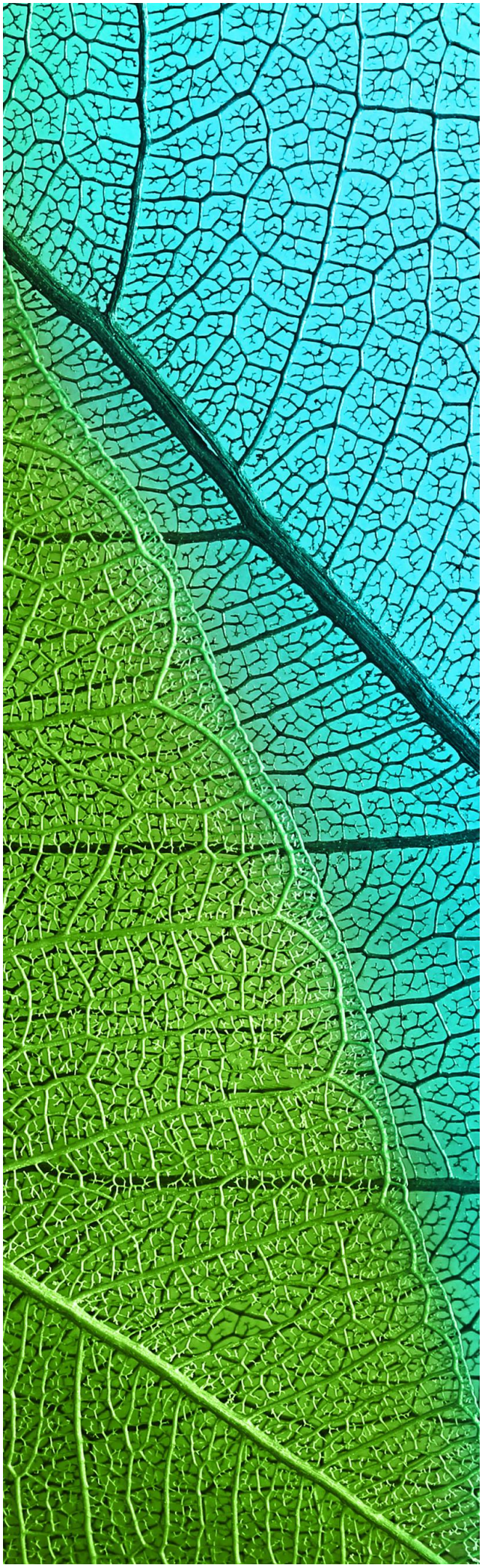

Bodangora Wind Farm

Bird and Bat Adaptive Management Plan: Fifth annual report

Prepared for Bodangora Wind Farm Pty Ltd

November 2024
Report No. 15124.8 (3.1)

Nature Advisory
5/61-63 Camberwell Road
Hawthorn East, VIC 3123
PO Box 337, Camberwell VIC 3124
(03) 9815 2111
www.natureadvisory.com.au

Nature Advisory acknowledges the traditional owners and sovereign custodians of the land on which we work from – the Wurundjeri people of the Woi Wurrung language group. We extend our respect to their Ancestors and all First Peoples and Elders past, present, and future.

Contents

Tables

Figures

Appendices

1. Introduction

Nature Advisory Pty Ltd (formerly Brett Lane & Associates Pty Ltd) was commissioned by Iberdrola Pty Ltd to assist in the implementation of the Bird and Bat Adaptive Management Plan (BBAMP) (BL&A 2017) for Bodangora Wind Farm (BWF), located in New South Wales (NSW). BWF is in central NSW approximately 20 km northeast of Wellington, within the Dubbo Regional Council jurisdiction.

The BBAMP for BWF was approved in June 2017 and will operate for the life of the wind farm. Nature Advisory began implementing the BBAMP upon commencement of operation of BWF in June 2019 and the first two years focused on monitoring to inform impacts and mortality estimates on birds and bats at the wind farm. The results of this period were presented in annual reporting for the first 12 months (Nature Advisory 2020) and the first 24 months (Nature Advisory 2021d). This initial 24 months of monitoring informed and recommended the continued adapted BBAMP implementation. As such; during 2022, BWF staff reported any incidental carcasses and carrion removal occurrence, as per the second annual report recommendations, with results presented in the third annual report (Nature Advisory 2022a). Since then, consultations between Biodiversity, Conservation and Science Directorate (BCS) of the Department of Climate Change, Energy, Environment, and Water (DCCEEW), BWF and Nature Advisory resulted in the decision to implement a third year of carcass monitoring using a scent detection dog (BCS 2022), which commenced in January 2023.

This report is part two of the fourth annual report on BBAMP implementation for BWF during July 2023 – December 2023 and is based on the project Conditions of Consent, and outcomes of consultation with representatives from the NSW Office of Environment and Heritage (OEH) (Central West region) (now the BCS) under the Department of Planning, Industry and Environment (DPIE) (now the Department of Climate Change, Energy, the Environment and Water (DCCEEW)).

1.1. Previous reporting

Annual reporting on implementation of the BBAMP, including refinements to the monitoring methods based on progress each year, are outlined below. Each annual report contains references to other subsequently required reporting, such as trigger investigations, the details of which can be found in the relevant reports below:

- Nature Advisory (2020) 'Annual Report on the Implementation of the Bird and Bat Adaptive Management Plan'. Consultant's report to Bodangora Wind Farm Pty Ltd, Report 15124 (20.0).
- Nature Advisory (2021) 'Bird and Bat Adaptive Management Plan – Second Annual Report'. Consultant's report to Bodangora Wind Farm Pty Ltd, Report 15124 (20.3).
- Nature Advisory (2022) 'Bird and Bat Adaptive Management Plan – Third Annual Report'. Consultant's report to Bodangora Wind Farm Pty Ltd, Report 15124.8 (1.1).
- Nature Advisory (2023) 'Bird and Bat Adaptive Management Plan – Forth Annual Report'. Consultant's report to Bodangora Wind Farm Pty Ltd, Report 15124 (2.1).

1.2. Monitoring requirements

The condition for approval C6 for BWF requires annual reporting as outlined below (BL&A 2017):

> *"(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;*

(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.

The reports referred to under part (f) shall be submitted to the Secretary [of the Department of Planning and Environment (DPE)] *and* [Office of Environment and Heritage] *OEH on an annual basis for the first five years of operation and every two years thereafter (unless otherwise agreed to by the Secretary), and shall be prepared within two months of the end of the reporting period. The Secretary may, at the request of the Proponent at anytime, vary the reporting requirement or period by notice in writing to the Proponent."*

Monitoring during January 2023 – December 2023 was conducted to meet previous recommendations and BCS's requirements as outlined below:

- All incidental carcasses found shall be recorded on the appropriate record form and shall be removed after being photographed for species identification and stored where required.
- Any carcasses of threatened species (*Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Biodiversity and Conservation Act 2016* (BC Act) listed will be reported to BCS as soon as practicable but within two business days of the identification of species.
- BWF staff will identify the carcasses of impacted species, however, when there is uncertainty, carcass identification must be clarified with an expert prior to reporting.
- Wedge-tailed Eagle (WTE) (*Aquila audax*) mortalities to be documented photographically to ensure the age estimate can be recorded, and to be reported to BCS as soon as possible within five business days of species identification.
- Any rabbit warrens, sheep or kangaroo carcasses within close proximity of operating turbines continue to be monitored, controlled and carcasses swiftly removed (within 200 metres) where feasible and in consultation with the landowner.
- No lambing within 200 metres of turbines, where feasible, and in consultation with the landowner.
- Targeted Little Red Flying Fox (LRFF) (*Pteropus scapulatus*) and Grey-Headed Flying Fox (GHFF) (*Pteropus poliocephalus*) surveys including:
    - Monthly inspections of the known camp in Wellington to determine LRFF and GHFF presence.

  These surveys were conducted by a Nature Advisory staff member proven competent in Flying Fox identification. Results must be maintained in a log-book or database for submission as part of annual reporting. Additionally, in the event LRFF are observed to return, the following actions need to be undertaken:

    - BCS will be notified within two business days of presence and estimated numbers at the Wellington camp;
    - Carry out nocturnal surveys within the wind farm to determine presence, flight paths, and occupation by Flying Foxes;
    - Assessment of the floral resources on site and in the surrounding areas; and
    - Undertake additional carcass searches to determine high-risk turbines.

Discussion with BCS resulted in recommendations to continue monitoring impacts to avifauna at BWF through a third year of carcass searches. Data collected between January 2023 and June 2023 were presented in fourth annual report, and data collected between July 2023 and December 2023 are presented in this annual report.

- Monthly carcass searches (out to 60m to target small carcasses) and searches every 4 months out to 100 m (to detect WTE) using the scent detection dog (Nature Advisory 2022a, BCS 2022).

- Incidental raptor monitoring has also been undertaken opportunistically to provide additional data on presence and activity of raptors on site.
- Matters to be addressed in the annual reports must include:
    - Report on outcomes of the above monitoring activities;
    - Summary of any events recorded as a significant impact;
    - Report on status of rabbit warrens, lambing and kangaroo/sheep carcasses in close proximity of the turbines. Details on how many carcasses removed from within 200 metres of turbines;
    - Report on results of the Flying Fox camp monitoring and any related/consequent surveys at BWF
    - Need for mitigation measures;
    - Progress with implementation of mitigation measures;
    - Effectiveness of mitigation measures;
    - Discussion on overall trend in results as the years go by including changes in species seen, or carcasses found; and
    - Reference significant results from previous years.

This annual report includes the following sections:

Section 2 provides bird and bat incidental mortalities.

Section 3 flying fox monitoring methods and results.

Section 4 continued carcass search program method, results, and discussion.

Section 5 Summarises impact triggers that have occurred during this monitoring period.

Section 6 provides information and results of mitigation measure implementation.

Section 7 provides conclusion and recommendation.

This investigation was undertaken by a team from Nature Advisory, comprising Jess Johnson (Zoologist and Dog Handler), “Kitty” Scent Detection Canine, Rebecca Spence (Zoologist and Project Officer), Divyang Rathod (Zoologist and Project Manager), Jackson Clerke (Senior Ecologist and Project Manager) and Bernard O'Callaghan (Director).

