288 turbines and associated tracks and infrastructure.

The current LRWF project combines the assessment for the transmission line and wind farm areas. The transmission line route has been streamlined into one preferred route. The project is for a reduced number of turbines (up to 282), associated tracks, utilities and infrastructure. Refer to Map Set, Appendix A.2 which compares the current infrastructure to that presented in the 2014 Environmental Assessment (EA; Epuron 2014).

Refinements of the proposal have been undertaken in response to ecological constraints, agency and landholder concerns and other construction and operational considerations. Six turbines have been deleted from the project and 20 have been relocated from the indicative location shown in the public exhibition phase of the original project. Details are given in Table 2-1 and Table 2-2 for changes to turbines and supporting infrastructure respectively.

Note, all areas outside of the original survey area have been subject to additional assessment (based on either surveys or extrapolation of adjacent survey data where appropriate), as reported in Sections 3 and 4 of this Addendum and demonstrated in Map set A.3 Survey effort.

2.1.1 Detail regarding infrastructure location and impact areas

Table 2-1 shows the changes that have been made to the turbine locations since the original BAs (NGH Environmental 2013a,b) and the reasons for the changes. Many of the turbine relocations have been undertaken to avoid vegetation communities or habitat. These are shaded in blue.

Table 2-1 Changes to turbine layout since the original assessment

BA Turbine ID	Final Turbine ID	Distance relocated (m)	Bearing relocated	Reason for move
2	2	398	SW	Avoid White Box / Grey Box Grassy Woodland
14	14	43	NW	Improve constructability
16	16	277	W	Avoid Norton's Box Woodland
53	53	80	W	Improve constructability
69		Deleted		Landowner request to avoid existing airstrip
77	77	3218	N	Landowner request to avoid existing airstrip
78	78	80	N	Avoid woodland
83	83	95	NW	Avoid woodland
90	90	72	W	Improve constructability
92		Deleted		Landowner request to avoid existing airstrip
102	102	199	SE	Improve constructability
117	117	69	N	Avoid White Box / Grey Box Grassy Woodland

BA Turbine ID	Final Turbine ID	Distance relocated (m)	Bearing relocated	Reason for move
118	118	29	N	Avoid White Box / Grey Box Grassy Woodland
119	119	585	W	Reduce visual impact for E3-3
120	120	86	NW	Improve constructability
145	145	99	SW	Avoid woodland
155	155	2065	SW	Relocated the single turbine proposed within Liverpool Plains Shire Council
168	168	65	W	Improve constructability
179		Deleted		Avoid noise and shadow flicker impacts at residence F7-3
186	186	523	NW	Improve native vegetation separation (White Box / Grey Box Grassy Woodland). Reduce noise and visual impacts for neighbouring residents.
204		Deleted		Avoid noise and shadow flicker impacts at residence F7-3
214	214	68	NE	Avoid White Box / Grey Box Grassy Woodland
216		Deleted		Avoid noise and shadow flicker impacts at residence F7-3
223	223	1946	SW	Avoid Norton's Box Woodland
224	224	123	SW	Improve constructability
228		Deleted		Avoid noise and shadow flicker impacts at residence F7-3
245	245	97	W	Avoid White Box / Grey Box Grassy Woodland

Table 2-2 shows the changes that have been made to the supporting infrastructure and the reason for the changes.

Table 2-2 Changes that have been made to supporting infrastructure and the reason for changes

Comment	Reason for change
Main Powerline running from the southern boundary of the WFSA down to the Connection Substation at Ulan.	OEH expressed significant concern at the potential fragmentation resulting from this corridor, and in response Epuron and OEH reviewed alternatives and identified a corridor which more closely follows the reserve boundaries.
Gundare Substation (Preferred) relocated 785m E	To accommodate simplification of the Main Powerline.
Turee North Substation (Preferred) removed	Redundant substation option removed due to simplification of Main Powerline.
Coolah Tops Substation (Preferred) removed	Redundant substation option removed due to simplification of Main Powerline.
Coolah East Substation (Preferred) relocated 1,360m SE	To accommodate simplification of the Main Powerline.

Comment	Reason for change
Gundare Substation (Alternative) removed	Redundant substation option removed due to simplification of Main Powerline.
Starkeys Creek Substation (Alternate) removed and Starkeys Creek (Preferred) proposed 960m NE	Redundant substation option removed following design development.
Bounty Creek Substation (Preferred) reclassified as Bounty Creek Substation (Alternative)	Design development due to the Main Powerline simplification and the redistribution of substations
Construction compound and concrete batch plant situated between turbines 62 and 139 removed (On Coolah Creek Rd)	Removed in response to submissions received by nearby residents.
New construction compound location proposed 2,000m S of turbine 115	To replace removed compound on Coolah Creek Rd. New location provides improved screening from local road and nearby residents.
Construction compound and concrete batch plant situated between turbines 201 and 126 removed (on Turee Vale Rd)	Removed in response to submissions received by nearby residents.
New construction compound and concrete batch plant locations proposed 1,250m S of turbine 44	To replace removed compound on Turee Vale Rd. New location provides improved screening from local road and nearby residents.
New Site Access Point with construction compound and concrete batch plant locations proposed 1,000m SW of turbine 23	Improved access to turbine locations. Construction compound would be used for turbine component delivery and would reduce the number of movements for oversized and concrete vehicles on local roads
New Site Access Point with construction compound and concrete batch plant locations proposed 1,850m SE of turbine 5	To reduce vehicle movements on local roads by maximising the internal access tracks created for the project.
New construction compound location proposed 1,500m SE of turbine 10	Alternate compound location for new site access point.
330kV Connection Substation (Preferred) relocated 650m SW	Relocated at the request of the landowner Ulan Coal Mine Limited for operational reasons.
330kV Connection Substation (Alternative) removed	Redundant substation option removed following consultation with Ulan Coal Mine Limited.
Construction compound adjacent to 330kV Connection Substation (Alternative) relocated 400m S adjacent to 330kV Connection Substation (Preferred).	Relocated along with preferred Connection Substation.

2.1.2 Summary of infrastructure changes by clearing area

Table 2-3 provides a summary of the required clearing areas for each component of the LRWF project, including turbine footings, tracks and transmission lines. It also shows the clearing areas of the original wind farm and transmission line study areas (WFSA and TLSA) assessed in the EA[2]. This total impact area is less than assessed in the biodiversity assessment reports (NGH Environmental 2013a,b) but as the EA supersedes the BAs, it is the most relevant figure for consideration of changes. Total clearing areas summarised in the tables in this document always refer to the EA totals.

From this it can be seen that there have been significant reductions in the overall clearing requirements for the project; the revised project is 479.27 ha (a reduction of 39%) of the originally proposed impact area presented in the EA. Reasons for this include reduction in the width required for underground reticulation, reductions in track and transmission line lengths and clearing assumptions as outlined below.

Table 2-3 Break down of LRWF project component clearing areas, and comparison of original and revised layout

Infrastructure component	Original project footprint (ha)	Revised project footprint (ha)	Change (%)
Concrete batch plant	4	4.13	
Connection substation (330kV)	9	1.41	
Construction compound	36	32.45	
Crane hardstand (in pasture areas)	(see footing)	18.22	
Crane hardstand (in woodland and forest)	(see footing)	6.51	
New tracks (permanent formed width)	359.2	391.12	
New tracks for transmission connectivity		37.43	
Operation and maintenance facility	1	1.00	
Transmission (330kV) (in woodland and forest) [3]	568.8	192.76	
Transmission (33kV) (in woodland and forest)	140.5	34.67	
Turbine footing	44.5	17.88	
Underground reticulation (outside of tracks)	21.09	1.61	
Collection substation	48	13.63	
Total	**1,232.09**	**752.82**	**-479.27 (39%)**

2.2 ASSUMPTIONS OF CLEARING

In calculating the impact area required to construct the revised project it is noted:

- The revised calculations for turbine footings separate the foundations for the turbine from the crane hardstand areas, whereas previously these two areas were combined. The revised calculations provide a more accurate assessment of the impact, as each foundation and crane hardstand has now been mapped.

[2] Different impact areas appeared in the BAs (NGH Environmental 2013a and b) due to different buffer widths being used for infrastructure components. For ease of interpretation, only the EA areas are cited in these summary tables. In text, impact areas assessed by the BA are cited where relevant.

[3] Impacts for the transmission line are included only where they cross woodland and forest.

- Within the project boundary, all proposed tracks have an assumed impact width of 15 m, although some are already partly formed. Outside the project boundary, upgrades to road are anticipated to be minimal (and are not specifically assessed in this report).
- Revised calculations for new transmission lines in pasture areas assume an impact area equivalent to a new track for connectivity (4 m) which would run underneath the line.
- Collection substations are generally assumed to be 200 x 200 m but topographic constraints have altered the dimensions of some substations bringing down the overall footprint from 16 ha to 13.6 ha for this component.
- Construction compounds again vary across the site depending on the availability of suitable flat land; the largest one being 300 x 300 m and the smallest being 200 x 10 0m. The overall footprint is now around 32 ha.
- Underground reticulation is generally assumed to be within the impact area of new tracks and turbine foundations. Where the proposed underground reticulation diverges from the road it has been calculated separately.

The full list of assumptions is summarised in Table 2-4 below. The impact is broken down by vegetation type in the revised impact assessment, Section 5.

Table 2-4 Dimensions of infrastructure components assumed in the revised projects' impact area calculations

Infrastructure component	Quantity	Width (m)	Length (m)
Turbine footing		25	25
Crane hardstand (in woodland and forest)	82	22	40
Crane hardstand (in pasture areas)	200	22	40
New tracks (permanent formed width)	1	15	273,600
Underground reticulation (outside of tracks)	1	2	9,029
Transmission (33kV) (in woodland and forest)	1	25	14,700
Transmission (330kV) (in woodland and forest)	1	60	32,300
New tracks for transmission connectivity (33kV)	1	4	45,900
New tracks for transmission connectivity (330kV)	1	4	49,600
Collection substations (330kV)	1	165	85
Wind farm substation	4	200	200*
Operation and maintenance facility	1	100	100
Concrete batch plant	4	100	100
Construction compounds	6	Av. 232	Av. 233

*Av = average

2.3 JUSTIFICATION FOR CHANGES

The changes to the LRWF project since the exhibition period can be classified into two categories:

1. Changes to the wind farm site (wind turbines, powerline and substations)
2. Changes to the transmission line

2.3.1 Changes to the wind farm site

There have been a small number of changes to the turbine layout, all of which are in response to comments received by the Proponent. Wind turbine locations were reviewed following the receipt of submissions from public and government stakeholders along with requests from landowners involved in the project. A total of six turbines have been removed from the proposal and a number have been relocated for reasons described in Table 2-1. No additional turbines have been added to the project and the relocated turbines were all moved within the existing survey area, ensuring impacts were minimised within the known ecological values assessed. Where possible, the proposed turbine relocations considered, alongside impacts to native vegetation, visual amenity, noise, shadow flicker or existing land use. Having already conducted vegetation surveys the revised locations were chosen to ensure no additional vegetation clearing was necessary.

2.3.2 Changes to the main powerline

Two branches of the main powerline in the northern section of the site have been consolidated into one continuous line running from north to south. The overall number of substations on site has reduced from six to four and some alternate options have been removed. Small adjustments to the location of preferred substations were required to accommodate the realignment of the main powerline. Likewise, the onsite overhead reticulation cabling has been adjusted to fit into the new design of one single powerline. The net result of these changes means an overall reduction in the footprint required, in turn reducing the impact area for vegetation and habitat clearing. The new design utilises more lower voltage overhead cabling which requires a narrower easement. Some micro-siting of the Main Powerline has also occurred to ensure that the wider easement avoids wooded areas wherever possible.

The most noticeable change to the proposal is the alignment of the main powerline running from the southern boundary of the WFSA down to the Connection Substation at Ulan. Previously the powerline was proposed through a central area within the main Durridgere SCA. OEH expressed significant concern at the potential fragmentation resulting from this corridor, and in response Epuron and OEH reviewed alternatives and identified a corridor which more closely follows the reserve boundaries. While the currently proposed powerline includes a short additional section of SCA along the border of the Curryall SCA it also secures an adjoining block of land of 219 hectares as an offset, which creates significantly improved connectivity between two previously unconnected sections of the SCA. Section 5 of the Response to Submissions Report (Epuron 2017) provides more detail on this issue.

The final alignment of the preferred route has been achieved after extensive consultation with landowners and land authorities including:

- NSW Office of Environment and Heritage which manages the State Conservation Areas through which the powerline will pass.
- National Parks & Wildlife Service – which manages the State Conservation Areas
- NSW Crown Lands - which manages paper and crown road corridors
- Ulan Coal Mine Limited - which is a significant landholder within the corridor

- Mudgee Local Aboriginal Land Council (ALC) and NSW ALC which holds an undetermined land claim in relation to portions of the powerline corridor.

A contiguous powerline route which appears to be commercially, technically and environmentally acceptable has now been identified and included in the current layout of the project.

3 SURVEY METHODOLOGY AND SURVEY EFFORT

Biodiversity field survey for the LRWF project in its entirety is summarised below. It has included reconnaissance, constraints assessment, comprehensive targeted surveys and follow up surveys.

2009 – Liverpool wind farm preliminary ecological assessment

- A preliminary assessment was undertaken to assist comprehensive survey field planning.
- Main vegetation types and habitat types were evaluated and key constraints identified.

2012-13 - Original biodiversity assessment

- An extensive field program was undertaken in 2012 and 2013 to inform the original BAs for the project; one which considered the wind farm site and one the transmission line options. This work is detailed in NGH Environmental 2013a and 2013b. It included vegetation mapping and targeted flora and fauna field surveys.
- Agency submissions (provided in Appendix E) required additional clarification regarding some of the 2012-2013 survey methods. These issues are clarified in Section 7.

2015 – New areas of transmission line

- An additional survey program was undertaken in March 2015 to address specific changes to the proposed transmission route. The work focused on Turill State Forest and the Durridgere SCA and involved detailed vegetation surveys and targeted flora and fauna field surveys.
- Section 3.1 provides the methodology and effort for the additional surveys undertaken in 2015.

2016 - New areas of wind farm and transmission line

- A further survey program was undertaken in October 2016 to address specific changes to proposed wind farm infrastructure (including ancillary facilities such as tracks, substations, water crossings) and to the transmission route. This was a more rapid survey that involved vegetation mapping, targeted threatened flora transects and recording of fauna habitat values. Limited targeted fauna survey was undertaken. This strategy was developed with input from OEH prior to the field survey.
- Section 3.2 provides the methodology and effort for the additional surveys undertaken in 2016.

Finally, Section 3.3 summarises the total survey effort now undertaken for the LRWF project. Map set A.3 shows the survey effort for the project to date.

3.1 2015 – NEW AREAS OF TRANSMISSION LINE

An additional survey program was undertaken in March 2015 to address specific changes to the proposed transmission route. The work focused on Turill State Forest and the Durridgere SCA and involved detailed vegetation surveys and targeted flora and fauna field surveys. The work was carried out over three days between 20-23 March 2015 by two ecologists, including a botanist and zoologist.

While infrastructure in these areas has since been removed, the vegetation mapping and surveys for broad ranging species particularly contribute to the assessment of impacts for the project. Furthermore, as shown in map set A3, the survey effort in 2013 and 2015 on transmission routes that are no longer to be developed

is located in more contiguous habitat, likely to provide better habitat and activity than the more peripheral routes that now form the preferred alignments.

3.1.1 Survey methodology

The following surveys were undertaken:

Flora

- Flora plot/ random meanders

Fauna

- Habitat assessment and hollow-bearing tree survey
- Bird utilisation survey
- Spotlighting (on foot)
- Call playback
- Anabat detection

Survey methodology follows that given in NGH Environmental (2013a, 2013b) with and clarifications given herein.

Habitat assessment

The habitat assessment data sheet provided in the appendices of the BAs was also used for 2015 surveys.

Habitat types

Habitat types were identified in the field and are defined on the broad structure of main substrates present, in this case it is usually trees. For mapping purposes, it was necessary to use clear guidelines to extrapolate field observations of habitat type across the site using aerial photography (Table 3-1). These definitions were applied to all areas surveyed between 2012 and 2016 for habitat mapping, which was not undertaken in NGH Environmental (2013a, b).

Table 3-1 Guidelines used to determine habitat types by aerial photograph interpretation

Habitat type	Guideline
Open pasture	An area of mostly grass with gaps between trees around 500 m or more.
Pasture with scattered trees	A diverse intermediate zone between open pasture and woodland.
Woodland	To qualify as woodland, there must be nine or more trees per hectare (with the distance between crowns generally not more than 20 m) but the average distance between crowns is greater than one quarter the average crown diameter. Patches of trees of a least one hectare were required to qualify as woodland.
Forest	The distance between crowns is less than one quarter the average crown diameter.

It is expected that some errors will have be made with the aerial photograph interpretation, as well as in the field, as boundaries between pasture with scattered trees / woodland and woodland / forest were at times difficult to determine. However, the mapping provides a representation of the habitat types available across the project area suitable for undertaking impact assessment for the project.

Microhabitat availability/ quality

In the field, habitat features such as hollow-bearing trees, fallen timber, mistletoe and rocks were recorded as absent, scattered, common or abundant. These qualitative indices were later converted to numerical scores with:

Feature absent = 0
Scattered = 1
Common = 2
Abundant = 3

The average of a plot's scores were then calculated as follows to determine microhabitat quality for:

- Tree hollows (average of small and large hollows)
- Rock features (average of rock outcrop, small rock, large rock and ant tunnels)
- Ground layer (average of leaf litter, fallen timber less than 50 cm diameter, fallen timber greater than 50 cm diameter and rock outcrop).
- Mistletoe

Scores were rounded to the nearest whole number and scaled qualitatively where:

0 Habitat absent
1 Poor quality
2 Moderate quality
3 Good quality
4 Excellent quality

Overall abundance

Whereas microhabitat quality averages the scores for a set of microhabitat features within each plot, giving a score for the plot, the overall abundance indicator averages the scores for a single microhabitat feature across all plots and gives a score for each feature. A low score indicates rarity across the whole site; a high score indicates widespread abundance. Overall abundance is applied to 2015 data only and is comparable to the 'relative importance score' used in the BAs. As the 2015 surveys were undertaken in protected areas, it is useful to be able to compare the overall abundance of certain features in the new areas, such as hollow-bearing trees, to those in the original project area.

Hollow-bearing tree survey

In contrast to earlier surveys, hollow-bearing trees were classed in the field in 2015. Two hollow entrance diameter classes were used:

- Small/medium hollows - less than 20 cm in diameter, or
- Large hollows - greater than 20 cm in diameter

These two broad categories were used to reduce subjective error due to the number of field ecologists collecting data and the differing heights the hollows were being observed above ground. The results were used to assess potential for use by various vertebrate fauna (Table 3-2). A qualitative scale for recording abundance of each hollow class (as described above) was used to allow for rapid field assessment.

Recording the abundance of different hollow entrance size classes is relevant to assess the types of vertebrate fauna that may utilise the HBT. Although the entrance size gives no indication of internal dimensions or hollow quality, it is possible to estimate potential habitat for a number of threatened species based on availability of hollows with particular entrance diameters (NPWS 1999, DECC 2007). Table 3-2 gives types of fauna that could utilise hollows in each size class and examples of threatened species.

Table 3-2 Types of fauna and examples of threatened species covered by hollow-bearing tree methodology

	Small / medium hollows	Large hollows
Types of fauna	Microbats (single roosting), small - medium parrots, arboreal mammals (small/medium hollows)	Microbats (colonial roosting/maternity colonies), owls, large parrots and large arboreal mammals (large hollows)
Examples of threatened species	Little Lorikeet Gang-gang Cockatoo	Powerful Owl

Habitat quality scores

In order to provide a scale of habitat quality and to identify both better quality areas and high conservation value habitat, the numerical habitat plot data was used to calculate habitat quality scores (HQS). The HQS has been applied to both new habitat data (from 2015) and to earlier habitat assessment data (presented in NGH Environmental 2013a, b).

HQS is a simple sum of each component assessed in a plot and then compared to a sample score to provide a scale. The scale is not specific to LRWF project, so it provides an assessment of habitat quality that is independent of other habitat plots on site[4].

Table 3-3 The habitat quality score scale

HQS	Qualitative habitat description
≤ 11	Poor
12-18	Moderate
19-25	Good
26-34	Excellent

However, this method does bias findings of higher quality habitat toward areas with high habitat heterogeneity. Therefore, it is general in nature and does not provide a high resolution of habitat quality that can be used to determine where a particular species, e.g. Regent Honeyeater, may occur. Refer above for microhabitat quality for particular species or suites.

Microbats

New Anabat devices were used during the March 2015 survey period. The microphones on these devices are omnidirectional, therefore the positioning of the microphone is less important. Devices were placed in a variety of environments, including sandstone forest, woodland, and riparian areas. Where possible, they were placed on a large fallen tree or log. In forest areas, they were placed near large hollow-bearing trees or stags. On the first night (March 20) all four devices were deployed at Turill SF between 7.30pm and 8.30pm, but on the following nights at all sites they were operational half an hour before dusk. Details of Anabat placement are given in Table 3-4.

[4] This avoids an unintentional relative scale of quality developing where habitat is classed as 'good quality' because it is much better than habitat that occurs elsewhere on site, rather than because of the microhabitat features provides.

Table 3-4 Placement of Anabats in October 2015

Anabat ID	Location	No. nights	Description of habitat
AE1	Turill far north	1 (20/3)	Open grassy woodland on log
AE1	Turill SF far north	1 (21/3)	Open forest on slope on log (*E.macrorhynia* / Ironbark)
AE2	Turill SF	2	Open woodland near fence above creek
AE3	Turill SF	2	Grassy open woodland on log near creek (*A.floribunda*)
AE4	Turill north	2	Mid slope near clearing in forest on log

Weather conditions

Weather conditions during the survey were warm to hot during the day, and fairly mild at night (Table 3-5). The temperature did not drop below 10 ^{o}C throughout the survey period. Conditions were considered suitable to detect all target species.

Table 3-5 Weather data recorded at Merriwa weather station during the field surveys 20/03/15 – 23/03/15

Date	Temp (min)	Temp (max)	Rainfall	Max Wind Gust (km/h)
20/03/15	12.4	37.4	0	54
21/03/15	16.9	23.8	0	57
22/03/15	16.5	28	0	44

3.1.2 Survey effort

Table 3-6 provides a summary of March 2015 survey effort; a full break down is provided in Table 3-13. A total of 11 flora surveys were undertaken comprising nine inspection searches and two Biometric plots. Twenty-eight fauna surveys were undertaken over approximately 73.5 survey hours.

Table 3-6 Summary of survey effort for March 2015

Method	Target species	No. surveys	Total time (hours)	Total area (ha)
Flora plots / random meanders	All flora species	9	4.5	2.25
Biometric plots	All flora species	2	2	0.1
Total flora		**11**	**6.5**	**2.35**
Habitat assessment and hollow-bearing tree survey	All vertebrate fauna	**11**	**3.7**	**0.44**
Bird utilisation survey	All birds	**4**	**1.3**	**1.00**
Spotlighting - on foot	All nocturnal fauna with focus on threatened species	**3**	**3.0**	**n/a**
Call playback	Squirrel Glider, Powerful Owl, Masked Owl, Barking Owl	**2**	**1.5**	**n/a**
Anabat	Insectivorous bats	**8**	**64.0**	**n/a**
Total fauna		**28**	**73.5**	**1.44**

Table 3-7 shows the March survey type and effort sorted by location. Six nights of nocturnal work were undertaken at Turill SF and one each at Michael Power property and Durridgere SCA. Flora surveys and fauna habitat assessments were undertaken at all three locations while diurnal bird census and Biometric (flora) plots were completed at Turill SF only. Opportunistic sightings were also recorded throughout the survey period.

