Prepared for **Squadron Energy**

Bird and Bat Adaptive Management Plan V2

Boco Rock Wind Farm, NSW

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Table of contents

Figures

Tables

Appendices

Acronyms and abbreviations

AWS	Automatic weather station
BBAMP	Bird and Bat Adaptive Management Plan
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BCD	Biodiversity Conservation Division of DPE
BOM	Australian Bureau of Meteorology
BRWF	Boco Rock Wind Farm
BUS	Bird Utilisation Survey
CoA	Conditions of Approval
Cwth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment (Cwth) (formerly DoEE)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (formerly DAWE)
DPE	Department of Planning and Environment (NSW)
DPIE	(Former) Department of Planning, Industry and Environment (NSW) (now DPE)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
GIS	Geographic information system
ha	hectares
ID	identification
km	kilometres
m	metres
NSW	New South Wales
OEH	Office of Environment and Heritage, now BCD

SOD	Shut down on demand
Sp/spp	Species/multiple species
V	Vulnerable
WTE	Wedge-tailed Eagle
WTNT	White-throated Needletail

1. Introduction

1.1. Project Background

The Boco Rock Wind Farm (BRWF) was approved by the NSW Department of Planning on 9 August 2010 under Section 75 J of the *Environment Planning and Assessment Act 1979* (EP&A Act). Modification 1 of Approval MP09-0103 was granted by DPE on 23 December 2022, for the construction of up to 22 turbines for BRWF Stage Two. BWRF Stage Two has not commenced construction. BRWF is located in the Southern Tablelands of New South Wales (NSW), approximately 10 km south-west of the town of Nimmitabel.

BRWF Stage One commenced operation in December 2014 and consists of 67 GE 1.7-100 turbines mounted on 80m towers with blades approximately 49m long. The maximum blade tip height is 130m, and the minimum lower tip height is 31m above ground. The rotor-swept area is approximately 7,500m^2. Conditions of project approval by NSW Department of Planning (now Department of Planning & Environment, DPE) included an ongoing monitoring and management program to evaluate the operational impact of the wind farm to bird and bat species; a Bird and Bat Adaptive Management Plan (BBAMP). BRWF BBAMP v1 commenced in January 2015. The scope of this BBAMP is limited to Stage One only.

In its' ninth year of monitoring (2023), the BBAMP was updated following consultation with BCD and DPE to produce this document, BRWF BBAMP v2 (also limited to BRWF Stage One). The update of this BBAMP is pursuant to Conditions of Approval (CoA) 4.4c) of MP 09 0103 Modification 1, which enables the regular update of any plan required by the Approval, to ensure the updates incorporate additional measures or amendments to improve the environmental performance of the project.

1.2. Aims and Objectives

The overarching aim of this BBAMP is provided by CoA 3.3b) of MP 09 0103 Modification 1. Condition 3.3 is presented in full in Section 1.2.1

"… to assess the impact of the project on bird and bat populations… The monitoring program shall be capable of detecting any changes to the population of birds and/ or bats that can reasonably be attributed to the operation of the project…"

The objective of the BBAMP is to monitor the impact of the wind farm on bird and bat populations, to assess the potential impact of collisions on bird and bat pollutions; and to develop management measures to minimise the risk of collisions where a significant impact to a species is determined.

In accordance with Section 6.3 of the approved BBAMP v1.3, as the BBAMP is an adaptive plan, the survey design and intensity should be periodically reviewed and if required revised to ensure that the program is targeting species at greater risk of collision and potentially significant impact. As such, after eight years of operational monitoring of the BRWF (2015-2022 inclusive), the monitoring program has been updated to ensure the methodology is commensurate with the risk of collisions, and with the species at risk of significant impact.

This BBAMP v2 has been updated in consultation with BCD South East Planning, and the plan has been designed to:

1. Update the BBAMP for consistency with BCD South East Planning.

2. To provide an estimate of the number of birds and bats annually colliding with turbines at BRWF based on carcass searches, scavenger rates and carcass detectability.
3. Use annual mortality estimates to identify whether the operation of BRWF could be affecting local bird or bat populations, with particular focus on threatened species.
4. Target bird and bat surveys to increase the detection of particular 'at risk' species in order to more reliably inform management decisions to reduce collision risk.
5. Provide a framework for reducing survey effort over time if survey results remain consistent with observed outcomes from the 2015 to 2022 monitoring.

1.3. Conditions of Approval

The approval for the project includes a number of consent conditions required to be implemented as part of the project's construction and operation. Specific to the management of bird and microbat impacts, Condition of Approval (CoA) 3.3 sets out the requirement for a BBAMP, with a plan that sets out monitoring requirements, incorporates a decision-making framework, identifies 'at risk' bird and bat groups and/or areas within the site, identifies potential mitigation measures to reduce impacts and reports outcomes. The updated and approved BBAMP will be made available to the public via the project website in accordance with Schedule 2, Condition 5.1 of the development consent. CoA 3.3 is presented in full in Table 1-1

Table 1-1 CoA 3.3. of Project Approval MP 09 0103 Modification 1

Approval requirements	Section of BBAMP V2.0 (this document)
CoA 3.3 *Prior to the commencement of* ***construction of Stage One,*** *the Proponent shall prepare and submit for the approval of the Planning Secretary a* ***Bird and Bat Adaptive Management Program for Stage One****, which takes account of bird/ bat monitoring methods identified in the current editions of AusWEA Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia and Wind Farm and Birds: Interim Standards for Risk Assessment. The Program shall be prepared and implemented by a suitably qualified expert, approved by the Planning Secretary. The Program shall incorporate Monitoring, and a Decision Matrix that clearly sets out how the Proponent will respond to the outcomes of monitoring. It shall:*	This BBAMP V2.0 has been updated in consultation with BCD South East Planning. The DPE approved the nomination of Ms Deb Frazer as the suitably qualified expert on 9 January 2021. Section 1.4 summarises consultation.
a) incorporate an ongoing role for the suitably qualified expert;	Section 5.1
b) set out monitoring requirements in order to assess the impact of the project on bird and bat populations, including details on survey locations, parameters to be measured, frequency of surveys and analyses and reporting. The monitoring program shall be capable of detecting any changes to the population of birds and/ or bats that can reasonably be attributed to the ***operation*** *of Stage One, that is, data may be required to be collected prior to the commencement of* ***construction of Stage One;***	Section 5

Approval requirements	Section of BBAMP V2.0 (this document)
c) incorporate a decision making framework that sets out specific actions and when they may be required to be implemented to reduce any impacts on bird and bat populations that have been identified as a result of the monitoring;	Section 6
d) identify 'at risk' bird and bat groups, seasons (such as wet seasons where bird species may be attracted to nearby wetlands) and/or areas within the project site which may attract high levels of mortality and include monthly mortality assessments and periodic local population census' and bird utilisation surveys;	Section 4 identifies birds/bats and turbines Section 5 present monitoring program. Monitoring 2015-2022 has shown that seasonal influences and wetlands have not affected the impact (or lack therefore) of the wind farm on local bird and bat populations.
e) identify potential mitigation measures and implementation strategies in order to reduce impacts on birds and bats from Stage One such as minimising the availability of raptor perches, swift carcass removal, pest control including rabbits, use of deterrents, and sector management including switching off turbines that are predicted to or have had an unacceptable impact on bird/ bat mortality at certain times; and	Section 7
f) identify matters to be addressed in periodic reports in relation to the outcomes of monitoring, the application of the decision making framework, the mitigation measures identified, progress with the implementation of such measures, and their success.	Section 8
*The Reports referred to under part f) shall be submitted to the Planning Secretary on an annual basis for the first five years of **operation** and every two years thereafter from the commencement of operation (unless otherwise agreed to by the Planning Secretary), and shall be prepared within two months of the end of the reporting period. The Planning Secretary may, at the request of the Proponent, vary the reporting requirement or period by notice in writing to the Proponent. The Proponent may request the Planning Secretary to consider a variation to the reporting requirements at any time.*	Section 8
*The Proponent is required to implement **reasonable and feasible** mitigation measures for Stage One as identified under part e) where the need for further action is identified through the Bird and Bat Adaptive Management Program for Stage One, or as otherwise agreed with the Planning Secretary.*	Noted Section 7

1.4. Guiding documents and consultation

This BBAMP v2 has been developed in accordance with CoA 3.3 of the Project Approval (MP 09 0103 Modification 1). Consultation has been undertaken with the Biodiversity Conservation Division of DPE (BCD), South East Planning. NGH and Squadron Energy have consulted directly with BCD via meetings on 2 November 2022 and 7 June 2023 and by email in the intervening period between meetings. Topics covered during the consultation included:

- Survey effort and methodology (number of turbines, search radius and frequency)
- WTNT species surveys
- Turbine selection criteria
- Feasibility of using dogs instead of ecologists for carcass searches
    - It was agreed, dogs are not feasible at the site, due to complexity and unpredictability of amending existing lease agreements with host landowners
- Establishing impact triggers and significance impact levels
- Identifying suitable and feasible options for mitigation measures
- Providing raw data documentation and reports to BCD directly

NGH and Squadron have also sought input from environmental statisticians (Symbolix Pty Ltd) on the statistical aspects of this plan. Consultation with BCD is intended to be ongoing throughout the implementation of the BBAMP, triggered by specific events such as a threatened species mortality. The agency is provided with an assessment report (now biennial) and are consulted when management actions for threatened species are required.

2. Existing Environment

2.1. Regional Setting

BRWF is located near Nimmitabel on the Monaro Tablelands, NSW. Broadly, the Monaro Tablelands are located along the Great Dividing Range. The plateau of the Monaro Tablelands is located between two geographic areas renowned for their high biodiversity: the Australian Alps Range and the Great Escarpment of Eastern Australia (Pulsford *et al.* 2003). The grasslands of the Monaro plateau are bound on their eastern side by the low altitude coastal forests and wetlands of the South-East New South Wales, then the rainforests of the Great Escarpment and on their western side by the alpine forests and lakes of the Alps.

Due to their particular location and orientation (North-South), the Monaro Tablelands are on the pathway of birds and bats undertaking migratory and/or nomadic movements North-South bound (and vice versa) and/or East-West bound from the Murray-Darling catchment to the South-East Coast of the country (and vice versa).

2.2. Landscape Features

BRWF features mostly north-south aligned ridges near Nimmitabel at an elevation of around 1,000m. To the north and west of BRWF are a number of upland wetlands ranging from small ephemeral wetlands to large permanent waterbodies such as Boundary Lake and Coopers Lake. The majority of BRWF is utilised for low to moderate intensity sheep grazing over mixed native and exotic pasture. Thus, the habitat onsite consists of natural grassland, derived grassland and woodland patches. The ridges are mostly grassy with scattered trees and rock.

The McLaughlin River on the southern boundary of the site acts as a corridor for migrating and/or nomadic bird and bat species that use river systems and permanent water bodies as stepping stones for their inland movements. Patches of Snow Gum woodland are patchily distributed in the project area and a large area of woodland/open forest habitat occurs south of the wind farm.

3. Outcomes of BBAMP monitoring (2015-2022)

This section discusses the results and observations drawn from eight years of bird and bat monitoring at BRWF (2015-2022 inclusive). *Note: monitoring has continued throughout 2023 although analysis is not yet available.* The information has been used to inform the updated objectives and monitoring program of BBAMP v2.

3.1. Mortality Estimates

Statistical analysis of mortality monitoring data collected over eight years of the BRWF's operation has estimated a median of 470 birds and 447 bats lost over the period 2015-2022 inclusive. This represents around 59 bird and 56 bat strikes at BRWF per year between 2015 to 2022 (470 birds divided by 8 years; 447 bats divided by 8 years). The statistical report providing mortality estimates for years 1-8 is presented in Appendix B (note: refer to pages 9-12 of Appendix B). When taken year to year, there is a clear declining trend in annual mortality from 2015 to 2022. There was a peak in mortality in the first year of monitoring in 2015 with 119 birds and 160 bats estimated to have been stuck by a turbine. There has been a steady decline with some yearly variance to 2022. The estimated mortality in 2022 was approximately 21 birds and 15 bats.

3.2. Monitoring results and observations to 2023

The following results and observations are summarised, based on eight years of operational monitoring at BRWF (2015-2022 inclusive):

- Three threatened species carcasses have been detected: White-throated Needletail (WTNT - 2 carcasses found; listed Vulnerable at Commonwealth level), Grey-headed Flying-fox (1; listed Vulnerable at both NSW and Commonwealth level) and Large Bent-winged Bat (4; listed Vulnerable in NSW) carcases have been detected. Results to date do not indicate a significant impact to these species.
- Monitoring results were collated to inform an updated qualitative collision risk assessment for individual species (by NGH) and statistical risk assessment for individual turbines (by Symbolix). The most impacted species at BRWF to the end of 2022 (in terms of carcasses found), in descending order are: White-striped Freetail Bat, Gould's Wattled Bat, Eurasian Skylark, Australian Magpie and Nankeen Kestrel.
- No population scale effects have been detected for any bird or bat species through bird utilisation surveys or carcass searches.
- The operation of BRWF is not exerting a displacement effect on the local bird populations up to 500m from the turbine.
- Monitoring has detected a wide range of nomadic and migratory bird species that visit BRWF either regularly or sporadically in response to environmental conditions (particularly at nearby wetlands). However, there is no evidence that the operation of BRWF poses a threat to these species.
- Monitoring has identified a correlation between rainfall and bird species richness, although there is a lag between changes in environmental conditions and local populations. Changes in species richness at Bird Utilisation Sites (BUS) impact sites have been mirrored in control sites, indicating that BRWF does not appear to be affecting bird species and populations above the background environmental conditions.

- Threatened bird species have mostly been recorded in the woodland areas; there have been no correlations found between threatened woodland birds and collision mortality or displacement, indicating that BRWF does not appear to be affecting these species and populations.
- Microbat activity during colder months (April to October) is very low. A number of migratory microbat species visit during the warmer months (including Large Bent-winged Bat and White-striped Freetail Bat) and activity of resident species also peaks at this time.