Figure 1: Bodangora Wind Farm turbine locations

Project number: 15124.08
Project: Bodangora Wind Farm
Date: 24/08/2024

Wind Farm boundary
Turbine
Access tracks

N

Metres
0 1,000

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

15124 - Created by: - E:\GIS\2015 Jobs\15124\15124 FIG3 WF turbine locations 230824.mxd

2. Bird and bat incidental finds

On-going recording and reporting of bird and bat incidental carcasses were required to be undertaken in 2023 in accordance with annual reporting requirements.

2.1. Operational guidance to staff and procedures

BWF has adopted a standard methodology, based on the BCS protocol, for field staff to collect incidental records. This is illustrated in Figure 2. *Infigen is now Iberdrola Australia Pty Ltd

Figure 2. Elements include:

- Any bird or bat carcass (or scavenged remains i.e., wing, skeleton, leg etc) or feather spot (i.e., 10 or more feathers or 2 or more primaries) encountered incidentally on site should be recorded.
- All site personnel shall follow this guidance, including contractors. It contains the requirements of the BCS's recommended methodology for incidental finds of dead or injured birds and bats or feather spots.
- A copy of the requirements shall also be posted on the site noticeboard.
- All carcasses, feather spots or injured birds or bats encountered within 200m of a turbine outside of formal searches are considered as incidental fatalities.
- All incidental finds of injured and dead bats and birds within the site must be identified, recorded, and reported to BCS.
- Familiarisation training through site induction, toolbox talk or other appropriate forum, shall be provided to all site personnel, including BWF's contractors, to ensure they are equipped with the understanding and knowledge required with respect to the appropriate protocols for reporting injuries and fatalities and handling injured animals and carcasses.

2.2. Methodology

1. Photograph the carcass where it is found and record all details on the Bird and Bat Carcass sheet (Appendix 2).
2. Complete carcass record sheet prior to removing the carcass.
3. Wear protective puncture-proof nitrile or rubber gloves to remove or mark the carcass once details have been recorded to avoid recounting (if within 200m of a turbine it must be removed). Only dispose of carcass if the species can be readily identified. If the species cannot be readily identified, then the carcass must be placed in a sealed plastic bag or appropriate container and clearly labelled before storing in the on-site dedicated freezer so that it can be preserved until it is identified by a suitably qualified expert. Once identified, it can be appropriately disposed of.
4. Inform the BWF Site Manager and provide a copy of the record sheet before the end of the same working shift.
5. BWF Site Manager to record finding on the incident management system and notify the Iberdrola HSE Manager who shall notify the appropriate authorities as required.
6. All alive, but injured wildlife, must be transported to the nearest veterinary clinic.

Notifiable matters include any carcass, feather-spot or injured bird or bat of a threatened species or WTE. The relevant representative of the NSW BCS is to be notified as soon as practicable by email, within maximum two business days (for threatened species), after species identification. Details must be emailed to the BCS Central West Planning Team.

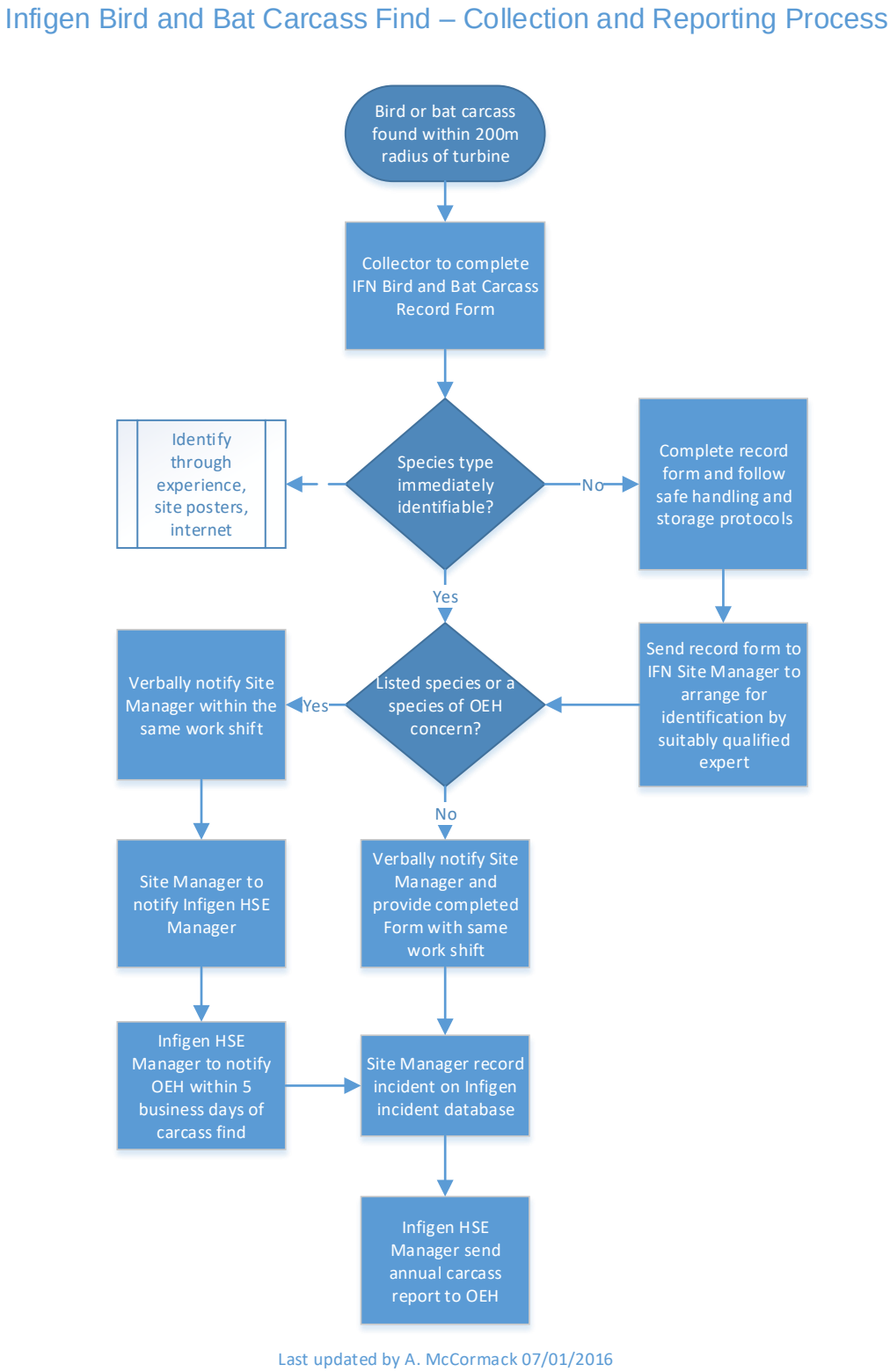

Figure 2: Collection and Reporting process for incidental carcasses found at BWF site.

2.3. Results

In this reporting period, one incidental find was recorded of a Grey-headed Flying Fox. This is discussed further in Section 5.2.

3. Flying Fox monitoring

Previously, LRFF and GHFF were found to have collided with turbines at BWF and were documented flying through the site to obtain floral resources during nocturnal spotlighting surveys (Nature Advisory 2019, Nature Advisory 2021b). Subsequently, BWF has been monitoring the Flying Fox camp at Wellington on a weekly (August-November 2021) or fortnightly (March-August 2022) basis, and Nature Advisory has monitored the camp monthly from January 2023.

The results of the monitoring efforts specified above are summarised below.

3.1. Methodology

The daytime inspections of the Flying Fox camp at Wellington consisted of the following:

- A daytime visit to the location of the Flying Fox camp at Wellington during the day, on a monthly basis;
- Inspection of the camp location for the presence of Flying Foxes
- If Flying Foxes are present, identification of which species are present, and estimation of numbers present

The presence of Flying Foxes at the Wellington camp would trigger the following:

- A notification of presence of the Flying Foxes, which species are present, and their estimated numbers to BCS

If the Flying Foxes were found to be LRFF, this would trigger:

- Nocturnal spotlighting surveys to determine Flying Fox presence, flight paths and occupation at BWF.
- Assessment of floral resources at BWF and the surrounding areas that could potentially attract the Flying Foxes and induce them to fly into or through the site
- Additional carcass searches to identify high-risk turbines

3.2. Previous reporting and investigations

Reporting on investigations into flying fox activity and presence at Wellington and BWF is presented in the following reports:

- Nature Advisory 2019, Bodangora Wind Farm BBAMP Implementation: Grey-headed Flying-Fox Field Investigation – Part II, Report no. 15124 (7.1) prepared for Bodangora Wind Farm Pty Ltd.
- Nature Advisory 2021a, Bodangora Wind Farm - Impact Trigger Lighting Trial Little Red Flying-fox (Pteropus scapulatus) (LRFF), June 2022 Nature Advisory Ref 15124.6 (3.0) – Report 15124 (26.0). Letter to Michael Bullock, Bodangora Wind Farm.
- Nature Advisory 2021b, Bodangora Wind Farm: Little red flying-fox Impact Assessment Report, Report no. 15124 (23.1) prepared for Infigen Energy Limited, April 2021
- Nature Advisory 2022, 'Bird and Bat Adaptive Management Plan – Third Annual Report'. Consultant's report to Bodangora Wind Farm Pty Ltd, Report 15124.8 (1.1).

A summary is provided below:

Nature Advisory has conducted targeted Flying Fox surveys and investigations at BWF in 2019 and 2021. These consisted of intensive carcass searches to identify high-risk turbines, monitoring of the Flying Fox camp flyout to determine the numbers present and understand the proportion headed towards BWF, nocturnal spotlighting surveys to determine flight paths used and occupancy on site, and assessment of nature, extent, location, and duration of floral resources that could attract them to fly into or through BWF

Additionally, in 2021 a trial was held to determine if lights around turbines could reduce collisions (Nature Advisory 2021a). These investigations are discussed in greater detail in section 4.3.3

3.3. Results

In July 2023, approximately 3000 Grey-headed flying foxes were recorded and observed flying around camp, with few flying north-east in the direction of BWF. In August and September 2023, between 3000-5000 individuals were observed at the camp. During the September inspection, the individuals were more sparsely spread out and observed flying in a south-east direction. No Flying-Foxes were observed at the Wellington camp between October and December 2023.