Table 3-7 Survey methods and effort in March 2015

Site	Survey	Effort	Notes
Turill SF	Anabat	6 nights	
	Call playback	2 surveys over 2 nights	Squirrel Glider, Powerful Owl, Masked Owl, Barking Owl
	Spotlighting	3 surveys over 1 night (120 person minutes)	Each survey covered 2 ha
	Fauna habitat survey	Entire easement traversed	HBTs, habitat features recorded
	Flora surveys	9 survey points including 2 biometric plots	
	Diurnal bird survey	4 surveys (20 mins each)	Each survey covered 2 ha
Michael Power Property (north of Ulan Rd)	Anabat	1 night	
	Spotlighting	1 survey (30 person minutes)	Linear transect
	Flora survey	1 survey point	

Site	Survey	Effort	Notes
	Fauna habitat survey	Half of patch traversed, remaining assessed through binoculars	Surveys were time constrained.
Durridgere SCA (south of Ulan Rd)	Anabat	1 night	
	Spotlight	1 survey (30 person minutes)	
	Call Playback	1 survey (40 minutes)	Squirrel Glider, Powerful Owl, Masked Owl, Barking Owl
	Flora survey	1 survey point	
	Fauna habitat survey	Entire easement traversed	HBTs and habitat features recorded

Microbats

A total of eight Anabat survey nights were conducted at Turill SF, Michael Power property, and Durridgere SCA (Table 3-8).

Table 3-8 Anabat survey effort March 2015

	Unit placement	Anabat units	Anabat survey nights	Nights that may have been below optimal overnight temperature (10^{o}C)	Total Anabat survey hours
Transmission line (20-23 March 2015)	Ground	4	8	0	248

3.2 2016 - NEW AREAS OF WIND FARM AND TRANSMISSION LINE

3.2.1 Survey methodology

Surveys were undertaken over three days between 4-6 October 2016 by two ecologists, including a botanist and a field assistant, targeting new areas of development envelope in both the TLSA (namely Durridgere SCA and Turill SF) and the WFSA.

Methods for this survey differ from those described in NGH Environmental (2013a, 2013b), and are given below. The following surveys were undertaken:

- Vegetation type and condition assessment
- Threatened flora species searches in suitable habitat
- Fauna habitat features
- Opportunistic observations of fauna

The 2016 rapid assessment was undertaken in order to assess additional areas. Its reduced intensity was considered appropriate given the large areas of intensive survey in adjacent habitat). For some areas, particularly in the WFSA, the current survey aimed to validate the extrapolation of basic habitat and vegetation attributes found in other parts of the project area. The detailed vegetation and habitat assessments that have been previously undertaken (in 2012, 2013 and 2015) provide context for the rapid assessment.

Map set A.3 shows all areas walked by ecologists, who covered around 50 km over three days. As shown in map set A.3 (Zoom view map 12), the intensive surveys undertaken in 2012 and 2013 are generally located in more contiguous habitat, likely to provide better habitat and activity than the more peripheral route that now forms the preferred alignment. These results have informed the assessment of the additional areas assessed in 2016.

Vegetation

Rapid assessments were undertaken in each vegetation type by recording dominant and subordinate species of each stratum. Species lists created from rapid assessments were used to either:

- Match the community to known vegetation communities occurring elsewhere in the study area, or
- Describe the floristic composition of new communities

Mapping the distribution of vegetation types involved the use of field maps with 500m grid lines and a handheld GPS. GPS points were recorded along vegetation boundaries and distribution patterns drawn onto field maps.

The random meander method (Cropper 1993) was used in preference to standard 0.04 ha quadrats because it maximises the opportunity to detect all the species present in a particular vegetation type at a particular location and improves opportunities for detecting significant or sparsely distributed plant species.

Understorey condition assessment was undertaken during all random meanders within the survey area. Vegetation surveyed was rated according to a six-point condition class scale, focusing on floristic integrity in the understorey (Table 3-9, Table 3-10).

Table 3-9 Six-point condition class scale for **grassy woodland** communities

Condition class	Characteristics	CEEC[5]	EEC[6]	Biometric condition
Exotic	Ground layer dominated by exotics, no native overstorey present.	No	No	Low
Poor	Trees absent to very sparse and ground layer dominated by one or two native grass species, <5 native non-grass species OR native overstorey present and ground layer dominated by exotics.	No	Yes	Low
Poor-moderate	Ground layer dominated by native grasses, 5-11 native non-grass species present in very low numbers.	No	Yes	Moderate-good
Moderate	Ground layer dominated by native grasses, 5-11 native non-grass species present and common.	No	Yes	Moderate-good
Moderate-good	Ground layer dominated by native grasses with a diversity of native non-grass (at least 12 native non-grass species).	Yes	Yes	Moderate-good
Good	Ground layer dominated by native grasses with a diversity of native non-grass (at least 20 native non-grass species)	Yes	Yes	Moderate-good

[5] Commonwealth listed Critically Endangered Community

[6] NSW listed Endangered Ecological Community

Table 3-10 Six-point condition class scale for **shrubby forest** communities

Condition class	Characteristics	Biometric condition
Exotic	Ground layer dominated by exotics, no native overstorey present.	Low
Poor	Trees absent to very sparse and shrub and ground layer dominated by one or two common native species. Grazing pressure moderate to high.	Low
Poor-moderate	Partially cleared, scattered trees, low diversity within the shrub and ground layer. Grazing pressure moderate.	Moderate-good
Moderate	Relatively intact canopy cover, young age class of trees (regrowth), moderate shrub and ground layer diversity. Grazing pressure low.	Moderate-good
Moderate-good	Intact canopy cover, advanced tree age class, moderate to high shrub and ground layer diversity. Grazing pressure low.	Moderate-good
Good	High structural and floristic diversity, old growth canopy trees with hollows present. Grazing pressure absent.	Moderate-good

Threatened flora searches

Targeted searches for potential threatened flora species were undertaken within areas of suitable habitat where access and time constraints permitted (all of the transmission line route was inspected by a botanist on foot). Plants that could not be positively identified in the field were collected for later identification using flora keys (Harden 1990, Harden 1991, Harden 1992, Harden 1993) and a microscope. Unknown plants that shared the same genera as threatened flora species with potential to occur, were collected and a GPS coordinate recorded.

Dedicated searches were not undertaken for threatened grass species during this survey, as most native grasses were not flowering and therefore not identifiable in the time frame of the surveys (October). In general, the low habitat quality of the WFSA suggests that threatened flora would not be expected, due to the long grazing history of many parts of the site.

Fauna habitat

Key habitat features were marked by handheld GPS as they were encountered.

- Hollow-bearing trees
- Rocky outcrops
- Chewed Casuarina cones (feeding signs of Glossy Black Cockatoo)
- Water features

Weather conditions

Weather conditions during the survey were warm to hot during the day. (Table 3-11).

Table 3-11 Weather data recorded at Merriwa weather station during the field surveys 04/10/16 – 06/10/16

Date	Temp (min)	Temp (max)	Rainfall	Max Wind Gust (km/h)
04/10/16	4.6	18.8	1.4	57
07/10/16	5.4	18.7	0	43
06/10/16	6.9	23.0	0	41

3.2.2 Survey effort

Survey methodologies included flora surveys, surveys of key habitat features and diurnal bird surveys (Table 3-7). Opportunistic sightings were also recorded throughout the survey period.

Table 3-12 Survey methods and effort in October 2016

Site	Survey	Effort
Transmission Line (South)	Flora Surveys (vegetation type, condition and targeted threated species surveys)	81 rapid assessments and survey points. 20 hours Traverse along whole transmission line
	Key habitat features recorded (rock outcrops, hollow bearing trees, waterways)	Opportunistic sightings
Windfarm site (North)	Flora Surveys (vegetation type, condition and targeted threated species surveys)	16 rapid assessments 10 hours Traverse along transmission line
	Key habitat features recorded	Opportunistic sightings

3.3 TOTAL SURVEY EFFORT FOR LIVERPOOL RANGES WIND FARM

This section presents a collated summary of total survey effort undertaken for the Liverpool Ranges Wind Farm project to date. Maps set Appendix A.3 shows the combined effort, undertaken in each of these surveys. In total, 1059 surveys, 1425.8 person hours and 329.1 ha have been surveyed over three survey seasons.

Table 3-13 Total survey effort for LRWF project

Date	Method	No. Surveys	Effort (hours)	Effort (hectares)
FLORA AND VEGETATION				
Flora TLSA	Random meanders (including targeted searches)	221	90.3	185.0
	Inspection searches	89	14.8	5.6
	Biometric plots	2	1.5	0.1
	All surveys combined	**312**	**106.6**	**190.7**
Flora WFSA	Random meanders (including targeted searches)	95	48.8	119.8
	Inspection searches	77	12.8	4.8
	All surveys combined	**172**	**61.7**	**124.6**
Flora - Liverpool Plains Wind Farm TLSA and WFSA combined	Random meanders (including targeted searches)	316	139.1	304.8
	Inspection searches	166	27.7	10.4
	Biometric plots	2	1.5	0.1
	All surveys combined	**484**	**168.3**	**315.3**
FAUNA				
Fauna TLSA	Habitat assessment and hollow-bearing tree survey	146	48.7	8.9
	Bird survey	135	22.5	33.8
	Herpetofauna search	135	22.5	33.8
	Bird utilisation survey	60	29.3	57.0
	Extended herpetofauna search	28	14.0	7.0
	Stagwatching /evening listening	21	14.0	
	Spotlighting - on foot	24	45.0	
	Spotlighting - vehicle	17	17.0	
	Call playback	21	16.5	
	Anabat	39	312.0	
	IR camera	67	536.0	
	All surveys combined	**704**	**1165.5**	**140.4**
Fauna WFSA	Habitat assessment and hollow-bearing tree survey	84	28.0	121.0
	Bird survey	85	14.2	21.3

Date	Method	No. Surveys	Effort (hours)	Effort (hectares)
	Herpetofauna search	79	13.2	19.8
	Bird utilisation survey	24	12.0	24.0
	Extended herpetofauna search	11	5.5	2.8
	Stagwatching /evening listening	15	10.0	
	Spotlighting - on foot	15	30.0	
	Spotlighting - vehicle	13	13.0	
	Call playback	13	6.5	
	Anabat	18	144.0	
	All surveys combined	**355**	**260.3**	**188.8**
Fauna - Liverpool Plains Wind Farm TLSA and WFSA combined	Habitat assessment and hollow-bearing tree survey	230	76.7	129.9
	Bird survey	220	36.7	55.0
	Herpetofauna search	214	35.7	53.5
	Bird utilisation survey	84	41.3	81.0
	Extended herpetofauna search	39	19.5	9.8
	Stagwatching /evening listening	36	24.0	
	Spotlighting - on foot	39	75.0	
	Spotlighting - vehicle	30	30.0	
	Call playback	34	23.0	
	Anabat	57	456.0	
	IR camera	67	536.0	
	All surveys combined	**1059**	**1425.8**	**329.1**

4 RESULTS

This section provides the combined results of all surveys undertaken subsequent to the public exhibition of the Environmental Assessment in 2014:

2015 – New areas of transmission line

- Work undertaken in March 2015 to address specific changes to the proposed transmission route in Turill State Forest and the Durridgere SCA.

2016 - New areas of wind farm and transmission line

- Work undertaken in October 2016 to address specific changes to proposed wind farm infrastructure and to the transmission route.

Maps sets Appendix A.4-A.8 show the combined flora and fauna results, as well as additional habitat mapping that has been undertaken to inform the assessment. The maps sets combine all survey results to date.

4.1 FLORA

4.1.1 Vegetation communities

Six vegetation communities were identified in the areas surveyed in March 2015. Thirteen vegetation communities were identified in the areas surveyed in October 2016, including three communities unique to the October 2016 survey area.

A total of 16 vegetation communities have now been recorded in total for the LRWF project area, mapped in Appendix A.4 and listed below.

Table 4-1 Vegetation communities present in LRWF project area and the survey period in which they were recorded

PCT[7] code	Veg type	Recorded in original 2012-2013 survey areas	Recorded in 2015 survey areas	Recorded in 2016 survey areas
084	River Oak - Rough-barked Apple - Red Gum - Box Riparian Tall Woodland (Wetland) of the Brigalow Belt South (BBS) and Nandewar Bioregions	Yes	No	Yes
278	A simplified form of the community known as Blakely's Red Bum – White Box-Grey Box Riparian Woodland	No	No	Yes
281	Rough-barked Apple - Blakely's Red Gum – Yellow Box Woodland on alluvial clay to loam soils on valley floors in the Northern NSW South-west Slopes and BBS Bioregions	Yes	Yes	Yes

[7] PCT = Plant community type

PCT[7] code	Veg type	Recorded in original 2012-2013 survey areas	Recorded in 2015 survey areas	Recorded in 2016 survey areas
395	Derived Speargrass – wallaby grass – wire grass mixed forb grassland mainly in the Coonabarabran – Pilliga – Coolah region	Yes	No	No
437	Yellow Box- Gum Woodland on Lower Hillslopes and Valley Flats in the Southern NSW Brigalow Belt South Bioregion	Yes	Yes	Yes
467	Blue-Leaved Ironbark – Black Cypress Pine Shrubby Sandstone Open Forest in the Southern BBS Bioregion	No	No	Yes
468	Narrow-leaved Ironbark – Blakeley's Red Gum shrubby open forest on sandstone low hills	Yes	No	No
479 [8]	Narrow-leaved Ironbark – Black Cypress Pine – stringybark – wattle shrubby open forest on sandstone hills	Yes	Yes	Yes
477	Inland Scribbly Gum – Red Stringybark – Black Cypress Pine – Red Ironbark Open Forest on Sandstone Hills in the Southern Brigalow Belt South Bioregion and Northern NSW South Western Slopes Bioregion	Yes	No	Yes
478	Red-ironbark Forest –Black Cypress Pine – wattle shrubby open forest on sandstone in the Gulgong – Mendooran region, southern BBS Bioregion	No	Yes	Yes
480	Black Cypress Pine – Ironbark – Wattle Low Open Forest Mainly on Narrabeen Sandstone	Yes	Yes	Yes
481	Sandstone Riparian Grass Fern Open Forest in the Southern BBS and Upper Hunter Regions	Yes	No	Yes
483	Grey Box x White Box grassy open woodland on basalt hills in the Merriwa region	Yes	Yes	Yes
488	Silvertop Stringybark - Yellow Box – Norton's Box Grassy Woodland on Basalt Hills Mainly on Northern Aspects of the Liverpool Range	Yes	No	Yes
490	Mountain Gum – Silvertop Stringybark – Forest Ribbon Gum tall moist open forest on basalt plateau on the Liverpool Range, BBS Bioregion	Yes	No	No

[8] 468 and 479 have been mapped as one community.

PCT[7] code	Veg type	Recorded in original 2012-2013 survey areas	Recorded in 2015 survey areas	Recorded in 2016 survey areas
495	Brittle Gum - Silvertop Stringybark grassy open forest of the Liverpool Range	No	No	No
588	White Box - White Cypress Pine shrubby open forest	No	No	Yes

Vegetation community descriptions are given below for the four communities that are have been added since the 2012-13 surveys and assessment.

1. A simplified form of the community known as Blakely's Red Bum – White Box-Grey Box Riparian Woodland (ID278)
2. Blue-Leaved Ironbark – Black Cypress Pine Shrubby Sandstone Open Forest in the Southern BBS Bioregion (Benson ID 467)
3. Black Cypress Pine – Ironbark +/- Narrow-leaved Wattle Low Open Forest Mainly on Narrabeen Sandstone in the Upper Hunter region of the Sydney Basin Bioregion (Benson ID480)
4. A simplified form of the community known as White Box – White Cypress Pine shrubby hills open forest mainly in the Nandewar Bioregion (Shrubby Woodland (ID588)

Refer to NGH Environmental (2013a, b) for descriptions of communities recorded in the original wind farm and transmission line assessments.

A simplified form of the community known as Blakely's Red Bum – White Box-Grey Box Riparian Woodland (ID278)

This community is typically found on flats and lower slopes adjacent sandstone slopes of the southern TLSA. It often forms a mosaic with grasslands on private lands adjacent Durridgere SCA. The canopy comprises *Eucalyptus albens x moluccana* (White box x Grey box hybrid) and *Eucalyptus blakelyi.* Other trees species occurring in lower number include *Eucalyptus melliodora* and *Eucalyptus crebra*. The understorey is grassy with a rich array of graminoids and forbs. A sparse shrub layer includes *Cassinia arcuata, Acacia paradoxa* (Kangaroo Thorn) and *Styphelia triflora*. The ground layer comprises *Gahnia aspera*, *Dianella revolua, Lomandra multiflora, Wurmbea biglandulosa, Calotis cuneifolia*, *Dichondra repens* (Kidney Weed), *Cymbonotus lawsonianus*, *Oncinocalyx betchei, Drosera peltata, Hydrocotyle laxiflora, Cheilanthes sieberi*, *Aristida ramosa* and *A. vagans.*

Figure 4-1 White Box/Grey Box hybrid – Blakey's Red Gum woodland

This community considered vulnerable by Benson *et al.* (2010). It is part of the listed EEC and CEEC Box-Gum Woodland. Most stands seen were in moderate, moderate-good or good condition, with a relatively high diversity of non-grass groundcover species.

This community is mapped as Grey Box x White Box hybrid – Blakely's Red Gum woodland in the vegetation maps provided in Appendix E.4.

Blue-Leaved Ironbark – Black Cypress Pine Shrubby Sandstone Open Forest in the Southern BBS Bioregion (Benson ID 467)

This community occupies southern parts of TLSA within the Durridgere SCA and other nearby sandstone remnants. It occurs on rocky skeletal sandstone ridges and shallow slopes. The presence of *Eucalyptus nubila* (Blue-leaved Ironbark) and *Callitris endlicheri* characterise this community. A small tree layer of *Acacia linearifolia* can occur. The understorey varies from sparsely vegetated ridges, to slopes with more cover and higher diversity. Shrub species include *Grevillea sericea*, *Brachyloma daphnoides, Calytrix tetragona, Cassinia arcuata, Cassinia laevis, Acrotriche rigida, Allocasuarina gymnanthera, Leucopogon muticus*, *Melichrus erubescens* (Ruby Urn Heath), *Podolobium ilicifolia* (Prickly Shaggy Heath) and *Prostanthera scutellarioides*. Groundcover species include *Pomax umbellata, Cheilanthes sieberi, Gonocarpus elatus, Lepidosperma laterale, Aristida vagans* and *Xanthorrhoea sp.*

Figure 4-2 Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern BBS Bioregion

This community is generally not grazed, although where they abut cleared paddocks there may be some penetration of livestock for a short distance. Past logging is the principal disturbance, which has reduced the frequency of large mature trees with large tree hollows and to localised dominance of *Callitris* and *Acacia* rather than eucalypts. Exotic species are very rare.

This community is generally considered to be of least concern by Benson *et al.* (2010), as substantial areas are conserved in large local reserves such as Goulburn River, Gardens of Stone and Wollemi National Parks, as well as several smaller reserves such as Durridgere SCA. This vegetation community is not listed as an EEC under NSW or Commonwealth legislation.

Black Cypress Pine – Ironbark +/- Narrow-leaved Wattle Low Open Forest Mainly on Narrabeen Sandstone in the Upper Hunter region of the Sydney Basin Bioregion (Benson ID480)

Figure 4-3 Black Cypress Pine – ironbark – wattle low open forest mainly on Narrabeen Sandstone

This community occupies southern parts of TLSA within the Durridgere SCA. It occurs on shallow sandy soils of low fertility. *Callitris endlicheri* dominates the canopy, sometimes forming dense monocultures of closely spaced small trees, interspaced with *Eucalyptus crebra*. Perhaps the result of past logging which has reduced the frequency eucalypts and promoted a dominance of *Callitris* species. The understorey is sparse and species poor. Shrub species include *Acacia linearifolia*, *Pimelea linifolia*, *Brachyloma daphnoides, Allocasuarina gymnanthera* and *Daviesia acicularis*. Similarly, the groundcover is also sparse sometimes completely covered in lichen (as shown in Figure 4-3 above). Groundcover plants characteristic of this community include *Xanthorrhoea sp., Gahnia aspera* (Rough Saw Sedge)*, Pomax umbellata, Goodenia hederacea* (Ivy Goodenia) and *Thysanotus patersonii* (Twining Fringe Lily).

Exotic species are very rare in this community.

This community is generally considered to be of least concern by Benson *et al.* (2010), as substantial areas are conserved in large local reserves such as Goulburn River, Gardens of Stone and Wollemi National Parks, as well as several smaller reserves such as Durridgere SCA. This vegetation community is not listed as an EEC under NSW or Commonwealth legislation.

A simplified form of the community known as White Box – White Cypress Pine shrubby hills open forest mainly in the Nandewar Bioregion ID588

This community occurs on mid to upper rocky slopes in the northern part of TLSA. The canopy contains *Eucalyptus albens x moluccana* (White box /Grey box hybrid) and *Angophora floribunda.* The understorey is shrubby and dominated by *Dodonaea viscosa, Dodonaea viscosa subsp. angustifolia, *Hypericum perforatum* (St John's Wort)*, Swainsona galegifolia* and *Cassinia laevis.* The groundcover includes *Lomandra filiformis subsp. filiformis, Mentha satureioides, Acaena ovina, Sigesbeckia australiensis, Aristida ramosa* and *Austrostipa scabra.*

4.1.2 Vegetation condition

All vegetation surveyed would be considered in moderate to good condition, using the Biometric Assessment Methodology condition ratings.

4.1.3 Conservation significant vegetation and flora species

Considerable areas of TSC and EPBC listed Box Gum Woodland EEC are present in Turill SF, refer Appendix A Map set A.5. The vegetation in this area is mostly good condition and high diversity Box Gum Woodland with numerous large old hollow-bearing trees.

Small pockets of TSC and EPBC listed Box Gum Woodland and derived native grassland are present on lower slopes adjacent Durridgere SCA and alluvial flats of Goulburn River. The vegetation these areas is generally in good condition with a high diversity of native graminoids and forbs.

One NSW listed EEC - White Box Yellow Box Blakely's Red Gum Woodland - was recorded within the LRWF area. This EEC includes communities ID 278, 281, 483 and sections of 395 that would have previously supported Box Gum Woodland species prior to clearing. Areas in moderate to good condition (using the five point condition scale in Table 3-9) also qualify as the EPBC listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC.

The updated EEC areas are mapped in Appendix A.5 impact areas tabulated in Section 5.

Noxious weeds

The following noxious weed species were found during 2015 and 2016 surveys:

- Cobbler's Peg *Bidens pilosa*
- Patterson's Curse *Echium plantagineum*
- St John's Wort *Hypericum perforatum*
- Sweet Briar *Rosa rubiginosa*
- Blackberry *Rubus fruticosus* sp. agg.
- Prickly pear *Opuntia* sp.
- Fireweed *Senecio* spp.

Threatened species

No threatened flora species were found during 2015 or 2016 surveys.

4.2 FAUNA

4.2.1 Habitat types and quality

The following habitat types were identified in 2015 and 2016:

- Open pasture
- Pasture with scattered trees
- Woodland
- Open Forest
- Riparian areas

These habitat types were also recorded in the original BAs. Habitat type and condition is now mapped for the LRWF in Appendix A.6. Overall habitat quality is assessed on the presence of a number of microhabitat features including leaf litter, fallen timber, hollow-bearing trees and rock. Each habitat plot (undertaken in 2015) was assigned a habitat quality score based on the microhabitat features recorded. Habitat quality is poor, moderate, good or excellent. Habitat in 2015 survey area for the LRWF project area was mostly poor or moderate quality. There were no excellent quality areas of habitat surveyed (Table 4-2). Refer to Section 3.1.1 for description of habitat quality methodology.

Table 4-2 Habitat locations and type sorted by habitat quality

Habitat quality	Location	Habitat type
Poor (HQS ≤12)	Hab 1, far north Turill SF Hab 2, far north Turill SF Hab 3, Durridgere SCA, south of Murrumbline Creek Hab 4, Durridgere SCA, south of Murrumbline Creek	Open forest Woodland Open forest Open forest / riparian
Moderate (HQS >12 ≤18)	Hab 11, Michael Power's property Hab 5, Turill SF, north of Kurrajong Creek Hab 6, Turill SF, near Kurrajong Creek Hab 7, near Kurrajong Creek Hab 8, Turill SF Hab 9, Turill SF	Open forest Woodland Woodland / riparian Woodland / riparian Woodland Woodland
Good (>18 ≤25)	Hab 10, Turil Creek in north Turill SF	Woodland / riparian
Excellent (>25)	None	n/a

Although habitat quality was recorded in the earlier (2012-2013) field surveys, a discussion was not included in the report. In order to undertake habitat mapping (refer Section 3.1.1) raw data from earlier surveys was analysed. The results are included here for completeness. Table 4-3 shows that the majority (91 from 132 habitat plots) of habitat in the LRWF project area is of poor quality. Only four plots recorded good quality habitat.

