B.7 WIND FARM RISKS TO BIRDS AND MICROBATS

(Appendix G of NGH Environmental 2009b)

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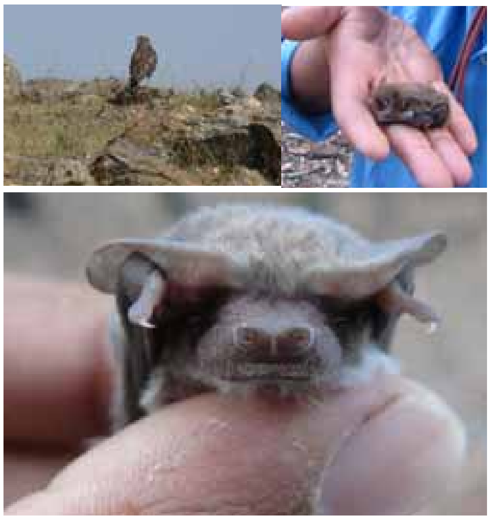
Proposed Yass Wind farm

WINDFARM RISKS TO BIRDS AND MICROBATS



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1 INTRODUCTION

Wind farm development has been steadily increasing over recent decades in many countries. However there are few Australian examples from which to draw upon when assessing the potential impact of wind farms on Australian birds and microchiropteran bats (microbats). By drawing on overseas examples and applying the specific ecological attributes of Australian native species, this addendum builds a base upon which to assess the risks of wind farm development to birds and bats in an area bridging the Southern Tablelands / South West Slopes and Plains of NSW where three wind farm precincts are proposed for development.

This addendum examines relevant background information in the areas of:

- Collision with wind turbines: mortality caused by direct collision with turbine blades and by birds and microbats being swept down by the wake behind a turbine blade.
- Sudden decompression: Rapid or excessive air-pressure change near moving turbine blades has been linked to microbat fatalities as a result of hemorrhaging of the lungs (pulmonary barotrauma) (Baerwald et al., 2008).
- Behavior modification, for example, avoidance of foraging areas due to the presence of the turbines and associated infrastructure.

A literature review is followed by a discussion of implications for this proposal and of monitoring and design of management and mitigation measures, specific to three proposed wind farm precincts west of Yass, NSW.

2 LITERATURE REVIEW

2.1 BIRDS

2.1.1 Quantifying mortalities at existing wind farms

There are a growing number of studies and monitoring programs in Australia and overseas which provide some insight into the nature and scale of potential risks to birds from wind farms.

Internationally

A review of overseas wind farms showed low mortality rates for most wind farms (Langston and Pullen 2002). On average for all birds, new generation projects in the US (outside California) have recorded three fatalities per megawatt per year (Erikson *et al.* 2001). A review of European and North American wind farms indicates that most wind farms in agricultural settings affect between 2 and 4 birds per turbine per year (Lane and Associates 2004). In Washington, America the estimated mortality was 3.59 birds per turbine per year (Erickson et al., 2003). However, the most commonly recorded bird group to collide with European and North American turbines were night-migrating songbirds, of which there are comparatively few in Australia.

In Europe, Winkelman (1994) produced an estimated average of 0.04 to 0.09 mortalities per turbine per day, or 14.6 to 32.9 mortalities per turbine per year. Forty-three percent of these were killed by being swept down by the wake behind a blade, 36% flew directly into a blade, and for 21% the cause of death was unknown. At Altamont Pass in the United States, 55% of raptors were killed by striking a blade, 8% from electrocution, 11% from wire collision and 26% from unknown causes (Orloff and Flannery 1992, cited in Canada Bird Studies 2001). Winkelman concluded that the number of birds killed per unit of energy produced is low compared to other human-related causes of bird death. A review of bird fatalities at 32 wind farms in North America produced an average of 1.4 birds per turbine per year, with a range of zero to 4.3 (Barclay et al., 2007).

Australia

There are relatively few published bird mortality studies at Australian wind farms, and most are of short duration. The studies do however suggest a generally low rate of blade collision, and that species at most risk are locally common birds which are active at the bladeswept height, including some raptors, skylarks, magpies and some seabirds (Meredith 2003, Hydro Tasmania 2004).

Monitoring research at the three operational wind farms in Victoria has recorded no rare, threatened or endangered birds killed by wind turbines to date. Searches for dead birds around seven turbines at the Codrington Wind farm (Victoria) showed three bird deaths attributable to impact with wind turbines (Biosis Research, 2006). The species concerned were the introduced skylark (1), Richard's pipit (1) and Australian magpie (1). Incidental carcass finds showed a further adult Brown Falcon death. The estimated total number of deaths likely from Codrington's 14 turbines over one year is 18 to 38 birds, or 1.2 to 2.7 birds per turbine per year (Brett Lane and Associates 2005).

At the Toora Wind Farm in Victoria, no bird carcasses were found during a year of monitoring or during informal inspections. Wedge-tailed eagles were regularly observed before and after operations began at this site. Eagles were observed to avoid the turbines by flying around or between them, not into them (Brett Lane and Associates 2005). A study at Codrington also found that all birds approaching the turbines were observed to take avoidance action, by flying over, around or under the rotating turbine blades (Biosis Research 2002).