3.2.1. Reducing carcass search effort

Recommendations arising from BRWF BBAMP Annual Reports for the past several years have been to reduce survey effort to reflect monitoring results and statistical outcomes demonstrating BWRF poses low risk to birds and bats. As a result, the aim of this updated BBAMP v2 is to reduce monitoring effort. BBAMP v2 is expected to commence in November 2023. The 27% proportion of turbines (refer to Section 5.2 for details) has been set in consultation with BCD South East Planning, despite the existing eight plus years of survey and despite the intention of an updated plan being to reduce survey effort. The survey effort for mortality monitoring, proposed in this BBAMP, will increase in terms of total area surveyed each month (BBMP v1.3 total search area 63.9 ha; BBMP v2 total search area 81 ha).

According to BCD, the new search radius (and increased hectare area) should result in an increase in modelled mortality estimates.

Notwithstanding, after the first year of monitoring under the updated BBAMP, if the statistical analysis and mortality analysis demonstrates a low risk to local bird and bat populations, the survey effort will be revised to a scale that is appropriate to the level of risk to avifauna; in consultation with BCD.

Each year, for the next 4 years of monitoring under the updated BBAMP (i.e. years 9, 10, 11, 12), a reduction in survey effort will be considered if:

- the new search radius does **not** result in a significant[1] increase in annual mortality estimate; and
- Trigger 2 for White-throated Needletail is not activated;

then the low risk detected during 2015-2023 will be deemed to have been upheld despite the increased survey effort. The proportion of turbines surveyed shall be reduced to an appropriate scale.

If after the 12th year of monitoring, results from year 9 to 12, are not substantially different from those gained in the first eight years and/or WTNT Trigger 2 has not been activated, the wind farm will be understood to pose a low (non-significant) risk to local bird and bat populations, including threatened species. At this point, monitoring may cease.

4. Risk Assessment

4.1. Turbine Risk Assessment

Prior to operation, higher risk turbines were defined as those in proximity to landscape features such as steep ridges, dense vegetation and aquatic habitat. For this updated BBAMP, Symbolix have performed model simulations to compare the number of mortalities estimated to have occurred at each turbine (based on actual carcasses found during 2015-2022. Refer to Appendix B pages 12-14 for details on statistical

[1] Annual variations in carcass finds and mortality estimates are to be expected. The change must be statistically significant.

methods. The resulting relative risk analysis (the risk of mortality occurring at one turbine relative to another at BRWF) provides four classes of risk based on estimated mortality for birds and bats separately, presented in Table 4-1 and Table 4-2. For the purpose of stratification, the four classes have been converted to two strata, low and high, as shown in the tables.

Table 4-1 Relative risk classes for turbines at BRWF for birds

Estimated mortality birds	Symbolix risk ranking	Turbine ID	BBAMP risk stratum
0-9	Low	2A, 2, 4, 7, 8, 9, 10, 12, 16, 18, 19, 21, 22, 23, 28, 29, 31, 33, 34, 37, 41, 45, 46, 47, 48, 50, 51, 55, 56, 58, 60, 61	Low
9-19	Moderate 1	6, 14, 15, 17, 20, 24, 30, 32, 35, 38, 40, 44, 52, 57, 59, 62, 64, 65, 66	Low
19-29	Moderate 2	1, 3, 5, 11, 13, 25, 26, 27, 39, 42, 43, 49, 53, 54, 63	High
29-39	High	36	High

Table 4-2 Relative risk classes for turbines at BRWF for microbats

Estimated mortality bats	Symbolix risk ranking	Turbine ID	BBAMP risk stratum
0-9	Low	3, 4, 6, 7, 8, 9, 10, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 26, 29, 30, 31, 32, 34, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 51, 57, 58, 61, 62, 63	Low
9-19	Moderate 1	2A, 5, 12, 17, 18, 25, 27, 28, 33, 35, 52, 53, 56, 59, 60, 64, 65, 66	Low
19-29	Moderate 2	2, 11, 49, 50, 54, 55	High
29-39	High	1	High

High risk stratum

The following 19 turbines have been sorted into the ‘high risk’ stratum for BRWF: 1, 2, 3, 5, 11, 13, 25, 26, 27, 36, 39, 42, 43, 49, 50, 53, 54, 55, 63. This includes turbines that Symbolix identified as high risk for birds only, bats only and both. Fifty percent (50%) of surveyed turbines have been randomly sampled from this stratum.

It must be noted however that the 'high risk' stratum represents only 28% of the turbines available (19 high risk ÷ 67 turbines at wind farm x 100%). This proportional bias will be accounted for during future statistical data analysis.

Low risk stratum

The following 48 turbines have been sorted into the 'low risk' stratum for BRWF: 2A, 4, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 40, 41, 44, 45, 46, 47, 48, 51, 52, 56, 57, 58, 59, 60, 61, 62, 64, 65, 66. Fifty percent (50%) of surveyed turbines have been randomly sampled from this stratum. It must be noted however that the 'low risk' stratum represents 72% of the turbines available (48 high risk ÷ 67 turbines at wind farm x 100%). This proportional bias will be accounted for during future statistical data analysis.

4.2. Species Risk Assessment

The initial 'at risk' bird and bat species list from BBAMP 1.3 has been revised based on mortality monitoring outcomes at BRWF. As such the current species risk assessment is for only those species that have been found during the last eight years of carcass searches. This risk assessment has been adapted from AS/NZS 4360 (now replaced by ISO031000) Risk Management Standard, where risk is a combination of likelihood and consequence. For this BBAMP, risk means the risk of a bird or bat species colliding with a turbine. For this species risk assessment, likelihood is relative and determined by the number of times a carcass has been found at BRWF based on 96 survey events undertaken between 2015-2022 (Table 4-3). Table 4-3 below is used to assess cumulative risk based on the 2015 to present monitoring period. Consequence (Table 4-4) used for this species risk assessment is based on potential population impacts which is informed by population size (where known), frequency of finds (whether carcasses are found regularly and/or whether they are found in groups – flocking behaviour increases the consequence of each event) and conservation status of the species.

Table 4-3 The likelihood of turbine collision for species known to have been impacted by turbine operation

Likelihood (qualitative)	% Survey events where species found (cumulative)	Cumulative number of carcasses found (2015-2022)
Rare An impact may occur only in unusual circumstances	<1 %	0 – 1 carcass
Unlikely An impact might occur at some time	≥1 < 5 %	> 1 < 4.8 carcass
Possible An impact could occur during	≥ 5 < 10 %	≥ 4.8 < 9.6 carcasses

Likelihood (qualitative)	% Survey events where species found (cumulative)	Cumulative number of carcasses found (2015-2022)
most circumstances		
Probable An impact is expected to occur in most circumstances	≥ 10 %	≥ 9.6 carcasses

Table 4-4 Consequence of turbine collision based on potential population impacts (informed by (DoE, 2015).

Consequence	Descriptor from BBMP v1.3	Population and conservation status
Insignificant	Impact on species not detectable in short term	Secure, abundant, common or introduced species.
Minor	Impact may cause non-significant changes to local abundance of species	Migratory or threatened species – annual mortality rate *unlikely* to exceed 0.1% of known population. Secure species – annual mortality rate *may* exceed 0.1% of local population.
Moderate	Impacts may cause significant changes to local abundance of species	Threatened or migratory species – annual mortality rate *likely* to exceed 0.1% of known population. Secure species – annual mortality likely to exceed 10% of known population.
Significant	Impacts may be significant at a population scale	Threatened or migratory species – annual mortality rate *likely* to exceed 1% of known population. Secure species – annual mortality rate likely to exceed 30% of the known population.

The consequence and likelihood outcome for each species is then used in the risk matrix below.

Likelihood	Consequence			
	Insignificant	Minor	Moderate	Significant
Rare	Low	Low	Moderate	High
Unlikely	Low	Low	Moderate	High
Possible	Low	Moderate	High	High
Probable	Moderate	High	High	High

The most commonly found carcasses are also the most commonly recorded bird and bat species during BUS and Anabat surveys: Eurasian Skylark, Australian Magpie, Gould's Wattled Bat and White-striped Freetail Bat. For most species, the number of carcasses found is equal to the frequency of finds. That is, usually just one carcass is found of a species during a mortality event. This is not the case for White-striped Freetail Bat; 58 carcasses have been found in 24 instances (an average of 2.4 carcasses per find).

Of note, waterbirds are not at risk at BRWF despite the presence of freshwater wetlands around the wind farm and the wind farm's regional setting. No waterbirds have been recorded during carcass searches from 2015 to 2022. The updated species risk assessment (Table 4-5) shows the following high and moderate risk species based on the likelihood and consequence criteria given in the tables above:

- Nankeen Kestrel – moderate risk
- White-throated Needletail (WTNT) – moderate risk
- Gould's Wattled Bat – high risk
- White-striped Freetail Bat – high risk

Table 4-5 Updated species risk assessment for all species found during carcass searches 2015 to 2022

Common Name	Species	**Total**	**Likelihood**	**Frequency**	**Conservation status**	**Consequence**	**Risk**
Australasian Pipit	*Anthus novaeseelandiae*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Australian Magpie	*Cracticus tibicen*	9	**Possible**	8	Secure	**Insignificant**	**Low**
Australian Raven	*Corvus coronoides*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Brown Falcon	*Falco berigora*	1	**Rare**	1	Secure	**Minor**	**Low**
Brown Goshawk	*Accipiter fasciatus*	1	**Rare**	1	Secure	**Minor**	**Low**

Common Name	Species	Total	Likelihood	Frequency	Conservation status	Consequence	Risk
Common Starling	*Sturnus vulgaris*	4	**Rare**	4	Introduced	**Insignificant**	**Low**
Eurasian Skylark	*Alauda arvensis*	15	**Probable**	13	Introduced	**Insignificant**	**Low**
Fairy Martin	*Petrochelidon ariel*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Grey Fantail	*Rhipidura albiscapa*	3	**Unlikely**	3	Secure	**Insignificant**	**Low**
Little Raven	*Corvus mellori*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Nankeen Kestrel	*Falco cenchroides*	7	**Possible**	7	Secure	**Minor**	**Moderate**
Peregrine Falcon	*Falco peregrinus*	2	**Unlikely**	2	Secure	**Minor**	**Low**
Raven sp.	*Corvus sp.*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Rufous Fantail	*Rhipidura rufifrons*	2	**Unlikely**	2	Migratory, secure	**Minor**	**Low**
Shining Bronze-cuckoo	*Chrysococcyx lucidus*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Silvereye	*Zosterops lateralis*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Southern Boobook	*Ninox boobook*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Stubble Quail	*Coturnix pectoralis*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Sulphur-crested Cockatoo	*Cacatua galerita*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Unidentifiable	*Unidentifiable*	3	**Unlikely**	3	n/a	**n/a**	**Low**
Wedge-tailed Eagle	*Aquila audax*	4	**Unlikely**	4	Secure	**Minor**	**Low**
White-throated Needletail	*Hirundapus caudacutus*	2	**Unlikely**	2	Threatened migratory	**Moderate**	**Moderate**

Common Name	Species	Total	Likelihood	Frequency	Conservation status	Consequence	Risk
Chalinolobus sp?	*Chalinolobus sp?*	1	**Rare**	1	Secure	**Insignificant**	**Low**
Large Bentwing Bat	*Miniopterus orianae oceanensis*	4	**Unlikely**	3	Threatened	**Minor**	**Low**
Gould's Wattled Bat	*Chalinolobus gouldii*	15	**Probable**	11	Secure	**Minor**	**High**
Grey-headed Flying-fox	*Pteropus poliocephalus*	1	**Rare**	1	Threatened	**Minor**	**Low**
Large Forest Bat	*Vespadelus darlingtoni*	1	**Rare**	1	Secure	**Insignificant**	**Low**
White-striped Freetail Bat	*Austronomus australis*	58	**Probable**	24	Secure	**Minor**	**High**

A revision of risk was undertaken for Large Bent-winged Bat (formerly Eastern Bentwing) and documented in *Risk Analysis: Eastern Bentwing Bat* (NGH Environmental 2016b). This report found that despite ecological characteristics suggesting the species is generally at higher risk of turbine collision (and barotrauma) than other bats, at BRWF the risk to Large Bent-winged Bat is moderate. This is due to:

- A clear migratory path not being evident at BRWF, based on Anabat surveys at BRWF during the migratory seasons.
- A low number of Large Bent-winged Bat call files obtained despite a high survey effort during appropriate seasonal timing, across two years of targeted surveys.
- No Large Bent-winged Bat calls obtained during Anabat surveys at nacelle height, suggesting that despite evidence (i.e. carcasses at the foot of turbines) that the bat does fly within the rotor-swept area, it does not do this regularly at BRWF.

5. Monitoring Program

5.1. Roles and Responsibilities

The specific roles and responsibilities of the five key stakeholders relevant to the implementation of this BBAMP are set in. The current holders of these positions may be updated as required without referral to DPE (Expert excepted).

Table 5-1 The roles as held at the time of writing (2023)

Role	Responsibility	Current (2023)
Operator	The Operator is ultimately responsible for the implementation of the BBAMP including managing landholders and making decisions in response to monitoring outcomes. This role is supported by the Ecologist. The Operator is responsible for submitting reports to the DPE on a biennial basis (once every two years). The Operator takes on all responsibilities formerly allocated to the Proponent.	Squadron Energy
Landholders	The Landholder works with the Operator to facilitate compliance with the BBAMP; this involves allowing access for monitoring or management actions and may also involve undertaking specific management actions, such as vegetation management, if the Landholder agrees to do so.	Various
Ecologist	The Ecologist is responsible for the specifics of BBAMP implementation along with accurate and timely reporting as set out in this plan. The Ecologist provides advice and recommendations to the Operator based on the ecological significance of monitoring outcomes. The Ecologist may involve sub-contractors for specialist aspects of the BBAMP, including field ecologists and statistics. The Ecologist will engage with BCD as required, and as directed by the Operator.	NGH Consulting
Expert	The Expert provides independent guidance to the Ecologist on an annual basis to ensure the implementation and outcomes of the program are technically and scientifically sound. The Expert has been approved by DPE and changes to the nominated Expert require approval from DPE.	Deb Frazer
Statistician	The Statistician provides advice when requested by the Expert, on the following matters: • Statistical modelling to define the survey design and intensity of the monitoring program. • Analysing data trends to recommend further investigation (field surveys or	Symbolix

Role	Responsibility	Current (2023)
	desktop) or to address potential triggers which may indicate an impact. The Statistician will provide statistical reports to support the preparation of the biennial assessment report, or to support the assessment of significant impact for an impact trigger.	