Table 4-3 Habitat type and quality results across the LRWF project area for habitat surveys undertaken in 2012, 2013, 2015

Habitat type	Good quality	Moderate	Poor	Total
Open forest		8	15	23
Open pasture			9	9
Pasture with scattered trees		9	24	33
Riparian		3	4	7
Rocky outcrop	1			1
Shrubland			1	1
Woodland	3	26	29	58
Totals	**4**	**46**	**82**	**132**

4.2.2 Microhabitat for particular species

Woodland birds

The suite 'woodland birds' includes nectar, seed and insect feeders (e.g. Regent Honeyeater, Diamond Firetail and Brown Treecreeper, respectively). Habitat for this suite is made up of the following habitat types, quality and microhabitat features:

- Good quality native grassland (EEC) - ground feeders (Diamond Firetail, Speckled Warbler)
- Moderate quality or better woodland habitat
- Mistletoe - nectar feeders (Regent Honeyeater, Black-chinned Honeyeater, Little Lorikeet)
- Tussock - ground feeders (Diamond Firetail, Speckled Warbler)
- Fallen timber and litter - insect feeders (Brown Treecreeper, Robins, Varied Sittella, Grey-crowned Babbler)
- Tree hollows - hollow nesting species (Brown Treecreeper)

Appendix A.7 Woodland Bird Habitat maps show moderate and good quality habitat for woodland birds.

Cockatoos

The suite 'Cockatoos' include threatened Gang-gang Cockatoo and Glossy Black Cockatoo. The latter has been recorded in the LRWF project area. These species are wide-ranging and Gang-gang Cockatoos are also altitudinal migrants, and may pass through habitat during dispersal and migration. Habitat for this suite is more general, although the following is key:

- Tree hollows for nesting
- Casuarina / Allocasuarina feed trees (Glossy Black Cockatoos) found in River Oak Woodland

Areas of moderate, good and excellent density of hollow-bearing trees are shown in Appendix Map set A.8 and River Oak Woodland habitat is shown the vegetation community mapping, Appendix A.4.

Diurnal raptors

The raptors utilise large home ranges and are highly mobile. In addition to the individual species' habitat preferences, key microhabitat requirements include:

- Good prey abundance
- Perching opportunities

- Diverse vegetation structure, including emergent trees
- Open areas

Specific data on these habitat elements were not collected, and it is assumed that the raptors would utilise all habitats on site (including poorer quality areas), but would focus breeding efforts in good or excellent quality habitat, and riparian habitat, shown in Appendix Map set A.7.

Owls

As for diurnal raptors, owls use large home ranges and are highly mobile. Key microhabitat requirements include:

- Hollows for nesting
- Dense vegetation for roosting
- Riparian, forest, woodland
- Prey especially mammals

The mapped riparian habitat (refer Appendix Map set A.6) and habitat for mammals (refer Appendix Map set A.8) provide an indication of better quality habitat for Owls.

Arboreal mammals and cave-dwelling bats (excluding Koala)

The following microhabitat components make up habitat for arboreal mammals and cave-dwelling bats:

- Habitat preferences of individual species (e.g. wattle midstorey for Squirrel Glider- not mapped)
- Good quality woodland and forest
- Caves (cave-dwelling microbats)
- Insect prey (fallen timber) (microbats)
- Tree hollows (tree-roosting microbats, Squirrel Glider, Eastern Pygmy-possum, Brush-tailed Phascogale)
- Canopy continuity - good quality or better habitat (including forest, woodland)

Refer to the Map set, Appendix A.8 for mammal habitat mapping (no caves have been identified in the impact areas).

Koala

Microhabitat for Koala centres around preferred feed tree species. Table 4-4 shows the Koala feed tree species (for Western Slopes & Plains and Northern Tablelands – DECC 2008) present on site and the community in which they occur. Vegetation communities are mapped in Appendix A.9. In addition to the species and communities listed in the table below, suitable shelter trees are an important habitat component (Smith 1992; Kavanagh and Barrott 2001; J. Callaghan, Australian Koala Foundation, pers. comm.). Shelter trees include Cypress Pine which is found in the Sandstone Forest types. Suitable habitat for Koala is assumed to be moderate to good and good quality remnants (according to the flora condition classes) of the forest types listed below.

The primary feed tree occurs only in some areas of Riparian Forest – Rough-barked Apple, Blakely's Red Gum (ID 481) that were surveyed in 2016. The tree species was not recorded in earlier vegetation surveys elsewhere in the LRWR project area. Thus, there are small pockets of secondary habitat (either class A – Phillips 2000b in DECC 2008, or class B – Callaghan in DECC 2008) capable of supporting medium to low densities of koala habitat. Elsewhere, habitat consists of secondary and supplementary habitat only, capable of support low koala densities (DECC 2008).

Table 4-4 Koala feed tree species present on site and the community in which they occur (species derived from SEPP 44 and Koala Recovery Plan

Koala feed tree species	Vegetation community
Primary feed tree	
Forest Red Gum *Eucalyptus tereticornis*	Riparian Forest – Rough-barked Apple, Blakely's Red Gum (ID 481) The tree was recorded in some of the areas surveyed in 2016 only.
Secondary feed tree	
Yellow Box *E.melliodora*	Riparian Forest – rough-barked Apple, Blakey's Red Gum and Yellow Box (ID 281) Yellow Box Grassy Woodland (ID 437)
White Box *E.albens*	White Box-Grey Box Grassy Woodland (ID 483) White Box - White Cypress Pine shrubby open forest (ID 588)
Large-flowered bundy *E.nortonii*	Norton's Box Woodland (Id 437)
Grey Box *E.moluccana*	White Box-Grey Box Grassy Woodland (ID 483) Riparian Blakely's Red Gum - box - sedge forest (ID 278)
Blakely's Red Gum *E.blakelyi*	Within communities already listed above
Mountain Gum *E.dalrympleana*	Mountain Gum – Silvertop – Stringybark Forest (ID 490)
Brittle gum *E.praecox*	Brittle Gum – Stringybark Woodland (ID 495)
Supplementary species	
Red Stringybark *E.macrorhyncha*	Sandstone Forest – Narrow-leaved Ironbark dominant (ID 468 and 479)
Narrow-leaved Stringybark *E.sparsifolia*	Sandstone Forest – Red Ironbark dominant (ID 478)
Silver-topped stringybark *E.laevopinea*	Within communities already listed above

Hollow-bearing trees

The results of hollow-bearing tree estimates from the 2015 habitat assessments are given in Table 4-6. Areas of moderate or better quality habitat for hollow-dependent species ('hollow quality') are shown in Appendix map set A.7 and A.8 also includes the hollow data from 2012 and 2013 which is based on the ratio of hollows: trees only. Hollow quality was determined by the following extrapolation:

- Number of hollow-bearing trees per plot (plot size = 0.25 ha) x 4 = hollow-bearing trees per hectare.

A quality rating was given according to the following scale (Table 4-5), devised based on figures from Lindenmayer & Gibbons (2002) given in NSW Scientific Committee (2011):

Table 4-5 Hollow quality rating based on number of hollow-bearing trees per hectare

Hollow quality rating	Woodland (hbt/ha)	Forest (hbt/ha)
Poor	< 5	< 10
Moderate	6 – 10	11 – 15
Good	11 – 20	16 – 25
Excellent	> 20	> 25

Table 4-6 The location and habitat type of hollow-bearing tree data (showing estimates of small-medium and large hollows), and the resultant hollow quality.

Location	Habitat type	Small hollows	Large hollows	Hollows/plot	Hollow quality
Far north Turrill SF	Open forest	Scattered	Absent	2	Poor
Far north Turrill SF	Open woodland	Absent	Absent	0	Absent
Durridgere SCA, south of Murrumbline Creek	Open forest	Absent	Absent	0	Absent
Durridgere SCA, south of Murrumbline Creek	Open forest / riparian	Absent	Scattered	1	Poor
Turrill SA, north of Kurrajong Creek	Open woodland	Scattered	Scattered	1	Poor
Turrill SF, near Kurrajong Ck	Open woodland / riparian	Absent	Absent	0	Absent
Turrill SF, vicinity of Kurrajong Ck	Open woodland / riparian	Scattered	Scattered	1: 23	Poor
Turrill SF	Open woodland	Scattered	Absent	1: 9	Poor
Turrill SF	Open woodland	Scattered	Absent	1: 14	Poor
North Turrill SF	Woodland / riparian	Scattered	Scattered	5: 28	Good
Michael Power's property	Open forest	Absent	Absent	0: 30	Absent

As outlined in Section 3.2, hollow-bearing trees were recorded by GPS in the 2016 surveys of new transmission line and wind farm areas. 113 hollow-bearing trees were recorded. The points show that hollow-bearing trees are not distributed equally through habitat but tend to be clustered in patches. These points show that there are no 2016 survey areas with more than four hollow-bearing trees per hectare. That is, all these parts are poor hollow quality. This survey also indicates that extrapolation of 2012-2015 hollow plot data is likely to lead to an overestimate of hollow quality, as hollows are not spread evenly through an area.

4.2.3 Fauna species recorded

Bird surveys

Forty-six bird species were recorded during bird surveys and including opportunistic bird sightings, a total of 53 bird species were identified on site. Raptors are considered a species of particular interest in wind farm developments (refer to NGH Environmental 2013a). A single Wedge-tailed Eagle was observed flying above the canopy over open forest in the far north of Turill SF in 2015. The birds observed were mostly birds common to forest and woodland habitats such as Grey Shrike-thrush *Colluricincla harmonica*, Rufous Whistler *Pachycephala rufiventris* and Sacred Kingfisher *Todiramphus sanctus*. Several threatened birds were recorded and are listed in Section 4.2.4.

Active nocturnal surveys

Spotlighting and call playback were undertaken. A number of common species were seen and heard including White-striped Freetail Bat *Austronomus australis*, Eastern Grey Kangaroo *Macropus giganteus* and Red-necked Wallaby *Macropus rufofriseus*. Arboreal species included Common Brushtail Possum *Trichosurus vulpecula*, Sugar Glider *Petaurus breviceps* and Common Ringtail Possum *Pseudocheirus peregrinus*. A number of reptile and amphibians were detected during nocturnal surveys including Thick-tailed Gecko *Underwoodisaurus milii*, Red-naped Snake *Furina diadema* and Broad-palmed Frog *Litoria latopalmata*. Red-naped Snake is a new species for the project. No threatened species were recorded during active nocturnal surveys.

Passive nocturnal surveys - Anabat

Around 4400 Anabat files were recovered from eight overnight surveys. Sixteen species or species-complexes were identified by consultant Glenn Hoye:

- White-striped Freetail Bat *Austronomus australis*
- Large-eared Pied Bat *Chalinolobus dwyeri*
- Gould's Wattled Bat *Chalinolobus gouldii*
- Eastern Bentwing Bat *Miniopterus orianae oceanensis*
- Eastern Freetail Bat *Mormopterus ridei*
- Southern Freetail Bat *Mormopterus sp.4*
- Long-eared Bat species *Nyctophilus spp*
- Large Forest Bat *Vespadelus darlingtoni*
- Southern Forest Bat *Vespadelus regulus*
- Little Forest Bat *Vespadelus vulturnus*
- Chocolate Wattled Bat *Chalinolobus morio*
- Miniopterus / Vespadelus species complex
- Large-footed Myotis *Myotis macropus*
- Eastern Horseshoe Bat *Rhinolophus megaphyllus*
- Inland Broad-nosed Bat *Scotorepens balstoni*
- Eastern Cave Bat *Vespadelus troughtoni*

The most common species recorded at AE1 in open grassy woodland was Southern Freetail Bat (54 calls), and the least common was Eastern Bentwing Bat (3 calls). AE1 was moved to open forest the following night where the highest activity level was again for Southern Freetail Bat (142 calls) and the lowest for Southern Forest Bat (1 call).

AE2 was placed in open woodland near a creek in Turill SF for both nights and recorded Southern Freetail Bat the most (total 152 calls) and Southern Forest Bat the least (1 call). Other species recorded included White-striped Freetail Bat and *Nyctophilus* sp. AE3 was placed in open grassy woodland near a creek in Turill SF/private for both nights and recorded the highest activity level for Southern Forest Bat (total 466 calls) and the lowest for Eastern Horseshoe Bat (total 1 call). Large Forest Bat was also recorded in a high number of files (total 372 calls) along with Eastern Bentwing Bat (total 107 calls).

AE4 was located at mid slope near a clearing in forest in the northern part of Turill SF. Large Forest Bat was the most frequently recorded bat here (total 210 calls), with the lowest number of calls to the Eastern Cave Bat (total 10 calls). Other species at this location included Southern Freetail Bat, Eastern Freetail Bat and Chocolate Wattled Bat.

The results indicate that habitat exists for both tree-dwelling and cave-dwelling bats, including obligate cave dwellers such as Eastern Horseshoe Bat.

4.2.4 Threatened fauna species

Species recorded

Eleven threatened fauna species were recorded during both 2015 and 2016 field surveys, listed in Table 4-7. Six threatened bird species were observed and an additional species identified through feed signs. Four threatened microbats were identified along with two species complexes which include threatened species. Locations of these identifications are given in Appendix A.7. Additionally, Rainbow Bee-eater was recorded during both surveys. This species is listed as migratory under the EPBC Act.

Table 4-7 **Threatened species recorded during field surveys within the TLSA March 2015 and October 2016**

Name	Status
Birds	
Brown Treecreeper	V TSC
Speckled Warbler	V TSC
Varied Sittella	V TSC
Diamond Firetail	V TSC
Little Lorikeet	V TSC
Grey-crowned Babbler	V TSC
Glossy Black Cockatoo	V TSC
Microbats	
Large-eared Pied Bat	V TSC / V EPBC
Eastern Bentwing Bat	V TSC
Long-eared Bat species complex	V TSC /V EPBC
Miniopterus / Vespadelus species complex	V TSC
Large-footed Myotis	V TSC

5 REVISED IMPACT ASSESSMENT

5.1 IMPACT ASSESSMENT APPROACH

The types of construction and operational impacts identified in the NGH Environmental 2013a and b remain unchanged by the proposal modifications. They include:

1. Habitat loss: direct impacts of vegetation / flora and fauna habitat removal for wind turbines, transmission easement and supporting infrastructure
2. Collision risk: Direct impacts of collisions with infrastructure (most relevant to wind turbines)
3. Indirect impacts of the above, potentially leading to avoidance or disturbance to flora and fauna

These impacts types are discussed in NGH Environmental 2013a and b and have not been repeated here.

The revised impact areas for vegetation and vertebrate fauna habitat loss (clearance) have been quantified and compared to the original estimates of clearing impact. These quantifications are given in Section 5.2 and where required (due to substantially increased impact areas or in response to an OEH submission comment) Assessments of Significance (pursuant to NSW and Commonwealth criteria) have been redone. These are provided in full in Appendix C and summarised in Section 5-2.

Wind farm collision impacts (blade-strike/barotrauma) have been discussed in detail in NGH Environmental (2013a). Collision impact assessment uses a risk assessment methodology. Where required, an updated Collision Risk Assessment (CRA) is provided in full in Appendix C and summarised in Section 5-3.

Indirect impacts at the wind farm site are considered to be reduced based on the reduced turbine number now proposed and are not discussed further in this report. Indirect impacts of the transmission line are also considered to be reduced based on the selection of a route reflecting extensive consultation with landowners and land authorities (including NSW OEH which manages the State Conservation Areas through which the powerline will pass). The route is now 50% less in area than that considered in the original assessment and indirect impacts are not discussed further in this report.

5.1.1 Assumptions and limitations

The following assumptions were used in preparation of this impact assessment (this list includes those outlined in Section 10 of NGH Environmental, 2013a).

- Impacts on native vegetation and threatened species habitat:
    - The clearance area calculations for each component of the LRWF, which are given in Table 2-3, have been generated by Epuron using GIS files for the new infrastructure footprint, over vegetation mapping provided by NGH Environmental (2012-13, 15 and 16). They have been used to determine impacts upon flora, fauna and vegetation communities.
    - The vegetation mapping is informed by walked transects and in some cases extrapolation based on what could be seen in adjacent areas. Despite uncertainties of extrapolation in some areas, the mapped vegetation community extent and condition is considered a reasonable representation of what is found in the LRWF project area.

  - Habitat quality has been derived from vegetation mapping and field assessment to inform estimates of impact on species habitat.
- Collision risk:
  - Lack of site-specific bird utilisation data for the Liverpool Range Wind Farm site necessitates extrapolation from other areas and reliance on scientific literature and assumptions regarding species movement.
  - Lack of detailed ecological information for a number of species, particularly with regard to nomadic and migratory movements, necessitates assumptions, usually based on surrogate species for which more information is available.

5.2 FLORA

5.2.1 Updated habitat loss

Overall native vegetation clearing

Table 5-1 shows the amount of clearing of vegetation communities in the revised LRWF project. EECs are shaded blue. It also provides a comparison of the magnitude of change in impact between the previously assessed project[9] (Epuron 2014) and the revised proposal (revised area). The revised proposal overall is reduced in terms of total clearing area (479.27 ha less overall; a 39% reduction). As detailed in Section 2, this is mostly due to changes to the transmission line route and reduction of clearing area widths for transmission and underground cabling.

Reductions will occur for the following vegetation types:

- River Oak Woodland (ID 084)
- Riparian forest - Rough-barked Apple, Blakely's Red Gum and Yellow Box (ID 281) EEC
- Native Pasture (ID 395) (some parts are EEC)
- Sandstone Forest – Scribbly Gum dominant (ID 477)
- Sandstone Forest - Red Ironbark dominant (ID 478)
- White Box - Grey Box Grassy Woodland (ID 483) EEC
- Mountain Gum – Silvertop – Stringybark Forest (ID 490)
- Sandstone Forest - Narrow-leaved Ironbark dominant (ID 468 and 479)

However, there will be some *increased* clearing of the following vegetation types:

- Blakely's Red Gum – Grey Box-White Box Riparian Woodland (ID 278)
- Sandstone Forest – Blue-leaved Ironbark dominant (ID 467)
- Sandstone Forest – Black Cypress dominant (ID 480)
- Riparian Forest – Rough-barked Apple, Blakely’s Red Gum (ID 481)
- Norton's Box Woodland (ID 488)
- Norton's Box Woodland (ID 488)
- Brittle Gum - Stringybark Woodland (ID 495)
- White Box – White Cypress Pine shrubby open forest (ID 588)

[9] Except where assessments of significance undertaken in the BAs are directly referred to, comparisons are to figures provided in the EA (Epuron 2014)

Overall, the magnitude of increases is considered small (no greater than 5.8 ha in any community and 393.1 ha less overall) and therefore is not considered to affect the conclusions drawn in the NGH Environmental (2013a, b) assessments or the EA (Epuron 2014).

Conservation significant vegetation and threatened species habitat are discussed separately in the sections below.

Table 5-1 Comparison of total impact area (original versus revised proposal) by vegetation type

Vegetation type	Original area[10] (ha)	Revised area (ha)	Difference (ha)	% change
River Oak Woodland (ID 084)	9.82	6.66	-3.2	32% reduction in proposed clearing
Blakely's Red Gum – Grey Box-White Box – riparian woodland (ID 278) EEC	0.03	4.14	4.1	New impact area
Riparian forest - Rough-barked Apple, Blakely's Red Gum and Yellow Box (ID 281) EEC	34.24	19.13	-15.1	-44%
Native Pasture (ID 395) (some parts are EEC)	268.97	86.02	-182.9	-68%
Yellow Box Woodland (ID 437) EEC	1.51	1.51	0.0	No change
Sandstone Forest - Blue-leaved Ironbark dominant (ID 467)	0	3.30	3.3	New impact area
Sandstone Forest - Inland Scribbly Gum dominant (ID 477)	34.19	31.59	-2.6	-7%
Sandstone Forest - Red Ironbark dominant (ID 478)	17.78	0.02	-17.8	-99%
Sandstone Forest - Black Cypress dominant (ID 480)	3.41	8.72	5.3	155% increase in proposed clearing
Riparian forest - Rough-barked Apple and Blakely's Red Gum (ID 481)	27.26	27.41	0.2	0.5%
White Box - Grey Box Grassy Woodland (ID 483) EEC	100.65	100.34	-0.3	-0.3%
Norton's Box Woodland (ID 488)	65.07	67.82	2.8	4%
Mountain Gum - Silvertop -	1.11	1.05	-0.1	-5%

[10] 'Original' impact areas are from the *preferred* infrastructure layout as presented in the EA (2014).

Vegetation type	Original area[10] (ha)	Revised area (ha)	Difference (ha)	% change
Stringybark Forest (ID 490)				
Brittle Gum - Stringybark Woodland (ID 495)	2.36	3.12	0.8	32%
White Box - White Cypress Pine shrubby open forest (ID 588)	0	0.36	0.4	New impact area
Sandstone Forest - Narrow-leaved Ironbark dominant (ID 468 and 479)	60.17	41.02	-19.2	-32%
Exotic	489.58	347.26	-142.3	-29%
Unknown [11]	29.77	0.00	-29.8	No unknown areas
Disturbed	0.0	3.35	3.4	New impact area
Total	**1145.92**	**752.82**	**-393.1**	**-34%**

Endangered Ecological Communities

Table 5-2 shows clearing areas for EEC and CEEC for the LRWF project by Biometric condition classes. A further break down of condition (5 class scale – poor to good) is provided in the left hand column to provide better characterisation of the impacts.

Table 5-2 Break-down of proposed clearing of EEC and CEEC for the LRWF project

Condition class	CEEC	EEC	Biometric condition	Vegetation clearance (ha)	
				EEC (with native tree cover)	EEC (native pasture)
Poor	No	Yes	Low	87.5	4.0
Poor-moderate	No	Yes	Moderate-good	18.2	3.9
Moderate	No	Yes	Moderate-good	9.0	67.4
Moderate-good	Yes	Yes	Moderate-good	9.1	0
Good	Yes	Yes	Moderate-good	1.3	0
			Sub-total	*125.1*	*75.3*
			Total EEC	**200.41**	
			Total CEEC	**10.37**	

[11] Unknown areas mapped in the original assessment have now either been avoided or classified based on field assessment results.

Table 5-3 shows a comparison of EEC and CEEC clearing areas between the previously assessed project (Epuron 2014) and the revised proposal.

NSW EEC

There is a very large reduction in the clearing for NSW listed Box Gum Woodland EEC. In the original BA (NGH Environmental 2013a, b), the removal of around 460 ha[13] of Box Gum Woodland EEC was not considered significant under the TSC Act due to the generally poor condition of the community. It was considered that there was scope to microsite around better quality patches. The clearing area has now been more than halved compared to the BA, although the EA presented a smaller area (refer to Table 5-3). The finding of a non-significant impact for Box Gum Woodland EEC remains unchanged and no further assessment or additional mitigation is considered to be required.

EPBC CEEC

There has however, been an increase in the clearing of EPBC Act listed Box Gum Woodland CEEC; the impact is an additional six ha (166% increase) compared to the EA. In the original assessment (NGH Environmental 2013b), the removal of around 3.9 ha of Box Gum Woodland CEEC was not considered significant under the EPBC Act. It is noted that the BAs assessed three options. The AoS for CEEC assessed clearing of 23 ha, 14 ha and 3.9 ha. It found that careful planning and site management within CEEC during the works phase would minimise tree clearing and allow the CEEC community to maintain ecological functionality. The AoS concluded that with implementation of controls and recommendations the proposal would not lead to a significant impact. The current clearing area of CEEC for the LRWF project is within the range originally assessed in the BA. The conclusions of the original AoS are supported here and no further assessment or additional mitigation is considered to be required.

Table 5-3 Comparison of clearing areas for EEC and CEEC between the original proposal and the current.

EEC	Original area[14] (ha)	Revised area (ha)	Difference (ha)	%
Box Gum Woodland EEC (with native tree cover)	132.5	125.12	-7.4	-6%
Box Gum Woodland EEC (native pasture)	171.8	75.3	-96.5	-56%
Total EEC	**304.2**	**200.41**	**-103.8**	**-34%**
Total CEEC	**3.9**	**10.37**	**+6.47**	**166%**

Threatened flora

The following threatened flora are relevant to the site

- Silky Swainson-pea (*Swainsona sericea*)
- Ausfeld's Wattle *(Acacia ausfeldii)*

These were identified in the 2012-13 surveys, none are relevant to the 2015 or 2016 surveys.

[13] This refers to the clearing assessed in the Assessments of Significance in NGH Environmental (2013a, b)

[14] Figures are from the layout originally assessed in EA (Epuron 2014).