Table 1: Summary of Flying Fox records during inspections

Inspection date	Location	No. Observed	Species
26/07/2023	Wellington Camp	>3000	Grey-headed flying fox (*Pteropus poliocephalus*)
23/08/2023	Wellington Camp	3000-5000	Grey-headed flying fox (*Pteropus poliocephalus*)
19/09/2023	Wellington Camp	3000-5000	Grey-headed flying fox (*Pteropus poliocephalus*)
24/10/2023	Wellington Camp	0	N/A
20/11/2023	Wellington Camp	0	N/A
18/12/2023	Wellington Camp	0	N/A

Previously identified foraging resources on site were inspected to determine the flowering status. White Box (*Eucalyptus albens*) patches were visited on site from July to September 2023 and identified that some patches, but not all, had some flowering around the bases of the tree, but that this was not prolific. This indicated late stages of the flowering period.

3.4. Comparison between monitoring periods

Following the initial impact trigger in 2019, inspections were conducted at Wellington camp in June and July 2019 with approximately 500 GHFF identified roosting at the camp (Nature Advisory 2019). There were patches of White Box on site observed to be heavily flowering, likely attracting GHFF to the site to forage (Nature Advisory 2019).

Following the LRFF impact trigger in 2021, there were inspections of the Wellington camp between March and June with a result of 2,500 GHFF observed to be present and a peak population of approximately 50,000 LRFF recorded flying in the direction of BWF (Nature Advisory 2021b). In June 2021, the camp was observed to be abandoned by both species. According to the site manager, the box-ironbark woodland present at the eastern end of BWF flowered again in spring in 2021, but it was not as abundant as it was earlier in the year during the 2021 LRFF impact triggers (Michael Bullock, pers. comm). No flying fox mortalities were detected incidentally by BWF staff in spring 2021.

About 500 individuals of unidentified species were recorded mid-May 2022, and they largely appeared to be flying southeast towards Burrendong Dam, not northeast towards BWF. This is far smaller than during the Flying Fox inspections in 2021, when there was a total of roughly 52,500 individuals (2500 GHFF and 50,000 LRFF) and it is highly likely that these were GHFF. The camp was reportedly abandoned by the flying fox again during flooding condition around July in 2022. No incidental records or impact triggers for GHFF or LRFF were reported during that period.

In early 2023, there were similar results of GHFF camp sizes compared to inspections conducted in 2021 after the LRFF impact trigger (2,500 GHFF). However, there have been no LRFF recorded at the camp. Between June and September 2023, approximately 2500 to 5000 GHFF were observed each month, aligning with similar records from March and June in 2021. Nature Advisory staff visited White Box eucalypt patches on site between May and September 2023 and identified that some patches, but not

all, had flowering around the bases of the trees. The flowering was considered relatively light and was diminishing by the October 2023 inspection. In October 2023, the camp was observed to be abandoned.

4. Carcass search program

This section outlines the methods for the continuation of the carcass search program at BWF.

4.1. Methodology

4.1.1. Carcass searches

Mortality detection was undertaken at the same 17 turbines monitored during the initial 24-month monitoring program at BWF (Table 2). Each turbine is searched to a radius of 60 metres monthly except every third month, which is searched to 100 metres (Table 3).

Table 2. Turbine locations that were surveyed

Turbine number	Turbine Number
T02	T19
T04	T20
T05	T23
T07	T24
T09	T25
T12	T30
T13	T31
T14	T33
T15	-

Table 3: search radius for each monthly search

Search month	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Radius (m)	100	60	60	100	60	60	100	60	60	100	60	60

Methods for carcass searching during the third year utilise a scent detection dog and handler team rather than trained human only searchers to identify mortalities under turbines, as was used during the initial 24 months of monitoring. The search pattern is conducted by the handler walking 20 metre transects, into or across the wind direction (depending on terrain), over the search radius and controlling the highly trained scent detection dog to find any birds and bats either side of each transect. Figure 3 provides a representation of the search method.

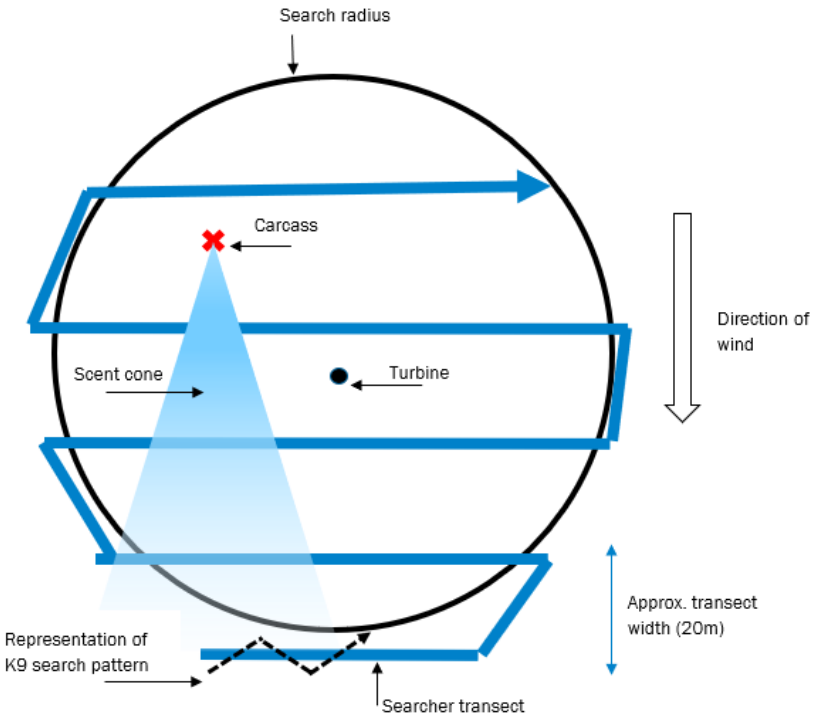

Figure 3: Diagram of search zone, transect width and search pattern at turbines

The dog's position regarding the search radius is tracked in real time via a hand-held GPS unit linked to a GPS tracking collar fitted to the dog. The searches were undertaken by one experienced zoologist and dog handler from Nature Advisory. All search tracks of the human and dog were recorded via GPS, which can be made available on request.

When a dead bird or bat was recorded under a turbine, a report was completed (Appendix 1) and a photograph of the carcass was taken. When only feathers were recorded this was recorded as a feather spot. It is likely that feather spots represent a bird that collided with a turbine and was later scavenged. Finds are removed to avoid recounting in subsequent searches and stored in a freezer on site.

4.1.2. Incidental raptor monitoring

Incidental raptor monitoring was undertaken during monthly carcass searches in order to assess utilisation of BWF. Observations were taken opportunistically using binoculars while conducting carcass searches under turbines and while traversing the site.

Information recorded included;

- Date, locations and duration of observation period,
- Time and duration of observation
- Number and age of birds
- Flight height above ground
- Habitat over which the flight was observed
- Flight behaviour,
- Other occasional behaviours,
- Nest locations of WTE.

Flight paths were plotted on maps.

4.1.3. Detectability trials

Detectability trials were undertaken primarily by two zoologist and a scent-detection dog from Nature Advisory. The groundcover at the time of the first trial in September 2023 was short to medium grass and for the second in November 2023, short grass. Sites used in both trials were generally grazed pasture, some with scattered trees or woodland areas. Detectability trials are intended to determine the probability with which the searcher is likely to detect a carcass on the ground. All personnel who have carried out monthly mortality searches at BWF undertook detectability trials. The searcher is referred to as the combination of zoologist and dog who regularly undertakes the mortality detection. The assessor is the person who sets up the trials and assesses the searcher. Detectability trials (as per the BBAMP Section 3.2.5) are implemented to determine the efficiency of the detection dogs at BWF.

Detectability trials were undertaken in September 2023 and November 2023.

4.2. Results

4.2.1. Carcass searches

A total of 101 bird and bat carcasses were found comprising of 21 bird carcasses, 35 bird feather spots and 45 bat carcasses during the formal searches between January to December 2023. Out of 45 bat records there were 11 carcasses that could not be identified due to decomposition or a lack of identifying features remaining due to scavenging. A total of 13 feather spots could not be identified due to the same issues. Table 4 presents the results of carcass searches and detailed carcass data is provided in Appendix 2.

Table 4:Summary of bird and bat carcasses detected during the 2023 monitoring period

Common Name	Scientific Name	Jan -23	Feb -23	Mar -23	Apr -23	May -23	Jun -23	Jul-23	Aug -23	Sep -23	Oct -23	Nov -23	Dec -23
Birds													
Australian Magpie	*Gymnorhina tibicen*							1	3	1	1		
Noisy Miner	*Manorina melanocephala*		1										
Black-shouldered Kite	*Elanus axillaris*										1	1	
Brown Falcon	*Falco berigora*				1				1	1			
Crested Pigeon	*Ocyphaps lophotes*										1		
Crimson Rosella	*Platycercus elegans*								1				
Eastern Rosella	*Platycercus eximius*										1		
Galah	*Eolophus roseicapilla*						2			1		1	
Grey Fantail	*Rhipidura albiscapa*								1	1			
Grey Currawong	*Strepera versicolor*							1					
Laughing Kookaburra	*Dacelo novaeguineae*										1		
Little Friarbird	*Philemon citreogularis*											1	

Common Name	Scientific Name	Jan -23	Feb -23	Mar -23	Apr -23	May -23	Jun -23	Jul-23	Aug -23	Sep -23	Oct -23	Nov -23	Dec -23
Musk Lorikeet	*Glossopsitta concinna*					1	1				1		
Nankeen Kestrel	*Falco cenchroides*				1	1	1	2		1		1	
Rainbow Lorikeet	*Trichoglossus moluccanus*							1	1				
Robin spp.	Petroica spp.												1
Rock/Feral Pigeon	*Columba livia*										1		
Striated Pardalote	*Pardalotus striatus*										1		
Superb Fairywren	*Malurus cyaneus*											1	
Unknown Bird spp.	*NA*						3	1	2	2	4		1
Wedge-tailed Eagle	*Aquila audax*										1	1	
Yellow-Rumped Thornbill	*Acanthiza chrysorrhoa*								1				
Bats													
White-striped Freetail Bat	*Austronomus australis*	2		3				1					1
Little Forest Bat	*Vespadelus vulturnus*		3		1	1							
Chocolate Wattled Bat	*Chalinolobus morio*		2										
Gould's Wattled Bat	*Chalinolobus gouldii*		1										
Chalinolobus spp.	*Chalinolobus* spp.		1										
Free-tail Bat Spp.	*Ozimops spp.*										2	1	5
Southern Freetail Bat	*Mormopterus planiceps*			1	1				1	5			
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*			1									
Unknown Bat spp.	NA		5	1					1	2			2
Grey-headed Flying Fox	*Pteropus poliocephalus*					1							

4.2.2. Incidental raptor monitoring

Four species of raptors were recorded across the wind farm site during the monitoring period from January - December 2023. The data for each raptor flight is presented in Table 5: Incidental raptor observations and Figure 4: Raptor flight path. No listed species have been recorded in this survey period and all raptor species recorded were common farmland/grassland/ woodland species of NSW. Observations included 12 observations of Wedge-tailed Eagle (WTE) and Nankeen Kestrel respectively, 11 Brown Falcon observations and 5 Black-shouldered Kites.