The rate of bird collisions at Woolnorth Wind Farm stage 1 in north-west Tasmania is estimated at 14 native birds per year or 2.3 birds/turbine/year (Hydro Tasmania 2004). Monitoring at Woolnorth recorded 18 bird collisions in 2003, 7 of which were the introduced Skylark. One of these collisions was a Wedge-tailed Eagle, which is threatened in Tasmania. Eagles have been observed living near the turbines for more than 12 months and the collision occurred during a period of limited visibility (Hydro Tasmania 2003).

A summary of the average number of recorded bird fatalities from literature reviewed is provided in Table 2-1, where possible represented as birds per turbine per year.

Table 2-1 Average number of bird fatalities in reviewed literature

Location	Author	Average fatalities
North America	Erikson *et al*. 2001	3 per MegaWatt per year
Europe/North America	Lane and Associates 2004	3 per turbine per year
Europe	Winkelman 1994	23.5 per turbine per year
North America	Erickson *et al.* 2003	3.59 per turbine per year
North America	Barclay *et al*. 2007	1.4 per turbine per year
Victoria, Australia	Brett Lane Associates	2 per turbine per year
Tasmania, Australia	Hydro Tasmania 2003	2.3 per turbine per year

2.1.2 Risk factors for bird impacts

It is logical to assume that there may be a number of factors which affect the risk of birds colliding with wind farm infrastructure, and that some of these relate to the ecology of a species, site-specific features or to the design and location of the infrastructure.

Species-specific risks

The capacity of birds to 'habituate' to turbines may vary between species. Some species groups appear disproportionately vulnerable to bladestrike. Northern hemisphere studies point to three groups which are most vulnerable to bladestrike; gulls, raptors and migrant songbirds (Airiola 1987, cited in Canada Bird Studies 2001). Risk factors include:

- Foraging in the bladesweep area
- Flocking or colonial movements
- Awkward flight characteristics
- Migrating at night

Night-flying waterbirds have been identified as a risk group for wind farm developments. Small numbers of waterbirds were recorded throughout the proposed Yass Wind farm, in dams and wet drainage lines. Short-range foraging journeys by these species may follow chains of small wetland habitats scattered over the lowland areas of the district. Major migration routes for these species are not known.

Experience elsewhere in Australia suggests that Wedge-tailed Eagle mortality is a possibility, although there are examples of this species habituating to, and co-existing with wind turbines. Of greater concern may be the alienation of hunting habitat ('behaviour modification'), and the longer term affect on Wedge-tailed Eagle breeding success.

Species which are rare or declining, or which are naturally distributed at low density (such as top order raptors) may be at greater risk. While collision rates may be low, each mortality has a higher significance. Similarly, species with low reproductive rates, or poor capacity to disperse and recolonise habitats may be at greater risk of significant impacts from blade collisions or avoidance behaviour at the population level.

Environmental risks

Many studies have shown that poor weather conditions increase the occurrence of turbine collisions (Canada Bird Studies 2001). Weather conditions which reduce the ability of birds to perceive the turbine blades or avoid collisions (such as fog and strong gusty winds) add to risks for susceptible species. Hence, sites which experience these conditions at higher frequency may be correspondingly riskier for these species. The relative location of key habitat areas (such as updraft zones, prey populations, wetlands and nesting sites) and natural diurnal and seasonal migration routes also affects risks to birds.

Structural characteristics of the development

Features such as guy lines, aerial cabling and perching opportunities (especially lattice structures) may also be critical factors affecting the frequency of collisions (Erickson *et al.* 2001). Warning lights on towers may attract night migrating birds (Cochran and Graber 1958 in Canada Bird Studies 2001). US studies suggest that red flashing lights on wind turbines do not attract night migrants (Kerlinger and Kerns 2003), and would not attract insects, which are generally not sensitive to the red end of the spectrum.

2.1.3 Behaviour modification

In Europe, the effects of wind farms on habitat utilisation are considered to have a greater impact on birds than collision mortality (Strickland 2004). Bird abundance data from 19 globally-distributed windfarms found a significant negative impact on bird abundance (Stewart *et al.* 2007). Howeverit was unclear whether this related to a decline in population abundance or a decline owing to avoidance behavior. European studies suggest that most habitat displacement involves migrating, resting and foraging birds. Studies have reported displacement effects ranging from 75 metres to as far as 800 metres from turbines (Strickland 2004, Winkelman 1994). This is likely to reduce the risk of bird mortality, but may affect populations where the alienated habitat is particularly important or limiting.

Wind farm developments can alter resource availability and distribution by removing or creating water bodies, removing vegetation and hollows for foraging and roosting, creating an obstacle, increasing or decreasing prey activity. Construction impacts such as clearing may increase edge effects and fragmentation which for some species may represent a barrier to dispersal or movement (Lindemayer & Fischer 2006). The activity patterns of local bird species may also alter based on food resource movements (Kunz et all 2007, Grindal & Bingham 1998).

2.2 MICROBATS

There has been little study of wind farm impacts on microbat species Most papers, both in Australia and overseas, are focused on identifying species presence and qualifying possible impacts. Sterner et al (2007) claim that study in the USA to c.2007 were post operation of wind energy centres. Many of the scientific programs in the USA designed to test impacts have been hampered by operational requirements at wind farms (Kunz et al 2007).