SILKY SWAINSON-PEA (*SWAINSONA SERICEA*)

Silky Swainson-pea was recorded in the TLSA in native pasture / White Box-Grey Box Grassy Woodland. Suitable quality habitat does not occur in the WFSA. The BA (NGH Environmental 2013a) concluded that the found individuals would not be affected as they were no longer in the impact area. However, the LRWF project is now expected to affect some individuals of this species (refer to Appendix A.5; one individual occurs on the transmission easement and two individuals are located adjacent to this, outside the impact areas). Habitat for this species in the LRWF project is Box Gum Woodland and native pasture. Total clearing of actual and potential Silky Swainson-pea habitat has been greatly reduced as shown in Table 5-4. The conclusion of the AoS in NGH Environmental (2013b) that the proposal is unlikely to result in a significant impact remains unchanged and no further assessment is considered warranted. The loss of this species would be offset as part of the project's offset package, unless demonstrated that in this area the species would be avoided.

Table 5-4 Clearing of Silky Swainsona habitat

Silky Swainson-pea habitat	Original area (ha)	Revised area (ha)	Difference (ha)	%
Box Gum Woodland with trees	132.5	119.2	-7.4	-5.6
Native pasture	269.0	86.0	-182.9	-68.0
Total	**401.5**	**205.2**	**-190.3**	**-47.4**

AUSFELD'S WATTLE (ACACIA AUSFELDII)

Ausfeld's Wattle *(Acacia ausfeldii)* was recorded at two locations in the TLSA, one in Sandstone Forest, the other in good quality Box Gum Woodland in 2013 surveys. At least one individual (that in the Sandstone Forest) was expected to be impacted by clearing. However, all recorded individuals are now outside the revised impact areas. Suitable potential habitat is assumed to be good quality Box Gum Woodland and Sandstone Forest. Total clearing of actual and potential Ausfeld's Wattle habitat has been reduced as shown in Table 5-5. The conclusion of the AoS in NGH Environmental (2013b) that the proposal is unlikely to result in a significant impact remains unchanged and no further assessment is considered warranted.

Table 5-5 Clearing of potential Ausfeld's Wattle habitat

Ausfeld's Wattle habitat	Original area (ha)	Revised area (ha)	Difference	%
Good quality Box Gum Woodland	1.3	1.3	0.0	0.7
Sandstone Forest (all conditions)	55.4	43.6	-11.8	-21.2
Total	**56.7**	**44.9**	**-11.7**	**-20.7**

As recommended by the original assessments, a pre-clearance survey remains a recommendation for Finger Panic Grass, Lobed Blue-grass and Bluegrass within better quality Box-Gum Woodland EEC during flowering season from mid-January to late February. If found, turbines and infrastructure are to be microsited to avoid areas of at least moderate quality condition of these species in this vegetation type. No further assessment is considered warranted.

5.3 FAUNA

5.3.1 Estimated fauna habitat loss

Fauna habitat and microhabitat features have now been mapped with reference to mapped vegetation types and field assessment data. The estimated fauna habitat and microhabitat feature clearing impacts for the revised project are shown in Table 5-6 and

Table 5-7. Refer Appendix Map Sets A.6 – A.8. They were not calculated for the original proposal and therefore cannot be directly compared.

Durridgere SCA consists of several unconnected blocks of vegetation on either side of Ulan Road as well as north of the Golden Highway. The transmission line crosses a small section of Durridgere where the SCA straddles Ulan Road (approximately one kilometre through the SCA near the intersection with Cliffdale Road). The transmission line route passes through Durridgere SCA on the eastern side of Ulan Road and runs parallel to the road (within about 1.5 km of the road) for approximately 4 km within the SCA. This compares to the original proposal of crossing the SCA through the centre of this block. The relocation of the transmission line is considered to have a reduced effect upon this section of Durridgere SCA, in that a larger contiguous block of vegetation is left undisturbed. The transmission line now diverts eastward north of the Golden Highway thereby avoiding the northern block of Durridgere SCA (the original proposal ran through the north-western corner of this block).

The majority of the impacts are seen to occur in pasture with scattered trees and woodland. Forest habitat to be affected is all of poor quality. A conservative approach, extrapolating survey results into adjacent habitat, results in a large area (145.7 ha) of habitat that may contain moderate to excellent hollow bearing tree abundance. Areas that did not meet the threshold for moderate or better hollow-bearing tree habitat were not mapped. However, it is possible to work out the area of habitat that is poor in hollow-bearing trees by subtracting the total moderate or better hollow-bearing tree area (145.7 ha from Table 5-7) from the total habitat area (752.5 ha from Table 5-6). There is approximately 606.8 ha of habitat to be affected that is poor in terms of hollow-bearing trees.

Table 5-6 Proposed areas of clearing (habitat loss) in the LRWF project impact area, by habitat type and quality

Habitat type/quality	Poor (ha)	Moderate (ha)	Good (ha)	Excellent (ha)	Total (ha)
Open forest	66.2	0	0	0	66.2
Open pasture	42.5	0	0	0	42.5
Pasture with scattered trees	437.8	32.3	0	0	470.0
Riparian	9.6	0	0	0	9.6
Rocky outcrop	0.0	0	0	0	0
Shrubland	0.3	0	0	0	0.3
Woodland	140.9	23.0	0.01	0	163.9
Total	**697.2**	**55.3**	**0.01**	**0**	**752.5**

Table 5-7 Proposed clearing (habitat loss) of microhabitat features at LRWF project impact area (areas with poor hollow-bearing quality have not been calculated).

Habitat type	Hollow-bearing area (ha)				Features		
	Moderate	Good	Excellent	Total	Caves (point features)	Ground-layer (point features)	Mistletoe (point features)
Open forest	35.1	0.2	0	**35.3**		3	1
Open pasture	0	0	0	**0**			
Pasture with scattered trees	41.9	2.7	0	**44.5**			1
Riparian	3.5	0	0	**3.5**		1	1
Rocky outcrop	0.001	0	0	**0**		1	1
Shrubland	0	0	0	**0**			
Woodland	44.2	17.9	0.3	**62.3**		7	4
Total	**124.6**	**20.8**	**0.3**	**145.7**	**0**	**12**	**8**

It is noted that this modelling of micro habitat features is conducted separately for hollows (which are extrapolated to an area) and point features (caves, mistletoe etc.) and that not all species requirements would be met within these areas. This information is used to understand the abundance of habitat across the impact area but is not a species specific potential habitat map, as such.

With the above assumptions in mind, to understand these impacts more specifically for suites of species, the quantified impact of habitat loss is also presented in Table 5-8 for the following groups:

- Woodland birds
- Diurnal raptors
- Owls
- Mammals (including bats)

The Koala and Eastern Pygmy-possum are considered separately, due to its preference for a limited selection of species.

Table 5-8 Fauna group habitat loss

Woodland birds					
Native grassland EEC (ha)	**> Moderate quality woodland (ha)**	**Total**	**Mistletoe (no.)**	**Ground layer (no.)**	**Hollows (ha)**
75.3	23.0	98.3	4	7	62.3
Diurnal raptors					
> Moderate quality woodland (ha)	**> Moderate quality forest**	**Total**			
23.0	0.0	23.0			
Owls					
> Moderate quality woodland (ha)	**> Moderate quality forest (ha)**	**Total**	**Hollows (ha)**		
23.0	0.0	23.0	101.1		
Mammals (excluding koala)					
> Moderate quality woodland (ha)	**> Moderate quality forest (ha)**	**Total**	**Hollows (ha)**	**Caves (no)**	**Ground layer**
23.0	0.0	23.0	101.1	0	10
Koala					
Relevant forest types for primary and secondary feed trees					**(ha)**
Riparian Forest – Rough-barked Apple, Blakely's Red Gum (ID 481)					27.4
Riparian Forest – rough-barked Apple, Blakey's Red Gum and Yellow Box (ID 281)					19.1
Yellow Box Grassy Woodland (ID 437)					1.5
White Box-Grey Box Grassy Woodland (ID 483)					100.3
White Box - White Cypress Pine shrubby open forest (ID 588)					0.4
Norton's Box Woodland (Id 437)					1.5
Riparian Blakely's Red Gum - box - sedge forest (ID 278)					4.1
Mountain Gum – Silvertop – Stringybark Forest (ID 490)					1.1
Brittle Gum – Stringybark Woodland (ID 495)					3.1
Total					**158.6**
Eastern Pygmy-possum					
Mountain Gum – Silvertop – Stringybark Forest (ID 490)					1.1
Sandstone Forest - Black Cypress dominant (ID 480)					8.7
Sandstone Forest - Narrow-leaved Ironbark dominant (ID 468 and 479)					41
Total					**50.8**

These figures are used in the updated threatened species Assessments of Significance, where required (Appendix C). Refer to the evaluation of species requiring revised assessments, below.

5.3.2 Threatened fauna

Evaluation of species requiring revised assessments

An evaluation was undertaken of threatened fauna species considered in the original assessments (NGH Environmental 2013a and b). This is given in tabular form below (Table 5-9) and considers whether further assessment is warranted on the basis of:

a) Impact types assessed in the original BAs (habitat and collision risk impacts)
b) Extent of habitat that may be affected by the revised project area

Table 5-9 Evaluation of fauna impacts in consideration of original assessment and the revised impact area

Refer to original BAs (NGH Environmental 2013a, b) for detailed information (such as local records, habitat preferences, etc.) that underpin this evaluation.

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Non-migratory				
Forage within canopy or at canopy height				
Varied Sittella *Daphoenositta chrysoptera*	Yes, recorded in surveys in 2015 but these areas no longer included in the LRWF.	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Brown Treecreeper *Climacteris picumnus*	Yes, recorded in surveys	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Diamond Firetail *Stagonopleura guttata*	Yes, recorded in surveys in 2015 but these areas no longer included in the LRWF.	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Grey-crowned Babbler *Pomatostomus temporalis*	Yes, recorded in surveys	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Grey-crowned Babbler *Pomatostomus temporalis*	Yes, recorded in surveys	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Speckled Warbler *Pyrrholaemus sagittatus*	Yes, recorded in surveys	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Hooded Robin *Melanodryas cucullate cucullate*	No, not recorded in the study are despite extensive surveys. Records occur in the locality.	No AoS was undertaken as habitat considered marginal and presence was not assumed.	No further assessment undertaken.	No change
Scarlet Robin Petroica boodang	Yes, recorded in surveys	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Little Lorikeet *Glossopsitta pusilla*	Not recorded in surveys. Habitat present in LRWF and records in locality.	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Turquoise Parrot *Neophema pulchella*	Not recorded in surveys. Habitat present in LRWF and records in locality.	Habitat loss – AoS undertaken	Current proposed clearing within the range of the original. No further assessment required.	No change
Eastern Cave Bat *Vespadelus troughtoni*	Yes, recorded in surveys	Habitat loss and collision – AoS undertaken. Considered at high collision risk.	OEH requested further information to support conclusions of assessment, particularly regarding collision (this includes barotrauma). Literature review undertaken (Section 7), CRA undertaken (Section 5). Current proposed clearing within the range of the original; updated AoS not required.	New CRA
Corben's Long-eared Bat *Nyctophilus corbeni* (form. *timorensis)*	Yes, recorded in surveys	Habitat loss and collision – AoS undertaken.	OEH requested further information to support conclusions of assessment, particularly regarding collision (this includes barotrauma). Literature review undertaken (Section 7), CRA undertaken (Section 5). Current proposed clearing within the range of the original; updated AoS not required.	New CRA
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	Not recorded in LRWF despite extensive Anabat surveys. Marginal habitat occurs in small pockets along riparian areas.	No AoS was undertaken as habitat considered marginal and presence was not assumed.	Additional Anabat surveys were undertaken in the TLSA in 2015, and this species was not recorded. This species is *not* assumed to occur. No further assessment required.	No change

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Little Pied Bat *Chalinolobus picatus*	Not recorded in LRWF despite extensive Anabat surveys. Marginal habitat occurs in LRWF project area.	No AoS was undertaken as habitat considered not present and presence was not assumed.	Additional Anabat surveys were undertaken in the TLSA in 2015, and this species was not recorded. This species is *not* assumed to occur. No further assessment required.	No change
East Coast Freetail Bat *Mormopterus norfolkensis*	Not recorded in LRWF despite extensive Anabat surveys. Marginal habitat present, no records in locality.	No AoS was undertaken as habitat considered not present and presence was not assumed.	Additional Anabat surveys were undertaken in the TLSA in 2015, and this species was not recorded. This species is *not* assumed to occur. No further assessment required.	No change
Greater Broad-nosed Bat *Scoteanax rueppellii*	Not recorded in LRWF despite extensive Anabat surveys. Marginal habitat present on site; recorded in locality.	No AoS was undertaken as habitat considered not present and presence was not assumed.	Additional Anabat surveys were undertaken in the TLSA in 2015, and this species was not recorded. This species is *not* assumed to occur. No further assessment required.	No change
Large home range and/or forage above canopy				
Glossy Black Cockatoo *Calyptorhynchus lathami*	Yes, recorded TLSA in surveys and extensive local records	Habitat loss and collision – AoS undertaken. Re collision: forage within canopy, reducing risk.	Current proposed clearing within the range of the original, assumptions of collision AoS supported (forage within canopy). No further assessment required.	No change
Grey Falcon *Falco hypoleucos*	Not recorded in LRWF; habitat not considered to be present.	No AoS was undertaken. Presence not assumed and collision risk considered low.	No change to assumptions; further assessment not required.	No change
Little Eagle *Hieraaetus morphnoides*	Not recorded in LRWF. However, records do occur in the locality and updated habitat assessments have identified suitable habitat.	Habitat loss and collision – AoS undertaken. Habitat was assumed to be marginal. Re collision: forage above canopy (soaring)	Now assumed to be present, at least from time to time, based on updated habitat assessment. Current proposed clearing within the range of the original (AoS) and collision assumptions supported. No further assessment required.	Presence assumed.

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Barking Owl *Ninox connivens*	Not recorded in LRWF. Records occur in the locality and assumed to occur. Updated habitat assessments have identified suitable habitat (not marginal).	Habitat considered marginal. AoS undertaken. Collision risk considered moderate to high.	Current proposed clearing within the range of the original. Updated AoS not required. OEH requested further information to support conclusions of assessment, particularly regarding collision. CRA undertaken (Section 5).	New CRA
Powerful Owl *Ninox strenua*	Recorded in the TLSA, local records also present. Updated habitat assessments have identified suitable habitat (not marginal).	Habitat considered marginal. AoS undertaken. Collision risk considered moderate to high.	Current proposed clearing within the range of the original. Updated AoS not required. OEH requested further information to support conclusions of assessment, particularly regarding collision. CRA undertaken (Section 5).	New CRA
Masked Owl *Tyto novaehollandiae*	Recorded in the TLSA, local records also present.	Habitat considered marginal. AoS undertaken. Collision risk considered moderate to high.	Current proposed clearing within the range of the original. Updated AoS not required. OEH requested further information to support conclusions of assessment, particularly regarding collision. CRA undertaken (Section 5).	New CRA
Migratory / nomadic / dispersive				
Forage within canopy or at canopy height				
Spotted Harrier *Circus assimilis*	Not recorded in LRWF. However, records do occur in the locality and updated habitat assessments have identified suitable habitat.	Habitat was assumed to be marginal – no AoS undertaken. Collision risk assumed to be low.	Suitable habitat present, species may occur from time to time. OEH requested further information to support conclusions of assessment, particularly regarding collision. CRA undertaken (Section 5).	New CRA
Regent Honeyeater *Anthochaera phyrygia*	Not recorded in LRWF. However, records do occur in the locality and updated habitat assessments have identified suitable habitat.	No AoS undertaken as habitat was considered marginal.	Suitable habitat present, species may occur from time to time. OEH requested AoS for this species. Literature review in Section 7. AoS required for habitat loss. CRA Section 5.	New AoS New CRA

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Black-chinned Honeyeater *Melithreptus gularis gularis*	Recorded in TLSA and local records are present.	Habitat loss – AoS undertaken.	Current proposed clearing within the range of the original. No further assessment required.	No change
Painted Honeyeater *Grantiella picta*	Not recorded in LRWF, although habitat and records are present in locality.	Habitat loss – AoS undertaken.	Current proposed clearing within the range of the original. No further assessment required.	No change
Swift Parrot *Lathamus discolor*	Not recorded in LRWF and there are a small number of records locally. Updated habitat assessments have identified suitable habitat.	No AoS undertaken as habitat was considered marginal. Collision impacts not considered.	Based on records of this migratory species in BioNet and ALA, the locality has not been historically important. Habitat requirements for this nectivorous species are similar to the honeyeaters and parrots already assessed. AoS undertaken for Little Lorikeet and Regent Honeyeater are considered a suitable surrogate for Swift Parrot, although there is a lower likelihood of occurrence for the latter species. No AoS required. However, the National Recovery Plan for this species (Saunders and Tzaros 2011) lists "flight collision hazards" as a threat to this species. Therefore, a literature review and CRA has been undertaken (Section 5).	New CRA
Flame Robin *Petroica phoenicea*	Not recorded in LRWF although survey season may not have been appropriate for detection. Suitable habitat present.	No AoS undertaken as habitat was considered marginal. Collision impacts not considered.	This is a migratory species and collision risk for migratory species is discussed generally in Section 7. Flame Robin is considered unlikely to enter the rotor-swept area as it forages close to the ground by perch-pounce (Schodde & Tidemann 2007). Little is known of migratory movements (Garnett *et al.* 2011). Based on anecdotal observations of small groups of birds 'appearing' and 'spreading out' seasonally (COG undated, Schodde & Tidemann 2007), it is assumed to tree-hop or move low between patches of habitat, rather than fly high in large flocks like northern hemisphere robins (to which they are not related). CRA is not required. No further assessment undertaken.	No change.

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Gang-gang Cockatoo *Callocephalon fibriatum*	Not recorded in LRWF although there are several local records.	No AoS undertaken as habitat was considered marginal. Collision impacts not considered.	No change to assumptions re habitat loss; no AoS required. Re collision: Gang-gang Cockatoos are altitudinal migrants – refer to Section 7 for a general discussion. Gang-gang Cockatoos are assumed to fly slowly in small flocks a short distance above the canopy, or within canopy height, between forest patches when migrating. It is assumed they stop intermittently to forage along the way and roost overnight. These assumptions are based on recorded behaviour (e.g. Schodde & Tidemann 2007, Birds Australia 2017, NSW Scientific Committee 2008) and anecodotal observations. There is little specific information available on migration behaviour as such. The foraging and migrating behaviour of Gang-gang Cockatoos make it unlikely to enter the rotor-swept area and therefore a CRA is not required.	No change.
Large-eared Pied Bat *Chalinolobus dwyeri*	Recorded in LRWF, several other records in locality.	Habitat loss and collision – AoS undertaken	OEH requested further information to support conclusions of assessment. An updated AoS is in Section 5, and an CRA in Section5.	Updated AoS New CRA
Little Bentwing-bat *Miniopterus australis*	Not recorded in LRWF and habitat is not present.	No AoS undertaken as habitat is not present.	No further assessment required.	No change.
Forage above the canopy				
Dusky Woodswallow *Artamus cyanopterus*	Recorded in LRWF	Not applicable; recently listed as Vulnerable under the TSC Act (not listed at time of BAs)	Habitat is present. AoS and CRA required.	New AoS New CRA

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Square-tailed Kite *Lophoictinia isura*	Recorded nesting in TLSA. Several other records occur nearby.	Habitat loss and collision – AoS undertaken.	OEH requested further information to support conclusions of assessment, particularly for collision. OEH requested further information to support conclusions of assessment. An updated AoS is in Section 5, and an CRA in Section 5. The Square-tailed Kite is a nomadic bird but pairs may occupy a large and permanent territory (Simpson et al. 1999, Schodde & Tidemann 2007). Given the rarity of this species and that there are a relatively high number of local records, it is assumed that the pair observed permanently occupy a territory which includes the TLSA. Therefore, migratory or nomadic movements are not a risk factor for this species at LRWF. Foraging and fledging are considered in the CRA.	Update Aos New CRA
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	Recorded in the WFSA with small number of local records.	Habitat loss and collision – AoS undertaken.	OEH requested further information to support conclusions of assessment, particularly for collision. Re habitat: Eastern Bentwing-bat is a cave roosting bat. No caves would be disturbed or destroyed by the proposal. There are no maternity caves nearby. The proposal would affect foraging habitat only. Eastern Bentwing-bat forages over a variety of habitat types including the following which are present in the LRWF project area: dry sclerophyll, woodland and open grassland (Churchill 2008). Given that the habitat clearing would not affect breeding or roosting habitat, and clearing affects a small proportion of the LRWF project area, the conclusions of the original AoS are supported here. An updated AoS is not required. Re collision: a CRA undertaken in Section 5.	New CRA
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	Recorded by Anabat in the TLSA. Based on ALA records, it is relatively common regionally although only a few lcoal records exist.	Habitat loss and collision – AoS undertaken.	OEH requested further information to support conclusions of assessment, particularly for collision. Updated habitat assessments also provide more information about habitat impacts, including for hollow-bearing trees (roosting and breeding habitat). An updated AoS has been undertaken, based on literature review (section 5). CRA also undertaken in Section 5.	Update AoS New CRA
Non-flying mammals				

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Spot-tailed Quoll *Dasyurus maculatus*	Not recorded in LRWF although there are two local records (one dated). Assumed to occur in Coolah Tops NP (NPWS 2002).	Habitat assumed to be marginal, local population assumed to be absent. No Aos undertaken.	No further assessment required.	No change.
Yellow-bellied Glider *Petaurus australis*	Not recorded in LRWF and there are no local records.	Habitat assumed to be marginal, local population assumed to be absent. No Aos undertaken.	OEH requested that in lieu of further hollow-bearing tree survey, threatened arboreal mammals be assumed to occur and assessed accordingly. However, in the case of Yellow-bellied Glider, a conspicuous species, this is not appropriate. There are no records in the region (BioNet/ALA), including not in the nearby protected areas. No further assessment required.	No change.
Squirrel Glider *Petaurus norfolcensis*	Recorded in WFSA and TLSA. Other records nearby the Ulan Colliery.	Habitat loss – AoS undertaken.	Updated habitat mapping has been provided for mammals (Appendix A map set A.8) along with updated clearing figures (section 5). These support the conclusions of the assessment. Current proposed clearing within the range of the original. Mitigation strategies incorporate a number of ameliorations for this species (section 8). No further assessment required.	No change
Brush-tailed Phascogale *Phascogale tapoatafa*	Not recorded in LRWF and there are no local records.	Habitat assumed to be marginal, local population assumed to be absent. No Aos undertaken.	OEH requested that in lieu of further hollow-bearing tree survey, threatened arboreal mammals be assumed to occur and assessed accordingly. However, in the case of Brush-tailed Phascogale this is not appropriate. There are no records in the region or generally west of the Great Dividing Range (BioNet/ALA), including not in the nearby protected areas. No further assessment required.	No change
Koala *Phascolarctos cinereus*	Not recorded in LRWF although there are nearby records.	Habitat assumed to be marginal – no AoS undertaken.	Updated habitat assessment suggests that habitat may be suitable for Koala. Aos undertaken.	New AoS

Subject species	Present at LRWF?	Impact type identified by original assessment (2013a and b)	Further assessment required to address revised project?	Outcome
Eastern Pygmy-possum *Cercartetus nannus*	Not recorded in LRWF, there are regional records and it has been recorded in Coolah Tops NP (NPWS 2002).	Habitat assumed to be marginal, local population assumed to be absent. No Aos undertaken.	OEH requested that in lieu of further hollow-bearing tree survey, threatened arboreal mammals be assumed to occur and assessed accordingly. Given that there are some records in the area and that the species is extremely cryptic, it is assumed that Eastern Pygmy-possum may occur in the LRWF project area. Refer to Section 5 for habitat information. AoS undertaken.	New AoS

The outcome of Table 5-9 is that additional Assessments of Significance (Appendix C) and Collision Risk Assessments (CRAs) (Appendix D) have been completed for several species to ensure the revised impacts are properly characterised for these species.

In accordance with Table 5-9, the following species were subject to an Assessment of Significance (AoS), or the original AoS was revised:

1. Regent Honeyeater (new)
2. Dusky Woodswallow (new)
3. Koala (new)
4. Eastern Pygmy-possum (new)
5. Large-eared Pied Bat (revised)
6. Square-tailed Kite (revised)
7. Yellow-bellied Sheathtail Bat (revised)

These are provided in Appendix C and summarised below.