5.2. Carcass search methodology

Purpose: *Assess the impact of the project on bird and bat populations by estimating the annual number of turbine collision fatalities. Mortality rates are estimated for all bird species and all bat species combined and can also be considered for a particular species if sufficient data is available.*

The most common and widespread method of monitoring bird and bat mortalities for wind farm developments is the carcass search. This involves regular searches within a specified radius under operating wind turbines for bird and bat carcasses and remains. Any bird or bat carcass (complete or partial, including feather scatters) found in the turbine search area is assumed to have died due to turbine collision or barotrauma, unless the cause of death is obviously due to another cause (e.g. bullet wounds).

5.2.1. Search radius and detectability

Although research has shown that both visibility of carcasses and carcass density decreases with distance from wind turbines (Huso & Dalthorp, 2014; Hull & Muir, 2010), and that density approaches zero around 70 metres horizontal distance from turbines (Huso & Dalthorp, 2014), BCD request that searches be conducted to 120m horizontal distance from turbines.

Thus, a search radius of 120m[(2)] from the turbine tower will be used for each searched turbine, based on consultation with BCD South East Planning. BRWF is characterised by steep and rocky terrain and patches of dense vegetation, therefore visibility or detectability of carcasses is not equal throughout the search area of each turbine (NGH Environmental, 2016). Differing parameters around detectability need to be built into statistical assumptions in order to minimise bias (Maurer, Huso, Dalthorp, Madsen, & Fuentes, 2020). The previous methodology at BRWF (BBMP v1.3) accounted for this difference with 'high detectability' and 'low detectability zones' based on the road and pad search protocol.

Using a 120m radius, the total search area of each turbine is 45,239m^2 (4.5 ha) calculated by πr^2(π 120^2). Based on these zones, the assumptions built into the new search radii are that 2% (880m^2) of the search area is 'high detectability' and the remainder (98%) is 'low detectability'. The detectability rate previously calculated at BRWF for the high detectability zone (NGH Environmental, 2016) will be used.

Fresh detectability trials will be undertaken in the new search radius for an updated rate reflecting changed vegetation conditions and monitoring methodology since previous trials. If the models show that the new trial

[2] This increases the previous extended zone search radius from 80m.

results are not significantly different from the original trial result, the data should be aggregated (i.e. combine data obtained from BBAMP v1.3 with BBAMP v2). This maximises the precision of the search efficiency estimates, which in turn decreases the uncertainty on the overall mortality estimate. Field methods in detectability trials are to match carcass search methods; these are prescribed in Appendix B.

5.2.2. Turbine selection

Eighteen of the 67 turbines at BRWF will be searched monthly during the period October to April for two years (2023-2024), representing 27%[3] of the wind farm; this proportion has been negotiated with BCD. The number of turbines may be reduced following the first year of monitoring results, if these results are consistent with results from previous years (refer to Section 1.1 for details).

Turbines have been divided into two strata: High Risk and Low Risk, described in Section 4.1. To avoid selection bias that cannot be readily corrected during statistical analysis, nine turbines within each stratum has been randomly sampled using QGIS 'random selection tool' for a total sample size of 18 turbines. As discussed in Section 4, taking an equal sample size from strata which are not proportional (uneven distribution of turbines amongst strata) introduces a proportional bias where higher risk turbines are favoured (i.e. proportionally higher rate of sampling in the high risk stratum compared to low risk stratum). This will be accounted for during statistical data analysis.

Table 5-2 Randomly selected turbines from each stratum to be monitored.

Low risk turbine ID	High risk turbine ID
WTG 6	WTG 1
WTG 12	WTG 2
WTG 14	WTG 5
WTG 24	WTG 13
WTG 28	WTG 39
WTG 45	WTG 42
WTG 51	WTG 53
WTG 52	WTG 54
WTG 60	WTG 55

[3] 25% was the agreed proportion to be surveyed. Seventeen turbines is 25%, however, as an even number were desired, 18 turbines were chosen. This is 27%.

5.2.3. Timing and frequency

Carcass monitoring will be undertaken once per month during periods of highest seasonal risk to species of concern at BRWF, particularly threatened migratory birds and bats:

- White-throated Needletail – usually present in Australia between October and April
- Large Bent-winged Bat – active at BRWF between October and March
- White-striped Freetail Bat – active at BRWF between November and March
- Gould's Wattled Bat – most active at BRWF between October and April
- Wedge-tailed Eagle – nestlings fledge between October and December
- Nankeen Kestrel – present and active year-round at BRWF, however majority of observations (70%) and carcasses (70%) are found between October and April.

Thus, carcass searches will be undertaken monthly from October to April inclusive each year, for a total of seven survey events annually.

5.2.4. Data recording

Data recording will be undertaken electronically. Separate data sheets would be used for survey effort, found carcasses, incidental finds, detection records and scavenger records. Datasheets are provided in Appendix B.

All carcasses found will be removed from the search area to avoid re-counting during subsequent surveys and attracting predators. Although the updated BBAMP will commence during the ninth year of monitoring at BRWF, the new monitoring program is sufficiently similar, and the mortality estimator used sufficiently flexible, that data will be handled and analysed together with the data collected 2015-2023 under BBAMP v1.3.

5.2.5. Statistical analysis and bias

Statistical analysis will be undertaken by a suitably qualified statistician. Statistical methods are described in Appendix D. There are several sources of bias that will need to be accounted for during analysis. With carcass searches being undertaken over the seven months from October to April (rather than over 12 months), mortality estimates for annual mortality will be biased, as results for higher activity periods will be extrapolated to lower activity periods for the rest of the year; this will result in an overestimate for annual mortality rates (estimator bias). This can be qualified during discussion of mortality generally; however, it complicates comparison with previous years. If results are higher than for previous years, for example, it will not be possible to distinguish between estimator bias and a shift in mortality. For this reason, the comparison of year-on-year mortality estimates will be shifted to an October to April comparison. For example, the 2023/2024 mortality estimate (Oct-Apr) will be compared to the 2022/2023 October–April mortality estimate, yet to be calculated.

Proportional bias in surveying risk strata is another aspect of survey design that need to be accounted for statistically and was discussed in Section 4. Surveyor bias is accounted for by detectability trials already undertaken in 2015 (high detectability zone) to be updated in 2023 (low detectability zone) and scavenger bias is accounted for by scavenger trials undertaken in 2015.

5.2.6. Incidental Carcass Find

Personnel at the BRWF may find carcasses during day to day activities at the Project. The following protocol applies in this circumstance:

- The individual will notify the Site Manager immediately.
- The individual should provide, as a minimum, photographs to enable species identification, the location and distance from the nearest turbine.
- The Site Manager will immediately notify the Environmental Advisor, and complete the information required in Datasheet 1.
- If the species is not immediately identifiable, photographs will be provided to the Ecologist within one (1) business day of the find. The Ecologist must reply within two (2) business days for the possible reporting of an impact trigger.
- If the carcass is a threatened species, the impact trigger procedure described in Section 6 must be implemented by the Site Manager/Environmental Advisor.
- In order to avoid re-counting of the carcass, the carcass will be removed from the site.
- The Site Manager will pack the carcass into a plastic bag (gloves should be worn) and include a label marking the location and date. The carcass will be stored in a freezer for species confirmation by the ecologist at their next monitoring survey. The carcass may then be disposed.

This incidental carcass procedure will be included in site induction training for all on site personnel.

5.3. Bird surveys

Since 2015, bird utilisation surveys (BUS) have been undertaken at ten different sites each month, with approximately 120 BUS sites surveyed annually over the last eight years (more than 320 hours of bird survey undertaken). Sites have been stratified by habitat type: grassland and woodland. Within the grassland stratum, they are further divided into control (greater than 500m from a turbine) and impact (within 500m of a turbine) sites. The three stratification layers are independent of each other.

The assessment from these surveys concludes:

- Changes in bird species assemblage and richness detected in the grassland impact stratum have been mirrored in the control stratum. There is a correlation between local rainfall and bird species richness. Thus, operation of BRWF is not driving the change but rather other processes such as climate, resources, habitat change and stochastic events.
- Bird species assemblage and richness in the woodland stratum shows clear seasonal variation (with activity peaks between spring and autumn) but has generally been stable, indicating that these birds are not being impacted by BRWF.
- There has been little change year to year in the most frequently recorded species in both stratums; these are common and introduced species.

Given monitoring outcomes, bird surveys at BRWF will focus on species identified as moderate to high risk based on BUS and mortality monitoring between 2015-2022:

- White-throated Needletail (WTNT).
- Wedge-tailed Eagle.
- Nankeen Kestrel.

Survey data/results will be recorded in the datasheets provided in Appendix B.

5.3.1. White-throated Needletail

Rationale: *At present, WTNT have been detected only once (in a flock of 50) during BUS despite 320+ hours of survey. BCD have suggested that the survey method used for BUS is not ideal for detecting WTNT. Given that WTNT appears to utilise traditional roost sites* (DoE, 2015)*, we propose to modify surveys to incorporate the methods given in the referral guidelines (DoE 2015, p.18).*

Survey would be undertaken during the non-breeding migratory period when WTNT is present in southern Australia. Broadly, this is October to April. To date, WTNT has been recorded at BRWF in December and March. Results of more targeted surveys will verify whether occupation at the site is limited to a narrower window than October to April. If so, the survey window can be refined adaptively based on results of targeted surveys.

1. Evening roost survey

   Step 1 – Survey for roosting habitat within BRWF and a one kilometre buffer. Roosting habitat is described as 'tall trees along ridge tops" (DoE, 2015). This survey would be undertaken at the commencement of the updated BBAMP (v2). This would involve initially identifying stands of woodland along ridge tops within the BRWF area using aerial imagery and GIS contour layers. Prospective areas would then be surveyed in the field using rapid assessment points and habitat assessment. Based on our knowledge of the site (the project area and the surrounding landscape within involved properties), there are few locations likely to meet this criterion as the majority of the ridge lines are cleared.

   Step 2 – Monthly evening (dusk) point count surveys of birds coming into roost habitat identified by step 1. Beginning half an hour before sunset and finishing with darkness. This would involve identifying suitable vantage point watch locations using both GIS and ground truthing methods. One survey is to be undertaken each evening while on site for carcass searches.

2. Sky scanning from elevated viewpoints – opportunistically throughout time on site, e.g. during carcass searches. Regular scanning for flocks of White-throated Needletails. If a flock of needletails are observed, the number of birds and area of movement will be plotted on aerial maps, where possible.

5.3.2. Wedge-tailed Eagle and Nankeen Kestrel

Nesting survey

Monthly surveys, from October to December, of a Wedge-tailed Eagle (WTE) nest near turbines 58 and 65 has been undertaken every year since 2015. The nest was checked during each survey for the presence of chicks until the chicks fledged. The WTE pair have successfully fledged one or two chicks each year in 2016, 2017, 2018, 2019, 2020 and again in 2021.

The updated BBAMP proposes to continue WTE monitoring at this site and to include the following:

Step 1 – Using satellite imagery and eight years of BRWF survey experience, identification a subset of suitable habitat trees located 500m of a turbine.

Step 2 - Survey for Wedge-tailed Eagle and Nankeen Kestrel nests within selected suitable habitat trees located 500m of a turbine, in October/November. Nests would be mapped as either active or inactive at the time of survey, noting that eagle pairs may alternate use of several nests within a territory.

Step 3 – Check active nest sites (up to four based on proximity to turbines) identified in step 2 for signs of activity and fledging, from October to December. The following would be recorded:

- Date, nest ID.
- Signs of nest use (e.g. fresh sticks, carrion below).
- Presence and numbers of chicks inside/near the nest.
- Progress toward fledging based on feather status.
- Behaviour of adults/nestlings observed (e.g. feeding).

Site use survey

Monitoring of raptor movements will be undertaken opportunistically during each survey event at BRWF. During carcass searches or when ecologists are traveling across the site, the sky will be scanned regularly for raptors and information recorded on datasheets. When observed, the following information will be included:

- Date, location and time of observation.
- Species, number and age (adult, juvenile, 1st year, etc.) of birds.
- Duration of flight observation.
- Estimation of flight height above ground.
- Flight behaviour (e.g. soaring, circling, active flight (flapping), diving, quartering, gliding).
- Habitat over which the flight was observed.
- Other behaviours such as territorial displays.
- Flight paths plotted on aerial photographs or maps of the site.

5.3.3. Periodic census surveys

Pursuant to Condition 3.3, the Proponent may request the Planning Secretary to consider a variation to the reporting requirements at any time. As such, with regards to the requirement for *periodic local population census survey* (aka Bird Utilisation Surveys), as described in Condition 3.3d), these surveys will be discontinued under the updated BBAMP for reasons described in Section 5.3. The proposed targeted surveys described above will be continued instead.

5.4. Microbat surveys

Over the last eight years of monitoring, four Anabats have been passively deployed for four consecutive nights in each quarter of survey (16 nights, four times per year), to identify threatened and susceptible (to blade-strike/barotrauma) species. The monitoring results show that activity levels have clear seasonal variations and there is no correlation between activity levels and carcass finds for any species. As such, Anabat monitoring will be discontinued. Microbats will continue to be a focus for carcass monitoring.

6. Impact triggers and response management

CoA 3.3 c) requires a:

> '*decision making framework that sets out specific actions and when they may be required to be implemented to reduce any impacts on bird and bat populations that have been identified as a result of the monitoring.'*

This section establishes mortality events that would require Agency notification and/or consultation. This section also provides a procedure to determine the significance of an event and whether additional monitoring or application of mitigation measures are required.