Without this information, assumptions must be made using what we know of species ecology and limited case studies and investigations. The difficulty in estimating impact to microbats is compounded by the fact that relatively little is known about their ecology and behaviour.

2.2.1 Quantifying mortalities at existing wind farms

Compared to available data on bird mortalites, microbat collision events appear to be greater in number. Migratory microbats comprise the majority of mortalities in all wind farm studies to date (Erickson *et al.* 2002, Arnett 2005).

Fatalities at USA wind-energy facilities went as high as 53.3bat/MW/year at the Buffalo Mountain Wind Energy Centre for small Vestas V47 turbines producing 0.66-MW and 38.7 bats/MW/year for larger Vestas V80 turbines producing 1.8MW(Kunz et al 2007). Erickson *et al.* (2003) found an estimated mortality of 3.21 bats per turbine per year in North America.

Erickson *et al.* (2002) in a North American study, state that based on available data, microbat collisions during the breeding season are virtually non-existent. Further, North American research has shown that most microbat collisions have occurred with adults, hence collisions in this area were not thought to be attributed to dispersing juveniles (ABS 2005).

A review of 32 North American wind farm monitoring studies demonstrates a trend between turbine height and mortality numbers, with higher towers appearing to cause more bat deaths. The same review shows an average of 5.9 bat fatalities per turbine per year, with a range of zero to 42.7, when towers are at or greater than 65 metres in height (Barclay et al., 2007) . The variation of impact to microbats would appear dependent on the nature of the receiving environment and the siting of turbines.

While microbat fatalities in the USA at wind farms have been high, extrapolation of this data to Australian conditions would be inappropriate. This is mainly because climatic patterns are quite different, in the USA where extreme changes occur during winter as the jetstream moves southwards, rendering much of the country unsuitable for bat foraging (Greg Richards pers. comm. May 2009). These extreme changes cause dramatic changes to the areas occupied by a number of bat species that move very long distances as they migrate, making them more susceptible to collision in much larger numbers (Greg Richards pers. comm. May 2009). Monitoring in Victoria, based on carcass monitoring, has identifies fatality rates in the order of 1-2 bats per turbine per year (Brett Lane pers. Comm., via Greg Richards). This data from Victoria is likely to represent more accurate data in an Australian context. Fatalities may however be higher, but this would be dependent on habitat quality and proximity of significant bat roosts.

2.2.2 Risk factors for microbat impacts

In addition to the collision and habitat avoidance risks as described for birds, decompression, or pulmonary barotrauma, has been identified as a significant mortality causing factor for microbats.

Rapid or excessive air-pressure change has the potential to cause fatalities as a result of haemorrhaging of the lungs (pulmonary barotrauma) as fauna pass near moving turbine blades. Moving turbine blades can cause a drop in air pressure by 5 to 10 kPa (Horn et al 2008; G. Richards 2008 pers. comm. Via Vanessa Place). Mammals are thought to be more susceptible to barotrauma than birds (Baerwald et al., 2008) demonstrated by a recent Canadian study, which found evidence of barotrauma in 90% of 75 microbats that had been killed at wind turbines, while only 50% of these had had direct contact with turbine blades (Baerwald *et al* (2008).

Barotrauma potentially poses significant risks to microbats at wind farms as microbats are unable to detect rapid pressure reductions, even though echolocation may allow microbats to detect and avoid turbine blades.

Species-specific risks

There are a number of factors which make Microchiropteran order as a whole susceptible to negative impacts from wind farm developments. These include:

- Low reproductive rates
- Foraging patterns in response to weather conditions and resource pulses
- Flocking or colonial movements

All species of microbat have a low fecundity with most producing only 1 young per year (Law 1996). Species with low reproductive rates, or poor capacity to disperse and recolonise habitats may be at greater risk of significant impacts from blade collisions at the population level. This suggests that populations would recovery slowly from one-off large scale mortality events, or perhaps not recover at all from an ongoing threat (Racey and Entwhistle 2003 in Arnett 2005).

Many microchiropteran bat species hibernate or aestivate during cold periods to reduce their energy requirements when resources are low. In a compilation of survey results for wind farms in the United States, most microbat mortality documented occurred in late summer and autumn (nearly 90% from mid-July through mid- September) (Erickson *et al.* 2002). Resource abundance at this time would be expected to be high and bats requiring fat stores for aestivation would need to take advantage of the resource pulse. This higher rate of activity is likely to be the reason for a greater number of collisions.

Horn *et al.* (2008) noted direct collision with moving turbine blades during their study at the Mountaineer Wind Energy Centre, West Virginia. Many microbats actively investigated turbine structures when blades were both moving or stationary, be it for possible roosting, stop-over roosting in migration or as a mating site.

It is not known whether particular groups of microbats are more vulnerable than others, however risk factors are likely to include:

- Long distance migration (nocturnal)
- Foraging within the blade-sweep area

Current theory suggests that in the eastern United States, the microbats most likely to be impacted by wind energy turbines are long-distance migratory species (USGS 2008; Reynolds 2006). In Australia, long-distance migrating microbats include the Eastern Bentwing-bat and Yellow-bellied Sheath-tailed Bat, both recorded in the Carrolls Ridge Precinct proposal area. During migration, microbats may cease the use of echolocation to conserve energy (Keeley et al 2001 cited in Sterner et al 2007). Echolocation has been assessed as functional only over small distances of c.20 metres (Grindal & Bringham 1998). Navigational aids such as rivers, waterbodies, tracks and ridges may also be used by microbats during foraging or migration movements (Grindal & Bringham 1998; Vestjens and Hall 1977; Richards 2001). Tracks and riparian areas facilitate movement through the canopy (Law & Chidel 2002).