The following species were subject to a CRA:

1. Eastern Cave Bat
2. Corben's Long-eared Bat
3. Barking Owl
4. Powerful Owl
5. Masked Owl
6. Spotted Harrier
7. Regent Honeyeater
8. Swift Parrot
9. Large-eared Pied Bat
10. Dusky Woodswallow
11. Square-tailed Kite
12. Eastern Bentwing Bat
13. Yellow-bellied Sheathtail Bat

These are provided in Appendix D and summarised below.

Summary of additional Assessments of significance

The table below summarises the results of new and revised AoS.

Table 5-10 Evaluation of fauna impacts in consideration of original assessment and the revised impact area

Species	Key impact determined by AoS	Changed mitigation strategy?
Regent Honeyeater (new)	Low potential to affect breeding habitat. Collision risk rated as high due to consequence but considered unlikely, due to habitat preferences.	No change to mitigation strategy proposed; a risk based adaptive bird and bat monitoring plan is already included for the project and would manage risks to this species. Buffers on turbines near high quality woodland will minimise collision risks. An offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity.
Dusky Woodswallow (new)	Low potential to affect breeding habitat. Collision risk rated as high.	No change to mitigation strategies proposed; a risk based adaptive bird and bat monitoring plan is already included for the project and would manage risks to this species. Buffers on turbines near high quality woodland will minimise breeding and collision risks. An offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity.
Koala (new)	Low potential to affect breeding, foraging or dispersal. Low risk of *Phytophthora cinnamomi infection*, if managed.	Relevant mitigation strategies proposed include an offset plan to secure and manage for improvement habitat similar to that being removed in perpetuity. Additionally, a management protocol to detect and manage *Phytophthora cinnamomi infection* is now recommended in this report.
Eastern Pygmy-possum (new)	Low potential to affect breeding, foraging or dispersal.	No change to mitigation strategies proposed; an offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity.

Species	Key impact determined by AoS	Changed mitigation strategy?
Large-eared Pied Bat (revised)	Low potential to affect foraging and breeding habitat. Collision risk rated as low.	No change to mitigation strategies proposed; a risk based adaptive bird and bat monitoring plan is already included for the project and would manage risks to this species. Buffers on turbines near high quality woodland will minimise breeding and collision risks. An offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity.
Square-tailed Kite (revised)	Low potential to affect foraging and breeding habitat (with management measures prescribed). Collision risk rated as high.	Relevant to mitigation strategies proposed include a risk based adaptive bird and bat monitoring plan is already included for the project and would manage risks to this species. Buffers on turbines near high quality woodland will minimise breeding and collision risks. An offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity. Additionally, a buffer and additional investigation to manage breeding impacts on an identified nest is now recommended in this report.
Yellow-bellied Sheathtail Bat (revised)	Low potential to affect foraging and breeding habitat. Collision risk rated as moderate.	No change to mitigation strategies proposed; a risk based adaptive bird and bat monitoring plan is already included for the project and would manage risks to this species. Buffers on turbines near high quality woodland will minimise breeding and collision risks. An offset plan will secure and manage for improvement habitat similar to that being removed in perpetuity.

Summary of updated Collision Risk Assessments

A summary of CRA for wind turbine collisions of key bird and bat species are given Table 5-11. Key species for the project in terms of collision risk are considered to include the Regent Honeyeater, Dusky Woodswallow and Square-tailed Kite.

Table 5-11 Summary of CRA results for LRWF

Species	Likelihood	Consequence	Risk
Non-migratory			
Forage within canopy or at canopy height			
Eastern Cave Bat	Rare	Moderate	Moderate
Corben's Long-eared Bat	Rare	Minor	Low
Large home range and/or forage above canopy			
Barking Owl	Rare	Moderate	Moderate
Powerful Owl	Rare	Moderate	Moderate
Masked Owl	Rare	Minor	Low
Spotted Harrier	Rare	Minor	Low
Migratory / nomadic / dispersive			
Forage within canopy or at canopy height			
Regent Honeyeater	Rare	Significant	High
Swift Parrot	Rare	Moderate	Moderate
Large-eared Pied Bat	Rare	Moderate	Moderate
Large home range and/or forage above canopy			
Dusky Woodswallow	Possible	Moderate	High
Square-tailed Kite	Unlikely	Significant	High
Eastern Bentwing Bat	Unlikely	Minor	Low
Yellow-bellied Sheathtail Bat	Unlikely	Moderate	Moderate

The full CRA is provided in Appendix D; summaries of the 'high risk' assessments follow.

REGENT HONEYEATER

The critically endangered Regent Honeyeater is strongly associated with the inland/eastern slopes of the Great Dividing Range, as well as several coastal regions, particularly the Hunter Valley and Central Coast of NSW (Bird Life Australia 2016). While Regent Honeyeaters were not observed during surveys in the LRWF project area, the Regent Honeyeater is known from the region. The Mudgee-Wollar Important Bird and Biodiversity Area (IBA) is located approximately 15 km south of the southern extent of the project (south of the TLSA) and was dedicated in part due to regular use by Regent Honeyeater. Records nearby the proposed LRWF project are few. The closest BioNet records to the WFSA are north-east of the wind farm within Coolah Tops National Park. BioNet records also exist south and east of the southern portion of the TLSA near the Goulburn River National Park.

Regent Honeyeaters are a highly mobile species that may visit the site from time to time, depending on the availability of food resources both at the site and in other areas. A Regent Honeyeater fatality has not been recorded in any available wind farm monitoring data in Australia. The likelihood of a collision is assessed to be rare, given the location of the proposed turbines at LRWF is inconsistent with the known habitat requirements and the supposed migration style of the species:

- Turbines are proposed on ridges while the Regent Honeyeater is thought to forage and follow pathways through forest in lower elevations and linking riparian corridors during migration
- Turbines are proposed in fragmented and degraded habitat while the Regent Honeyeater depends upon 'rich patches' for foraging, and vegetated corridors for movement paths.

Thus, the number of individuals and flights over the turbine ridges is likely to be low.

Considering the consequence of any fatalities:

- The species is now critically endangered (population may be as low as 350-400 individuals; DoE 2016)
- The species has low reproductive output (DoE 2016)
- Breeding occurs in the region from time to time (Mudgee-Wollar)

Thus, the consequence of any individual's fatality could be significant. Using the risk assessment matrix, this places the Regent Honeyeater at high risk from turbine interactions. It is stressed that the high risk is an outcome of consequence due to the low population size and that collisions are considered unlikely.

DUSKY WOODSWALLOW

Dusky Woodswallow is a flocking seasonal migrant to the area (Schodde & Tidemann 2007, BirdLife 2017) and has been recorded at the LRWF project area. The likelihood of a Dusky Woodswallow collision is possible, given that they occur in the LRWF project area and that they have been previously recorded amongst mortality data for other wind farms in Australia. The consequence of a collision is moderate given that:

- The species is a flocking species: multiple fatalities may occur in a single event
- The western slopes, nearby the LRWF project area, are the core breeding habitat in NSW (NSW Scientific Committee 2016).

Collisions are possible and could have a moderate consequence to the local population. This gives the Dusky Woodswallow a high risk rating for collision.

SQUARE-TAILED KITE

The Square-tailed Kite was recorded nesting in riparian vegetation along the Goulburn river in the southern part of the TLSA. Construction activity restrictions within 500 m of the Square-tailed Kite nest would be developed restrict activities that may affect breeding in this location. The likelihood of a Square-tailed Kite collision with a turbine is considered unlikely based on:

- WFSA assumed to be outside of the territory of the resident pair identified (at the southern end of the transmission line), therefore regular encounters with turbines is unlikely.
- The species is highly manoeuvrable.

The consequence of a Square-tailed Kite collision with a turbine is considered potentially significant, on the following basis:

- Breeding occurs nearby and a collision risk may generate a population sink
- Low fecundity, low breeding density and low recruitment
- Sparsely distributed species across its range.

Therefore, the Square-tailed Kite is potentially at high risk of collisions with turbines.

5.4 CONCLUSION

5.4.1 Habitat loss

Additional and revised Assessments of significance concluded local population level impacts are unlikely for the species considered, generally on account of clearing for the wind farm area is relatively minor in any one location; discrete patches would be cleared that are unlikely to include important habitat for a population.

With the exception of the Square-tailed Kite, existing mitigation strategies are expected to address the risks to these species, which centre on buffering higher quality woodland areas, undertaking an adaptive bird and bat monitoring program to better understand utilisation and respond to collisions such that ongoing collisions do not produce population level impacts and offsetting clearing impacts in perpetuity.

Of relevance to several recovery plans for subject species:

- The LRWF project contributes positively to expanding the knowledge of birds and bats locally, in the collection of baseline and ongoing utilisation and collision data, as part of the adaptive bird and bat management plan for the wind farm site.
- The LRWF project contributes positively to the reduction of the effects of anthropogenic Climate Change (another KTP). The LRWF project is consistent with the *Priorities for Biodiversity Adaptation to Climate Change* (DECCW 2010), which acknowledges the need for mitigation of climate change impacts through reduction of greenhouse gas emissions.

5.4.2 Collision risks

Three species have been determined to have potentially significant collision risk due to the operation of wind turbines; the Regent Honeyeater, Dusky Woodswallow and Square-tailed Kite. A significant impact on a local population would not occur suddenly, it would be a result of ongoing collisions. A monitoring program (Bird and Bat Management Plan; BBMP) based on risk was a recommendation of the original assessment (NGH Environmental 2013a). It includes the following:

- Monitoring surveys should include an understanding of breeding activity (i.e. nest locations) and foraging movements.
- Baseline (pre-construction) and operational collision and abundance data would be collected, focused on higher risk species and higher risk locations in order that actions can be taken to address unforeseen impacts, should they occur.
- Management Plan should include management response options (i.e. restriction of lambing on ridges with high raptor activity to reduce collision risks) to be implemented where significant impacts are anticipated.

The original assessment also includes a requirement to buffer high habitat value for birds and bats by 100 m which will assist in minimising collision risks.

Additionally, this report requires additional measures for the operational wind farm including:

- The Adaptive BBMP would include bird utilisation surveys. Data would be provided annually to OEH and then be accessible for use by recovery teams, such as the Regent Honeyeater Recovery Team.

- As a high risk species, consultation should be undertaken as part of the BBMP with the Regent Honeyeater Recovery Team Co-ordinator if any Regent Honeyeaters are found onsite.

Being adaptive, information collected at the site, including monitoring data and the effectiveness of any management measures, provides certainty that the program will be focussed and improved with time, as required. With the implementation of these measures, it is considered that significant local population impacts can be avoided.

6 REVISED OFFSET STRATEGY

A revised offset strategy has been prepared and is appended in Appendix F. It includes:

- A preliminary calculation of the likely credit requirement for the project, using a FBA BioBanking scenario (using benchmark data as opposed to field collected plot data)
- The identification of viable offset areas for the project
- How offset land will be identified, secured and managed (and monitored) in perpetuity

The key elements are summarised below. Since preparation of the Revised Offset Strategy v1, the impact area figures have changed slightly (an addition of 7.8 ha). However, the offset calculations have not been re-done as the process used in preparation of the preliminary offset requirement was precautionary and the additional area would not have a material impact on the requirement. A commitment to undertake the final Biobanking calculations based on the approved construction footprint and field data remains and would address any discrepancies. The impact areas used in the current calculations are shown in the Offset Strategy Appendix F.

6.1 CREDIT REQUIREMENT

Two assessments were run as the development spans two CMAs:

- The northern section: Central West CMA, Section 2.2 (map provided in Appendix A.1)
- The southern section: Hunter / Central Rivers CMA, Section 2.3 (map provided in Appendix A.5)

The vegetation impact areas used are separated in to two assessments (northern and southern). Note: Fauna habitat quality is used not tree hollow habitat areas. The latter is a very conservative extrapolation.

6.1.1 Northern section

For the northern assessment, the following species were assumed to occur and be impacted, and therefore generated species credit requirements:

- Squirrel Glider *Petaurus norfolcensis* – 19 ha of moderate or better woodland habitat.
- Large-eared Pied Bat *Chalinolobus dwyeri* - 19 ha of moderate or better woodland habitat

Other species known to occur but that the BCC assumes to occur (and that generate ecosystem credits) include:

- Eastern Bentwing-bat *Miniopterus schreibersii oceanensis* - 19 ha of moderate or better woodland habitat

6.1.2 Southern section

For the southern assessment, the following species were assumed to occur and be impacted, and therefore generated species credit requirements:

- Squirrel Glider *Petaurus norfolcensis* – 19 ha of moderate or better woodland habitat.
- Silky Swainson-pea *Swainsona sericea* – one individual
- Large-eared Pied Bat *Chalinolobus dwyeri* - 19 ha of moderate or better woodland habitat.
- Diamond Firetail *Stagonopleura guttata* –- 19 ha of moderate or better woodland habitat.

- Black-chinned Honeyeater *Melithreptus gularis gularis* - 19 ha of moderate or better woodland habitat.
- Grey-crowned Babbler *Pomatostomus temporalis*- 19 ha of moderate or better woodland habitat.
- Speckled Warbler *Pyrrholaemus sagittatus* - 19 ha of moderate or better woodland habitat.
- Eastern Cave Bat *Vespadelus troughtoni* - 19 ha of moderate or better woodland habitat.
- Corben's Long-eared Bat *Nyctophilus corbeni (*form. *timorensis)* - 19 ha of moderate or better woodland habitat.
- Masked Owl *Tyto novaehollandiae* - 19 ha of moderate or better woodland habitat.
- Glossy Black Cockatoo *Calyptorhynchus lathami* - 19 ha of moderate or better woodland habitat.
- Powerful Owl *Ninox strenu* - 19 ha of moderate or better woodland habitat.
- Dusky Woodswallow *Artamus cyanopteru s*- 19 ha of moderate or better woodland habitat.

Other species known to occur but that the BCC assumes to occur (and that generate ecosystem credits) include:

- Square-tailed Kite *Lophoictinia isura*
- Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*

6.1.3 Combined credit requirement

The combined credit requirement is set out below for these impacts.

Table 6-1 Credit statement for the LRWF proposal

Entity requiring offsets		Credit requirement	Area of land required, as determined by the credit calculator (ha)
Northern section: Central West Catchment Management Area			
CW180	River Oak - Rough-barked Apple - red gum - box riparian tall woodland (wetland) of the Brigalow Belt South Bioregion and Nandewar Bioregion	518	55.7
CW111	Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion	562	60.4
CW304	Silvertop Stringybark - Yellow Box +/- Nortons Box grassy woodland on basalt hills mainly on northern aspects of the Liverpool Range, Brigalow Belt South Bioregion	581	62.5
CW322	White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion	4078	438.5

Entity requiring offsets			Credit requirement	Area of land required, as determined by the credit calculator (ha)
CW304	Silvertop Stringybark - Yellow Box +/- Nortons Box grassy woodland on basalt hills mainly on northern aspects of the Liverpool Range, Brigalow Belt South Bioregion		4789	514.9
CW303	Silvertop Stringybark - Forest Ribbon Gum very tall moist open forest on basalt plateau on the Liverpool Range, Brigalow Belt South Bioregion		32	3.4
CW210	White Box - Red Stringybark shrubby woodlands on basalt slopes of the Nandewar Bioregion and Brigalow Belt South Bioregion		210	22.6
CW225	Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion		118	12.7
CW214	White Box - White Cypress Pine shrubby open forest of the Nandewar Bioregion and Brigalow Belt South Bioregion		22	2.4
Subtotal				**1,173.10**
Petaurus norfolcensis		Squirrel Glider	418	70
Chalinolobus dwyeri		Large-eared Pied Bat	247	41
Miniopterus schreibersii subsp. oceanensis		Eastern Bentwing-bat	247	41
Subtotal				**152.00**
Southern section: Hunter Rivers Catchment Management Area				
HU681	Blakely's Red Gum - Yellow Box grassy woodland of the New England Tableland Bioregion		266	28.6
HU714	Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion		836	89.9
HU690	Grey Box x White Box grassy open woodland on basalt hills in the Merriwa region, upper Hunter Valley		6273	674.5
HU682	Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern Brigalow Belt South Bioregion (including Goonoo)		242	26

Entity requiring offsets		Credit requirement	Area of land required, as determined by the credit calculator (ha)
HU707	Red Ironbark - Black Cypress Pine - stringybark +/- Narrow-leaved Wattle shrubby open forest on sandstone in the Gulgong - Mendooran region, southern Brigalow Belt South Bioregion	2511	270
HU707	Red Ironbark - Black Cypress Pine - stringybark +/- Narrow-leaved Wattle shrubby open forest on sandstone in the Gulgong - Mendooran region, southern Brigalow Belt South Bioregion	85	9.1
HU678	Black Cypress Pine - ironbark +/- Narrow-leaved Wattle low open forest mainly on Narrabeen Sandstone in the Upper Hunter region of the Sydney Basin Bioregion	838	90.1
HU713	Rough-barked Apple - Blakely's Red Gum - Narrow-leaved Stringybark +/- Grey Gum sandstone riparian grass fern open forest on in the southern Brigalow Belt South Bioregion and Upper Hunter region	2439	315.7
HU690	Grey Box x White Box grassy open woodland on basalt hills in the Merriwa region, upper Hunter Valley	2936	315.7
HU702	Narrow-leaved Ironbark- Black Cypress Pine - stringybark +/- Grey Gum +/- Narrow-leaved Wattle shrubby open forest on sandstone hills in the southern Brigalow Belt South Bioregion and Sydney Basin Bio	3196	343.7
Subtotal			**2,163.30**
Swainsona sericea	Silky Swainson-pea	18	2
Calyptorhynchus lathami	Glossy Black-Cockatoo	342	52
Melithreptus gularis subsp. gularis	Black-chinned Honeyeater (eastern subspecies)	247	41
Ninox strenua	Powerful Owl	570	90
Nyctophilus corbeni	Corben's Long-eared Bat	399	70
Pomatostomus temporalis subsp. temporalis	Grey-crowned Babbler (eastern subspecies)	247	41
Stagonopleura guttata	Diamond Firetail	247	41
Tyto novaehollandiae	Masked Owl	570	90

Entity requiring offsets		Credit requirement	Area of land required, as determined by the credit calculator (ha)
Vespadelus troughtoni	Eastern Cave Bat	247	41
Subtotal			**468.00**

Combined for the project, approximately 3,336.40 ha would be required to satisfy ecosystem credits. Subject to this area being able to also satisfy species credits, up to an additional 620 ha may be required for species credits.

6.2 OFFSET OPTIONS FOR THE PROJECT

The proponent commits to securing a formal vehicle to secure and manage the project's offset sites in perpetuity. It is understood that a number of options may be available including:

- Purchase of existing credits from the BioBanking Public Register
- Establishment of BioBanking sites
- Payment into an Offset Fund.

Given the extensive offsets required, a suite of sites is likely to be required if physical offsets are secured for the project, rather than the purchase of credits or payment into and offset. Ten candidate offset sites have been so far been identified, totalling 3,025 ha and including vegetation and habitat types required to be offset. These landowners have been approached and are amenable to further investigation and to having suitable areas managed for conservation in perpetuity. As such, all of the candidate sites so far considered are feasible to include within the offset package for the project, subject to further investigation to verify their suitability.

6.3 IMPLEMENTATION

The following stages of implementing the final Offset Package for the project are proposed. The aim of this timeline is to provide a clear path to identifying, securing and managing suitable offset lands prior to any construction impact.

Post approval, documented within the project's detailed Offset Plan

1. Determine final credit requirement using the FBA in consultation with OEH, based on:
    a. Detailed construction drawings, (which will be submitted to Department of Planning and Environment (DPE) and deemed by the proponent to be final)
    b. Plot data collected for the project footprint, in accordance with the FBA.
2. Select the final suite of offset sites including accurate calculation of credits able to be retired at each offset site based on plot data collected for the offset sites, in accordance with the FBA.
3. Develop detailed management actions in consultation with the landowners who will be responsible for implementing the actions, referencing the templates provided by OEH for BioBank site management.

After construction

4. Verify that the actual post construction impact area does not exceed that used to calculate the offset requirement in Step 1.
5. Formally secure the offset sites as BioBanking sites, including detailed management plans for each offset site and delineation of the final offset site boundaries. All costs of site assessment and credit purchase will be borne by the proponent.
6. Landowners become responsible for Biobank site management actions in accordance with the site specific management plans, with funding provided by the Biobanking fund, to ensure ongoing biodiversity improvement at the offset sites for the life of the project.

6.4 SUMMARY

The offset strategy demonstrates means to secure suitable and adequate offsets, prior to any construction impacts, with reference to the Framework for Biodiversity Assessment (FBA, 2016) for Major Projects.

Combined for the project, approximately 3,336.40 ha would be required to satisfy ecosystem credits. Subject to this area being able to also satisfy species credits, up to an additional 620 ha may be required for species credits.

The assessment is considered preliminary, to ensure suitable and adequate offsets will be achievable for the Liverpool Wind Farm Project, in advance of plot data collection and some remaining pre-clearance surveys to be undertaken prior to construction.

The final offset requirement is proposed to be calculated using field collected plot data, and would be based on the final impact areas derived from civil construction drawings (not yet available). This will provide a further incentive throughout the detailed design to minimise the clearing impacts of the works and thereby reduce the offset requirement.

The proponent commits to working with the DPE and OEH to find a suitable in perpetuity security mechanism for the project. Implementation notes are included in this strategy to ensure the final offsets account for the final clearing impacts.

7 SPECIFIC ADDITIONAL INFORMATION TO ADDRESS AGENCY SUBMISSIONS

While generally agency submissions have been addressed where relevant in other sections of this report, additional information to address specific issues raised by OEH and DPE is provided in this section. The cross reference of issues raised and how they have been addressed is provided in Appendix E. The specific additional information requested can be grouped broadly as issues related to:

1. Clarification of effort and methods undertaken in 2012-13
2. Expected impacts of the operational stage of the project
3. Analysis of migratory species

The additional information is presented under these headings, below.

7.1 CLARIFICATION OF EFFORT AND METHODS UNDERTAKEN IN 2012-13

7.1.1 Information request

Agency comments included a request to clarify how microbat surveys and hollow-bearing trees were surveyed, specifically:

- Flora surveys and extrapolated vegetation mapping
- Microbat surveys
    - Anabat placement
    - Anabat survey effort
    - Survey limitations relating to Anabat placement, site coverage, survey timing and weather conditions, choice of microbat survey technique.
- Hollow-bearing trees
    - Hollow size classes and justification for size classes
    - Hollow use by threatened species

These clarifications also apply to surveys undertaken in 2015 but are not relevant for the 2016 survey.

Clarifications are provided below. The full description of methods from NGH Environmental 2013a, 2013b is not repeated here.

7.1.2 Flora surveys and extrapolated vegetation mapping

As shown in Table 3-13, more than 160 hours were spent in actual flora survey time and over 300 ha were physically inspected and searched. Given the vast extent of the study area and steep terrain however, in some locations vegetation communities and condition have been extrapolated from survey sites. The exception is the current transmission line project footprint, which was traversed on foot for its entire extent.

Aerial photograph interpretation is an important component of vegetation and habitat mapping. With experience and high resolution photographs, it is possible to identify vegetation boundaries using colour, terrain, landholder boundaries and paddock fences supplemented by ground-truthed flora plots. Particularly in areas where the vegetation is complex and varied, the precautionary principle is applied and an area may be mapped as EEC or a higher condition category applied even though the determination is uncertain.

7.1.3 Microbat surveys

Anabat placement

Passive Anabat surveys were undertaken with detectors left in place overnight in locations chosen to maximise the potential for detecting multiple species of bats, such as

- Likely flyways through vegetation
- Along drainage lines and near dams
- Overlooking dams on ridgetops

(NGH Environmental 2013a, Section 4.2.3, pp.23):

To ensure detection of high-flying species (such as the Yellow-bellied Sheathtail Bat and Eastern Bentwing-bat) in vegetated areas, Anabat detectors were generally set up on ridgetops overlooking steep slopes where bats flying above the tree canopy were within range of detection. Successful detection of high-flying non-threatened species (White-striped Freetail Bat and Gould's Wattled Bat) during these surveys (NGH Environmental 2013a, Section 9.3.4, pp.66) confirmed that Anabat setup was suitable to detect high-flying species.

In more open areas, high-flying bats fly at lower levels above the ground (Churchill 2008) and would likely have been detectable. Further, Anabat detectors set up near dams is suitable to detect high-flying species, as demonstrated by Rhodes and Hall (1997) that recorded Yellow-bellied Sheathtail Bat flying at a height of 1.5 m and concluded that this was due to the bats coming in to drink at a nearby waterhole.