Table 5: Incidental raptor observations

Flight no.	Species	Scientific name	Date	Start time	End time	Species count	Height	Flight Direction	Duration (min)	Comments
1	Brown Falcon	*Falco berigora*	24/01/2023	12:05	12:06	1	25m	NW	1	direct flight for about 50m
2	Brown Falcon	*Falco berigora*	24/01/2023	13:30	13:31	1	10m	-	1	Perched
3	Wedge-tailed Eagle	*Aquila audax*	25/01/2023	10:00	10:05	1	200m	SE	5	soaring in updraft. Seen from T30
4	Brown Falcon	*Falco berigora*	26/01/2023	10:47	10:48	1	6m	NE	1	flew into tree near T16 and perched
5	Brown Falcon	*Falco berigora*	2/03/2023	14:04	14:07	1	50m	N	3	powered flight, and then glided in circles
6	Brown Falcon	*Falco berigora*	2/03/2023	14:32	14:34	1	60m	SW	1	glided in a single circle then powered flight
7	Wedge-tailed Eagle	*Aquila audax*	3/03/2023	10:58	10:59	1	150m	NW	1	glided in circles
8	Black-shouldered Kite	*Elanus axillaris*	28/03/2023	-	-	1	-	-	-	-
9	Brown Falcon	*Falco berigora*	23/05/2023	14:28	14:35	1	30-50m	SE	7	Circling
10	Wedge-tailed Eagle	*Aquila audax*	23/05/2023	16:10	16:15	1	200m	NW	5	Soaring
11	Black-shouldered Kite	*Elanus axillaris*	23/05/2023	11:40	11:41	1	5-100m	NE	1	Powered (flapping) flight

12	Brown Falcon	*Falco berigora*	23/05/2023	14:45	14:48	1	50-100m	E	3	Gliding
13	Wedge-tailed Eagle	*Aquila audax*	23/05/2023	15:30	15:34	2	200m	S	4	Soaring
14	Nankeen Kestrel	*Falco cenchroides*	27/06/2023	7:35	7:36	1	2.5m	NE	1	Perched on post then flew North, adjacent to T31 for approx. 100m
15	Nankeen Kestrel	*Falco cenchroides*	27/06/2023	8:27	8:28	1	2.5m	S	1	Perched on post then flew South towards woodlands
16	Brown Falcon	*Falco berigora*	25/07/2023	13:25	13:27	1	15m	SW	2	Was hovering, then got chased south by other birds (ravens)
17	Wedge-tailed Eagle	*Aquila audax*	26/07/2023	10:19	10:25	1	100m	W	6	Circling over woodlands then soared really high
18	Wedge-tailed Eagle	*Aquila audax*	26/07/2023	10:33	10:35	1	150m	N	2	Gliding parallel to ridge, could be same individual as previous observation
19	Nankeen Kestrel	*Falco cenchroides*	26/07/2023	10:58	11:01	1	30m	W	3	hovering, then glided, hovered again, then glided and hovered
20	Nankeen Kestrel	*Falco cenchroides*	23/08/2023	12:42	12:44	1	1m	W	2	Sitting on a rock, then flew to fence post, the flew west
21	Nankeen Kestrel	*Falco cenchroides*	23/08/2023	12:48	12:49	1	-	SW	1	Likely to be the same Kestrel as Obs1, hovering then flew 10m, hovered again
22	Nankeen Kestrel	*Falco cenchroides*	18/09/2023	14:38	14:39	1	15	E	1	Bird resting in tree. As I approached the bird flew towards the adjacent tree (north)
23	Black-shouldered Kite	*Elanus axillaris*	20/09/2023	6:49	6:50	1	20	NE	1	Flew around a tree and then perched on a dead tree nearby

24	Black-shouldered Kite	*Elanus axillaris*	20/09/2023	7:45	7:47	1	20	E	2	Bird hovering over access road, then circled around, hovered over the grassland and then glided towards T24
25	Nankeen Kestrel	*Falco cenchroides*	20/09/2023	11:37	11:38	1	10	N	1	Kestrel flying into the strong wind. Appeared to be something in his talons
26	Wedge-tailed Eagle	*Aquila audax*	24/10/2023	11:56	12:02	1		S	6	WTE flying in circles slowly soaring upwards, whilst five crows were attacking it. It then soared in a north-west direction over the woodlands.
27	Wedge-tailed Eagle	*Aquila audax*	25/10/2023	14:22	14:25	3		SE	3	Two WTE's getting harassed by other birds, started circling and soaring. A third WTE flew in from south-west direction, before all soaring east
28	Nankeen Kestrel	*Falco cenchroides*	26/10/2023	7:22	7:23	1		N	1	Flying really low to ground near some boulders, then flew south
29	Brown Falcon	*Falco berigora*	26/10/2023	8:32	8:33	1		S	1	Perched on dead tree branch, flew in a circle back onto the branch, then down onto the ground
30	Black-shouldered Kite	*Elanus axillaris*	21/11/2023	9:20	9:21	1		N	1	Hovering north of T31
31	Brown Falcon	*Falco berigora*	21/11/2023	10:45	10:46	1	25	SE	1	Perched on dead tree SE of T15
32	Nankeen Kestrel	*Falco cenchroides*	22/11/2022	7:18	7:21	1		S	3	Hovering east of T22 & T23, then flew over grassland foraging. Hovered again between T23 & T24 before hovering extremely close the T23, just metres from the blades

33	Wedge-tailed Eagle	*Aquila audax*	22/11/2022	8:28	8:30	1		SW	2	Soaring whilst circling over woodlands
34	Wedge-tailed Eagle	*Aquila audax*	22/11/2022	9:13	9:14	1		E	1	Soaring east of Turbines T23 & T24
35	Nankeen Kestrel	*Falco cenchroides*	22/11/2022	9:14	9:16	1		S	2	Circling over grassland
36	Wedge-tailed Eagle	*Aquila audax*	22/11/2022	9:48	9:50	1		N	2	WTE flew past T8 & T9 and continued in that direction for about 1.5km, then soared really high
37	Brown Falcon	*Falco berigora*	22/11/2022	10:05	10:06	1		NW	1	Hovering then flew north 2-5m before hovering again
39	Wedge-tailed Eagle	*Aquila audax*	22/11/2022	10:27	10:30	1		S	3	Circling whilst soaring upwards south of T7 & T8 before soaring in south direction
40	Nankeen Kestrel	*Falco cenchroides*	19/12/2023	8:45	8:48	1	30	N	3	Flying and hovering in various spots just north-east of T32
41	Nankeen Kestrel	*Falco cenchroides*	19/12/2023	13:42	13:45	2	10	W	3	Two kestrels resting on the powerlines approx. 60m apart. The one closest to the road flew NW