Foraging behaviour is a key risk factor to consider when determining species risk. The majority of microbats rely on forested areas for hollow bearing trees for roosts, and/or aggregations of insects to prey upon. Different species utilise different levels of the forest canopy, though Law & Chidel (2002) found that activity levels dropped in heavily cluttered regrowth areas or thick understorey rainforest.

It is considered that species which fly along the edges or above the canopy during foraging are most at risk from turbine impacts, compared to those that forage close to the ground or within the forest. These species include Eastern Bentwing-bat, Yellow-bellied Sheath-tailed Bat, Gould's Wattled Bat.

While most microbats are known for their highly manoeuvrable flight , some species are less mobile than others. Species which utilise open areas and tend to forage above the canopy may have limited manoeuvrability, such as the Eastern Free-tailed Bat and Gould's Wattled Bat (Van Dyck and Strahan, 2008).

Environmental risks

Monitoring in the USA has revealed that large numbers of microbats are killed in windfarms situated in forested, ridge top areas as opposed to agricultural areas (Kunz et al 2007). Whilst most microbat species do not utilise open paddocks for foraging, isolated paddock trees are important resources in fragmented landscapes (Lumsden and Bennett 2003).

Evidence suggests that microbat collisions with structures during migration are common, and that these are normally associated with inclement weather (Erickson *et al.* 2002). US studies show that bats tend to be killed on low wind nights, when blade speeds were at or close to full operational speed (17 rpm) (Arnett 2005). Fatalities tended to increase just before and just after the passage of storm fronts, when microbat activity would increase in response to insect abundance, in a similar manner to swallows during the day. This study also found that microbat activity was greatest during the first two hours after sunset, which may also be a relatively high risk time for collisions. However, based on echolocation recordings within the three precincts, it appears that different species are more active at different times of the night, rather than all active during a short period.

Structural characteristics of the development

German studies have shown higher collision rates from turbines located near hedgerows, suggesting turbine placement adjacent to or within forest patches may increase risk to microbats (Australian Bat Society 2005). Further, many species use linear vegetation or topographic features while commuting (Limpens and Kapteyn 1991, in Erickson *et al.* 2002) and migrating (Humphrey and Cope 1976, Timm 1989, in Erickson *et al.* 2002).

Lights on turbines may increase the probability of microbat collisions, as insect abundance is higher under lights (Erickson *et al.* 2002). However, similar mortality rates at sites lit by aircraft lighting and sites which had no lights was found by Arnett, 2005. As a precaution where lighting is required, mitigation may involve the use of red flashing lights that are less likely to attract insects, which are generally not sensitive to the red end of the spectrum.

Table 2-2 Risk factors based on microbat ecology and turbine structures

Turbine Structure Risk Factors	Microbat Risk factor
• Lattice design appears most attractive for roosting • Turbine height and blade length • Turbine number	• Low fecundity, limited ability to recover from stochastic events • Long distance migration • Curiosity/attraction to turbine structures

Turbine Structure Risk Factors	Microbat Risk factor
• Constructed along forested ridges	• Forage and roost in forested ridgetops, including about the canopy
• Lighting ▪ May attract night migrating species ▪ May attract insects (prey)	• Periods of high activity: ▪ Just before and just after storm fronts ▪ First two hours after sunset (unsubstantiated) ▪ Summer ▪ Low wind conditions ▪ During resource pulses • Utilise flyways and topographic features (such as ridges) for navigation • Different species forage at different levels of forest, including above the canopy

2.3 SUMMARY

Good design and turbine placement is the first step to minimising bird and microbat mortalities. Key risk factors identified from the literature review were:

- Between areas of forest or waterways (animals will cross the turbine areas to move between fragments
- Along forested ridge or waterways (often used as navigational aids by birds and bats
- Abutting forest or remnants (increased foraging activity along edges)
- Reducing the attractiveness of turbine areas for birds and bats by minimising perching opportunities (e.g. guy lines) and lighting.

Once built, ongoing management to reduce deaths during periods of high risk, such as those listed below, may be necessary:

- During peak foraging activity times
- Poor weather conditions (rainy, foggy, poor visibility)

3 A FRAMEWORK FOR MANAGEMENT

Monitoring habitat utilisation prior to finalising turbine layout is important to effectively manage potential impacts to birds and microbats, firstly through avoidance and minimisation. There are three main parts to a bird and microbat management plan (California Energy Commission and California Department of Fish and Game, 2007; DEH, 2005):

1. Impact avoidance and minimisation (monitor and avoid)
2. Impact mitigation and adaptive management (monitor and mitigate)
3. Operations monitoring and reporting (monitor, report and adjust)

Step 1 is about avoiding impacts in the first place, which is preferable to mitigating against impacts. Steps 2 and 3 are not discrete phases, but rather will constantly inform each other as part of an adaptive management cycle. Each step would be part of the Bird and Bat Management Plan for each of the Yass Wind Farm Precincts.