Impact triggers and the corresponding decision-making framework are separated for threatened and non-threatened species. The objective is that the wind farm does not have a significant impact on the population of any bird or bat species. Government guidelines inform the approach adopted herein to determine significance of impacts, including:

- Matters of National Environmental Significance: Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (SEWPAC, 2013).
- EPBC Act Policy Statement 2.3 Wind Farm Industry (DEWHA, 2009).
- Referral guideline for 14 birds listed as migratory species under the EPBC Act (DoE, 2015).

6.1. Threatened species

6.1.1. Impact trigger

The threatened species impact trigger described in Table 6-1 has been established to determine when BCD notification is required. This trigger is based on approved BBAMP triggers at other NSW wind farms.

Table 6-1 Threatened species impact trigger

Impact trigger	Description	Notification	Further Action
Threatened species	One or more threatened species carcasses found during any survey event.	Ecologist to notify the Proponent immediately upon positive identification. Operator to notify BCD within 2 business days of notification.	Supplementary survey within 4 business days of the first observation, within the 120m search zone of the turbine and next adjacent turbine (total 3 turbines).

6.1.2. Significance category, significance level and management actions

The Referral Guideline (DoE, 2015) provides a useful measure of impact significance where estimates of population size exist for [migratory] species. The quantification is:

*"Actions which constitute serious disruption to an ecologically significant proportion of a population are those that are predicted to have **annual mortality rates** or affect breeding cycles of individuals meeting or exceeding the upper of the thresholds (1%). Actions likely to meet or exceed the lower thresholds (0.1%) should also be investigated further through more targeted surveys."*

On this basis, a tiered approach has been developed where threatened species impact significance is initially assigned into one of the below categories in Table 6-2 (definitions adapted from (Biosis, 2018)):

Table 6-2 Threatened species impact significance category and action

Impact Significance category	Definition	Action
'Low or unlikely' to exceed the lower threshold of 0.1%	The number of annual collisions is low and unlikely to have a substantial ecological effect on the local population.	No further action required. Provide a report to BCD within 10 business days of completing the supplementary survey. Report should identify the category of the Impact Significance.
'Uncertain or likely' to exceed the lower threshold of 0.1%	The number of annual collisions is low but there is uncertainty about the potential to cause a negative effect on the local population.	Determine significance level as per Table 6-3. Consult with BCD within 10 business days of completing the supplementary survey to determine suitable response actions, refer to Table 6-3.

Where a species is in the impact significance category 'uncertain or likely', additional 'significance levels' provide triggers to develop the most suitable management response, as described in Table 6-3. 'Significance levels' have been developed for threatened species that were detected during mortality monitoring at BRWF at the request of BCD:

- Large Bent-winged Bat *Miniopterus orianae oceanensis.*
- Grey-headed Flying-fox *Pteropus poliocephalus.*
- White-throated Needletail *Hirundapus* caudacutus.

Large Bent-winged Bat

Following detection of four Large Bent-winged Bat carcasses in 2015, a fatality management response procedure was developed for this species (BBMP v1.3), assessed as moderate risk (NGH Environmental, 2017). That procedure is now superseded by the decision-making framework in Section 6.2.3. The remedial actions listed in Table 6-3 will be adapted for Large Bent-winged Bat if required.

Grey-headed Flying-fox

One Grey-headed Flying-fox carcass was found in April 2019. A follow-up letter was sent to OEH in May advising that the mortality of Grey-headed Flying-fox was considered unusual and possibly related to drought conditions. Ongoing carcass searches have not found any further carcasses from this species. The decision-making framework in Section 6.4 addresses this species and actions in Table 6-3 may be adapted if required.

White-throated Needletail

Over almost nine years of carcass searching (Jan 2015 – September 2023), WTNT carcasses have been found twice:

1. March 2018 – one carcass found in the hardstand zone.
2. December 2020 – one carcass found in the hardstand zone.

Statistical analysis undertaken in 2021 by Symbolix estimated a mean of 21 WTNT losses for these years (or ~10 birds annually for the years a carcass was found). It was classified by Symbolix as a medium relative collision risk (relative to other species detected during carcass searches). In 2021 NGH assessed BRWF as presenting a low risk to the WTNT population. This is consistent with the risk assessment undertaken prior to the commencement of operational monitoring (in BBAMP v1.3).

Impact 'significance levels' and ameliorative actions have been developed for WTNT in consultation with BCD. The actions in Table 6-3 are based on Conditions of Approval and BBAMPs at other Australian wind farms where WTNT is known to occur as well as best practice overseas; they are therefore consistent with the current industry standard.

For WTNT, a key response is to increase targeted surveys within four days of a WTNT carcass find, in order to identify a cause for mortalities and to assess the level of the impact significance. The results of the surveys and assessment will lead to an appropriate remedial action in consultation with BCD.

Based on a population estimate of 41,000 individuals[4], 'Significance Level 1' occurs when 0.1% of the population (41 WTNT individuals) are thought to have been killed annually. 'Significance Level 2' occurs when 1% (410 individuals) are thought to have been killed annually.

In a wind farm carcass search, the actual number of carcasses found are unlikely to represent the annual mortality rate. The annual mortality rate is modelled based on carcasses found, detectability rates and scavenger rates along with other variables. Previous modelling for WTNT at BRWF has estimated that every one carcass represents around 10 birds. Using this modelling would allow for rapid response if WTNT

[4] The population of White-throated Needletail has not been quantified. Global estimates vary widely from between 10,000 – 100,000 breeding pairs in parts of Asia (DoE, 2018; BirdLife International, 2023). When determining eligibility to be listed as Vulnerable, TSSC (2019) states that the population size is *not* considered to be less than 10,000 mature individuals (TSSC, 2019). Yet, DoE (2015) recommends 100 individuals be considered 1% of the population, thereby assuming the White-throated Needletail population is around 10,000 individuals. Compared to the BirdLife (2023) estimates, the DoE estimate appears to be highly conservative. A recent wind farm approval by the DCCEEW sets out impact triggers for White-throated Needletails based on a population estimate of 41,000 individuals (DCCEEW, 2022). This most recent population advice (41,000) is the estimate that will be used for BRWF.

carcasses are found. Table 6-3 details the BRWF significance level for WTNT and the two bat species described above.

An evaluation of the effectiveness of response measures is to be provided to BCD in a report 12 months post implementation of the mitigation measure (refer to Section 8.1).

Table 6-3 Significance level definitions and response actions for WTNT (can be adapted for other threatened species when required)

Significance level	Significance definition	Response actions
Significance 1	≥0.1% < 1% population WTNT: Total of four or more carcasses detected between October-April survey period, which statistically represents ~41 birds[5] over a 12-month period.	• Increase surveys to understand local WTNT population and site usage to inform collision risk modelling. Survey methodology and program to be determined in consultation with BCD. • Quantitative collision risk modelling based on detailed site surveys specific to WTNT and the model chosen. • Determine periods of risk to WTNT. • Identify and implement suitable mitigation measures from the list provided in Section 7 and in consultation with BCD. • Monitor mitigation measures for effectiveness.
Significance 2	≥ 1% population WTNT: Total of ≥41 carcasses detected between October-April survey period, which statistically represents ~410 birds over a 12-month period.	Response depending on whether ≥41 carcasses are detected a) over a 12 month period or b) detected in low number (<3) of survey events within the 7 month period. Response to be negotiated with BCD but as well as those listed above, may include: • Temporary curtailment of involved turbines during migration months. • Investigation of Shut-down on Demand (SOD) programs.
Significance 1a	Repeated Impact trigger notifications, but no Significance 1 attained, over two consecutive survey seasons.	• Increase flight path survey effort to understand site usage. • Quantitative collision risk modelling. • Determine periods of risk to WTNT.

[5] Based on WTNT estimates provided in (Symbolix, 2021) and Appendix C.

6.2. Non threatened species impact significance

6.2.1. Impact trigger

The impact triggers described in Table 6-4 have been established to determine when BCD notification is required. These triggers are based on approved BBAMP triggers at other NSW wind farms. Trigger levels do not apply to introduced species.

Table 6-4 Non-threatened species impact trigger

Impact trigger	Description	Notification	Further Action
A carcass of a non-threatened raptor species	A total of three or more carcasses or parts thereof, of the same non-threatened raptor species in three consecutive months.	Ecologist to notify the Proponent upon identification. Proponent to notify BCD within 5 business days of notification.	Evaluate category of impact significance and provide conclusion (memo style report) to BCD within 10 business days of notification. See Table 6-5 for category definition.
Other non-threatened species	A total of ten or more carcasses, of the same non-threatened species, in two consecutive months at the same turbine.	Ecologist to notify the Proponent upon identification. Proponent to notify BCD within 5 business days of notification.	

6.2.2. Significance category

Where populations are known and reported by BCD for the period concerned, the category of impact significance for non-threatened species is described in Table 6-5. This table is informed by the 'common assessment method' used by NSW and the Commonwealth which is based on IUCN criteria for threatened species category listings (DCCEEW, 2022), and the NSW Threatened Species Test of Significance Guidelines. These additional surveys, investigations and assessments, and mitigation measures will be documented in a report. The report will be available for inspection by BCD or the Secretary of DPE if requested.

Table 6-5 Non-threatened species impact significance category and action

Significance category	Definition	Action
Unlikely to be significant at a relevant population scale	The number of annual collisions is low and unlikely to have a substantial ecological effect on the local population, giving consideration to	No further action

Significance category	Definition	Action
	effect on life cycle stages.	
Likely to be a significant impact at a relevant population scale	Based on effect on lifecycle, the number of annual collisions is likely to • lead to a greater than 50% reduction over a five-year period in the **local** population (where known) that utilises the wind farm; AND • act in an ongoing way to reduce the wider, regional population (where known) by more than 30% over a five-year period; OR • reduce the total species population (where known) by more than 10% over a five-year period.	Consultation with BCD to determine procedures and decision framework for additional monitoring if required. If further monitoring confirms that significant impact is likely, then mitigation measures may be required. Mitigation measures will be based on the species involved and the outcome of investigations. Evaluations and decisions will be undertaken in consultation with BCD.

6.2.3. Decision making framework for management actions

Figure 6-1 and Figure 6-2 documents the decision-making framework for an impact trigger and is based on similar recently approved BBAMP frameworks in NSW.