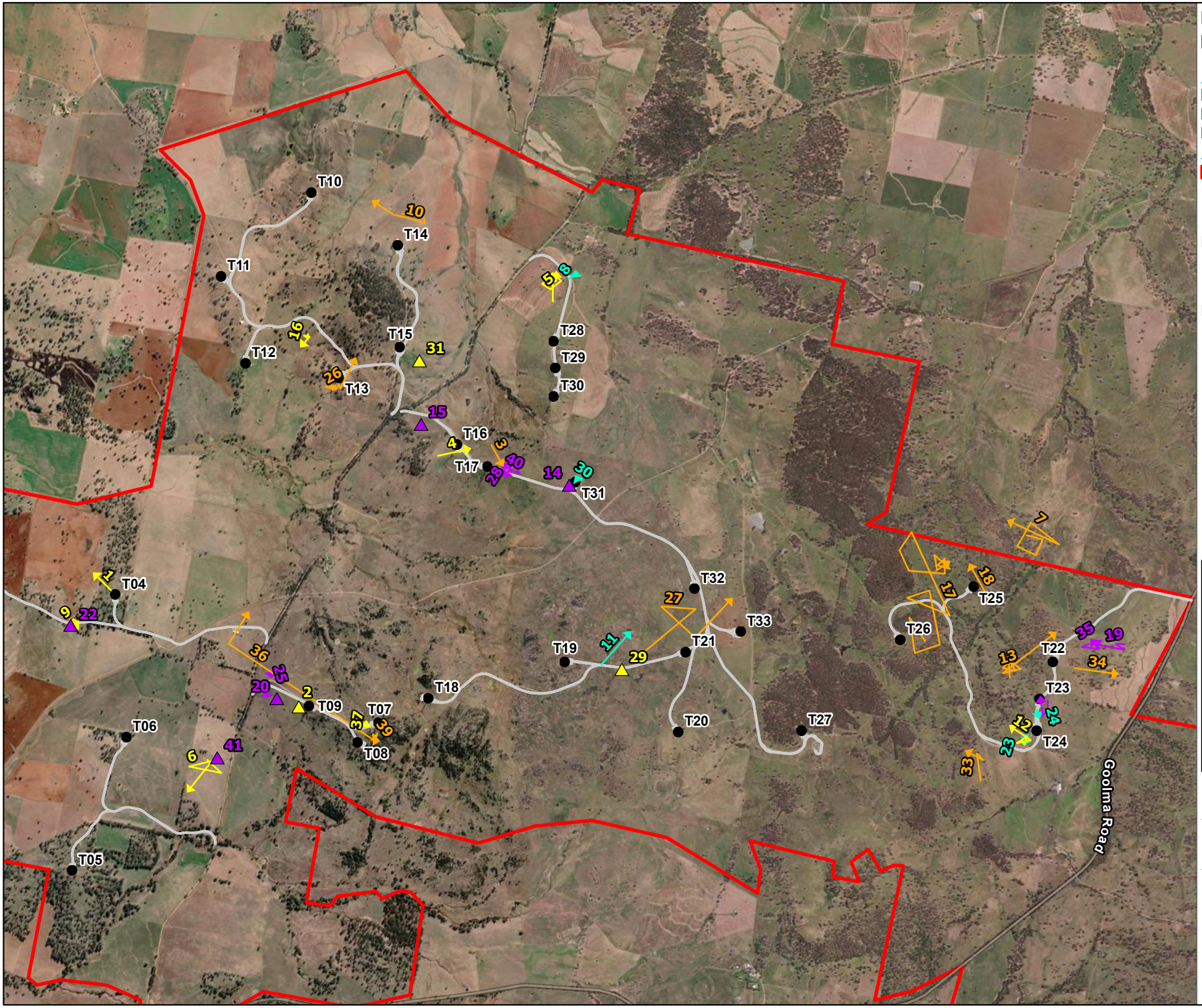

Figure 4: Raptor flight paths

Project No: 15124.08
Project: Bodangora Wind Farm
Date: 13/08/2024

- Wind Farm boundary
- Turbine
- Access tracks

Perched observation

- Brown Falcon
- Nankeen Kestrel

Flight observation

- Black-shouldered Kite
- Brown Falcon
- Nankeen Kestrel
- Wedge-tailed Eagle

N

Metres

0 350 700 1,050 1,400 1,750

Nature Advisory
PO Box 337, Camberwell, VIC 3124, Australia
www.natureadvisory.com.au
03 9815 2111 - info@natureadvisory.com.au

Figure 1: Raptor flight observations during the survey period - Created by: - E:\GIS\2015 Jobs\15124\15124.8 Figure 1 Raptor flight observations 2023 annual report 240813.aprx

4.2.3. Detectability Trials

Searchers detected 93% of carcasses after the initial placement of carcasses during the September 2023 trial (Table 6), and 100% for searches during November 2023. Searchers did detect 100% of the placed carcasses during periods of both long and short grass, with the exception of two occasions during September 2023 where the placed carcass was scavenged before the searcher could locate it (resulting in the 93% detection rate).

Table 6. Results from detectability trials during Sept 2023

Turbine	Searcher	Carcass	Grass Length	Detected
31	Searcher 1	Bat species	Short	✓
31	Searcher 1	Bat species	Short	✓
31	Searcher 1	Bat species	Medium	✓
31	Searcher 1	Bat species	Short	/
31	Searcher 1	Bat species	Medium	✓
15	Searcher 1	Nankeen Kestrel	Short	✓
15	Searcher 1	Australian Magpie	Short	✓
15	Searcher 1	Australian Magpie	Short	✓
15	Searcher 1	Nankeen Kestrel	Medium	✓
15	Searcher 1	Nankeen Kestrel	Short	✓
15	Searcher 1	Noisy Miner	Medium	✓
15	Searcher 1	Brown Falcon	Short	✓
15	Searcher 1	Nankeen Kestrel	Medium	✓
15	Searcher 1	Bat species	Medium	✓
15	Searcher 1	Bat species	Short	✓
13	Searcher 1	Bat species	Short	✓
13	Searcher 1	Bat species	Short	/
13	Searcher 1	Bat species	Short	✓
13	Searcher 1	Wedge-tailed Eagle	Short	✓
13	Searcher 1	Nankeen Kestrel	Medium	✓
13	Searcher 1	Brown Falcon	Short	✓
14	Searcher 1	Australian Magpie	Short	✓
14	Searcher 1	Nankeen Kestrel	Short	✓
14	Searcher 1	Noisy Miner	Short	✓
14	Searcher 1	Brown Falcon	Medium	✓
14	Searcher 1	Australian Magpie	Short	✓
12	Searcher 1	Wedge-tailed Eagle	Medium	✓
12	Searcher 1	Nankeen Kestrel	Medium	✓
12	Searcher 1	Nankeen Kestrel	Medium	✓
12	Searcher 1	Nankeen Kestrel	Long	✓

*/ denotes carcass was scavenged before search was conducted and ✓denotes carcass was found

Table 7. Results from detectability trials during Nov 2023

Turbine	Searcher	Carcass	Grass Length	Detected
5	Searcher 1	Bat Proxy	Short	✓
5	Searcher 1	Bat Proxy	Long	✓

Turbine	Searcher	Carcass	Grass Length	Detected
5	Searcher 1	Bat Proxy	Long	✓
5	Searcher 1	Bat Proxy	Short	✓
5	Searcher 1	Bat Proxy	Short	✓
19	Searcher 1	Large Bird	Short	✓
19	Searcher 1	Large Bird	Long	✓
19	Searcher 1	Large Bird	Short	✓
19	Searcher 1	Large Bird	Long	✓
19	Searcher 1	Large Bird	Short	✓
20	Searcher 1	Small Bird	Long	✓
20	Searcher 1	Small Bird	Short	✓
20	Searcher 1	Small Bird	Short	✓
20	Searcher 1	Small Bird	Long	✓
20	Searcher 1	Small Bird	Long	✓
31	Searcher 1	Bat	Short	✓
31	Searcher 1	Bat	Long	✓
31	Searcher 1	Small Bird	Short	✓
31	Searcher 1	Bat	Long	✓
31	Searcher 1	Small Bird	Short	✓
14	Searcher 1	Bat	Short	✓
14	Searcher 1	Large Bird	Short	✓
14	Searcher 1	Bat	Long	✓
14	Searcher 1	Large Bird	Long	✓
14	Searcher 1	Large Bird	Long	✓
15	Searcher 1	Small Bird	Long	✓
15	Searcher 1	Small Bird	Short	✓
15	Searcher 1	Large Bird	Long	✓
15	Searcher 1	Large Bird	Long	✓
15	Searcher 1	Small Bird	Short	✓

*/ denotes carcass was scavenged before search was conducted and ✓denotes carcass was found

4.2.1. Mortality estimates

Mortality estimates were undertaken by Symbolix (2024) using data provided by Nature Advisory. The full analysis, including methods and results, is provided in a report in Appendix 3

Based on the number of detected bat carcasses and the detectability and scavenging rate, an estimated total site loss (all turbines combined) of approximately (median) 1093 bats was estimated over 12 months of 3rd year of the BBAMP Implementation.

Based on the number of detected bird carcasses and feather-spots, and detectability and scavenging rates, there was an estimated loss of approximately (median) 639 birds was estimated over 12 months of 3rd year of the BBAMP Implementation.

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

upper limit was not applied on the number of bats and birds that could be on site, and the assumptions was made that bats and birds are present all year round. The ecological feasibility of this assumptions must be accounted for when using these results to evaluate overall ecological impact.

4.3. Discussion

4.3.1. Bird Mortality

A total of 56 bird strikes were recorded within the BWF site from January to December. Feather spots formed most bird mortalities identified with 35 finds, and the remaining 21 were carcasses. It has been assumed that feather spots discovered beneath turbines are the result of an initial turbine collision, with scavengers such as Foxes, Ravens and Raptors later consuming the carcass and leaving feather remains (Bernardino et al. 2020). Zero to thirteen mortalities were recorded each month during formal searches, with no mortality detected in January and March, and with October having the highest count at thirteen mortalities (Figure 5).

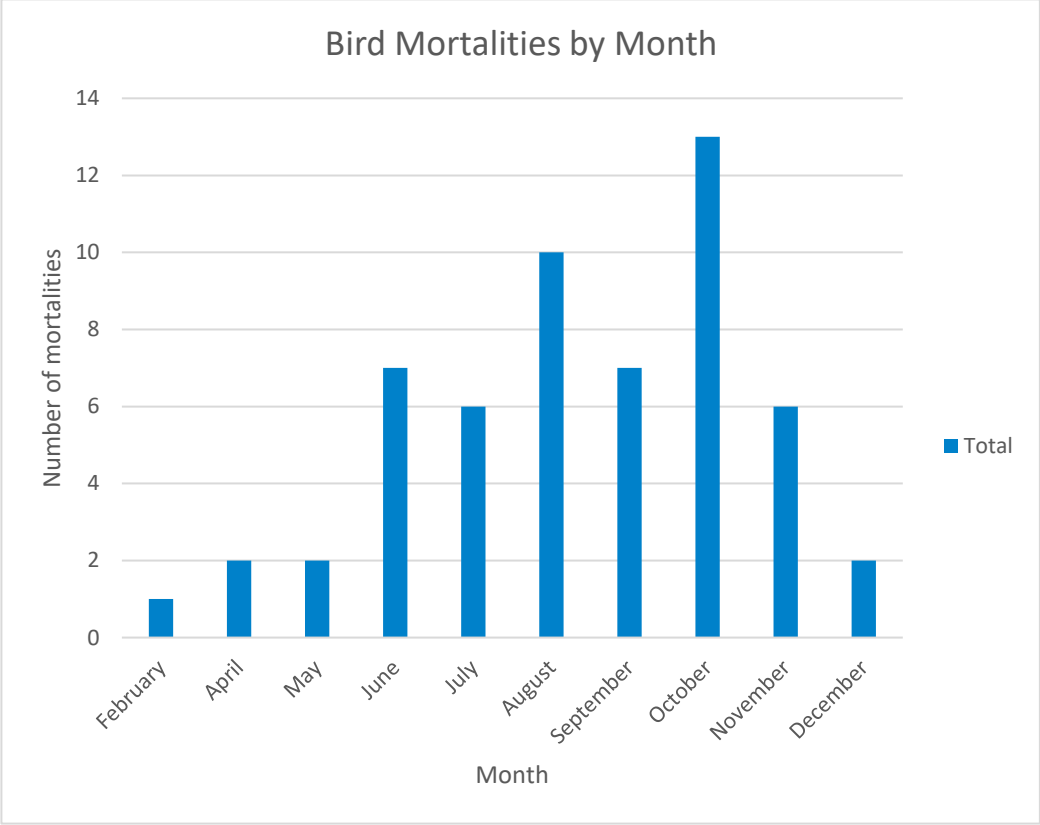

Figure 5: Monthly bird mortalities

The most common species found were Nankeen Kestrel (7) followed by Australian Magpie (6) during the survey period. The unidentified bird finds (13) were mostly white, brown and/or grey down feathers and were either clumped or spread 0.5 – 1.5 metres which made identification of species difficult. The high number of feather spots generally may be indicative of a high rate of scavenging of small carcasses, such as small birds and microbats.