Central to the management of hazards to birds and bats are biologically appropriate triggers, informed by both pre-operation monitoring and ecological species information. A management plan will specify requirements to adjust management or mitigation measures if trigger points are met (e.g. x number of x species fatalities over x period of time), and provide realistic timelines for periodic review and adjustments to both monitoring and mitigation phases of the management plans (California Energy Commission and California Department of Fish and Game, 2007).

The management plans should utilise the principle of adaptive management. Adaptive management allows the initiation of a project in the absence of complete knowledge by providing a framework to incorporate new information as it comes to hand. With new information, management strategies can be adapted appropriately (Johnson, 1999). Adaptive management is similar to a "monitor-and-modify" approach, but is more flexible in response to new information (Johnson, 1999).

3.1 IMPACT AVOIDANCE AND MINIMISATION

The first principle is to avoid and minimise potential impacts. Further recommendations for monitoring and managing significant microbat species will come from the *Microbat Study,* and should be considered in concert with this addendum report. The actions described in Table 3-1 provide a framework for impact and avoidance at the Yass Wind Farms Precincts, although each action may not relevant to all the precincts.

Table 3-1 Impact aviodance and minimisation actions

Action to avoid/minimise impact	Detail
Minimise habitat disturbance and fragmentation	This can be achieved by creating detailed maps of habitat utilisation (through early monitoring) and then avoiding high use areas.
Establish buffer zones to minimise collision hazards	The appropriate extent of buffer zones can be determined based on high habitat value features (e.g. hollow-bearing trees or raptor nests) and biological and species-specific information.
Reduce impacts with appropriate wind farm siting	Wind farms should not be sited near habitat of listed threatened or migratory species, or areas of high bird or bat movement and activity. All associated infrastructure should avoid: • Wetlands • Important breeding, roosting or feeding habitat for threatened or migratory species
Reduce impacts with appropriate turbine design	Turbine selection should consider biodiversity constraints. For example: • Turbines that operate at low speeds may cause a greater number of microbat fatalities. • Guy lines should be avoided as known to pose a hazard to birds. If guy lines area necessary, bird deterrents such as markers should be part of the design.
Reduce impacts with appropriate turbine layout	It is assumed that careful siting of turbines could significantly reduce the risk of high bird and bat mortalities: • Turbines should not fragment areas of habitat, as this poses a greater hazard to birds and microbats passing between them. • Turbines should avoid core areas of microbat activity, such as winter hibernacula, important foraging areas and areas close to potential migration routes. • Turbines at the end of linear ridges have been identified as responsible for greater numbers of collisions, as animals appear to use topographical features as a navigational aids.
Avoid making turbine areas attractive for foraging	The proposal should not increase habitat for prey species such as insects and small mammals (e.g. rabbits).
Avoid lighting that attracts birds and bats	Red flashing lights with a long dark interval and short flash on-time is thought to be the safest lighting configuration for night flying birds (California Energy Commission and California Department of Fish and Game, 2007). Lighting at operation and maintenance facilities should be on sensors, hooded and directed to minimise skyward illumination (Horn *et al.* 2008). Bats do not appear to be attracted to lights,

Action to avoid/minimise impact	Detail
	although there has been little study on this.
Minmise power-line impacts	All powerlines should be underground rather than overhead where possible to minimise impacts to birds, unless this is considered to have a greater potential impact.
Decommission non-operational turbines	Remove non-operational turbines so they do not continue to present a collision hazard for birds (microbats appear not to collide with stationary turbines).
Offset	To achieve a 'maintain or improve' environmental outcome, a wind farm development would need to be accompanied by offsets to compensate for the loss of biodiversity values in the long term. Considering the key impacts are bird and microbat collisions, offset options are presented below: • Conservation of lands important to species at greatest risk (i.e. Eastern Bentwing-bat) • Proactively addressing DECC priority actions for species at greatest risk • Funding scientific research that would address information gaps and areas of uncertainty, i.e. barotrauma, low and high speed rates of movement for bats, modeling work based on microbat activity periods/weather conditions. Information should be passed into the public arena to assist in future assessments.

3.2 IMPACT MITIGATION AND ADAPTIVE MANAGEMENT

The first step is to avoid potential impacts. However, where this is not possible, mitigation actions can be undertaken. In all cases, mitigation is second best to good turbine design and layout (California Energy Commission and California Department of Fish and Game, 2007; DEH, 2005). Potential mitigation options include:

1. Appropriate timing of construction activities to minimise impacts to birds and microbats, i.e. outside of known nesting periods.
2. Maintenance activities or habitat modification to make the site less attractive as habitat
    a) Carcasses should be removed as soon as possible to avoid attraction of scavengers (e.g. Wedge-tailed Eagle)
    b) Acoustic deterrents, such as high frequency sonar emissions, are currently being investigated for their use in discouraging microbats from utilising areas around turbines. This method has been trialled in Australia for removing flying-fox colonies from urban areas.
3. Seasonal changes to cut-in speed. Pre-operational monitoring will help to determine peak activity periods (seasonal or event-based) for birds and bats, such as:

a) Before and after storm fronts (bats – high activity)

b) Prior to migration (bats – high activity)

c) During times of high insect abundance (bats and insecivorous birds – high activity)

d) Periodic feathering of turbines during low wind nights during migratory or peak activity periods (for example, the Eastern Bentwing-bat will not fly in wind speeds greater than 20-25km/hr; birds tend to fly less in high wind also)

4. Removal of particular turbines or seasonal shut-down if high levels of fatalities (exceed trigger values and mitigation methods ineffective to reduce mortality rates).