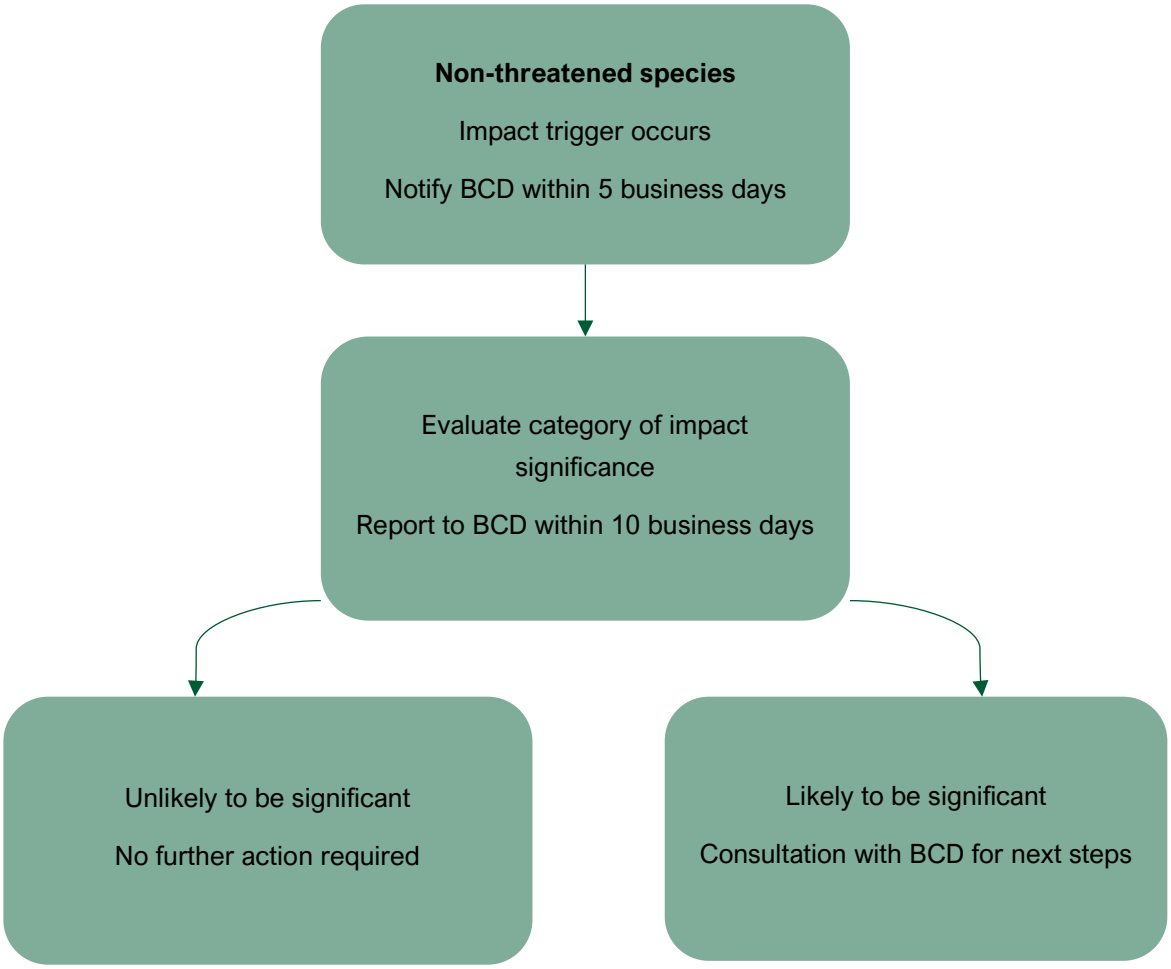

Figure 6-1 Decision-making framework for non-threatened species impact trigger

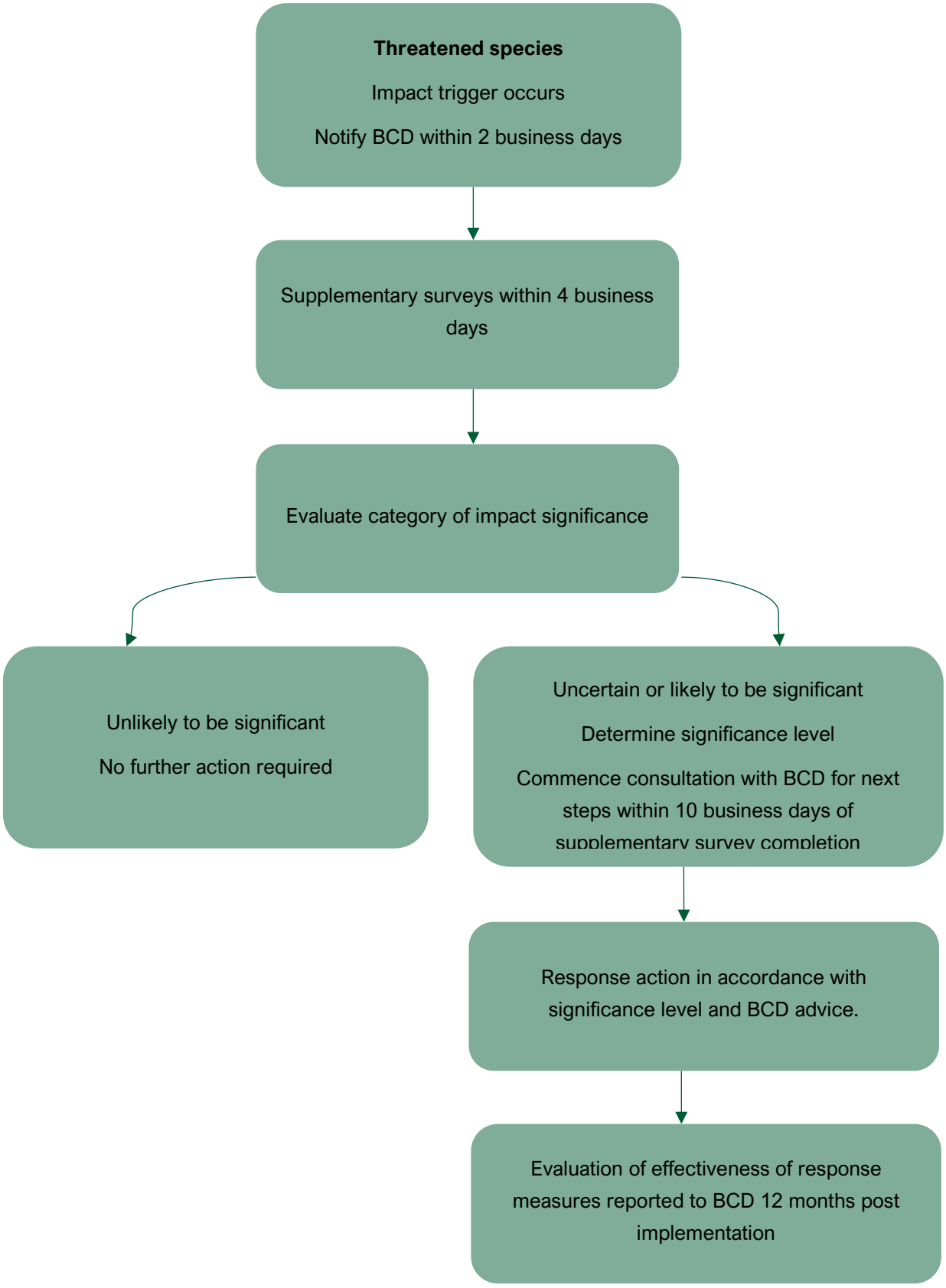

Figure 6-2 Decision making framework for threatened species impact trigger

7. Mitigation and adaptive management

7.1.1. Mitigation measures

Mitigation measures will be implemented in response to triggers to reduce impacts on birds and microbats. It should be noted that CoA 3.3 states that Squadron Energy is *"required to implement **reasonable and feasible** mitigation measures…"*. The measure taken in any given scenario will depend on the specific circumstances and species involved and will necessarily take into account the potential commercial impact upon the wind farm. A range of mitigation measures are listed below as response options; other suitable measures not listed here may be developed in response to an event:

- Increase in survey effort (generally undertaken to better understand the issue). Depending on the issue, this may entail expanded search area, greater intensity of surveys, changed timing of survey or specific targeted surveys for a particular species, either onsite or in the locality.
- Investigate ecological or environmental parameters in more detail (undertaken to better understand the issue) such as weather preceding the event, evidence of nesting.
- On site habitat modification *e.g.* removing livestock carcasses to reduce site utilisation by scavenging birds (as a way of reducing the risk).
- Offsite habitat protection and / or enhancement for the targeted species, particularly of breeding areas, to offset the increased mortality caused by the wind farm.
- Surveys to inform collision risk modelling for the targeted species.
- Quantitative collision risk modelling for a targeted species or suite.
- Update mortality estimates for the targeted species as required.
- Investigation of known deterrents for the targeted species *e.g.* bird scanners (as a way of reducing the risk).
- Flight path surveys to understand site usage of the targeted species.
- Determine periods of risk to targeted species based on ecology, environmental conditions and site data.
- Investigate long term mitigation such as altering wind turbine cut-in speeds, acoustic deterrents, radar systems, shut down-on-demand (SOD) program and so forth.
- Mitigation measures involving management of a threatened species would be implemented in consultation with BCD.

8. Reporting and reviewing

The aim of reporting is to document outcomes of monitoring (survey results and analysis) along with adaptive management. That is, document the application of the decision-making framework, mitigation measures identified, as well as progress and success (or otherwise) of measures. There are three reporting types for this project, expanded upon below:

- Formal reports.
- Raw results.
- Notifications and trigger specific.

8.1. Reporting requirements

Formal reporting

Pursuant to CoA 3.3, a report *shall be submitted to the Planning Secretary on an annual basis for the first five years of operation and every two years thereafter from the commencement of operation (unless otherwise agreed to by the Planning Secretary), and shall be prepared within two months of the end of the reporting period. The Planning Secretary may, at the request of the Proponent, vary the reporting requirement or period by notice in writing to the Proponent. The Proponent may request the Planning Secretary to consider a variation to the reporting requirements at any time*.

The next report is due to DPE for the 2022-2023 survey period. This report would have been due in February 2024. Upon acceptance from the Planning Secretary, the Monitoring Report will be submitted within **three** months of the end of the monitoring period for the updated BBAMP. Therefore, the next report will be submitted end of July 2024. The variation from two months to three months is a more feasible timeframe for analysing and compiling two years of monitoring data. The shift to extend the reporting period to include the seven months of monitoring under the new BBAMP ensures that those seven months of monitoring are analysed in one report.

The second biennial report would be submitted by end of July 2026, and would again cover seven months of monitoring from October 2024-April 2025 and October 2025 - April 2026.

The report will include:

- Summary of monitoring outcomes, including a list of any threatened species finds with BCD notification dates.
- Statistical analysis of mortality data (refer to Section 5.2.5) including calculating annual mortality estimates and comparison with mortality estimates produced in the years 2015-2022 (to determine whether scale back is acceptable in accordance with Section 3.2.1).
- Analysis of any anomalies in monitoring outcomes, data collection or statistical analysis.
- Discussion on triggers, application of decision-making framework, progress and efficacy of any mitigation measures enacted and ‘lessons learned' (adaptive management).
- Qualitative analysis of whether thresholds have been achieved for reducing carcass search effort in line with Section 3.2.1.

Raw results reporting

Raw results will be provided to the Operator using the spreadsheet in Appendix C on a monthly basis during the survey period (October-April) after data has been validated. Pursuant to requests from BCD, the raw data will be provided annually to the BCD within three months of the end of the monitoring period (i.e. October to April raw data will be compiled and provided by end of July).

Notifications and triggers

Notification procedures for trigger events are detailed in Section 6, along with BCD consultation and trigger specific reporting.

Table 8-1 Reporting requirements, responsibilities and timing

Report type	Provided by whom (responsibility)	Provided to	Timing
Post field work raw results	Operator	BCD by email rog.southeast@environment.nsw.gov.au	Within three months of end of reporting period, annually.
Notifications and triggers	Operator	BCD by email rog.southeast@environment.nsw.gov.au	Notify within 2 business days of threatened species trigger. Notify within 5 business days of non-threatened species trigger.
Significance category	Operator	BCD by email as above	Provide report within 10 business days of supplementary survey including category of Impact Significance.
Significance level	Operator	BCD by email as above	Evaluate effectiveness of response measure as per Table 6-3 within 12 months post implementation
Monitoring Report	Operator	DPE via Major Project Portal BCD by email rog.southeast@environment.nsw.gov.au	Within three months of end of reporting period on a biennial basis. Next report due end of July 2024 for 2022 and 2023 monitoring.

8.2. Reviewing

Pursuant to CoA 4.4c), with the approval of the Secretary, the BBAMP may be reviewed on a regular basis in order to improve the environmental performance of the Project.

As such, this BBAMP would be reviewed, where appropriate, to consider changes to the following issues:

- Efficiency and relevance of monitoring methodology.
- Species risk rating and trigger levels.
- Mitigation strategies.
- Notification procedures.
- Reporting requirements and frequency.

- Revisions would be carried out in consultation with the BCD, and approval sought from the Department.

8.2.1. Adaptive management

Adaptive management is the process of incorporating learning from the operation of the plan into the plan itself. In this case, as the document itself is static (requiring consultation and departmental approvals to modify), adaptive management is incorporated by:

- Setting objectives for mitigation measures.
- Monitoring the effect of mitigation measures to determine whether they meet objectives.
- Documenting the process in the reports prepared every second year.

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Appendix A BRWF Mortality Estimate

Symbolix Mortality Estimate report dated 19 July 2023 is appended overleaf (refer to pages 9-12 for cumulative mortality estimate for Years 1-8).

symbolix

Boco Rock Wind Farm Mortality Estimate - Year Eight

Prepared for NGH Environmental, 19 July 2023, Ver. 0.9

This report outlines an analysis of the eighth year mortality data collected at Boco Rock Wind Farm from 2022-01-19 to 2022-12-11. The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from trials in summer 2014-15 and winter 2015
- Scavenger loss rates – consisting of trials in August 2015.
- Mortality estimates - based on monthly surveys throughout 2022, and also all surveys conducted throughout 2015 - 2022

The data was collected and provided by NGH Environmental (NGH). A brief summary of the data is provided below, and the ultimate focus of this report is a discussion of the potential mortality.

Available data

The data was collected, verified and provided to us from NGH[1], and combined with previous years' supplied data.

Methodology overview

Mortality through collision is an ongoing environmental management issue for wind facilities. Different sites present different risk levels; consequently different sites have different monitoring requirements. In order to estimate the mortality loss at a given site (in a way that is comparable with other facilities) we must account for differences in survey effort, searcher and scavenger efficiency. We used a Monte-Carlo simulation to achieve this.

The analysis used survey data to estimate the average time to scavenge loss and searcher efficiency (and related confidence intervals). The algorithm then simulated different numbers of

[1] BRWF 2022 Mortality data sent to Symbolix v2.xlsx

virtual mortalities. We could then estimate how many carcasses were truly in the field, given the range of searcher and scavenger efficiencies, and the survey frequency and coverage, and the true "found" details. After many simulations, we can estimate the likely range of mortalities that could have resulted in the recorded survey outcome.

This method has been benchmarked against analytical approaches (Huso (2011), Korner-Nievergelt et al. (2011)). Its outputs are equivalent but it is able to robustly model more complex survey designs (e.g. pulsed surveys, rotating survey list).

Searcher efficiency

Two searcher efficiency trials were held (summer 2014-15 and winter 2015). A range of small, medium and large avian carcass sizes were used. For bird detectability, all carcass sizes were used, while for bat detectability only small sized bird carcasses were used.

No additional data has been collected since the original trials, and thus the analyses are unchanged. Tables 1 and 2 summarise the results.

Table 1: Detection efficiencies for small sizes (used for bat modelling).

Variable	Hardstand + Road	Extended Area
Number found	43	8
Number placed	51	38
Mean detectability proportion	0.84	0.21
Detectability lower bound (95% confidence interval)	0.71	0.1
Detectability upper bound (95% confidence interval)	0.93	0.37

Table 2: Detection efficiencies for all sizes (used for bird modelling).

Variable	Hardstand + Road	Extended Area
Number found	121	53
Number placed	131	111
Mean detectability proportion	0.92	0.48
Detectability lower bound (95% confidence interval)	0.86	0.38
Detectability upper bound (95% confidence interval)	0.96	0.57

On the hardstand and road, bat detectability is 84%, with a 95% confidence interval of [71%, 93%]. Bird detectability is 92% with a 95% confidence interval of [86%, 96%].

The detection rate is lower on the extended region. Bat detectability is 21%, with a 95% confidence interval of [10%, 37%]. Bird detectability is 48% with a 95% confidence interval of [38%, 57%].

Scavenger efficiency

An analysis of scavenger efficiency was also conducted at Boco Rock from the 31st August 2015 for a 28 day period. A mix of bats and other carcasses of various sizes were used to measure the scavenger activity – as bats can be difficult to source in the numbers required. Additional species including chickens, rats, quails, mice and one eagle.

The survey plan was defined by placing the carcasses in several locations in the site and checking the carcasses for up to four weeks, initially every 12 hours for the first three days, then daily for four days, then every two days for a week, then twice a week until the last day of survey.

Survival analysis (Kaplan and Meier 1958) was used to determine the average time until complete loss from scavenge. Survival analysis was required to account for the fact that we do not know the exact time of scavenge loss, only an interval in which the scavenge event happened. In threes cases we have "right-censored" intervals, as an eagle and two chickens were still found on the ground the final day of the survey. By performing survival analysis we can estimate the average survival percentage after a given length of time, despite these unknowns.

No additional data has been collected since the original trials, and thus the analyses remain unchanged.

The mean time to total loss via scavenge is 7.8 days, with a 95% confidence window of [5.3, 11.3] days.