Anabat survey effort

Anabat surveys were undertaken in 2012, 2013 and 2015, as follows:

2012-13 - Original biodiversity assessment

- Anabat surveys were undertaken in the WFSA during October 2012. A total of 18 nights using three Anabat devices was undertaken in the WFSA between October 8 and October 18 in 2012.
- In the TLSA, 12 nights of Anabat survey was also conducted during this time, as well as an additional 19 nights using four Anabat devices in October 2013. Anabat detectors were recording from 7pm to 7am each night (12 hours per night). Overall, an approximate total of 144 survey hours were undertaken in the WFSA, and 248 hours in the TLSA.

2015 – New areas of transmission line

- Anabat surveys were undertaken in the TLSA in March 2015, focusing on Turill SF. Eight nights were undertaken with detectors operating for 12 hours as described above. Overall a total of 64 survey hours were undertaken. Anabats were generally placed on logs in grassy open woodland near flyways such as creek lines or clearings.

2016 - New areas of wind farm and transmission line

- No anabat surveys were undertaken during 2016 surveys.

A total of 456 Anabat survey hours have been undertaken at LRWF. Anabat survey effort for LRWF is summarised in Table 7-1and mapped in Appendix A.3.

Table 7-1 Anabat survey effort and placement (all surveys to date)

	Unit placement	Anabat units	Anabat survey nights	Nights that may have been below optimal overnight temperature (10°C)	Total Anabat survey hours
Wind farm 8-18 October 2012	Ground	3	18	10	144
Transmission line 8-18 October 2012	On tree	3	12	10	96
Transmission line 2-7 October 2013	Ground	4	19	7	152
Transmission line 20-23 March 2015	On log	4	8	0	64
Total					**456**

Survey limitations

HARP TRAPPING AND ANABAT TECHNIQUES

Harp trapping was not undertaken during surveys of the Project Area as capture methods do not work effectively in open habitats, thereby making it impossible to compare between a variety of habitat structures (Richards 2012). However, limitations in the use of Anabat and bat call analysis include difficulty in accurately separating some species (e.g. Long-eared Bats have very weak calls with little structural characters to separate them to species level (Richards 2012)). Also, the distance at which Anabat detectors can detect calls varies enormously, and can depend on frequency and amplitude of the bat calls, as well as atmospheric attenuation. However, many bats are easily detected over 30 m under typical conditions (Titley Scientific 2012). For these reasons, the placement of Anabat devices is an important factor.

BAT SURVEYS IN NORTH-WESTERN SECTION OF THE WIND FARM

The north-western section of the wind farm was generally not subject to the same level of survey effort as it was much more open and disturbed and further from the high quality habitat found in the National Park and in vegetated gullies in the north-eastern part of the wind farm project area. Access into this area was also an issue. Overall, this area was considered to provide lower value habitat for microbats (and other fauna), particularly targeted threatened species. Therefore, finite survey effort was bias to areas with greatest potential of detecting the maximum number of species.

SURVEY TIMING

Microbat surveys were undertaken at the start of the recommended field season (October) in both 2012 and 2013. Weather data in NGH Environmental (2013a) used the nearest weather station at Merriwa which is located at an altitude of 250 metres above sea level while areas of the proposed LRWF project are in excess of 1000 m ASL. As such, minimum temperatures in the WFSA may have been considerably lower than that recorded at Merriwa. In 2012, ten of the 13 survey nights had minimums of less than 10°C at Merriwa, while in 2013 seven of nine nights recorded minimums less than 10°C. Average minimum

temperatures at or below 10°C is consistent with the long term mean for this area (BOM 2016a, BOM 2016b).

At these temperatures, it could be expected that bat activity (for both threatened and non-threatened species) may have been reduced. However, 11,000 call files were collected during this period suggesting that cold weather was not a major limitation. Further, Anabat survey timing was within the known migration period of the southern population of Eastern Bentwing Bat (October, Churchill 2008) and this was an important consideration.

ACTIVITY LEVELS OF THREATENED BATS

NGH Environmental (2013a, section 7.1.2) notes that the detected activity level of threatened bat species was "quite low" compared to non-threatened species. Threatened species activity was less than one percent of total activity and this is notable as the five threatened species represent 35% of the total 14 species detected. As all the microbats detected fall across a range of foraging styles and habitat preferences, the lower activity levels are unlikely to be a result of survey method. Reasons for lower activity of threatened species may include the lower occurrence of threatened species across the landscape compared to common species.

7.1.4 Hollow-bearing trees

Hollow size classes and justification for size classes

Hollow classes (small, medium or large hollow entrance size) were not collected in the field in 2012 or 2013. This information was collected for areas surveyed in 2015. The 2012-13 field data sheets provide details of habitat assessment and are given in Appendix B of the original BAs. Rather, the total number of hollow-bearing trees in relation to the total number of trees in quadrat (e.g. 2 of 7) was recorded. Hollow-bearing tree details from all surveys are discussed in Section 4.2.2.

The large scale of the LRWF project and the need to retain flexibility in micro-siting infrastructure components under the final design has influenced the survey method. The aim of the iterative assessment process is very much to identify the more important areas within the project envelope[15] and to avoid and minimise impacts in these areas as much as possible, reducing the need for detailed assessments in these areas and focusing infrastructure in areas of lesser biodiversity value. Identifying mature forest with higher abundance of mature and hollow bearing trees was considered a more achievable and appropriate survey method than mapping each hollow bearing tree and providing hollow classes. The strategy adopted for mitigation is then to provide protocols to further reduce impacts on specific features such as hollows within impact areas, as a part of the final design and construction management process. The project's history of avoiding and minimising is summarised in Section 2.3. The updated mitigation measures showing how hollows will be protected where possible is provided in Section 8.

Hollow use by threatened species

Birds, microbats and arboreal mammals rely on hollows in trees for roosting, nesting and breeding, however hollow requirements differ and are often related to body size. Goldingay (2009) found that mean hollow entrance size was significantly related to body length in birds, with small species (<30 cm in length) having entrances averaging 3–12 cm, whereas large species (≥40 cm) mostly averaged 24–34 cm. Table 7-2 outlines the threatened species that occur or have the potential to occur within the project area, the hollow

[15] The broader area within which infrastructure may be located, under the final design.

size requirements of each species, and areas and habitats they are likely to occur in. Refer also to Section 4.2.2.

Table 7-2 Threatened species hollow size requirements

Threatened species requiring hollows	Hollow size requirement	Habitat	Reference
Glossy Black Cockatoo	Large	TL (Southern section) Coolah Tops NP	Gibbons and Lindenmayer (2002)
Little Lorikeet	Small/medium	WF and TL (open forest and woodland within. Durridgere SCA and west of Ulan Road) Coolah Tops NP	NSW Scientific Committee (2009a)
Turquoise Parrot	Small/medium	WF and TL (open forest, woodland or patches of eucalypts and available grassland foraging habitat, paddock trees)	NSW Scientific Committee (2009b)
Powerful Owl	Large	TL Coolah Tops NP	Gibbons and Lindenmayer (2002)
Masked Owl	Large	North-east corner of **original** WF study area, and Coolah Tops NP	Gibbons and Lindenmayer (2002)
Barking Owl	Large	North-east corner of **original** WF study area Coolah Tops NP	Gibbons and Lindenmayer (2002)
Brown Treecreeper	Small/medium	WF and TL (north of Ulan Colliery), Coolah Tops NP. Woodland and open forest.	Noske (1984)
Squirrel Glider	Small/medium	WF (open woodland), TL (near Durridgere SCA and southern end of Ulan Rd)	Gibbons and Lindenmayer (2002)
Spotted-tailed Quoll	Small/medium and large	TL Coolah Tops NP	Andrew (2005)
Yellow-bellied Glider	Small/medium and large	TL Coolah Tops NP	Gibbons and Lindenmayer (2002)
Brush-tailed Phascogale	Small/medium	WF, TL (open woodland, Isolated paddock trees)	Gibbons and Lindenmayer (2002)
Eastern Pygmy-possum	Small/medium	TL Coolah Tops NP	Goldingay (2011)
Little Pied Bat	Large	WF, TL (Paddock trees)	Goldingay (2009)
Little Bentwing-bat	Small/medium and large	Paddock trees Prefers caves and tunnels	Schulz (1997)

Threatened species requiring hollows	Hollow size requirement	Habitat	Reference
Eastern Freetail Bat	Small/medium	Paddock trees, TL	Goldingay (2009)
Corben's Long-eared Bat	Small/medium	TL (Paddock trees, open forest with grassy understorey), and WF Coolah Tops NP	
Yellow-bellied Sheathtail-bat	Small/medium and large	TL (southern section near Durridgere SCA), isolated paddocks trees, Coolah Tops NP	
Eastern False Pipistrelle	Small/medium	Paddock trees, Coolah Tops NP	
Greater Broad-nosed Bat	Small/medium and large	Paddock trees, Coolah Tops NP	

MICROBATS

Microbats may require maternity hollows as well as roosting hollows, which means that they require a variety of hollow size categories (Goldingay 2009). Rhodes and Wardell-Johnson (2006) found five colonies of White-striped Freetail Bat (two of these were maternity roosts) with a large majority of the roost trees with a hollow diameter over 30 cm (large) (Goldingay 2009). Goldingay (2009) reviewed roost attributes for microbats from a number of sources. Information on the diameter of hollow entrances was found for ten microbat species. Of these, two species were found to use hollows with a diameter of 20 cm or above:

- Little Pied Bat (*Chalinolobus picatus*)
- Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus*)

7.2 EXPECTED IMPACTS OF LRWF OPERATION

7.2.1 Information request

Agency comments included a request to:

- Provide specific information on what impacts may be expected
- Conduct further assessment of the potential for bird and bat strike and barotrauma within the LRWF project.
- Investigate potential for the LRWF project to disrupt migratory route of birds and bats, including non-listed species.
- Investigate potential for LRWF project to reduce the area of habitat available to fauna in particular seasonal migratory species.
- Consideration of cumulative impacts both state-wide and regionally

Terms used in this assessment are defined as follows:

- Avoidance: The ability for a bird or bat to avoid collision with a turbine blade by changing their flight while close to or around the turbine, directly in response to the movement of the blades, e.g. a bird suddenly swerving or dropping in altitude so that it is no longer in the path of a rotating blade.

- Barrier effect: where species avoid the broad area where turbines are located (e.g. the ridgeline). Closely related to habitat and behavioural displacement.
- Habitat displacement: where an area of habitat is indirectly reduced/lost to a species due to barrier effect e.g. an animal no longer accessing habitat on the other side of the ridge due to unwillingness to cross over the ridge through turbines. (Also known as habitat alienation).
- Behavioural displacement: where an animal's behaviour is changed in response to the broad presence of turbines, at the cost of increased energy expenditure. For example, flying around rows rather than between turbines.
- Estimated mortality rates: site specific estimates of the number of all birds or all bats or a particular species that die as a result of collision or barotrauma. Based on actual carcass counts obtained during operational monitoring and corrected to account for scavenging, carcass detectability and days without surveys, amongst other factors. Usually presented as a number (e.g. 5 birds) per turbine per year.

7.2.2 Turbine interactions: Collision / barotrauma

Australian birds and bats behave quite differently to their northern hemisphere counterparts in terms of foraging style and migration pathways mainly due to differences in topographic, climatic and resource conditions.[16] Thus, using collision mortality data from the northern hemisphere to predict the species or guilds that would be affected here in Australia is deeply flawed (although it was necessary in the early days of the Australian wind farm industry). Although more data has emerged from Australian wind farms in the past few years, there is still a paucity of publicly available information about actual collision impacts. Results available to date do indeed show that guilds affected here in Australia are different than those overseas. As requested by agencies, below follows specific information as to what and how many species may be affected by blade-strike.

Species most frequently colliding with turbines

Smales (2015) reviewed collision monitoring data from eight wind farms operating in south-eastern Australia, totalling approximately 195 monitored turbines, monitored for between one and nine years. Covering "916 turbine-years of operation" (Smales 2015 p.26), there were 125 documented fatalities of 28 species (four bat species and 24 bird). Note this does not provide estimated mortality rate; only a number of carcasses found during searches.

Of the data reviewed in Smales (2015):

- One quarter of the fatalities were Australian Magpie *Cracticus tibicen*
- Considered together, Nankeen Kestrel *Falco cenchroides* and Brown Falcon *Falco berigora* accounted for a further quarter of all fatalities.

[16] For example, the northern hemisphere is strongly seasonal and affected by severe cold including extended periods of snow and ice. Deciduous trees and shrubs are prevalent. Mountain ranges are varied and include steep and icy peaks. Consequently, fauna tend to follow fairly predictable behaviours (e.g. hibernation or migration) (Somveille *et al.* 2013). Migrating species tend *en masse* to also follow certain routes based on predictable resource availability and on landscape features. (Smales 2015)

By contrast, Australia's mountains are of comparatively low elevation and (excluding the far north of the country), seasons are less important than relatively unpredictable boom-bust cycles. Thus, while many species are seasonally migratory, a great many more are nomadic or partially nomadic (Somveille *et al.* 2013). Very little is known about migration routes partly because movements appear to be diffuse (Smales 2015).

- White-striped Freetail Bat Tadarida ausralis, Swamp Harrier Circus approximans and Wedge-tailed Eagle Aquila audax each accounted for approximately seven percent of all fatalities.
- Other species accounted for one to two percent of fatalities

NGH Environmental also has experience with operational wind farm monitoring in southern tablelands NSW. Although this information is not publicly available, it is possible to say that the following species account for the majority of collisions:

- White-striped Freetail Bat
- Gould's Wattled Bat
- Eurasian Skylark

Threatened species that have collided with turbines

It can be seen that the species most affected to date in mainland Australia are generally common and widespread. However, there have been a number of threatened and EPBC listed migratory species found in low numbers at mainland wind farms (Smales 2015, NGH Environmental unpubl. data):

- Little Eagle
- Dusky Woodswallow
- White-throated Needletail
- Eastern Bentwing-bat

These species (excluding Dusky Woodswallow, which was listed under the TSC Act this year) were assessed for collision risk in NGH Environmental (2013a). A Collision risk assessment is now included for the Dusky Woodswallow (Appendix D and summarised in Section 5.3.2; high risk).

Quantified estimates of bird and bats fatalities based on collision monitoring

Three Australian wind farms have publicly published estimated mortality rates (Smales 2015):

- Waubra (1.5 birds / turbine / year)
- Bluff Point (1.7 birds / turbine / year)
- Studland Bay (0.9 birds / turbine /year)

The average figure derived from the above estimates of 1.4 birds / turbine / year is a more reliable figure than that provided Table 9-1 of NGH Environmental (2013a), as the former include calculations to allow for scavenger rates and detection variability. Estimated fatality rates are not provided for microbats, and therefore the estimate given in Table 9-1 of NGH Environmental (2013a) of 0.55 bats / turbine / year remains valid.

Approximations for LRWF project

The LRWF project is for to 282 turbines. Based on the average fatality rates above, it is approximated that 395 birds and 155 bats could collide with turbines each year (i.e. 1.4 birds multiplied by 282 turbines). However, this estimate is limited as the data is not specific to Liverpool. Those involved in the industry note that there is often an initial peak of fatalities in the first year or so of turbine operation followed by a decline in subsequent years (Greg Richards & Associates 2016, Auswind 2006, Hull 2013, De Lucas et al. 2008). The estimated rates would be skewed by fatality spikes that may have occurred in the early years of operation and in fact, ongoing rates may be lower.

NGH Environmental (2013a) recommended a Bird and Bat Management Plan (BBMP) be developed to monitor, amongst other things, collision fatalities at the LRWF project during the operational phase.

Operational monitoring is generally a condition of consent of wind farms in NSW. After one or more years of operational monitoring, mortality rate estimates would be possible for LRWF project based on actual carcass finds.

Further, estimated mortality rates should be put into context against fatalities caused by other human activities such as roads (mostly unaccounted for), aeroplanes (information available) and climate change (renewable energy may help to reduce climate change impacts).

7.2.3 Barrier effect and behavioural displacement

Rows of turbines throughout the project area could act as multiple barriers to the movement of birds and bats (Smales 2006, Masden *et al.* 2009, Brett Lane & Associates 2009). Barrier effect was discussed in NGH Environmental (2013a, section 9.2.3). Long term or permanent behaviour displacement leading to barrier effect has been clearly demonstrated at overseas and offshore wind farms, but has yet to be demonstrated at Australian terrestrial wind farms (BirdLife International 2009, Masden *et al.* 2009, Hull and Muir 2013, EPHC 2010, Hull 2013).

Affect upon local species

Masden *et al.* (2010) found that the energy expenditure of avoiding the turbine array during daily movement patterns was much less than the costs due to low food abundance or adverse weather. Whilst an overseas study, it indicates that the energetic costs of displacement due to wind farms for locally-foraging birds are proportionally very low compared with other environmental factors, such as a lack of food availability (e.g. flowering eucalypts in Australia), adverse weather, or habitat degradation.

Behavioural displacement of fauna (flying and terrestrial) is likely to be a short-term effect during wind farm construction and possibly during the early phase of operation until fauna habituate to the presence of turbines (Fox & Petersen 2006, Hull 2013).

Affect upon migratory species

Barrier effect could be seen in migrating species if they were to modify their trajectory in response to the wind farm (behavioural displacement) (e.g. Larsen and Guillemette 2007, Masden *et al.* 2009). Very little research has been conducted on the potential barrier effect of wind farms, with no substantial data readily available in an Australian context. Overseas, Masden *et al.* (2009) provides one of the few examples worldwide of before-and-after data relating to the barrier effect, and their study showed that "the additional distance travelled [by common eiders, *Somateria mollissima*] as a consequence of the wind farm's presence" was 500 m, a negligible length considering the total migration event was 1400 km. They also suggest that the *cumulative effect* of multiple wind farms along a migration route may have a more substantial impact on a population (cumulative impacts for LRWF are considered in Section 7.4).

However, studies reveal that changes in foraging and migratory behaviour over time are highly site- and species-specific, and causes are difficult to isolate from other variables (e.g. Madsen and Boertmann 2008, Pearce-Higgins et al. 2009, Tosh *et al.* 2014). Further, migration of Australian species tends to be diffuse rather than concentrated along known and predictable routes (Smales 2015). This makes any analysis specific to Liverpool Range Wind Farm limited. No species-specific discussion is provided for barrier effects and behaviour displacement.

7.3 ANALYSIS OF MIGRATORY SPECIES

Long distance bird migration is a mostly northern hemisphere phenomenon, with the exception of shorebirds and those listed below (Somveille *et al.* 2013, Bamford *et al*. 2008). In Australia, birds and bats are mostly short-distance latitudinal and altitudinal migrants or nomadic.

7.3.1 Long distance migration: international flyways

There are a number of international flyways; these are recognised broad migratory routes used by migrating birds such as shore birds. Australia is within one Flyway, the East Asian – Australiasian Flyway (EEA Flyway) (Bamford *et al.* 2008). The closest internationally important sites in the EEA Flyway in Australia (Ramsar wetlands) to the project area are Lake Bathurst (nearly 500km south of WSFA), near Goulburn and Tuggerah Lakes in the Wyong Shire (approximately 300 km south-east of WFSA). Species using the EEA Flyway are not likely to be at risk of collision or barrier effects from the proposed LRWF project.

Several long-distance migrants are listed under the EPBC Act and have potential to occur in the LRWF project area: White-throated Needletail (*Hirundapus caudacutus*), Fork-tailed Swift (*Apus pacificus),* Rainbow Bee-eater (*Merops ornatus*).

WHITE-THROATED NEEDLETAIL

In NSW, the White-throated Needletail is common along the coast, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains (Department of the Environment 2015c). The White-throated Needletail is widespread and abundant in eastern and south-eastern Australia and does not breed in Australia. This species is almost exclusively aerial. The White-throated Needletail occurs in most habitats, but when flying above farmland, is often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks (Department of the Environment 2015c).

White-throated Needletails are one of the few bird species for which there is some available Australian data on blade strike and barotrauma (see page 55 of NGH Environmental 2013a). On available data, it appears as though we could expect 0.04 deaths per turbine per year for this species, which in the case of the LRWF project, would amount to 11 or 12 individuals killed per year. Such a level of mortality is not expected to considerably impact upon a species that is identified as secure by Birdlife Australia and least concern by Birdlife International and considered to be abundant in many parts of south-eastern Australia. Smales and Venosta (2005) estimate that less than 2% of the Australian population of this species are likely to encounter wind farms (current or proposed in Gippsland) and that there is a low likelihood of species-level impact on the species as a result of turbine collisions. No further assessment has been undertaken for this species.

FORK-TAILED SWIFT

The Fork-tailed Swift is common east of the Great Dividing Range, however few populations have been found west of the Great Divide (Department of the Environment 2015a). The Fork-tailed Swift is a non-breeding visitor to all regions of NSW, has broad habitat requirements and is almost exclusively aerial. It usually arrives in Australia around October and is said to be highly mobile whilst in Australia (Department of the Environment 2015a). The Fork-tailed Swift is an aerial eater, flying anywhere from 1 m to 300 m above the ground to forage. They forage along the edge of low pressure systems (Department of the Environment 2015a).

Also being a high flier, the Fork-tailed Swift may have a similar level of mortality to the White-throated Needletail although it has not been recorded in as high numbers in any published data for Australian wind

farms. Its population is similarly secure. However, this species is unlikely to be a regular visitor to the LRWF project area, as they are more common to the east of the Great Divide. No further assessment has been undertaken for this species.

RAINBOW BEE-EATER

The Rainbow Bee-eater is distributed across much of mainland Australia, and will move into northern Australia and/or Asia during our winter. Populations of the Rainbow Bee-eater gather together and assemble into flocks before migration. These flocks can consist of tens to hundreds or thousands of birds, often flying high above the ground when on passage (Department of the Environment 2015b). Rainbow Bee-eater occurs in a range of habitats, usually foraging from open perches, from which it may scan for prey (typically flying insects). It captures most of its prey in flight, although it also takes food items from the ground and from foliage (Department of the Environment 2015b).

When migrating this species has the potential to be impacted by blade strike and barotrauma as they may fly over the top of non-preferred habitats such as rainforest or treeless plains (Department of the Environment 2015b). The species is not known to have any serious current threats, although it is known to have occasional collisions with lighthouses. Such collisions are considered uncommon, with threats from Cane Toads and Foxes, in combination with (probably historical) shooting by apiarists, considered much more substantial (Department of the Environment 2015b). No further assessment has been undertaken for this species.

7.3.2 Short-distance and altitudinal migration

Migration is undertaken by around 40% of land birds that breed in Australia (Chan 2001). Of these, some are short-distance migrants (i.e. they migrate within Australia), while others are altitudinal migrants (moving from higher to lower altitudes in winter). Partial migrants are those in which some individuals of a species are migrants while others are residents (Chan 2001). Species such as Eastern Bentwing Bat, White-striped Freetail Bat, Silvereye, Yellow-faced Honeyeater, Noisy Friarbird, Regent Honeyeater and Swift Parrot, amongst many others are short-distance migrants. These species generally move north for winter and south for summer. Movements tend to be diffuse across the landscape and responsive to resource availability, although flocks are funnelled through some areas with predictability each year, such as the Blue Mountains (Probets 2006).

Other species such as Flame Robin, Gang-gang Cockatoo and many more are altitudinal migrants, generally spending summers at cooler higher altitude locations. In response to Australia's boom-bust biology, many species are nomadic, partially nomadic or irruptive in when resources are plentiful. Examples of such species include Regent Honeyeater, Painted Honeyeater and many parrot and cockatoo species.

Little specific information is available as to the mode of migration for the many native species that migrate latitudinally and altitudinally, making it difficult to do more than speculate about the risk that turbines pose to migrating flocks or individuals. Most published information on migration focuses on birds (rather than bats) and on how species orientate themselves and navigate, rather than how they move through the landscape at a micro-scale (e.g. Dingle 1996). Some sources suggest that normally diurnal birds such as Silvereyes may move at night (Fraser 2008, Probets 2006). Observations indicate that honeyeaters such as Yellow-faced Honeyeaters fly in shorts hops at treetop level, resting frequently and regrouping in prominent trees, following deep valleys, major gullies, creeklines, clifftops and corridors of vegetation (Probets 2006).

As to which migratory species may be at risk, Smales (2015) provides the most comprehensive list of species that have collided with turbines in Australia to date. Nankeen Kestrel and Brown Falcon are altitudinal migrants /nomadic in some parts of their range and, as documented in Section 7.2.3, are known to constitute a large proportion of collision fatalities at some wind farms (Smales 2015). However, it is the *foraging* style of these birds that is most likely to result in turbine collisions rather than migration. Nankeen Kestrel was recorded on site and could be expected to occur in in collision data for the Liverpool Wind Farm site.