3.3 OPERATIONS MONITORING AND REPORTING

The rationale for operations monitoring at the Yass Wind Farm Precincts is to collect bird and bat fatality data and habitat utilisation data. Monitoring options were discussed in detail in Section 3. Before and after monitoring information is required to evaluate, verify, and report on effectiveness of avoidance and minimisation measures. At a minimum, the primary objectives for operations monitoring are to determine (California Energy Commission and California Department of Fish and Game, 2007):

- Whether the avoidance, minimisation, and mitigation measures implemented for the project were adequate or whether additional corrective action or compensatory mitigation is warranted
- Whether overall bird and bat fatality rates are low, moderate, or high relative to other projects

4 MONITORING

Monitoring of birds and microbats around wind farms should be undertaken during two discrete phases: during the planning phase (prior to construction and preferably prior to final layout determination) and during the operational phases.

The accepted experimental design for monitoring the impacts of a proposal is the 'Before-After-Control-Impact' (BACI) design. This involves establishing monitoring sites both where impact is expected (impact site) and where the proposal would not have an effect (control site). Monitoring data from the operational phase at both points is compared to the baseline (planning phase data), with the control site helping to account for effects of environmental variables (such as unusual seasonal conditions) (Brett Lane & Associates, 2005).

The Interim standards for assessing the risks to birds from wind farms in Australia recommend planning phase surveys at three levels, described below, depending on the level of risk (Brett Lane & Associates, 2005). Level One investigations have been undertaken for each of three Precincts.

Level One	Initial risk assessment. Where risk is low or can be reduced to low through planning, management and/or mitigation measures, no further investigation is required; otherwise, Level Two investigation are recommended
Level Two	More intensive surveys are undertaken to determine whether or how risk can be reduced to low; otherwise Level Three investigations are recommended.
Level Three	More intensive surveys provide baseline data for use in design and planning to avoid risks as well as to inform monitoring during the operational phase. Risk assessment at this level is more rigorous and may include estimates of collision impacts (i.e., x number of birds/bats per turbine per year), which will be re-evaluated after operational monitoring.

The 'population source-sink' model may provide a context to guide the design of monitoring to measure local populations and activity both before and after development. Monitoring of a good quality habitat patches close to proposed turbine sites may give an indication of the level of use (see Richards, 2005). Conversely, pre-construction monitoring in areas of degraded habitat (potential sink-habitat areas), may provide an indication of the robustness of nearby source populations (Jonzen et al., 2005). An effective monitoring program will utilise a range of methods to ensure data collection is robust.

4.1 BEFORE: MONITORING IN THE PLANNING PHASE

Monitoring programs should have multiple methods of data collection, to increase the reliability of data. Kunz *et al.* (2007) found that reliance on one method alone did not give adequate risk predictions for operational aspects of wind energy facilities. Appropriate monitoring options during the planning phase include the following and are shown in Table 4-1 below:

- Anabat recording and/or harp trapping to determine species present
- Habitat utilisation monitoring to determine habitat use
- Roaming surveys
- Raptor nest searches

Table 4-1 Methods used for monitoring potential impacts of wind farms to birds

	Investigation level	Direct impacts	Indirect impacts
Pre-operational risk assessment	Level One	• regional overview • indicative bird utilisation survey • roaming surveys	• regional overview • indicative bird utilisation survey • roaming surveys
	Level Two	• continuing bird utilisation studies • gradient studies • roaming surveys • risk modelling	• continuing bird utilisation studies • gradient studies • roaming surveys • risk modelling
	Level Three	• population assessment • population viability analysis	• population assessment • population viability analysis

Source: (Brett Lane & Associates, 2005)

4.1.1 Descriptions of monitoring methods for Levels One to Two

Combinations of the following monitoring methods are suggested for use in the planning or pre-operation phase of wind farm monitoring to determine the level of risk to birds and bats from the proposal. The information obtained would also inform the Bird and Bat Management Plan.

Habitat utilisation monitoring (Level 1/2)

Habitat utilisation is used to provide baseline data on bird and bat species composition, occurrence, frequency, and behavior to compare with operations use and fatality data, inform micrositing decisions, provide estimates of potential collision risk based on time spent in rotor-swept area and provide an estimate of spatial and temporal use of site by all bird and bat species. Monitoring should be undertaken regularly over a full year to establish seasonal patterns (California Energy Commission and California Department of Fish and Game, 2007).

For microbats, acoustic detectors can be located on wind monitoring towers and set to record information every night, ideally within the proposed rotor-swept zone (California Energy Commission and California Department of Fish and Game, 2007)

Habitat utilisation monitoring aims to answer the following questions (Brett Lane & Associates, 2005):

- Which bird and bat species use the site?
- With what frequency does each species occur at the site?
- At which height do birds and bats of each species fly?
- What is the distribution of bird and bat species across the site?