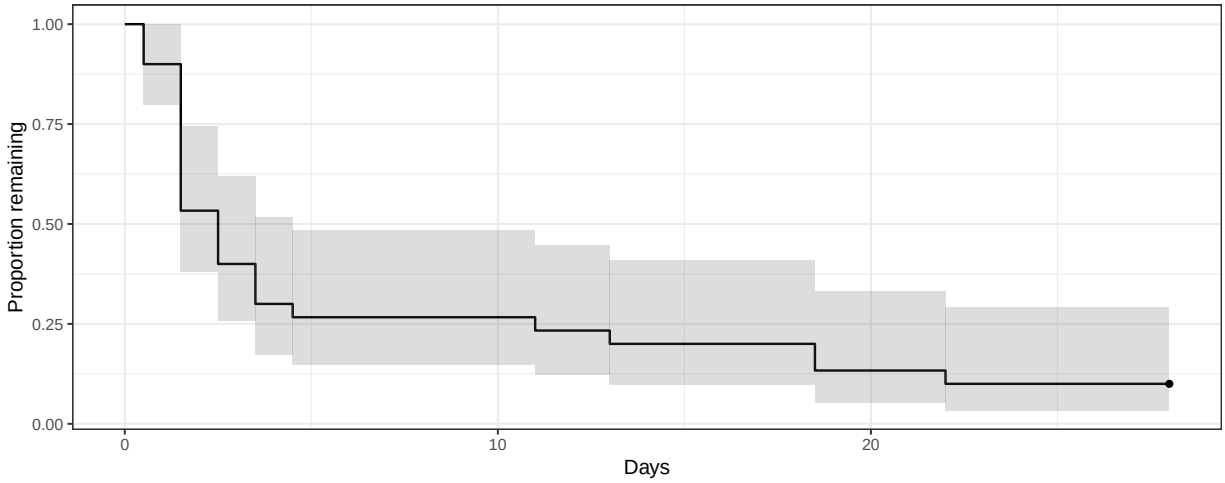

Figure 1: Combined survival curves for birds and bats, with 95% confidence interval shaded.

Other scavenger patterns

There are three general types of scavenger behaviour:

- "perfect"
- "olfactory"; and
- "visual"

These names are classifiers only, and not necessarily accurate descriptions of the actual processes employed by the scavenger. A "perfect" scavenger will find the carcass with constant efficiency, irrespective of the amount of time it has lain on the ground. "Visual" scavengers are more efficient in the earlier period post-mortem, and are less likely to find a carcass the longer it has lain there. "Olfactory" scavengers are the opposite of "visual" scavengers. They require the carcass to lie for some period, before their efficiency of detection increases.

Due to the small number of trials, we have focused on the mean loss rate, and not the shape. This means that we have assumed all scavengers to be "perfect", which is the middle of the two other types.

Mortality projection inputs

Carcass search data

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 3.

The searched areas consisted in two zones.

The high detectability search area is:

- each turbine's hardstand area
- an approximately 4x120m road.

Searches were conducted at 4 m transects within the search area. The hardstand / road zone around the turbines was searched twice per survey month for each turbine (Table 3).

The low detectability (extended) search area is:

- **pre June 2019**[2]: an approximately 80x80m section sharing a border with the hardstand. The center of the extended section edge is aligned with the center of the hardstand edge.
- **post June 2019**: a circular area with radius 80m, centered on the turbine, excluding the hardstand and access road

Searches were conducted at 12 m transects within the extended search area in the "pre" setting, and at 10 m in the "post" setting. The extended area was searched once per survey month for 21 turbines.

Custom shape files were generated for each turbine's search area.

[2]This only applies to the combined Years 1-7 estimate, not to the Year 7 estimate.

Table 3: Number of surveys per month in 2022.

Month	Extended Zone Surveys	Hardstand / Road Surveys
Jan	21	134
Feb	21	134
Mar	21	134
Apr	21	134
May	21	134
Jun	21	134
Jul	21	134
Aug	21	134
Sep	21	134
Oct	21	134
Nov	21	134
Dec	21	134

Mortality estimate - year eight

Methodology

With estimates for scavenge loss and searcher efficiency we then converted the number of bat and bird carcasses detected into an estimate of overall mortality Boco Rock from 2022-01-01 to 2022-12-31.

The mortality estimation is done via Monte-Carlo simulation. We used 20000 simulations with the survey design simulated each time. Random numbers of virtual mortalities were simulated, along with the scavenge time and searcher efficiency (based on the measured confidence intervals). The proportion of virtual carcasses that were "found" was recorded for each simulation. Finally, those trials that had the same outcome as the reported survey detections were collated, and the initial conditions (i.e. how many true losses there were) reported on.

The complete set of model assumptions are listed below.

- There were 67 turbines on site.
- Search frequency for each turbine was taken from a list of actual survey dates (see Table 3 for a summary).
- Mortalities were allowed to occur from 2022-01-01 until 2022-12-31.
- Birds are on-site at all times during this period.
- Bats are on-site at all times during this period.
- Finds are random and independent, and not clustered with other finds.
- There was equal chance of any turbine individually being involved in a collision / mortality.
- We assumed an exponential scavenge shape ("perfect" scavengers).
- We took scavenge loss and search efficiency rates as outlined above.
- The survey design involved searching every turbine twice per month on the hard-stand/access road. It also involved searching 21 turbines in the extended zone once per month. We estimated the "coverage factor" for the survey procedure - i.e. the total fall zone surveyed for birds and bats (using estimates from Hull and Muir (2010))[3].
  - For the hardstand/road we estimate that around 45% of the bat and 26% of the bird fall zone was searched per turbine (on average).
  - For the extended zone, around 55% of the bat and 62% bird zone was searched on average.

[3]Note that these values are indicative - the actual coverage factor calculation involves a complex weighted average which accounts for the different parts of fall zone searched at each survey at each turbine, and cannot be summarised with a single value for the whole survey.

Mortality projection results

After running the simulation we investigated the distribution of mortalities that could have resulted in the actual numbers found during the surveys. The breakdown of found carcasses per species are summarised in Table 4.

Table 4: Carcasses found during formal surveys in the eighth year of surveying.

Species	Bat	Bird
White-striped Freetail Bat	2	
Common Starling		1
European Skylark		1

No carcasses were found incidentally in 2022.

Bat mortality estimate – results

During the eightth year of surveys a total of two bats were found during formal surveys (Table 4). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is a median of 15 bats lost on site over the 12 months.

Table 5 and Figure 2 display the percentiles of the distribution, to show the confidence interval in this value.

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a median site loss of around 15 bats over the survey period, and are 95% confident that fewer than 38 individuals were lost.

Table 5: Percentiles of estimated total bat losses over the eighth year of surveying.

0%	50% (median)	90%	95%	99%	99.9%
2	15	30	38	53	62

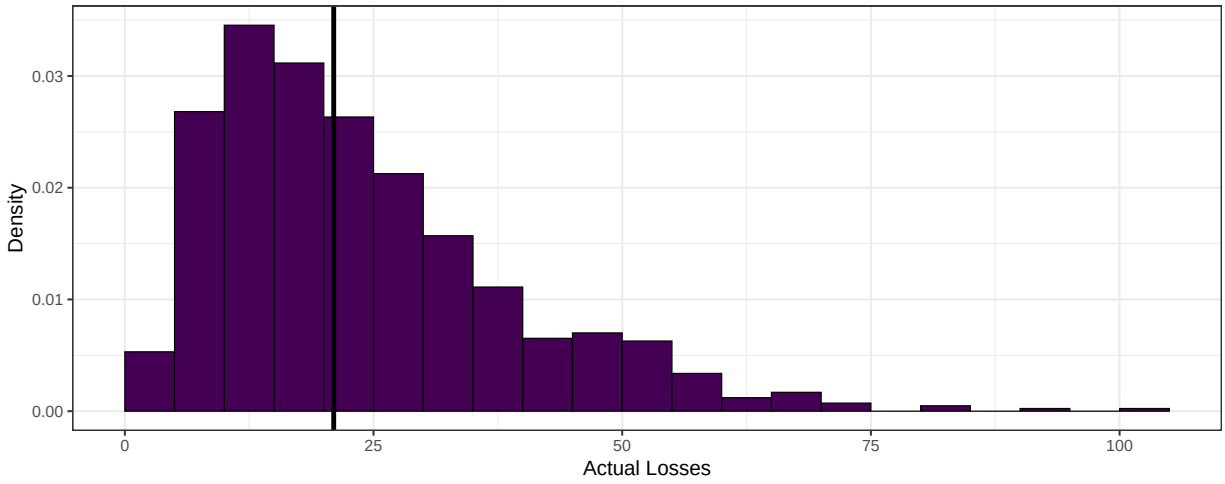

Figure 2: Histogram of the total losses distribution (bats), given 2 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During the eight year of surveys a total of two birds were found during formal surveys (Table 4). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is a median of 21 birds lost on site over the 12 months.

Table 6 and Figure 3 display the percentiles of the distribution, to show the confidence interval in this average.

Based on the detected carcasses and feather spots and measured detectability and scavenge rate, we expect that there was a total site loss of around 21 birds over the survey period, and are 95% confident that fewer than 38 individuals were lost.

Table 6: Percentiles of estimated total bird losses over the eighth year of surveying.

0%	50% (median)	90%	95%	99%	99.9%
2	15	30	38	53	62

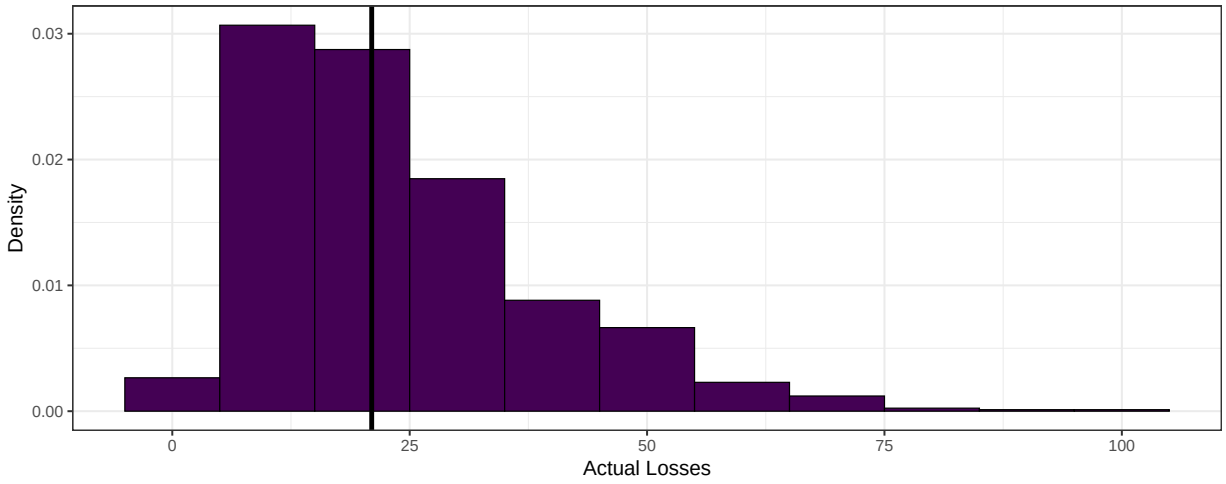

Figure 3: Histogram of the total losses distribution (birds), given 2 were detected on-site. The black solid line shows the median.

Mortality estimate - years one to eight combined

Methodology

The methodology for the combined estimate is the same as above.

The coverage factors have been updated:

- For the extended zone, around 14% of the bat and 17% bird zone was searched on average (pre June 2019). Post June 2019, see the Year Eight estimates.

Mortality projection results

The breakdown of found carcasses per species from 2015-2022 are summarised in Table 7.

Table 7: Carcasses found during formal surveys in eight years of surveying.

Species	Bat	Bird
Chalinolobus sp.	1	
Gould's Wattled Bat	15	
Grey-headed Flying-fox	1	
Large Bent-winged Bat	3	
Large Forest Bat	1	
White-striped Freetail Bat	51	
Australian Magpie		9
Australian Raven		1
Brown Falcon		1
Brown Goshawk		1
Common Starling		4
European Skylark		15
Fairy Martin		1
Grey Fantail		3
Little Raven		1
Nankeen Kestrel		6
Peregrine Falcon		1
Rufous Fantail		2
Shining Bronze-Cuckoo		1
Silvereye		1
Southern Boobook		1
Stubble Quail		1
Unidentified Bird		3
Wedge-tailed Eagle		3
White-throated Needletail		2

Bat mortality estimate – results

During eight years of surveys a total of 72 bats were found during formal surveys (Table 7). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is a median of 447 bats lost on site over the eight year period.

Table 8 and Figure 4 display the percentiles of the distribution, to show the confidence interval in this average.

Based on the detected carcasses and measured detectability and scavenge rate, we expect that there was a median site loss of around 447 bats over the survey period, and

are 95% confident that fewer than 609 individuals were lost.

Table 8: Percentiles of estimated total bat losses over eight years of surveying.