In previous years there have been large numbers of Nankeen Kestrel carcasses with the highest recorded in May 2021 being 25 carcasses and 36 in total for the second year of carcass monitoring. A trigger investigation for Nankeen Kestrel occurred during May 2021 after a high number of mortalities occurred during April and May 2021 (Nature Advisory 2021a). This investigation concluded that a high number of

fatalities was directly attributed to increased breeding success following a regional mouse plague. Large numbers of juvenile birds were recorded amongst the fatalities during March, April and May 2021. The report also concluded that as mouse numbers wane, the local Nankeen Kestrel population will likely return to pre-plague levels. The event was unlikely to have a significant impact on regional or local populations. This species is widespread and common, frequently recorded from farmland habitats (Marchant and Higgins 1993, Morcombe 2021), and often flies at RSA height putting it at risk of collision with turbines (Smales 2012). Seven collisions represent a large reduction in annual mortality by comparison.

Three Brown Falcons, Two Black-shouldered Kite and Two Wedge-tailed Eagle were recorded beneath turbines during formal searches. These species are common and widespread, frequently recorded from farmland habitats (Marchant and Higgins 1993, Morcombe 2021), and often fly at RSA height putting them at risk of collision with turbines (Smales 2012). These species were frequently observed during monthly monitoring, and flight height records correspond to this finding.

Four Galahs, three Musk Lorikeets, two mortalities each for Grey Fantail and Rainbow Lorikeet and one mortality each for Noisy Miner, Crested Pigeon, Crimson Rosella, Eastern Rosella, Grey Currawong, Laughing Kookaburra, Little Friarbird, Robin Spp., Rock Pigeon, Striated Pardalote, Superb Fairywren and Yellow-rumped Thornbill were recorded beneath turbines. These species are widespread and common in open country (Morcombe 2021), such as agricultural landscapes.

Mortality numbers observed do not indicate a significant impact to any of the species recorded during this monitoring period.

4.3.2. Bat Mortality

A total of 45 bat carcasses were detected within the BWF site during the survey period. Between 1 to 8 bat remains were recorded each month during formal searches, with February having the highest count (Figure 5.). Microbats are typically more active during these warmer months of the year (Geiser 2004), so this pattern of mortality over time is expected.

Two listed threatened species carcasses have been reported during the monitoring period; the Yellow-Bellied Sheathtail Bat (YBSB) (*Saccolaimus flaviventris*) was recorded under turbines during March 2023 and is listed under the BC Act. An impact trigger notification was sent to BCS on the 31st March 2023. A GHFF was incidentally found by BWF staff during May 2023 and is listed as Vulnerable under the EPBC Act. An impact trigger notification was sent to BCS on the 16th May 2023. These are further discussed in Impact triggers.

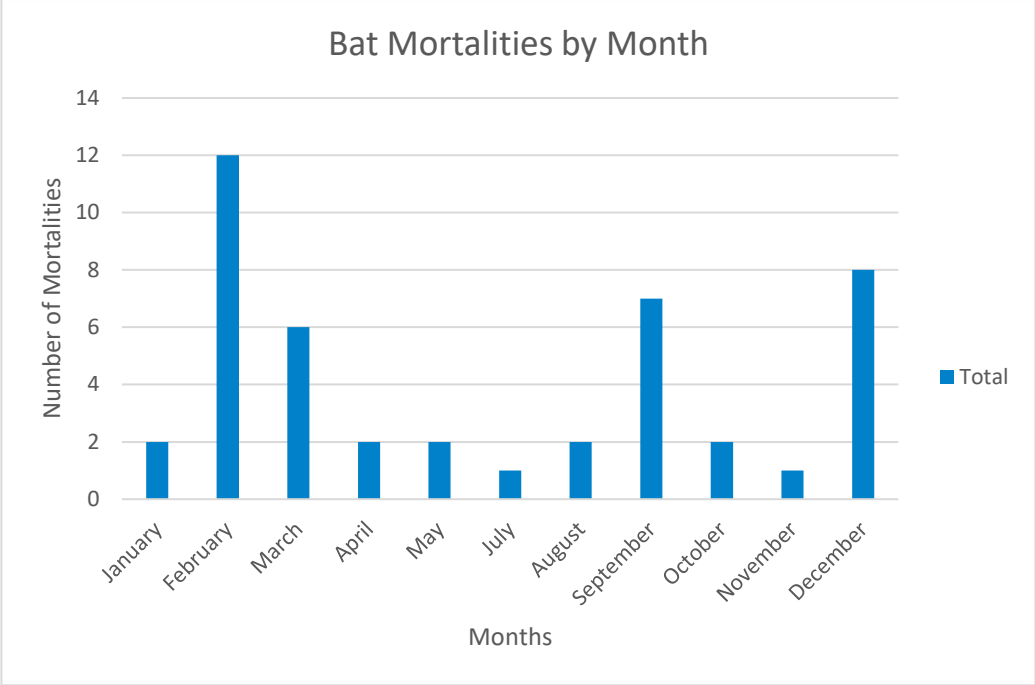

Figure 6: Monthly bat mortalities

Seven White-striped Freetail Bats, seven Southern Freetail Bats, nine Freetail Bat species and eleven unknown bat specimens were recorded as mortalities under turbines during the monitoring period. These species are all common and widespread, found in a wide range of habitats across south eastern Australia (Churchill 2008) and often fly at RSA height, putting them at risk of collision with turbines (Smales 2012).

Several studies (Symbolix 2020, Moloney *et al*. 2019, Smales 2012) have identified that these species are commonly impacted by wind farm operation generally and that particularly White-striped Freetail and Southern Freetail Bats and are over-represented as mortalities across many wind farms. Observations by Nature Advisory (unpublished data) at various wind farms in other parts of these species' range are consistent with these findings. This is related to the foraging habits of many species in which these will fly many times the height of the tree canopy in pursuit of high-flying insects (Churchill 2008). This unfortunately brings the species into collision with turbines. These species have previously been identified during initial carcass searches.

Eleven of the bat mortalities at BWF could not be identified to species level. Majority of these were mainly heavily decomposed or only a part of the bat was present (see Appendix 2 or more information) which made species identification difficult.

4.3.3. Mortality comparison by year

A total of 48 bird mortalities were observed in 1st year, 82 mortalities in 2nd year and 56 mortalities in the third year. Australian Magpie were the most affected birds in Year 1 and Year 3, with 8 and 6 mortalities respectively. This species is widespread and common in open country (Morcombe 2021), such as agricultural landscapes.

In the 2nd year of carcass monitoring at BWF, Nankeen Kestrel was the most affected species, with 36 mortalities observed. This species is widespread and common, frequently recorded from farmland habitats (Marchant and Higgins 1993, Morcombe 2021), and often flies at RSA height putting it at risk of collision with turbines (Smales 2012). The first year of monitoring had 8 Nankeen Kestrel mortalities and the third year of monitoring had 7 mortalities which demonstrate potentially wide year to year variation,

potentially due to varying abundance and breeding success of this species. This return to lower numbers further supports the findings of the Nankeen Kestrel Trigger Investigation.

There was also a slight reduction trend in detected Wedge-tailed Eagle mortalities with 5 casualties observed in Year 1 followed by 3 casualties and 2 casualties in Year 2 and Year 3 respectively. Observations of WTE flights across the carcass monitoring periods varied widely, including; 22 in Year 1, 4 in Year 2 and then 12 in the 3rd year. This indicates that WTE utilisation of the site continues, potentially in low numbers. WTE have a unique scavenging profile in that individuals tend to not be scavenged at all and instead remaining in-situ until total decomposition (Symbolix 2020). It is likely, given the accuracy of the dog teams, that WTE mortality was not significantly higher than this at the turbines monitored.

The Black-shouldered Kite mortality occurred in the third year, with two carcasses observed in Spring 2023, both the carcasses were observed under Turbine 5 and the casualties were one month apart. There were no previous moralities of Black-shouldered Kite recorded at BWF, and similar to Nankeen Kestrel they are widespread and common and tend to fly at the RSA height which increases their risk of collision with the turbines (Smales 2012). The number of mortalities is unlikely to affect the population dynamics of this species in the area.

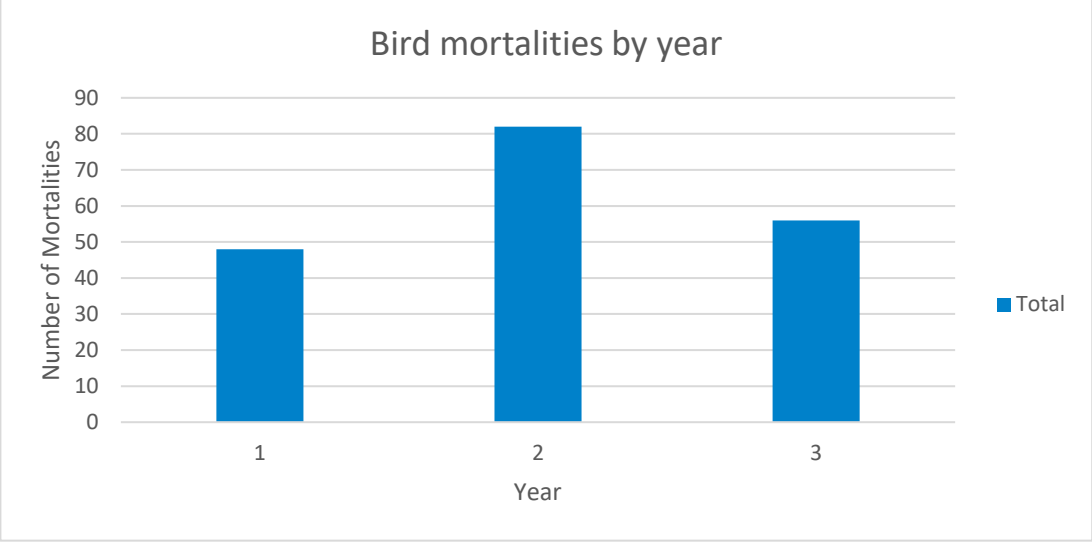

Figure 7: Yearly bird mortalities

A total of 41 bat mortalities in Year 1, 298 mortalities in Year 2 and 45 mortalities in Year 3 were observed at BWF. LRFF were the most affected species of bat in Year 2, with 269 mortalities for which targeted species survey were conducted to understand and the reduce the impact by the turbines, in Year 3 there were no LRFF carcass observed at BWF.