Roaming surveys (Level 1/2)

Roaming surveys are practical to survey particular diurnal birds, such as rare or threatened species. The purpose is to describe the usage of the proposal area and the region by the target species in the context of regional population levels, as well determine management and mitigation options. This method is used (Brett Lane & Associates, 2005):

- Where there are known populations of a threatened species within or near (within around 5 kilometres) the proposal that could be potentially affected (e.g. Superb Parrot)
- Where there are known congregations of birds, such as on wetlands
- Where initial risk assessment has found a particular species, or groups of species (e.g. raptors) are at high risk from collision impacts

  (Brett Lane & Associates 2005)

Migration counts can be part of a roaming survey to provide a more complete picture of species composition, passage rates, and flight height if diurnal migrants are known to congregate at or near the proposal area, or if the proposal site is within a known or likely migration corridor (California Energy Commission and California Department of Fish and Game, 2007).

Raptor nest searches (Level 1/2)

Where initial surveys demonstrate that raptors are of concern, raptor nest searches can be used to boost habitat utilisation monitoring. These provide baseline data on location and activity level of nesting raptors in relation to proposed wind turbine sites (California Energy Commission and California Department of Fish and Game, 2007). This information can then be used to:

- Microsite turbines to reduce potential impacts to nesting raptors
- Develop appropriate buffer zones around breeding territories

Gradient studies (Level 2)

Gradient studies provide an extra level of information to habitat utilisation monitoring by ascertaining how bird and bat habitat useage changes across an environmental gradient, such as topography or time (Brett Lane & Associates, 2005). This method is appropriate where turbines are situated near important habitat features (such as Lake Burrinjuck near Carrolls Ridge) or known core breeding or foraging habitats for a species of concern (such as Eastern Bentwing-bat) at Carrols Ridge.

Reynolds (2006) conducted a spatial and temporal study of microbat activity at a proposed wind energy site in Northeastern USA, recording microbat activity through acoustics (Anabat) and mist netting. Dividing nights into three distinct phases, early (7pm to 10.59pm), middle (11pm to 2.59am) and late (3am to 7am), he measured activity over multiple areas (ie varying habitat types- riparian, trackways, dams, open fields, and closed and open forests). Anabats were stationed at three levels vertically (ground, 25metres, and 50 metres) to record microbats using different canopy levels (Reynolds 2006). Acoustic monitoring provides information about bat presence and activity, as well as seasonal changes in species composition.

Collision risk modelling (Level 2)

The data from habitat utilisation, gradient studies and roaming surveys informs collision risk modelling, which basically provides a quantitative species-specific impact assessment. Modelling is useful where the proposal is considered likely to cause high risk to populations based on qualitative assessments. Modelling will help to inform turbine layout options as well as any operational adjustments (such as restricted periods of operation) by providing an estimate of the number of bird and bat passes that may result in a collision based on variables including the following (Brett Lane & Associates, 2005):

- Turbine layout
- Turbine number
- Wind direction information
- Bird or bat species habitat utilisation data

4.1.2 Descriptions of monitoring methods for Level Three

If the risk to a population of bird or bat species is still deemed to be above low following Level One and Two investigations and a suite of management and mitigation measures, further study is recommended under the Interim Standards to more accurately gauge population scale risks. This would involve population assessments and population viability analyses. Once these studies are complete, another risk assessment should be undertaken, after which a decision on viability of the project can be made (Brett Lane & Associates, 2005).

Population assessments

This would involve desktops assessments to collate regional information about a species from a variety of scientific and other published sources, and entail detailed analysis of the nature and scope of impacts based on species life history and distribution data.

Population viability analysis

This is a detailed formal modelling study to determine the likelihood of a species' extinction based on the additional threat (additional to the range of threats faced by a threatened species) posed by the proposal. This would involve substantial research and consultation and would result in a range of impact scenarios being presented for a particular species.

4.1.3 Population source-sink

The source-sink model (Pulliam 1988) provides a model for population dynamics based on the quality of habitat patches. Patches of good quality habitat, known as sources, have a net positive population growth. Patches of poorer habitat, known as sinks, have a net negative population growth (Hill et al., 2005). The source is usually a large tract of forest, and the sink a series of patches in a developed landscape (Ferriere et al., 2004).

In the case of this proposal, large nearby tracts of forest (such as Burrinjuck Nature Reserve and privately owned forest in the area of Carrols Ridge Precinct) may provide a population source for species breeding in the area, such as Superb Parrot. Population sinks may be areas of heavily cleared farmland or the freeway, for example, where the habitat quality is degraded and ongoing species mortality occurs.

The aim of this proposal would be to ensure the precincts do not create a population sink due to habitat degradation and ongoing species mortality from either blade-strike, barotrauma or habitat loss (due to avoidance). Monitoring during operation, such as through carcass searches, will help to inform and refine management strategies. Monitoring of potential sink-populations is the most effective method for detecting the affect on the source population, as migration to the sink depends on source populations breaching carrying capacity (therefore reflecting breeding health) (Jonzen et al., 2005).

Modelling of source-sink populations has shown that a small amount of habitat loss (10%) resulting from development could lead to significant reductions in populations (49%) through source-sink dynamics (Aurambout et al., 2005). However, alternative research suggests that populations may adapt to sub-optimal conditions in sink habitats, thereby stabilising these sink-populations (Ferriere et al., 2004). The ability of a population to adapt to habitat change would be species-specific and therefore it is important to gather site-specific data at the proposed Yass windfarm precincts.