0%	50% (median)	90%	95%	99%	99.9%
294	447	575	609	664	752

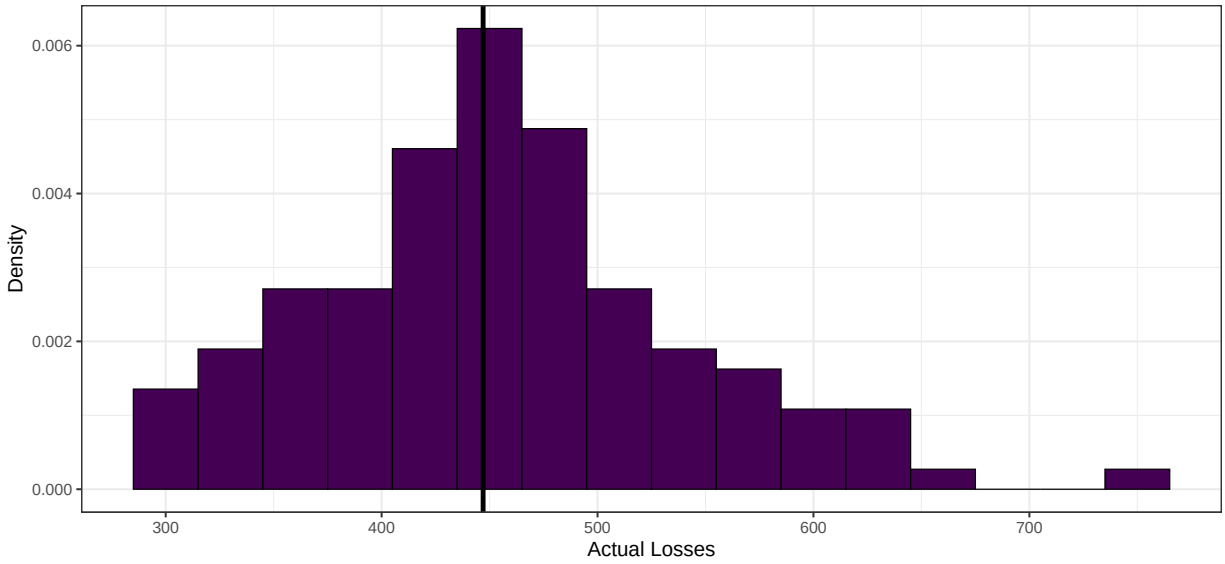

Figure 4: Histogram of the total losses distribution (bats) over eight years, given 72 were detected on-site. The black solid line shows the median.

Bird mortality estimate - results

During eight years of surveys of surveys a total of 57 birds were found during formal surveys (Table 7). The resulting estimate of total mortality, accounting for searcher efficiency, scavenge rate, search area and timing of surveys is a median of 470 birds lost on site over the eight year period.

Table 9 and Figure 5 display the percentiles of the distribution, to show the confidence interval in this average.

In determining the estimate, we have used the standard practice of assuming that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.

Based on the detected carcasses and feather spots and measured detectability and scavenge rate, we expect that there was a median site loss of around 470 birds over the survey period, and are 95% confident that fewer than 668 individuals were lost.

Table 9: Percentiles of estimated total bird losses over eight years of surveying.

0%	50% (median)	90%	95%	99%	99.9%
258	470	636	668	766	839

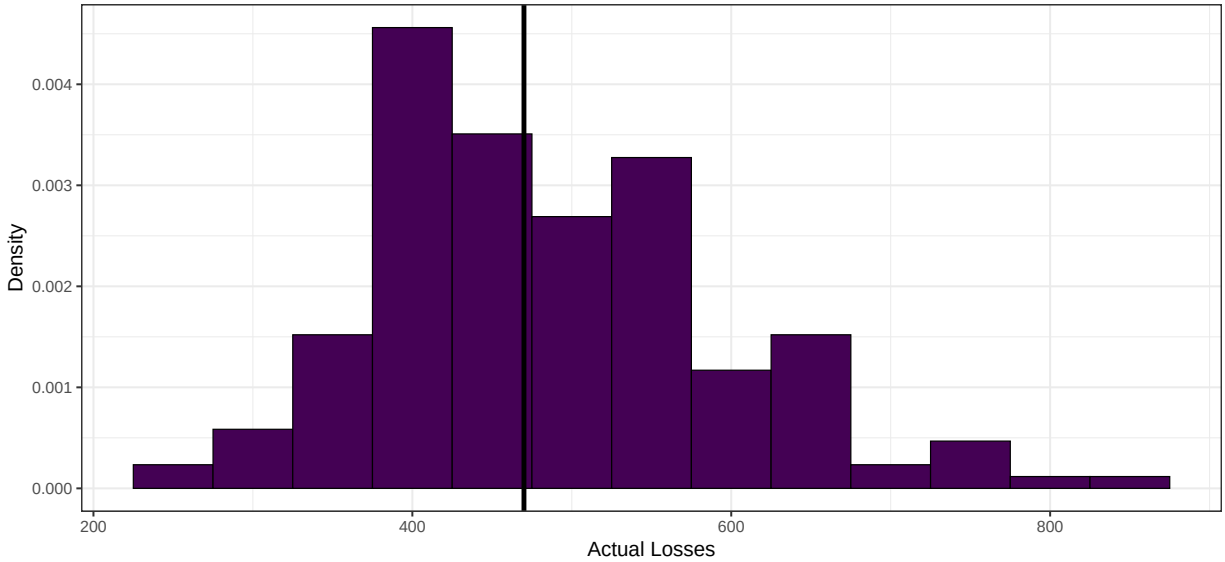

Figure 5: Histogram of the total losses distribution (birds) over eight years, given 57 were detected on-site. The black solid line shows the median.

Mortality estimate - per-turbine relative risk

The purpose of this is the provide a per-turbine assessment of relative risk, for bats and birds.

Methodology

The methodology for the combined estimate is the same as above, with the exception of the number of simulations has been reduced to 8000. A simulation has been run for each individual turbine, and compared to the number of finds at each turbine.

To succinctly compare the quantity of data and look for spatial patterns, we have taken the median mortality estimate for each turbine and species class (bat/bird), and plotted them on a map. The medians have been grouped into bins: [0,9], (9,19], (19,29], (29,39], to examine broad patterns in relative risk. Figure 6 shows the relative risk for each turbine.

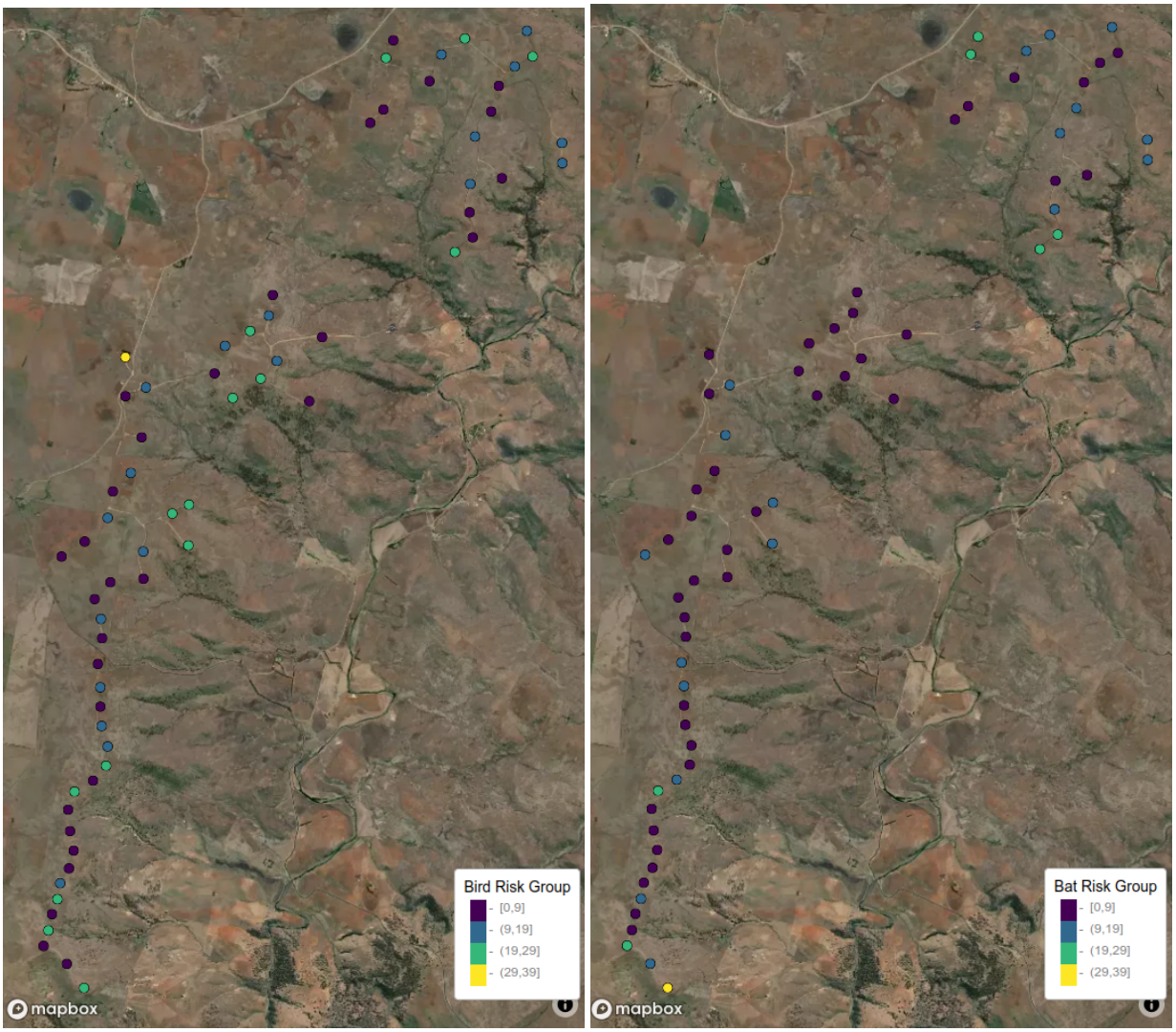

Figure 6: Relative risk of each turbine, for birds (left) and bats (right).

This indicates that:

- birds have a flat risk profile across the site, with weak evidence for the middle of the site having a higher risk profile
- bats have a flat profile across most of the middle of the site, with the north-east and very south portions having a higher risk profile

Concluding remarks

In evaluating the potential impact, it is important to remember that all mortality estimators have an inherent assumption that there is an unlimited supply of carcasses to be found. In

particular, we did not apply an upper limit on the number of bats that could be onsite, and we assumed that bats were present all year round. The ecological feasibility of this assumption should be accounted for if using these results to comment on overall ecological impact.

References

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Appendix B Field methods and data sheets

B.1 Mortality datasheets

Datasheet 1 (carcass search results) forms the basis of the raw results report for statistical analysis and accurate documentation, this data needs to be linked with survey effort, weather conditions and incidental finds (recorded separately). These datasheets follow overleaf and are to be completed for each mortality survey event.

For every carcass found the following is to be noted:

- Turbine ID
- Date
- Distance and bearing from the turbine
- GPS location of carcass
- Distance from the observer to the carcass at the instant of detection
- Species and sex (if identifiable)
- Age and condition of carcass (complete, partially scavenged, feather spot)
- Fate of carcass (stored in freezer, left outside of search area)
- All carcasses found will be removed from the search area to avoid re-finding during subsequent surveys and attracting predators.
- Other notes.

Datasheet 2 is for survey data:

- Turbine id
- Survey date
- Start and end time
- Carcass found (yes/no)
- Ground search conditions (rocky, high grass, patchy ground cover, forest, etc)
- Comments – anything of interest or unusual noted by searcher.

Datasheet 3 is for weather conditions, datasheet 4 is for incidental finds.

Mortality 1: carcass finds

Turbine ID:	Month	Date	Common Name	Number	Threatened (Yes/No)	Condition:	Distance of carcass from tower (m)	Bearing of carcass from tower (deg)	Easting:	Northing:	Sex	Age	Notes:	Location	Carcass Mgt
			Only fill out this data sheet for carcasses found. Use weather conditions sheet for other survey information												

Mortality 2: survey effort

Wxuelqh#LG	Vxuyh|#gdwh	Vwduw0hqg#wlph	Carcass found?	Ground search conditions	Comments
4					
5					
8					
9					
45					
46					
47					
57					
5;					
6<					
75					
78					
84					
85					
86					
87					
88					
93					

Mortality 3: survey conditions

Month	Date	Weather conditions	Temp	Wind speed	Wind direction	Rain Y/N	Carcass/es found Y/N	Any turbines not searched?

Mortality 4: Incidental finds

Turbine ID:	Month	Date	Common Name	Number	Threatened (Yes/No)	Condition:	Distance of carcass from tower (m)	Bearing of carcass from tower (deg)	Easting:	Northing:	Found by whom?	Carcass Mgt

B.2 Targeted bird surveys

Surveys for WTNT roosting habitat will be undertaken in the early months of the implementation of BBAMP v2.

Bird datasheet 1 is for Sky scanning for WTNT. The following will be recorded:

- Date, location and duration of observation period
- Number of birds
- Estimation of flight height above ground
- Flight behaviour (e.g. soaring, circling, active flight (flapping)
- Habitat over which the flight was observed
- Whether the observation appears to be associated with a frontal system (identified by ground observations of clouds, wind, etc.)

Bird datasheet 2 is for raptor nesting. The following would be recorded:

- Nest ID – this is a survey identification number that is linked to a GPS point and includes species identification (e.g. WTE01 for a Wedge-tailed Eagle nest or NK01 for Nankeen Kestrel nest)
- Easting and northings (from GPS point)
- Survey date
- Nearest turbine
- Signs of nesting (sticks or nesting material on ground, fresh nesting material in nest, prey remains on ground around nest tree, pellets found around nest tree, behaviour of adults, etc).
- Nesting stage (preparing nest, egg laying or sitting, hatchlings, regurgitating food for hatchlings, feeding eaglets fresh food, fledging, left nest)
- Comments – any additional information relevant to survey.

Bird datasheet 3 is for raptor site use surveys. When raptors are observed, the following information is to be recorded:

- Date, location (including nearest turbine), time and duration of observation.
- Species, number and age (adult, juvenile, 1st year, etc.) of birds.
- Duration of flight observation.
- Estimation of flight height above ground.
- Flight behaviour (e.g. soaring, circling, active flight (flapping), diving, quartering, gliding).
- Habitat over which the flight was observed.
- Other behaviours such as territorial displays.
- Flight paths plotted on aerial photographs or maps of the site.

Birds 1: sky scanning WTNT

Date	Time start	Time finish	Flight behaviour	Flight height	Number	Habitat	Easting:	Northing:	Notes:	Weather?