Other migratory and nomadic species listed are Horsfield's Bronze-cuckoo *Chalcites basalis,* Dusky Woodswallow *Artamus cyanopterus* and Cockatoo/Corella species *Cacatua spp.* at one individual of each species from 916 "turbine years of operation" (Smales 2015 p.26). These numbers are negligible and not expected to greatly add to the risks (predation, starvation, exhaustion) associated with migration. All these species were recorded on site and have potential to occur amongst mortality survey results. Dusky Woodswallow is a threatened species and is considered further below.

A brief literature review regarding migration is provided below for a number threatened species for whom such information is available:

- Regent Honeyeater
- Swift Parrot
- Dusky Woodswallow
- Eastern Bentwing Bat

Regent Honeyeater

Despite the large national survey effort directed toward this species each year, much remains unknown about its movement patterns (Bird Life 2016). Regent Honeyeaters may use different areas in different years depending on food resources. They may move reasonably large distances to do this although more research is required to confirm the regularity and extent of this behaviour (DoE 2016, Powys 2010). For example, banding studies show that birds move between Capertee Valley and the NSW Central Coast, Capertee Valley and Canberra, but the route used is unknown (Roderick & Ingwersen 2014, DNRE 1999). It is thought that paths are likely to follow forest in lower elevations, and possibly riparian corridors link patches of remnant forest on fertile soils (Roderick & Ingwersen 2014). Research in grazing landscapes in southern NSW showed a pronounced trend for nectarivores such as the Regent Honeyeater to move along densely vegetated areas, and to use the same route for return journeys (Fischer and Lindenmayer 2002). The species was formerly recorded infrequently moving in flocks (DoE 2016).

Habitat fragmentation and degradation, including loss of mature trees and scattered paddock trees, is a threat to the dispersal ability of Regent Honeyeater. A CRA has been undertaken for this species in Appendix D, summarised in Section 5.3.2.

Swift Parrot

Swift Parrots spend the non-breeding season in two main habitats in NSW; one being the coastal winter-flowering eucalypt forests, and the other being the more inland Box-Ironbark Woodlands of the Western Slopes (Saunders & Tzaros 2011). Due to the species being an upper canopy blossom nomad, the distribution of the population may vary considerably from year to year, depending on available resources and climatic conditions (Bird Life International 2016). Thus the regional movement of flocks of Swift Parrots are likely to be different from year to year (Saunders & Tzaros 2011). Saunders and Heinsohn (2008) studied the habitat usage of Swift Parrots on the Australian mainland in winter, and found that:

- The abundance of the species fluctuated significantly between years and regions

- Coastal areas provided important drought-refuge habitats for a large proportion of the total population.
- On the western slopes of NSW, Swift Parrots display long-term repeated use of sites, suggesting high site fidelity in this region.

Movement pathways used by Swift Parrots throughout their range are not known (Saunders & Tzaros 2011). Although large scale movement trends have been demonstrated from Tasmania to mainland Australia, it is not known if long distance movements are predominantly undertaken in groups, nocturnally or diurnally, at specific heights or what triggers such movements (Saunders & Tzaros 2011). A CRA has been undertaken for this species in Appendix D, summarised in Section 5.3.2.

Dusky Woodswallow

The Dusky Woodswallow is an aerial insectivore (NSW Scientific Committee 2016) and is considered a 'woodland dependent bird', with most breeding records in woodland and dry open forest on the western slopes (NSW Scientific Committee 2016). It is known from a broad range west of the divide in NSW. There is some evidence of site fidelity for breeding (Higgins and Peter 2002). Despite breeding solitarily or only in small flocks, large flocks of up 300 have been reported in winter at abundant food sources e.g. grasshopper swarms and flowering trees (Higgins and Peter 2002).

Dusky Woodswallow is considered a flocking seasonal migrant to the area (Schodde & Tidemann 2007, BirdLife 2017) and has been recorded at the LRWF project area. However, depending on location and local climatic conditions (temperature and rainfall) the Dusky Woodswallow can be resident year round or migratory (Higgins and Peter 2002). In New South Wales birds migrate after breeding to the north of the state and to southeast Queensland. Migrants generally depart March–May moving north, along the coast or inland slopes of the Great Dividing Range (Higgins and Peter 2002). Migrants generally move south in spring (September – November) to breed (Higgins and Peter 2002). The species may also gather in flocks before migration and often migrates with other species (Higgins and Peter 2002).

A CRA has been undertaken for this species in Appendix D, summarised in Section 5.3. Collisions are possible and could have a moderate consequence to the local population. Regarding consequence:

- The species is a flocking species: multiple fatalities may occur in a single event
- The western slopes, nearby the LRWF project area, are the core breeding habitat in NSW (NSW Scientific Committee 2016).

Eastern Bentwing Bat

The Eastern Bentwing-bat is an obligate cave-dweller that roosts in caves rather than trees, although it will also utilise man-made structures such as abandoned mines and culverts (Churchill 2008, NPWS 2001, OEH 2016). The southern population migrate between maternity roosts used in summer and winter roosts used in the colder months. Both roost types have specific microclimatic conditions that are used to facilitate either pup development (warm temperatures and high humidity) or periods of torpor (colder temperatures of around 10°C) (Dwyer 1995, Van Dyck & Strahan 2008). The species is also a fast flier, with overnight movements of up to 65 km recorded (Dwyer 1966). There is a relatively large amount of information about this species.

Populations are centred on a maternity cave, and then the population disperses to other caves for winter within a territorial range (Churchill 2008, Dwyer 1969). There is a paucity of information on the activities of male bats over summer. Dwyer (1969) states that adult males are "virtually absent" from maternity caves. Thus, it is possible that over summer males disperse across the landscape perhaps with low roost fidelity at this time. Small colonies and groups found in culverts, etc, tend to suggest this to be the case,

but this remains unconfirmed by recent literature. Movement between territories is uncommon (Churchill 2008). Territorial range sizes are unknown but could be extrapolated to be around 31,400 km^2 (1.3 million ha) or a circle with a diameter of 200 km, based on a study that found over-winter caves generally occur within 100 km of a maternity site (Wilson 2008)[17]. This differs from earlier studies by Dwyer (1969). However, with little documented about migration, this assessment assumes that over-winter caves may be greater than 100 km from a maternity cave.

In southern parts of its range (in the temperate zone) species disperses for winter and females congregate for breeding in summer (Churchill 2008). The Willi Willi maternity cave, the closest maternity cave to LRWF, is approximately 450 km north-east of the proposed wind farm. Dwyer (1969) documents a study of banded Eastern Bentwing Bats undertaken in the 1960s. This study found bats that utilised Willi Willi Cave migrated both north and south. A bat marked at Willi Willi in August was re-trapped in August the following year at Murwillumbah (~300 km north of Willi Willi). A bat marked at Willi Willi in September was recaptured at Wombeyan in May two years later (~400 km south-west). Two bats marked at North Sydney in August and June were re-captured at Willi Willi in January and November (~350 km south of Willi Willi). The proposed LRWF may be within reachable distance from Willi Willi caves, if a suitable roosting site were located nearby.

Dwyer (1969) suggests that populations are separated by major physiographical features such as drainage basins and dividing mountain ranges. The Great Dividing Range has potential to act both as a barrier and funnel for migration movements. Therefore, it is assumed that the bats utilising Wee Jasper on the southern tablelands are more likely to winter at Borenore, on the western slopes, while bats utilising Kanagra-Boyd are more likely to winter at Timor, both being on the eastern side of GDR (DECCW 2010). However, BioNet Eastern Bentwing-bat records suggest a migration route between Timor Caves and Kanagra-Boyd on both sides of the range (refer Figure 7-1).

Either way, the proposed Liverpool wind farm does not sit along a migration pathway between known winter and maternity caves. A CRA has been undertaken for this species in Appendix D and summarised in Section 5.3.2.

[17] Assuming a maternity cave in the centre of a territory, then the area of the territory could be worked out using πr^2, with r = 100 km.

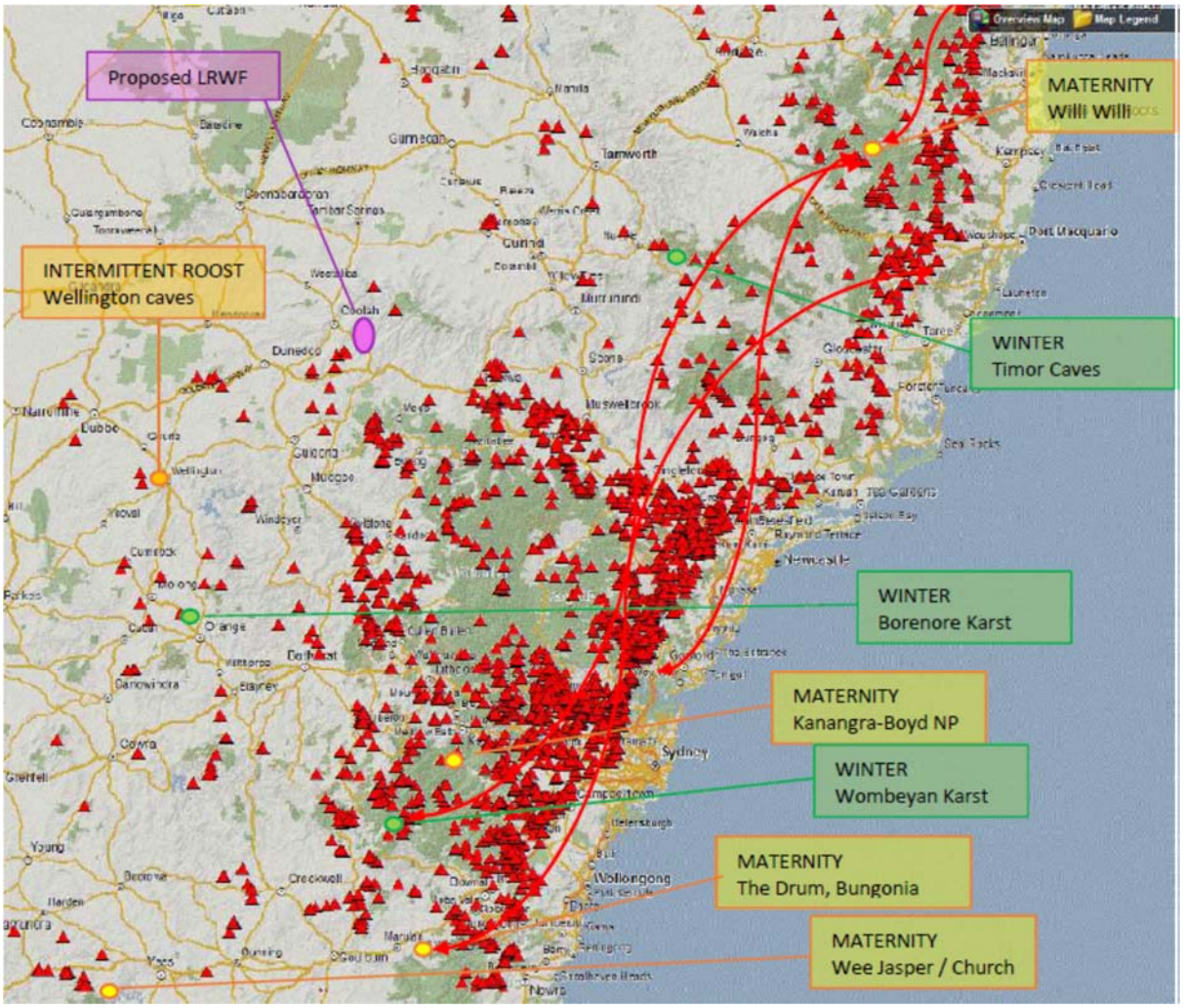

Figure 7-1 Location of known significant Eastern Bentwing-bat sites relative to proposed Liverpool WF, and assumed migratory pathways.

[Basemap from BioNet (OEH 2016), including Eastern Bentwing-bat records indicated by red triangle. Other elements added by NGH Environmental to represent approximate locations of known and assumed features as follows: yellow circles represent known maternity caves, as labelled. Green circles represent known wintering/hibernation caves, as labelled. Orange circle represents nearest known roost cave to the proposed windfarm (pink/purple circle). Assumed migratory pathways (red arrows) based on Table 1 in Dwyer (1969).]

7.4 CUMULATIVE IMPACTS

With an increase in the number of wind farms planned for development in Australia, bird and bat species with the potential to move large distances can be subject to impacts at multiple wind farms (Biosis Research 2006). For example, the cumulative effect of multiple wind farms along a migration route may have a more substantial impact on a population that would not necessarily be detected if assessing the impacts of a single wind farm (Masden *et al*. 2009). The LRWF project does not occur in an area with a high density of wind farms. Four wind farms occur in the wider region; Kyoto Wind Farm (approved – works underway), Bodangora Wind Farm (approved 2013), Uungula Wind Farm (DGRs issued), and Crudine Ridge Wind Farm (Assessment stage).

The closest wind farm (not yet constructed) is Kyoto Wind Farm, approximately 90 km to the east of the project study area. A potential habitat corridor occurs between the two wind farms, along a mountain range through Coolah Tops National Park, Warung State Forest, Towarri National Park, and Wingen Maid

Nature Reserve. Bodangora Wind Farm and Uungula Wind Farm are approximately 100 km to the south-west of the proposed LRWF project, while the proposed Crudine Ridge Wind Farm is around 150 km to the south of the project area.

Wide ranging species that occur or have the potential to occur within the project area, that have the potential to be subjected to cumulative impacts due to their movement patterns include the Regent Honeyeater, Swift Parrot, Eastern Bentwing-bat, and Yellow-bellied Sheathtail Bat. Disruption to migration routes has been discussed in Section 7.3. Monitoring collisions and evaluating when management actions must be undertaken to address identified impacts is a commitment of the project and will lead to better long term data on risks to these species.

At this stage, based on the information available from both overseas and Australian wind farm monitoring data, the key points are:

- Not all bird and bat species present at a wind farm site enter the rotor-swept area (only around 20% according to Hull 2013).
- Of those species that encounter the rotor-swept area, a very small percentage collide with turbine blades (around 0.5% according to Horn *et al.* 2008). Most species take evasive action and do not collide with blades.
- The majority of Australian wind farm collisions are accounted for by a limited number of common birds and bats (Smales 2015).
- Threatened species may suffer collision mortality from time to time (NGH Environmental unpubl. data) however, monitoring collisions and evaluating when management actions must be undertaken is a commitment of the project and will lead to better long term data on risks to these species. I

Further scientific research is required. Monitoring data from operational wind farms in Australia should be made publicly available in order to reduce reliance on assumptions and extrapolation from extensive ecological literature reviews. This has been added as an additional mitigation measure for this project.

The collision risks that have been identified in this section are considered manageable with the implementation of effective mitigation measures, outlined in Section 8. Even for high risk species, population level impacts would not occur in a single event. Adaptive monitoring will address this risk.

8 MITIGATION MEASURES

The suite of mitigation measures previously provided within the 2013 Biodiversity Assessments (NGH Environmental 2013a and b) was developed to:

- Avoid impacts where possible
- Minimise impacts that could not be sufficiently avoided
- Offset residual impacts

The measures have been updated below. Changed entries are shown in blue shading. These measures constitute of set of commitments that form part of the project.

Table 8-1 Design measures to avoid impacts for the Liverpool Range Wind Farm

MEASURES TO AVOID IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Design Phase					
Threatened Native Grasses	Wind Farm Study Area: areas of moderate condition Box Gum Woodland EEC.	Finger Panic Grass, Lobed Blue-grass and Bluegrass	Pre-clearance survey in better quality Box-Gum Woodland	After final alignments / development envelopes confirmed	– A Pre-clearance survey is to be conducted for Finger Panic Grass, Lobed Blue-grass and Bluegrass within better quality Box-Gum Woodland EEC during flowering season from mid-January to late February. If found, turbines and infrastructure are to be microsited to avoid areas of at least moderate quality condition of these species in this vegetation type.
Threatened Bats	**Wind Farm Study Area**	**Large-eared Pied Bat** **Eastern Bentwing Bat**	**Pre-clearance survey of any caves identified in the impact area**	**After final alignments / development envelopes confirmed**	– **One cave area was found during habitat surveys; this is no longer in the clearing area. A protocol should be developed for the unexpected find of a bat roost cave during clearing or construction. This should be done with consultation to the Australasian Bat Society. The protocol may include: watching at dusk for exiting bats, developing a strategy to block exit and entry points to the cave, seasonal restrictions.**
Threatened Reptiles	Wind Farm Study Area	Pink-tailed Worm-lizard	Pre-clearance survey in good quality Box-Gum Woodland (CEEC)	After final alignments / development envelopes confirmed	– Turbines and infrastructure would be micro-sited to avoid rocky outcrops in this habitat.

MEASURES TO AVOID IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Hollow-bearing Trees	Wind Farm Study Area within moderate or moderate-good quality Box Gum Woodland	Focus species: Squirrel Glider, microchiropteran bats. Other species: other threatened hollow dependent fauna considered to be at moderate risk from development (i.e. woodland birds).	Targeted HBT survey to accurately record the number of hollows to be cleared.	After final alignments / development envelopes confirmed	– Pre-clearance survey within final development envelope and alignment for HBTs – Infrastructure micro-sited to avoid HBT, where possible. – Ideally, construction and any required tree clearance should avoid the peak breeding time for fauna and nesting time for birds (e.g. spring-summer). – In particular, clearance of HBT trees potentially suitable for Squirrel Gliders should not be undertaken within a 100 m radius over the breeding season in the latter half of the year for Squirrel Gliders. – For HBTs to be cleared a management plan should be prepared by an ecologist detailing: procedures to minimise impacts to, and relocate resident fauna; timing of works to avoid breeding periods; number and type of HBT to be removed and offset (to be included in Flora & Fauna Mgt Plan). – Where HBT are to be cleared a standard pre-clearance survey, such as that described in *Biodiversity Guidelines* (**ngh**environmental / RTA 2011), should be undertaken and details of HBTs cleared including number and size of hollows and number of hollow-bearing trees recorded.

Table 8-2 Design, construction and operational measures to minimise impacts for the Liverpool Range wind farm proposal.

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Design Phase					
General Measures	Wind Farm Study Area	High risk birds and bats	Turbine infrastructure design to minimise operational impacts on birds and bats	Prior to operation	– Turbines and infrastructure would be micro-sited to avoid rocky outcrops in this habitat. – Red flashing lights should be fitted to turbine towers to reduce insect attraction and potentially night-flying birds. – No guy lines to be fitted to turbine towers. – Flags and/or marker balls to be fitted to wind monitoring mast guy lines – Turbines (e.g. nacelles) should minimise perching opportunities.
Construction Phase					
Flora and fauna	**All of project**	**All flora and fauna**	**Ensure coordinated management of flora and fauna impacts**	**During construction**	– **Prepare and implement detailed Flora and Fauna Management Plan to reflect the results of further surveys, demonstrate micrositing objectives have been achieved, clearly identify more sensitive areas and capture all biodiversity management measures (from this assessment and any additional consent conditions and agency stipulations).**
Box Gum Woodland and good quality fauna habitat	Wind Farm Study Area	Box Gum Woodland areas and threatened species	Prevent unauthorised clearance Minimise track and transmission line impacts in areas of high conservation value	During construction	– Clearly demarcate works areas nearby or within Box Gum Woodland areas to strictly define permitted clearance zone. – Minimise track width to the minimum required for safe access and operation – Install the 330kV powerlines (co-aligned with roads) as underground, where possible – Removal of topsoil and subsoil for trenching to be replaced and revegetate disturbed areas with local native grasses (i.e. Kangaroo Grass, Wallaby Grass or Spear Grass).

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
General Measures	Project Area	All species and vegetation communities	Minimise clearance and disturbance	During construction and as required	– Clearly demarcating works areas and restricting impacts to these. Including vehicle and equipment parking and access routes. – Co-locating underground and overhead 33kV powerlines with the track network to minimise additional impact area, where possible. – Establish construction compound in a disturbed area. – Use disturbed areas for vehicle and machinery access, materials laydown, stockpiling of cleared vegetation and deposition and retrieval of spoil, wherever practicable. – Fill in trenches as soon as possible. Trenches left open overnight to be inspected at first light for trapped fauna. Trapped fauna to be released appropriately in a nearby location. – HBTs and sensitive features to be retained to be communicated to staff via inductions and other methods.
Riparian Area Mgt	Project Area	All species and vegetation communities	Minimise clearance and disturbance	During construction	– Creek crossing to be designed in accordance with: NSW Fisheries Policy and Guidelines for Fish Friendly Waterway Crossings (2003). – Creek works not to be undertaken when heavy rain is forecast and should be avoided when there is flow. – Implement sedimentation and erosion controls in accordance with best practice guidelines.
General Habitat Mgt	Project Area	All species and vegetation communities	Minimise disturbance		– Bird and bat activity levels are generally concentrated around areas of vegetation. A buffer of 100 m from the turbine blades is recommended for areas of high habitat value for birds and bats. – Fallen timber > 50cm in length to be left in place or moved to a nearby area to retain fauna habitat. – Where rocky outcrops cannot be avoided, replace rock in nearby areas in consultation with an ecologist.

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Threatened species habitat Mgt	**Project Area**	**Square-tailed Kite**	**Minimise disturbance**	**Construction**	– **Construction activity restrictions within 500 m of the Square-tailed Kite nest would be developed. The buffer zone around the nest should be marked. No works of that may cause disturbance to the nest would be undertaken between July and February within this buffer zone, unless an ecologist with established raptor credentials assesses the risk to be low.**
		Raptors	**Minimise disturbance**	**Construction**	– **Any other active raptor nests found during construction would be allowed a buffer of a least 100 m from construction disturbance, unless an ecologist with established raptor credentials assesses the risk to be low.**
Weed Mgt	Project Area	All species and vegetation communities	Pre-construction inspection for noxious weeds within Project Area Prevention of spread of weeds and pathogens Weed monitoring	Before commencement of works and as required Monitoring – late spring / early summer after construction	– Control noxious weeds in works area according to plans and control measures of the LGAs – Control invasive but unlisted species such as African Lovegrass and Galenia where they occur on or adjacent to the site to prevent their spread into uninfested areas – Minimise use and adhere to best practice guidelines for herbicide treatment in environmentally sensitive areas (i.e. Box Gum Woodland) – Establish hygiene plan to ensure vehicle and machinery is absent of organic matter pre- and post-site access – Sign environmentally sensitive areas (i.e. CEEC areas) and designate clean-down area for entry / exit points into these areas. – Monitoring and weed control in areas of known noxious or invasive species. – Understorey vegetation in easements should be managed to maintain composition and quality to prevent weed invasion

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Weed Mgt	**Project Area**	**Particularly bat species**	**Minimise adverse impacts of spraying**	**During spraying**	– **Best Management Practices for Residual Herbicides and Water Quality (Rattray et al. 2006) would be referenced in developing weed management. It provides a comprehensive guide to best practice chemical use plan. The NSW DPI website also provides a number of species specific weed management guides (http://www.dpi.nsw.gov.au/biosecurity/weeds/publications/weeds-crc-pubs/wmg).**
Weed Mgt	**Project Area**	***Phytophthora cinnamomi* infection**	**Detect and minimise spread**	**All earthworks**	– **A management protocol to detect and manage *Phytophthora cinnamomi* infection would be developed and implemented during construction earthworks, as this fungus spreads in soil.**
Pollution Prevention	Project Area	All species and vegetation communities	Prevention of contaminants and erosion outside works zones	As required	– Establish a spill plan to prevent chemicals or pollutants from having an adverse effect on the environment. – Backfill cable trench where cement is used; at least 20 cm of cement free topsoil to be replaced as the top layer in the back fill. – Establish an erosion and sediment control plan so appropriate controls are in place prior to commencement of works.
Site Mgt	Project Area	All species and vegetation communities	Stabilisation of soil, rehabilitation and revegetation to be undertaken progressively to re-establish ground cover	As required	– Lightly mulch exposed soils with chipped vegetation or sterile hay in areas dominated by exotic groundcover species. Sow with an appropriate cover crop in consultation with land owners. – Lightly mulch exposed soils with chipped vegetation or sterile hay in areas dominated by native grasses using local provenance species. – Fertiliser should not be used to promote revegetation in areas dominated by native grasses.