4.2 AFTER: MONITORING DURING OPERATIONAL PHASE

Appropriate monitoring options during the operational phase of a wind farm include:

- Carcass searches (Kunz et al 2007; (Brett Lane & Associates, 2005)
- Indirect disturbance impact assessments (Brett Lane & Associates, 2005)
- Avoidance studies (Brett Lane & Associates, 2005)
- Radar (weather information radar recording has also been used in the USA to assist in identifying migration routes and timing, as well as peak activity times/movement patterns of microbat species in relation to wind turbines; Kunz et al 2007).

Carcass searches

In most cases reviewed, monitoring for bird and microbat strike at wind farms has relied principally on carcass searches under turbines. Carcass monitoring involves searches for dead birds and bats within a 50m radius around the base of each turbine, in circular transects. This may be undertaken twice weekly (Hydro Tasmania 2003) and should be done equally within each season and during peak activity time for target species (breeding periods, summer activity, pre aestivation activity).

However, carcass searches alone have not proven to be an efficient monitoring method, as it provides a poor measure of population size and health. Carcass monitoring tends to underestimate the bird and bat fatalities (CaliforniaEnergyCommissionandCaliforniaDepartmentofFishandGame., 2007). This is likely to be due to:

- High level of search effort and searcher error,
- Injured animals may move out of the monitoring area, or under cover and so not be recorded (Sterner et al 2007)
- Subsequent deaths of a young after a female is killed or injured go unrecorded
- Predation of carcasses by foxes, rats, mice, birds etc (Kunz et al 2007)

Erickson *et al.* (2003) estimate that the mean carcass removal time, that is, the time it takes for scavengers to remove or a carcass to break down, is approximately 11 days for small birds and 33 days for large birds (in America), suggesting that searches should be done at least weekly. Other studies suggest scavenging rates are as high as 50-75% over one to four weeks after death (Brett Lane & Associates, 2005).

Conversely, this method alone could also overestimate the fatality rates, attributing deaths from other sources (such as vehicles) to turbines. Both monitoring at the control site (BACI design) and pre-operation monitoring can assist remove 'background' fatalities by providing baseline data (California Energy Commission and California Department of Fish and Game, 2007). Maintaining the BACI design for carcass monitoring is particularly important where there is moderate to high risk for any species before the implementation of mitigation measures, as the data will be more accurate (Brett Lane & Associates, 2005).

Indirect disturbance impact assessment

Changes in habitat utilisation (caused by indirect disturbance) can be monitored using habitat utilisation surveys, gradient studies and roaming surveys. Experimental design must be using BACI for operational phase monitoring to be meaningful. Survey effort for both phases should be equal to allow for comparison and statistical analyses (Brett Lane & Associates, 2005).

Avoidance studies

Avoidance studies attempt to figure out how a bird (or bat) responds when encountering turbines as well the success of avoidance responses, resulting in an avoidance rate figure (e.g. Brown Falcon 97% avoidance rate – manages to avoid turbine blades 97% of the time it encounters them). This information would be used for wind farm assessments in the future. Avoidance studies do not determine whether an area of habitat is avoided by a species due to the presence of turbines (Brett Lane & Associates, 2005).

4.3 REPORTING

Monitoring assists the future development of wind farms in Australia by providing a pool of data, collected using methods consistent with other wind farms, that will improve planning on upcoming projects. Information about the occurrence, magnitude, and reasons for bird and bat fatalities will help to refine the development of avoidance, minimisation, and mitigation measures for wind farm projects. Hence, regular (e.g. annual) publically available monitoring reports are fundamental to the usefulness of data (California Energy Commission and California Department of Fish and Game, 2007).

5 CONCLUSION

The risks of collision with wind farm infrastructure for birds and microbats relate to species ecology, environmental conditions and structural characteristics of the infrastructure proposed. The extent to which species may modify their utilisation of habitat may be influenced by a number of factors including; the pattern of infrastructure placement, the degree to which indirect and offsite impacts are managed, the distribution of habitat features before and after site development (for example, water bodies or perch opportunities) as well as species ecology.

A Bird and Bat Management Plan would be adopted for each of the Yass Wind Farm Precincts, recognising that the issues would likely be different at each precinct with regard to both target species and magnitude. Monitoring would be part of the Bird and Bat Management Plan. Any bird and microbat monitoring program should include a combination of techniques to measure impact. Monitoring should be well planned and designed as a Before –After – Controlled - Impact (BACI) study to collect valuable baseline data from which to compare future results.

The recommendations of this addendum report are:

1. Pre-operational monitoring of habitat utilisation by birds and microbats in order to acquire baseline data, acurately assess risk and calculate potential mortality rates
2. Impact avoidance and minimisation through good design and layout (informed by pre-operational monitoring data) and offsets (preferable to mitigation)
3. Impact mitigation and adaptive management where avoidance has not been possible. Mitigation strategies should be informed by pre-operational monitoring findings and be adaptive and responsive to findings during operational monitoring.
4. Operational monitoring of habitat utilisation and mortalities to calculate actual mortality rates and compare data to the precinct's baseline information and other wind farms
5. Annual reporting during the period of monitoring (one or more years) with reports publicly available for use in future wind farm developments

Further recommendations for monitoring and managing significant microbat species will come from the *Microbat Study,* and should be considered in concert with this addendum report.

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