Birds 2: raptor nests

Qhvw#LGH		Q	Vxuyh|#gdwh	Qhduhvw# wxuelqh	Signs of nesting	Nesting stage	Comments

Birds 3: raptor use

Date	Time start	Time finish	Species	Flight behaviour	Flight height	Number	Easting:	Northing:	Location (broad habitat & nearest turbine	Flight path ID

B.3 Detectability trials

The carcass detectability trial will be conducted in the first year of implementation of the updated BBAMP and coincide with the carcass searches to maximise survey efficiency. That is, a small number of carcasses will be distributed at one or more turbines each month between November 2023 and April 2024. This will sample the warm season higher vegetative growth period that surveys are to be conducted in. The carcass detectability trial will be conducted at a subset of up to six randomly selected searched turbines as per Table 9-1 (three from each risk stratum).

Table 9-1 Turbines randomly assigned to detectability trials

Turbine ID	Low risk stratum	High risk stratum
1		✓
13		✓
42		✓
12	✓	
28	✓	
52	✓	

The detectability trial will involve one surveyor (controller) randomly placing carcasses within the 120m radius search area of the selected turbines. The locations of the carcasses will be unknown to the searcher. The number of replicates required per carcass size and/or type is shown in Table 9-1.

Table 9-2 Number of replicates for detectability trials for each carcass type (bat/bird) and size (large/medium) class. Microbats are surrogates for small birds.

Season	Microbat	Medium sized birds	Large-sized birds
Warm season (October to April) – high vegetation biomass conditions	10	5	5

The carcasses used for the trials will be chosen to reflect all three different sizes (small, medium and large) of bats and birds that are known for the BRWF. Carcasses previously found on site and stored frozen will be used where available. To supplement these, feathered birds such as Indian Mynas (from control programs), quail, and furred mice and rats may be used. Note that unfeathered carcasses (such as chicken frames) may not be used.

Results and analysis will be discussed in the Monitoring Report. See Section 8.1 for details.

Appendix C Statistical methodology

Overleaf is the statistical methodology for deriving annual mortality estimates by Symbolix Pty Ltd dated 1 August 2023.

symbolix

Mortality Estimation Methods

Prepared for NGH Environmental, 1 August 2023, Ver. 1.0

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1 Methods overview

The objective of a wind farm post-construction mortality program is to understand and quantify the impact on species of concern. This is done by estimating the local mortalities during a specific time period.

Best practice (Huso 2011) requires an estimator of the form:

$$\hat{M}_{ij} \cong \frac{C_{ij}}{\hat{g}_{ij}} \tag{1}$$

where

- $\hat{M}_{ij}$ is the estimated mortalities at turbine i during search j
- C_{ij} is the number of carcasses found
- $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

For a given turbine, $\hat{g}_{ij}$ is a function of

$$\hat{g}_{ij} \cong a_i r_{ij} p_{ij} \tag{2}$$

- a_i is the fraction of total carcasses within the searched area.
- r_{ij} is the fraction of the carcasses that arrived at turbine i but have not been lost to scavenge or decay before search j.
- p_{ij} is the probability that an existing carcass will be detected by the searcher.

The following sections outline how we estimate $\hat{\mathbf{a}}$, $\hat{\mathbf{r}}$ and $\hat{\mathbf{p}}$. $\mathbf{C}$ is given by the field observation data.

Our final task is to estimate $\hat{M}$ for each group of turbines and species.

One limitation of analytical methods is estimating r_{ij} when the time between surveys is not constant. In Australia, it is common for the time between searches to vary due to seasonal changes in effort or the use of a pulsed design in which the turbine is searched monthly with a return visit a few days later.

To allow for survey protocols with non-standard intervals, we developed a Monte Carlo algorithm. We have used this method for annual estimates at over a dozen wind farms in Australia to date.

Monte Carlo methods (Sawilowsky (2003), Ripley (1987)) simulate a large set of possible survey results, by simulating the actual sampling protocol and sampling from the empirical distributions for scavenge loss and searcher efficiency. In this way, we can directly sample the probability a carcass was lost before the survey, negating the need to calculate r_{ij} analytically each time.

We can then estimate how many carcasses were truly in the field, given the range of searcher and scavenger efficiencies, the survey frequency and coverage, and the true "found" details. After many simulations, we can estimate the likely range of mortalities that could have resulted in the recorded survey outcome.

This method has been benchmarked against analytical approaches (Huso (2011), Korner-Nievergelt et al. (2011)). Its outputs are equivalent but it is able to robustly model more complex survey designs (e.g. pulsed surveys, rotating survey list).

1.1 The Symbolix Monte-Carlo mortality estimator

Our Monte-Carlo simulator is an algorithmic approach to solving equations (1) and (2). The steps (Figure 1) are as follows:

Inputs

- Number of simulations
- Species class
- Start date and end date of the survey
- Start date and end date of carcass "arrivals"
  - 30 days before first survey (year 1)
  - Last date of previous year (subsequent years)
- Max and min number of annual carcasses - chosen to allow a broad selection of possible overall mortalities (e.g. 0 - 1000)
- A data list of the turbines and dates searched constructed from the survey data

Monte-Carlo simulation

For each iteration, simulate carcass collisions:

- Select a number of annual carcass collisions at uniform random.
- Select the date and turbine they arrive at. We generally use a uniform distribution of dates and turbines.

Simulate the survey protocol:

- For each actual survey date and turbine
  - Check if any simulated carcasses have arrived at that location prior to the survey

  - IF YES, determine if the carcass still remains (i.e. not scavenged), given the hazard decay function previously calculated
  - IF YES, determine if the carcass is detected by the observer, by sampling from the binomial distribution previously calculated
  - IF YES, mark as found
- After all surveys have been processed, record the number of carcasses arrived and the number found for that simulation and move to the next simulation round.

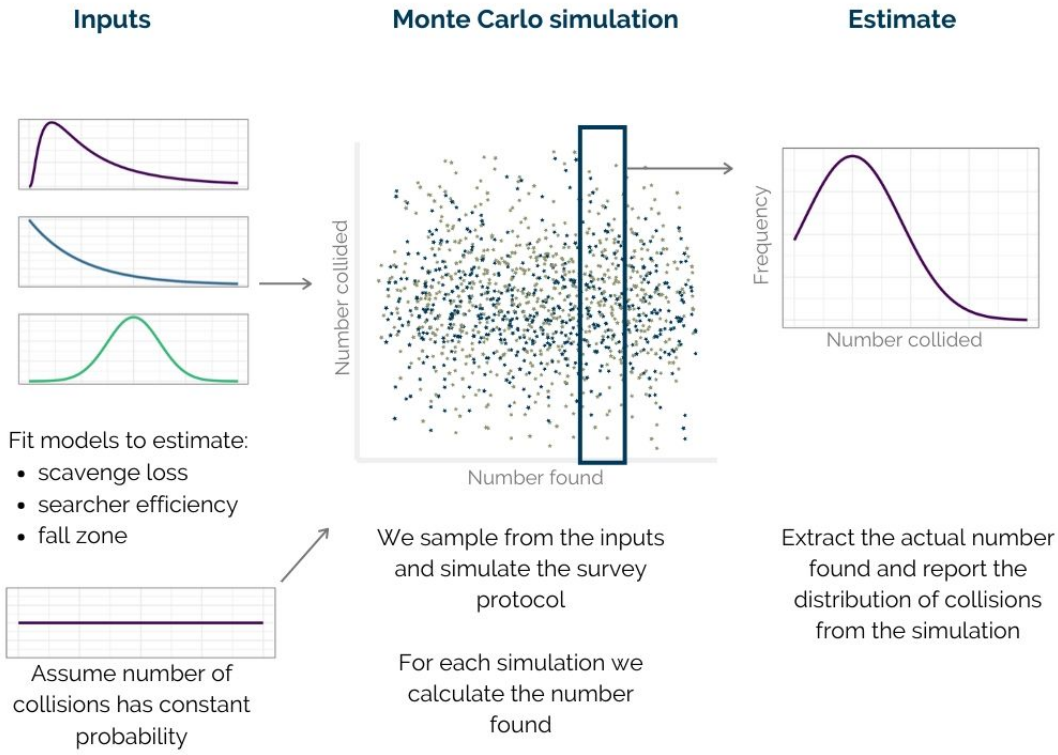

Figure 1: Schematic showing the application of the Monte-Carlo method to simulate the phase space of possible collisions and subsequent carcass finds. The inputs are based on empirical distributions estimated from field trials.

Estimate

The Monte-Carlo simulation generates a representative coverage of the phase space influencing the probability of detection. To generate an estimate of mortality, we extract all simulations with the same number of discovered carcasses as the "real" survey data under consideration. The distribution of simulated carcass arrivals is a direct estimate of the mortality estimate. From it, we extract the median and confidence intervals.

1.2 Required components

Therefore, mortality estimates require the following components:

- A formal mortality monitoring survey where found carcasses are recorded, to determine C_{ij}.
- An estimate of the fall zone of carcasses to determine a_i (this also accounts for potentially only searching a subset of all turbines).
- Scavenger trials to estimate r_{ij}.
- Searcher efficiency trials to estimate p_{ij}.

The latter three are known as the "adjunct surveys" or analyses.

1.3 Statistical uncertainty

It's important to note that point estimates (a single value estimate) of mortality are almost never correct; it's the range of probable values (confidence interval) which is important. The Symbolix estimator always reports a mid-point (the median), plus the spread of likely values.

Huso, Dalthorp, and Korner-Nievergelt (2015) gives an analogy explaining the difficulty of mortality estimation: if we consider mortalities to be the number of ones you observe on dice rolls, the question mortality estimation seeks to answer is: given we observe x ones, how many times was the dice rolled? If we observed $x = 3$ rolls that returned a one, it's possible the dice was rolled three times, and possible it was rolled 40 times. Both those are unlikely though; the true value is most likely somewhere in between, but we can't know for certain.

2 Mortality surveys

Mortality surveys give us two data sets. The first is a dated list of all turbines searched, possibly with relevant metadata such as search radius and vegetation conditions. The second is the set of carcasses (the C term in Equation (1)) found during these formal searches.

Assuming a number of statistical requirements in the survey design (e.g. random selection) and field methods (e.g. consistent effort with the searcher efficiency trials), no further analysis is required on this data to prepare it for the Monte-Carlo estimator.

3 Adjunct surveys and analyses

3.1 Scavenger trials

In order to accurately estimate mortality, we must account for carcass loss to scavengers. Scavenger trials are performed to quantify the time until a carcass is completely lost as a result of scavenger activity, which is the r term in (2).

Survival analysis (Kaplan and Meier (1958), Kalbfleisch and Prentice (2011)) is used to determine the distribution of time until complete loss from scavenge (or decay). Survival analysis is required to account for the fact that we do not necessarily know the exact time of scavenge loss, only an interval in which the scavenge event happened. For example, any carcass which is unscavenged at the end of the trial, has its scavenge event in the interval $[x, \infty]$ (where x is the length of the trial).

By performing survival analysis we can estimate the time until carcass loss after a given length of time, despite these unknowns.

We fit parameterised models to analyse significant factors influencing time to scavenge (carcass species type etc), and to find the most appropriate distribution to fit the time-to-loss curve (e.g. log-normal, exponential).

Time to carcass loss is influenced by the parameters discussed above and the distribution of the loss curve we fit to the data (Huso, Dalthorp, and Korner-Nievergelt 2015). The choice of loss function is important because it should capture the behaviours and relative time dependence of the various scavengers.

3.2 Searcher efficiency trials

The aim of searcher efficiency trials is the quantify the effectiveness of observers, at finding carcasses. They provide the p term in Equation (2).

We are interested in the Bernoulli parameter p, which is the probability that a searcher finds a carcass given it is within their search area. We treat each carcass placed as a Bernoulli random

variable with probability p of success where success = finding the carcass.

Binomial generalised linear models (otherwise known as logistic regression) are used to analyse this type of data. For more details see McCullagh (1989). If the models show that groups of carcasses (e.g. birds and bats) don't have significantly different find rates, the data should be aggregated. This maximises the precision of the searcher efficiency estimates, which in turn decreases the uncertainty on the overall mortality estimate.

3.3 Fall zone coverage

The coverage factor estimates the probability that, given a carcass falls at a searched turbine, that the carcass falls within the searched area. This contributes to the a term in Equation (2)

We generate a carcass fall-zone distribution for each species class, given the turbine size at the wind farm. The percentage of the fall zone not covered by the survey area, provides a correction factor in the mortality estimate. Because carcasses that fall outside the searched area have a zero probability of being detected by a survey, the likelihood of landing in this region is essential to understanding the relationship between detections and actual losses.

The fall-zone estimate is the end result of the calculation detailed in Hull and Muir (2010). This paper describes a simulation method for the distance a carcass will fall from the wind turbine, based upon physical parameters such as the turbine height, blade length, rotation period, and bird surface area presented.

4 Mortality estimation

After the mortality and adjunct surveys have been performed, we now have estimates for scavenge loss, searcher efficiency, and survey coverage. These are converted from the number of bat and bird carcasses detected (species-specific analyses can also be done), into an estimate of overall mortality.

The mortality estimation is done via Symbolix' Monte-Carlo algorithm. Random numbers of virtual mortalities are simulated, along with the scavenge time and searcher efficiency (based on the measured confidence intervals). The proportion of virtual carcasses "found" are recorded for each simulation. Finally, those simulations that have the same outcome as the reported survey detections are collated, and the initial conditions (i.e. how many true losses there were) reported.

The base model assumptions are listed below. Other assumptions may vary from site to site.

- Search frequency for each turbine are taken from a list of actual survey dates.
- Bats and birds that are struck are immediately replaced (i.e. strikes one day do not affect the chance of strikes the next).

- We use the standard practice of assuming that all carcasses and all feather spots (regardless of size or composition) are attributable to the wind turbines.
- Finds are random and independent, and not clustered with other finds.
- There is equal chance of any turbine individually being involved in a collision / mortality.
- We take scavenge loss and search efficiency rates as determined in the adjunct analyses.

4.1 Output

The output, for each simulation, is the number of carcasses found, and the number of carcasses struck. If x carcasses were found during the mortality survey, then we gather the simulations that also found x carcasses. From those surveys, we obtain a distribution of the number of carcasses struck.

The output is therefore a distribution. By examining the median, we obtain a point estimate of mortality during the given time period. By examining the upper and lower bounds of the distribution, we can get confidence values and thus understand the uncertainty on our estimate.

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