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Operational Phase					
Flora & Fauna Mgt Plan	Project Area	All species and vegetation communities	To avoid significant impact to flora and fauna outside of the accepted clearance boundaries and prevent 'unassessed' impacts occurring.	Implement prior to construction.	– An ecological professional to develop and implement a Flora and Fauna Management Plan to report on and manage impacts. – The management plan should highlight ecological important areas (vegetation communities and threatened fauna species habitat) and their management. – Specific areas requiring monitoring or management should be highlighted as well as timing for monitoring. – Weed species should be highlighted along with prescriptions for their management.
Adaptive Bird & Bat Mgt Plan	Wind Farm Study Area	High risk raptors and bats, Threatened Owls (Powerful Owl, Masked Owl, Barking Owl)	Development of an 'insurance' monitoring program to address uncertainty inherent in the assessment.	Implement prior to construction **and during operation**. Survey and monitor during 'high risk' periods, when species may be moving through or foraging in the area	– An ecological professional to develop and implement a Bird and Bat Monitoring Program to report on, and manage impacts with potential to be significant – Monitoring surveys should include an understanding of breeding activity (i.e. nest locations) and foraging movements. – Baseline (pre-construction) and operational collision and abundance data would be collected, focused on higher risk species and higher risk locations in order that actions can be taken to address unforeseen impacts, should they occur. – Mgt Plan methods would utilise AusWEA (2006) best practice guidelines. – Mgt Plan should include mgt response options (i.e. restriction of lambing on ridges with high raptor activity to reduce collision risks) to be implemented where significant impacts are anticipated.

MEASURES TO MINIMISE IMPACTS					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Adaptive Bird & Bat Mgt Plan					– **The Adaptive BBMP would include bird utilisation surveys. Data would be provided annually to OEH and then be accessible for use by recovery teams such as the Regent Honeyeater Recovery Team.** – **The BBMP would aim to monitor and report on whether the LRWF presents a barrier or has an observable behavioural displacement effect upon resident birds and bats.** – **Annual BBMP reports would be made publicly available, to improve the robustness of future wind farm assessments by providing data in an Australian context.** – **As a high risk species, consultation should be undertaken as part of the BBMP with the Regent Honeyeater Recovery Team Co-ordinator if any Regent Honeyeaters are found onsite.**
Habitat Connectivity	Transmission Line Easement	All common species, as well as threatened fauna, particularly owls, gliders and bats	Minimise fragmentation of landscape connectivity	After construction	– Promote growth of vegetation under the transmission line to the maximum allowable height to maintain fauna habitat connectivity. – Understorey vegetation in easements should be managed to maintain composition and quality to prevent weed invasion. – Install gliding poles for glider species, particularly the Squirrel Glider, if clearing for the transmission line easement exceeds 40m in areas of habitat for this species. – Near areas of intact woodland or forest a spacing of 600m should be considered for turbines.

Table 8-3 Offset measures to maintain or improve biodiversity for the Liverpool Range wind farm proposal.

OFFSET MEASURES TO MAINTAIN OR IMPROVE BIODIVERSITY					
Item	**Area**	**Target Species**	**Objective**	**Timing**	**Recommendation**
Construction Phase					
Development of offset strategy and offset plan	Project Area	Box Gum Woodland, Hollow-bearing trees, Threatened species habitat	Proponent will develop an offset plan to offset all permanent native vegetation removal to maintain or improve biodiversity in the longer term	Prior to construction	– Develop an offset strategy with input from OEH, the CMA and an ecological professional which will be finalised prior to any construction impacts an ecological professional, in accordance with Appendix F – Develop an offset plan with input from OEH and the CMA prior to operation, demonstrating the suitability of the final offset site and providing detailed management actions specific to the site. – Ensure the offset strategy complies with the *Principles for the use of biodiversity offsets in NSW* guidance document. – The offset ratio will be determined with reference to: the conservation status of the vegetation, the condition of the vegetation, and the actual threatened species habitat value lost (i.e. known threatened species habitat, not potential habitat). – The project offset plan includes suggested ratios but that these would be determined in consultation with OEH as part of the finalisation of the offset strategy.

9 CONCLUSION

This addendum identifies and assesses changes to the project since the exhibition of the Environmental Assessment that affect the conclusions of the original assessment (NGH Environmental 2013a and b). Key changes to the project that relate to biodiversity impacts show a substantive decrease in the impacts now proposed. These include:

- Removal of six turbines from the project
- Relocation of 11 turbines to avoid of minimise biodiversity impacts specifically
- Selection of an electricity easement route with input from OEH, to minimise impacts on biodiversity and conservation reserves
- Overall reduction in the project footprint of 34%
- Overall reduction in native vegetation clearing of 34%
- Reduction in the clearing of NSW EECs of 56%
- Reduction in the clearing of the following vegetation types:
    - River Oak Woodland (ID 084)
    - Riparian forest - Rough-barked Apple, Blakely's Red Gum and Yellow Box (ID 281) EEC
    - Native Pasture (ID 395) (some parts are EEC)
    - Sandstone Forest – Scribbly Gum dominant (ID 477)
    - Sandstone Forest - Red Ironbark dominant (ID 478)
    - White Box - Grey Box Grassy Woodland (ID 483) EEC
    - Mountain Gum – Silvertop – Stringybark Forest (ID 490)
    - Sandstone Forest - Narrow-leaved Ironbark dominant (ID 468 and 479)
- *Increased* clearing of the following vegetation types:
    - Blakely's Red Gum – Grey Box-White Box Riparian Woodland (ID 278)
    - Sandstone Forest – Blue-leaved Ironbark dominant (ID 467)
    - Sandstone Forest – Black Cypress dominant (ID 480)
    - Riparian Forest – Rough-barked Apple, Blakely's Red Gum (ID 481)Norton's Box Woodland (ID 488)
    - Norton's Box Woodland (ID 488)
    - Brittle Gum - Stringybark Woodland (ID 495)
    - White Box – White Cypress Pine shrubby open forest (ID 588)

  This includes an increased impact on Commonwealth listed EEC. Up to 8.9 ha would be impacted.

Additional and revised Assessments of significance concluded local population level impacts are unlikely for the species considered, generally on account of clearing for the wind farm area is relatively minor in any one location; discrete patches would be cleared that are unlikely to include important habitat for a population. With the exception of the Square-tailed Kite and Regent Honeyeater, existing mitigation strategies are expected to address the risks to these species, which centre on buffering higher quality woodland areas, undertaking an adaptive bird and bat monitoring program to better understand utilisation and respond to collisions such that ongoing collisions do not produce population level impacts and offsetting clearing impacts in perpetuity.

Of relevance to several recovery plans for subject species:

- The LRWF project contributes positively to expanding the knowledge of birds and bats locally, in the collection of baseline and ongoing utilisation and collision data, as part of the adaptive bird and bat management plan for the wind farm site.
- The LRWF project contributes positively to the reduction of the effects of anthropogenic Climate Change (another KTP). The LRWF project is consistent with the *Priorities for Biodiversity Adaptation to Climate Change* (DECCW 2010), which acknowledges the need for mitigation of climate change impacts through reduction of greenhouse gas emissions.

The suite of mitigation measures previously provided within the 2013 Biodiversity Assessments (NGH Environmental 2013a and b) has been updated and constitutes of set of commitments that form part of the project. Offsets remain a commitment of the project. To offset residual impacts, the offset strategy provided within the 2013 Biodiversity Assessments has also been revised to take into account the revised infrastructure footprint and apply the new FBA credit calculations to the project.

10 REFERENCES

ALA (undated) *Saccolaimus flaviventris* (Peters, 1867) [online] Accessed at: http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:cdb0482f-2292-4c84-a66d-d19ff52fe263

Andrew K. Benson, Scott A. Kelly, Ryan Legge, Fangrui Ma, Soo Jen Low, Jaehyoung Kim, Min Zhang, Phaik Lyn Oh, Derrick Nehrenberg, Kunjie Hua, Stephen D. Kachman, Etsuko N. Moriyama, Jens Walter, Daniel A. Peterson, and Daniel Pomp (2010) Individuality in gut microbiota composition is a complex polygenic trait shaped by multiple environmental and host genetic factors. PNAS 2010 107: 18933-18938.

Andrew, D. (2005) Ecology of the tiger quoll *Dasyurus maculatus maculatus* in coastal New South Wales, Msc thesis, School of Biological Sciences, University of Wollongong.

Auswind (2006) Best Practice Guidelines for the implementation of Wind Energy Projects in Australia, Australian Wind Energy Association.

Auswind (2006) Best Practice Guidelines for the implementation of Wind Energy Projects in Australia, Australian Wind Energy Association

Bamford, M., Watkins, W., Bancroft, G., Tischler, G. And Wahl, J. (2008) *Migratory Shorebirds of the East Asian – Australasian Flyway: population estimates and internationally important sites*, Wetlands International

BirdLife Australia (2016) Regent Honeyeater *Anthochaera phrygia* [online]. Accessed at: http://birdlife.org.au/bird-profile/regent-honeyeater on 10/10/2016.

BirdLife Australia (2017) Spotted Harrier [online]. Accessed at: http://birdlife.org.au/bird-profile/Spotted-Harrier

BirdLife International (2016) Species factsheet: *Lathamus discolor*. Downloaded from http://www.birdlife.org on 10/10/2016. Recommended citation for factsheets for more than one species: BirdLife International (2016) IUCN Red List for birds. Downloaded from http://www.birdlife.org on 10/10/2016.

BOM (2016a) *Merriwa, Daily Weather Observations October 2016, October 2015*. Available from: http://www.bom.gov.au/climate/dwo/IDCJDW2158.latest.shtml. Accessed in October 2016

BOM (2016b) *Climate Statistics for Australian Locations: Cassilis (Dalkeith*). Available from: http://www.bom.gov.au/climate/averages/tables/cw_062009.shtml. accessed in October 2016.

Brett Lane and Associates. (2009) Summary of investigation of Wedge-tailed Eagle breeding: Challicum Hills Wind Farm. Ecological Research and Management.

Chan, K. (2001) 'Partial migration in Australian landbirds: a review' *Emu* 101:4: 281-292

Chimimba, C.T. & Kitchener, D.J. (1987) Breeding in the Australian Yellow-bellied Sheath-tailed Bat, *Saccolaimus flaviventris* (Peters, 1867) (Chiroptera: Emballonuridae). *Records of the Western Australian Museum* 13(2): 241-248.

Churchill, S. (1998*) Australian Bats*. Reed New Holland, Sydney.

Churchill, S. (2008). *Australian Bats*. Unwin & Allen, Sydney.

CoG (undated) Canberra Birds: Flame Robin, Canberra Ornithologists Group, accessed online at http://canberrabirds.org.au/our-birds/canberra-garden-birds/robins/flame-robin/

De Lucas, M., Janss, G.F.E., whitfield, D.P., Ferrer, M. (2008) 'Collision fatality of raptors in wind farms does not depend on raptor abundance', *Journal of Applied Ecology,* 45: 6: 1695–1703

Debus, S (1998) The birds of prey of Australia: a field guide, Royal Australasian Ornithologist's Union, Oxford University Press, Melbourne Australia

DECC (2007) Hollow-bearing trees, Private Native Forestry Advisory Note 1, Department of Environment and Climate Change, NSW. Accessed online at http://www.environment.nsw.gov.au/resources/pnf/07353hollowtrees.pdf in 2016

DECC (2008) DECC (2008) Recovery plan for the koala (Phascolarctos cinereus). NSW Department of Environment and Climate Change Sydney.

DECCW (2010) *Guide to New South Wales Karst and Caves*, Department of Environment, Climate Change and Water, NSW.

Department of the Environment (2014) *Lathamus discolor* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 12 Jun 2014 13:40:53 +1000.

Department of the Environment (2015) *Merops ornatus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 13 Mar 2015 15:53:22 +1100.

DERM (2011) National recovery plan for the large-eared pied bat *Chalinolobus dwyeri*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DoE (2016) '*National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)*, Department of Environment, Commonwealth of Australia 2016'.

Dowell (2014) Climate Zone Maps. Available from: http://www.dowell.com.au/media/dowellimages/thermaline/Climate_zone_maps_lr.pdf. Accessed Mon, 3 Oct 2016

Dwyer, P.D. (1969) Population range of *Miniopterus schreibersii* (Chiroptera) in south-eastern Australia. *Aust. J. Zool*., 17, 665-86

Dwyer, P.D (1995) Common bentwing-bat. In: The Mammals of Australia (ed. R. Strahan) pp. 494–495. Reed Books: New South Wales.

Eco Logical (2012) Ulan Coal Mines Limited 2011 Annual Monitoring Report. Report prepared for Ulan Coal Mines Limited.

Epuron (2014). Liverpool Range Wind Farm: Environmental Assessment. Report prepared for submission to Department of Planning and Environment July 2014).

Epuron (2017). Liverpool Range Wind Farm: Response to Submissions Report. Report prepared for submission to Department of Planning and Environment May 2017).

Fischer, J. and Lindenmayer, D. B. (2002) The conservation value of paddock trees for birds in a variegated landscape in southern New South Wales. 2. Paddock trees as stepping stones*. Biodiversity and Conservation* 11:833-849.

Fox, A. & Petersen, I. (2006) 'Assessing teh degree of habitat loss to marine birds from the development of ooffshore wind farms', *Waterbirds around the world*. Eds G.C. Boree, C.A. Galbraith & D.A. Stroud. The Stationery Office, Edinburgh UK. Pp 801-804

Franklin, D. C., Smales, I. J., Quin, B. R. and Menkhorst, P. W. (1999) 'Annual cycle of the Helmeted Honeyeater Lichenostomus melanops cassidix, a sedentary inhabitant of a predictable environment' *Ibis*, 141: 256–268.

Franklin, D.C., Menkhorst, P.W. & Robinson, J.L. (1989) 'Ecology of the Regent Honeyeater *Xanthomyza phrygia', Emu*. 89:140-154.

Fraser, I (2008) Bird Migration to and from the ACT, Paper presented at the Australian Wildlife Rehabilitation Conference, accessed online at http://www.awrc.org.au/canberra-2008.html in January 2007

Gibbons, P. and Lindenmayer, D. (2002) *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Collingwood, Australia.

Goldingay, R.L. (2009) 'Characteristics of tree hollows used by Australian birds and bats', *Wildlife Research* 36, 394–409.

Goldingay, R.L. (2011) 'Characteristics of tree hollows used by Australian arboreal and scansorial mammals', *Australian Journal of Zoology* 59(5): 277-294.

Greg Richards & Associates (2016) *Boco Rock Wind Farm bat monitoring*, letter to NGH Environmental dated 17 May 2016

Gresser, S. (1996*) 'Anti-predator behaviour of the common brushtail possum* (Trichosurus vulpecula) *at Burrendong Dam*, N.S.W. B.Sc. (Honours) Thesis, University of Sydney.

Harris, J.M., Munks, S.A., Goldingay, R.L., Wapstra, M., and Hird, D. (2008) 'Distribution, habitat and conservation status of the eastern pygmy-possum *Cercartetus nanus* in Tasmania', *Australian Mammalogy* 29: 213-232.

Higgins PJ, Peter JM eds (2002) 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 6: Pardalotes to shrike-thrushes.' (Oxford University Press, Melbourne)

Huang, C., Ward, S., and Lee, A. K. (1987) 'Comparison of the diets of the feathertail glider, Acrobates pygmaeus, and the eastern pygmypossum, *Cercartetus nanus* (Marsupialia: Burramyidae) in sympatry', *Australian Mammalogy* 10: 47–50.

Hull, C. (2013) *Wind farm researcher debunks bird 'myths'*, accessed online at http://www.abc.net.au/radionational/programs/ockhamsrazor/5046460, on 24 May 2016

Hull, C., and Muir, S. (2013) 'Behaviour and Turbine Avoidance Rates of Eagles at Two Wind Farms in Tasmania, Australia', *Wildlife Society Bulletin* 37(1): 49-58.

Kavanagh, R. and Barrott, E. (2001) 'Koala populations in the Pilliga forests'. Pp. 93–103 in *Perfumed Pineries: Environmental History of Australia's Callitris Forests*. Dargavel, J., Hart, D. and Libbis, B. (eds). Australian National University, Canberra.

Kennedy, S.J. & A. Overs (2001) 'Foraging ecology and habitat use of the Swift Parrot on the western slopes of New South Wales' *Corella*. 25:68-74.

Kennedy, S.J. & C.L. Tzaros (2005) 'Foraging ecology of the Swift Parrot *Lathamus discolor* in the box-ironbark forests and woodlands of Victoria' *Pacific Conservation Biology*. 11:158-173.

Kitchener D.J. (1989) *Fauna of Australia*, Emballonuidae, AGPS Canberra.

Larsen, J. K., and Guillemette, M. (2007)' Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk' *Journal of Applied Ecology*, 44: 516–522.

Law, B. S., Chidel, M. and Turner, G. (2000) 'The Use by Wildlife of Paddock Trees in Farmland' *Pacific Conservation Biology*, 6(2): 130-143.

Madsen, J. & Boertmann, D. (2008) 'Animal behavioral adaptation to changing landscapes: spring-staging geese habituate to wind farms' *Landscape Ecology* 23: 1007-1011.

Masden, E. A., Haydon, D. T., Fox, A. D., Furness, R. W., Bullman, R., and Desholm, M. (2009)' Barriers to movement: impacts of wind farms on migrating birds' *ICES Journal of Marine Science*, 66: 746–753.

McKenzie, N.L., Stuart, A.N. and Bullen, R.D. (2002) 'Foraging ecology and organisation of a desert bat fauna' *Australian Journal of Zoology* 50: 529-548.

Natural Resource Management Ministerial Council (2009) *National Koala Conservation and Management Strategy* 2009 – 2014. Downloaded from https://www.environment.gov.au/system/files/resources/165139fc-3ab5-4c96-8b15-d11a1ad882ab/files/koala-strategy.pdf

New England (2014) *Technical Information Guidance Note TIN051*. *Bats and onshore wind turbines*.

NGH Environmental (2013a) *Biodiversity Assessment Liverpool Range Wind Farm – Wind Farm Study Area*, report prepared for Epuron Pty Ltd.

NGH Environmental (2013b) *Biodiversity Assessment Liverpool Range Wind Farm – Transmission Line Study Area*, report prepared for Epuron Pty Ltd.

Noske RA. (1984) *Comparative Behaviour and Ecology of Some Australian Bark Foraging Birds*. Doctoral thesis University of New England.

NPWS (2002) *Coolah Tops National Park: Plan of Management*, NSW National Parks & Wildlife Service, accessed http://www.environment.nsw.gov.au/resources/parks/pomFinalCoolah.pdf

NSW Scientific Committee (2001) *Eastern Pygmy-possum*- profile, accessed online at http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10155

NSW Scientific Committee (2008) *Gang-gang Cockatoo, Review of Current Information in NSW*, December 2008. Unpublished report arising from the Review of the Schedules of the Threatened Species Conservation Act 1995. NSW Scientific Committee, Hurstville. accessed online at http://www.environment.nsw.gov.au/resources/nature/schedules/Ganggang.pdf

NSW Scientific Committee (2009a) *Little Lorikeet* Glossopsitta pusilla - *vulnerable species listing*. Final determination. http://www.environment.nsw.gov.au/determinations/littlelorikeetFD.htm

NSW Scientific Committee (2009b) *Turquoise Parrot* Neophema pulchella*. Review of current information in NSW*. June 2009. Unpublished report arising from the Review of the Schedules of the Threatened Species Conservation Act 1995. NSW Scientific Committee, Hurstville.

NSW Scientific Committee (2013) *Final Determination: Key threatening process Noisy Miners*, accessed online at http://www.environment.nsw.gov.au/resources/threatenedspecies/FDNoisminerKTP.pdf

NSW Scientific Committee (2016) *Preliminary determination of Dusky Woodswallow as a vulnerable species* http://www.environment.nsw.gov.au/resources/threatenedspecies/determinations/PDDuskyWoodswallowVS.pdf

OEH (2013) *The Vertebrate Fauna of Durridgere State Conservation Area.* NSW Office of Environment and Heritage, Sydney.

OEH (2017) *Threatened Species Profiles* Accessed at:http://www.environment.nsw.gov.au/threatenedspeciesapp/

Olsen J, Fuentes E (2005) 'Collapse in numbers of breeding Little Eagles in the Australian Capital Territory' *Canberra Bird Notes* 30, 141-145.

Probets, C. (2006) *An autumn phenomenon*, accessed online at http://www.bmbirding.com.au/hemig.html in January 2017.

Rhodes, M.P and Hall, L.S. (1997) 'Observations on Yellow-bellied Sheath-tailed Bats *Saccoliamus* flaviventris (Peters, 1867) (Chiroptera: Emballonuridae)'. *Australian Zoologist* 30(3): 351-357.

Richards, G.C (2012) *Bat Fauna Impact Assessment – Liverpool Range Wind Farm*. Report prepared for NGH Environmental.

Roderick, M. and Ingwersen, D.A. (2014) *Swift Parrots and Regent Honeyeaters in the Lake Macquarie City Council area of New South Wales: an assessment of status, identification of high priority habitats and recommendations for conservation*. Report for Lake Macquarie City Council. BirdLife Australia, Melbourne.

Roderick, M., Geering, D., and Ingwersen, D.A. (2014) 'Significant breeding event of Regent Honeyeaters Anthochaera phrygia near Kurri Kurri, New South Wales during spring 2007' *Australian Field Ornithology* 31:113-121Roderick, M., Ingwersen, D.A. and Tzaros, C.L. (2013) *Swift Parrots and Regent Honeyeaters in the Lower Hunter Region of New South Wales*, Report for Sustainable Regional Development Program. Department of Sustainability, Environment, Water, Population and Communities. BirdLife Australia, Melbourne.

Saunders, D. & Heinsohn, R. (2008) 'Winter habitat use by the endangered, migratory Swift Parrot *(Lathamus discolor)* in New South Wales' *Emu*. 108:81-89. CSIRO Publishing.

Saunders, D.L. and Tzaros, C.L. (2011) *National Recovery Plan for the Swift Parrot* Lathamus discolor, Birds Australia, Melbourne.

Schultz M. (1998) 'Bats and other fauna in disused Fairy Martin *Hirundo ariel* nests', *Emu* 98: 184-191.

Schultz, M. (1997) 'The Little Bent-wing Bat *Miniopterus australis* roosting in a tree hollow', *Australian Zoologist* 30(3): 329.

Smales, I. (2005) *Modelled cumulative impacts on the Swift Parrot of wind farms across the species' range in southeastern Australia*. Biosis Research Pty Ltd., Melbourne. Report prepared for the Department of Environment and Heritage.

Smales, I. (2006) *Impacts of avian collisions with wind power turbines: an overview of the modelling of cumulative risks posed by multiple wind farms*. Biosis Research Pty Ltd., Melbourne. Report prepared for the Department of Environment & Heritage.

Smales, I. (2015) *Fauna Collisions with Wind Turbines: Effects and Impacts, Individuals and Populations. What Are We Trying to Assess?* Port Melbourne, Australia.

Smith, M. (1992) *Koalas and Land Use in Gunnedah Shire: A Report on the Bearcare Project*. NSW National Parks & Wildlife Service, Hurstville.

Somveille M, Manica A, Butchart SHM, Rodrigues ASL (2013) 'Mapping Global Diversity Patterns for Migratory Birds', *PLoS ONE* 8(8): e70907. doi:10.1371/journal.pone.0070907

SPRAT (2016) *Species Profile: Chalinolobus dwyeri — Large-eared Pied Bat,* Large Pied Bat [online]. Acessed at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=183.

Threatened Species Committee (2016) *Lathamus discolor — Swift Parrot profile [online*]. Accessed at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=744

Titley Scientific (2012) *Anabat - Frequently Asked Questions* [online]. Accessed at: http://www.titley-scientific.com/au/index.php/faqs.

Tulloch, A.I. & Dickman, C.R. (2006) 'Floristic and structural components of habitat use by the eastern pygmy-possum (*Cercartetus nanus*) in burnt and unburnt habitats', *Wildlife Research* 33: 627-637.

Turner, V. (1984) 'Banksia pollen as a source of protein in the diet of two Australian marsupials Cercartetus nanus and Tarsipes rostratus', *OIKOS* 43: 53-61.

Van Dyck, S. And Strahan, R. (2008) *The Mammals of Australia*, 3rd edition, Reed New Holland, Australia.

Wilson, P. D. (2008) 'Analysis of movements by Large Bent-wing Bats *Miniopterus schreibersii* based on 27 years of banding data', *The Australasian Bat Society Newsletter*, 21: 18-20.