Gould's Wattled Bat was the second most impacted species with 11 mortalities in Year 1, there were fewer casualties in Year 2 with 8 mortalities followed by even fewer in Year 3 with only 1 carcass observed under the turbine. Southern Freetail Bat was another species which was impacted but showed fewer collisions in successive years with 10, 7 and 7 mortalities observed in Year 1, Year 2 and Year 3 respectively.

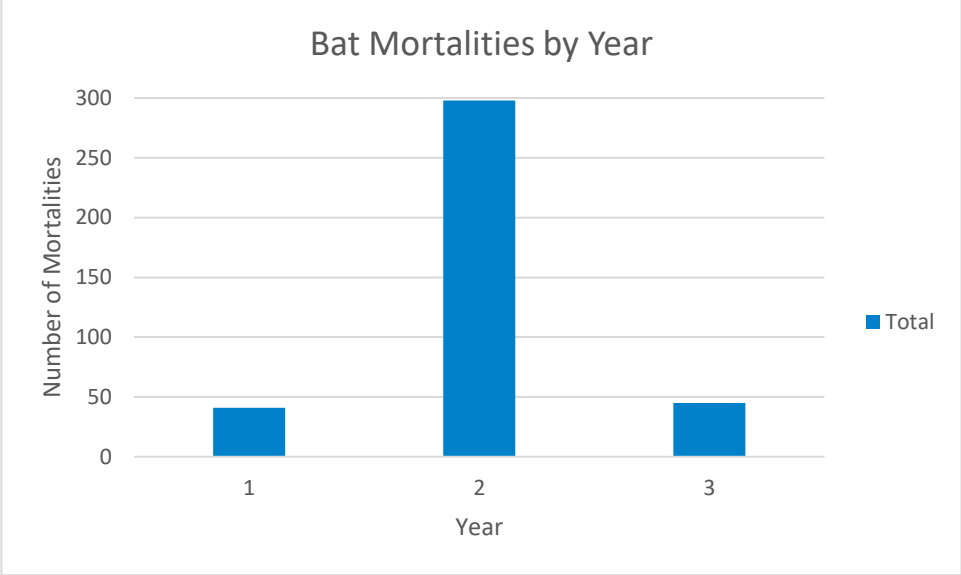

Figure 8: Yearly bat mortalities

4.3.4. Statistical mortality estimates comparison by year

Mortality estimates for Year 3 of carcass searches were undertaken by Symbolix (2024) using data provided by Nature Advisory. The full analysis, including methods and results in provided in Appendix 3.

The BWF mortality analysis over three years provides a detailed evaluation of the impact of turbine operations on bird and bat populations, highlighting both year-to-year trends and cumulative findings. Across the three years of surveys, 311 bat and 172 bird carcasses were formally recorded. The cumulative findings align with individual year analyses, offering insights into species-specific vulnerabilities and the ecological implications of wind turbine collisions.

In Years 1 and 2, the surveys combined identified 67 bat carcasses and 80 bird carcasses (excluding for comparison; Little Red Flying-foxes and Nankeen Kestrels given the extraordinary circumstances surrounding these events and subsequent additional investigations). Year 3 surveys alone identified 45 bat carcasses (including Little Red Flying-foxes) and 56 bird carcasses (including Nankeen Kestrels). The increased figures in Year 3 are likely attributable to refined survey methodologies, particularly the use of trained detection dogs, which achieved a 100% success rate in detecting carcasses for both bats and birds (93% during the September 2023 trial, as the carcass was scavenged before the searcher could locate it). In comparison, human searchers in Years 1 and 2 detected 86% of bird carcasses and 56% of bat carcasses, with efficiency varying by species size and survey conditions. Dogs' superior performance in carcass detection has been supported by other studies; for example, Paula et al. (2011) found dogs to be significantly more accurate in controlled trials (92% vs. 9% for humans), and Mathews et al. (2013) observed that dogs found up to 53% more bats than humans and completed surveys in 25% less time. This enhanced detection capability not only improves data accuracy but also highlights the benefits of incorporating trained detection dogs in survey methodologies.

Scavenger efficiency trials conducted across all years revealed consistent carcass removal patterns. For bats, the median removal time was 0.8 days (95% confidence interval: 0.3–1.9 days), while for birds it was 2.3 days (95% confidence interval: 0.9–5.8 days). Carcass distribution data showed a strong spatial pattern, with 88% of bats and 64% of birds found within a 60-meter radius of turbines, and nearly all carcasses (100% of bats and 99% of birds) falling within 100 meters (See Appendix 3).

Using Monte Carlo simulations, cumulative mortality over the three years was estimated at 5,990 bats and 1,441 birds. Year 1 alone accounted for an estimated 771 bat mortalities and 327 bird mortalities, while Year 2 contributed an estimated 628 bat mortalities and 330 bird mortalities and Year 3 accounted for an estimated 1093 bat mortalities and 639 bird mortalities. Statistical comparisons between Years 1 and 2 revealed no significant differences in mortality patterns, suggesting consistent impacts across the two years.

It is unlikely that the estimated deaths of almost 6,000 microbats from a small number of species is possible across a three-year period, given the ecology of these species. Group sizes are quite variable and change across seasons (during breeding versus non-breeding seasons). In Gould's Wattled Bats, core groups are typically made up of 8-20 individuals that also associate with multiple other similar-sized groups that use a network of roost trees spread across an area of several kilometres; in combination, this socially-connected local roosting population can include more than 200 bats (Godinho *et al.* 2015, Griffiths *et al.* 2019, Lumsden *et al.* 2020). In White-striped Freetail Bats, core groups typically comprise 5-10 individual bats that roost together over multiple years (Evans 2009, Griffiths *et al.* 2019) and these smaller groups also congregate in communal roosts with large groups that can contain 50-300 individuals (Rhodes 2007). Southern Freetails roost in groups of up to 40 female individuals while males roost in groups of three to four. Some roosts have been found to contain hundreds of individuals (Churchill 2008).

Local population sizes in the area around BWF have not been quantified but it is unlikely that this level of estimated mortality could possibly be achieved in reality, given that the bat actual observed mortality (excluding Flying-fox mortality) has been largely consistent between monitoring years, and would entail that dozens of large colonies to first exist in the relatively small areas of the site and then be totally wiped out, and potentially replaced to maintain mortality in year 3 of monitoring (Year 5 since BBAMP implementation).

That said, bat mortality is ongoing at a relatively high rate and is of concern given the population of the local area is unknown and what the impact on this is,

5. Impact triggers

Generally, an impact trigger is where there is evidence of death or injury to birds and/or bats by collision or other interaction with turbines. Under this BBAMP, the circumstances that define an impact trigger and unacceptable impact for threatened birds and/or bats are detailed below.

Impact Trigger for Threatened Species: A threatened bird/bat species (or recognisable parts thereof) listed under the Commonwealth *EPBC Act* or NSW *TSC Act* (now *Biodiversity Conservation Act 2016*), is found dead or injured under or close to a wind turbine during any mortality search or incidentally by wind farm personnel. The fatality shall be able to be attributed to the wind farm operations.

The significance of any threatened species impacts will be determined at a population scale relevant to that species as part of the decision-making framework outlined in Section 5.1.2. of the BBAMP and submitted in a report to BCS for review.

Impact Trigger for Non-threatened Species: In any two successive monthly carcass searches, two or more bird or bat carcasses (or parts thereof) of a non-threatened species, other than ravens, magpies, white cockatoos, corellas, and introduced species, are found at the same turbine (i.e. a total of four or more carcasses of the same species in two successive searches at the same turbine).

Definition of Unacceptable Impact on Non-threatened Species:

Where population numbers are known and reported by BCS for the period concerned, the definition of an unacceptable impact on non-threatened species is any impact that is likely to:

- lead to a greater than 50% reduction in the immediate population (i.e., local population, where known) that utilises the wind farm over a five-year period; 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.

Where population numbers are not known, the definition of an unacceptable impact on non-threatened species is:

- More than four carcasses of one non-threatened species (including raptor species, magpies, ravens, and introduced species) are found during both formal and incidental carcass searches in a two-month period.

Note that although the impact trigger does not include ravens, magpies, white cockatoos, corellas, and introduced species, detected mortalities for these species will still be recorded and reported as part of the annual reporting process.

Two impact triggers occurred during the monitoring periods for bat (none for birds).

5.1. Yellow-bellied Sheathtail Bat

During carcass searches that occurred at BWF; no new YBSB carcasses were observed at BWF.

Previous impacts and investigation on YBST Bats are summarised below:

One YBSB carcass was identified under Turbine 4 at BWF on 16th April 2020. The investigation concluded that the loss of one individual is unlikely to contribute significantly to the overall population decline of the species. In addition, there is no evidence of specific ecological reasons that draw the species to the vicinity of wind farm, other than this species being more common along the creek lines in valleys when compared to turbines higher on hills (Nature Advisory 2020).

A second YBSB carcass identified under Turbine 28 at BWF on 6th March 2021. The investigation concluded, given YBSB is believed to be a relatively solitary species which undertakes some migratory movements seasonally, a lack of contiguous habitat of a size that would indicate a high abundance of the species, and multiple records of the species on site but only two mortalities recorded to date across 18 months of monitoring; it is likely that BWF poses a low risk to the species and mortalities will likely be limited to an annual occurrence. Since few individuals were likely to have been impacted, and there is unlikely to be a large resident population on site owing to a lack of sufficiently large (>500 ha) remnant patches of woodland (Richards 2008), this impact was assessed as being unlikely to be significant at a population level (Nature Advisory 2021a).

In response to the first two YBSB collisions detected at BWF, a bat utilisation survey was undertaken. The investigation included bat recorders installed at BWF for several weeks from January-April 2021. It found YBSB were present at low activity levels from January – April with higher numbers recorded in March. Based on this, YBSB collisions were assessed as likely occurring in small numbers on an annual basis at BWF, potentially associated with an autumn northward migratory movement through BWF (Nature Advisory 2021b).

A third YBSB carcass was found under Turbine 7 on 23rd March, 2022 incidentally by the wind farm staff. In response, additional monitoring was proposed (Letter to BCS on 29th August 2022) to confirm previously observed patterns of mortality of YBST bat at BWF. This monitoring has been occurring monthly since January 2023 and was continued for 12 months in total i.e., until December 2023.

On 30th March 2023 a fourth YBSB carcass was found under Turbine 4 at 11 meters and 200 degrees from the base of the turbine. According to the decision-making framework, each trigger has been reported to the regulator, ongoing and relative investigations in relation to each has been undertaken (as above). With this being the only YBSB impact throughout the year, the timing of it supports previous conclusions that low numbers of YBSB impacts may occur at BWF during Autumn annually.

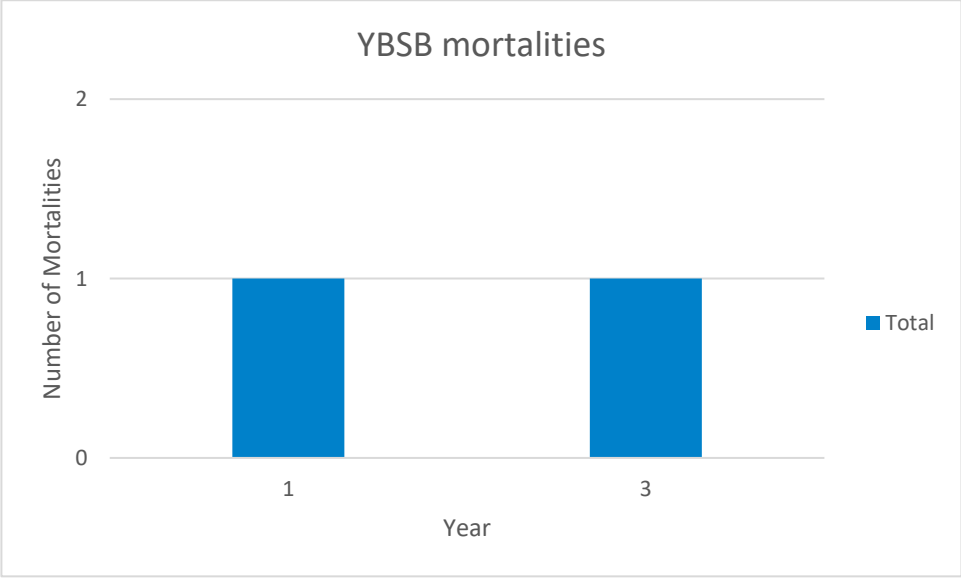

Figure 9: Yellow-bellied Sheathtail Bat yearly mortalities

Records on site to date, including mortalities indicate that the species mortality may occur annually between January to April. Considering a lack of adequate large remnant patches of woodland on site to accommodate a large population of the species (Nature Advisory 2021b&c), there is unlikely to be a large population of the species inhabiting the site. Therefore, mortality is considered likely to reoccur irregularly and in low numbers. The mortality of one to two bats per year, as detected to date is unlikely to have a

significant impact on the species population. As such the ongoing risk posed to the species by BWF is considered to be low.

5.2. Grey-headed Flying Fox

During carcass searches that occurred at BWF; no new GHFF carcasses were observed at BWF.

Previous impacts and investigation on GHFF are summarised below from the BWF fourth annual report (Nature Advisory 2023):

A trigger investigation was launched into the fatalities of the GHFF in July 2019 after several fatalities occurred during May and June of that year. The findings of the investigation were recorded in a report provided to BCD and BWF in August 2019 (Nature Advisory 2019) that concluded that GHFF utilising the wind farm site are attracted to the area due to flowering White Box (*Eucalyptus albens*) (approximately May to June). Any individuals utilising the wind farm were likely travelling from the Flying-fox camp in Wellington to BWF given the proximity and numbers observed at the Wellington camp. GHFF generally travel as individuals and disperse over a wide area, and the risk of further collisions by this species is considered to be possible, in particular while there is food in the area. This is likely to be a seasonal occurrence when the White Box flowers and a GHFF camp is resident in Wellington.

Four further fatalities have since been recorded during the BBAMP monitoring program, in March and April 2021. GHFF mortalities were identified during intensive monitoring of LRFF impacts in 2021 (Nature Advisory 2021b). This allowed for simultaneous GHFF monitoring as methods for both species are the same and as such, additional targeted investigation was not required for GHFF.

Up to 2,500 individual GHFF were found to be inhabiting the colony in Wellington during April 2021. The colony tended to disperse during flyout counts rather than in single directions, such as towards the wind farm, though individuals and small groups were sighted as travelling in that direction.

Seven GHFF mortalities have been detected at BWF to date. These individuals were likely travelling from the persistent camp located near Wellington that was abandoned in May 2021. The species will likely return to the camp at some stage, given historic annual records (DAWE 2021) and mortalities are also likely to reoccur, albeit in low numbers.

One GHFF mortality was detected incidentally by BWF staff on 12th May 2023. The carcass was identified and confirmed as a GHFF on the 15th May 2023 by Nature Advisory zoologists. The carcass was located at Turbine 5, at 20 metres NNE from the base of the turbine.

A significant impact in this case is taken from referral guidelines for migratory species (DoE 2015) wherein a development (i.e., wind turbines) has had an impact on 0.1% of the total population and this would constitute a significant impact. This would be the mortality of approximately 60 individuals occurring on an annual basis.

The species is unlikely to be attracted to the site outside of this flowering period. It unlikely that up to 60 individuals would be impacted annually given that they would likely only be attracted to the site for three months a year, and that only seven individuals were detected across 24 months, including in three months of intensive turbine monitoring undertaken as part of other investigations.

According to the decision-making framework, each trigger has been reported to the regulator, ongoing and relative investigations in relation to each has been undertaken (as above), it was determined that impacts to date were unlikely to be significant at a population level and mitigation was not recommended, and that impacts are likely to occur in low numbers annually.

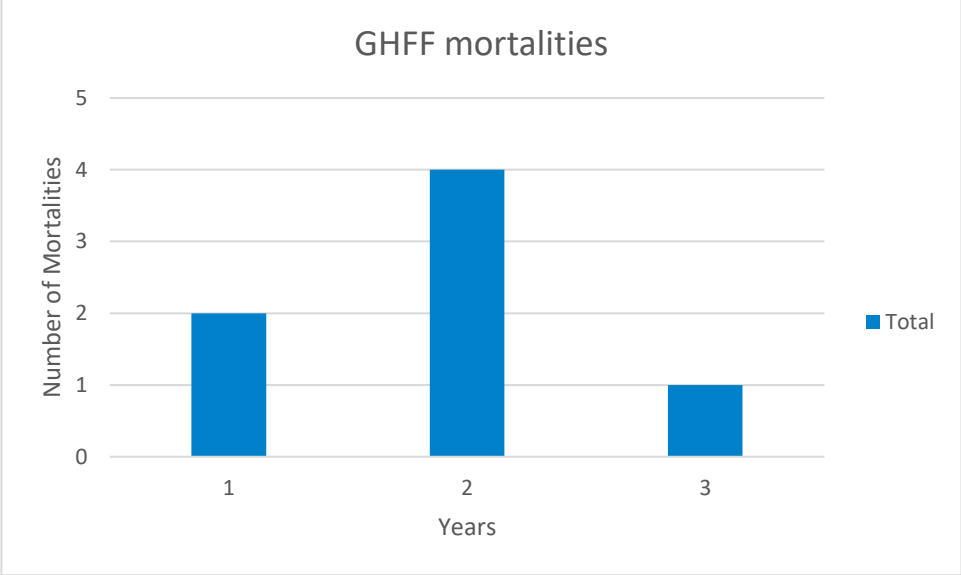

Figure 10: Grey-headed Flying Fox yearly mortalities

The incidental detection of a GHFF mortality during May supports the findings summarised in the annual report (above) that low numbers of casualties involving GHFF are likely to occur at BWF during the flowering period of White-box (May-June). The current find does not indicate an increase in impacts at this stage.

5.3. Little Red Flying Fox

No additional LRFF mortality was detected at BWF during carcass searches in 2023.

Previous impacts and investigation on LRFF are summarised below from the BWF second annual report (Nature Advisory 2021a):

A number of LRFF were recorded as mortalities under turbines at BWF during the monthly monitoring regime on 4 March 2021. This resulted in a non-threatened species impact trigger investigation consisting of extensive monitoring and mitigation measure trials during March to May 2021 and is described in a separate report (Nature Advisory 2021c).

In summary, surveys showed that LRFF were occupying the same camp as GHFF in Wellington in numbers of up to 50,000 individuals. Habitat assessments identified that LRFF were utilising large remnant patches of Red Ironbark (*Eucalyptus sideroxylon*) to the north-east of BWF. Flight path assessments of the species indicated that up to several thousand individuals were traversing the BWF wind farm on a nightly basis to access these areas and subsequently return to the camp.

To date, including additional mortalities detected during trials undertaken outside of the formal mortality monitoring program (Nature Advisory 2021c), a total of 302 LRFF mortalities have been detected. This number was draw from various searches including mortality found during carcass searches and additional searches (50 incidental and 219 formal). Carcasses found during clearance surveys and lighting trials (29 during clearance survey and 4 during trials).

Surveys of the camp indicated that this dispersed during early May 2021 and LRFF vacated the region. This is likely related to the decline in food availability. Occurrence of the species in the region of BWF is patchy and sporadic, and highly dependent on food resource availability. The same flowering event that attracted LRFF to the region in 2021 did not occur consecutively across two years and was influenced by

environmental conditions that are difficult to predict. LRFF will move and form camps as local foraging resources permit and typically coinhabit camps with other species.

The Wellington camp may be occupied by LRFF, given the historic records of persistent GHFF presence at the camp, but the potential for LRFF to return and at what date is unknown. Flying-foxes using the camp in Wellington could potentially take advantage of floral resources in or close to BWF and mortality impacts could occur as a result of this behaviour. A lighting trial was undertaken at BWF, which was subject to a permit amendment prior to having permission to be implemented, with the aim of deterring LRFF from approaching turbines and reducing mortality. The concept involved lighting the base and surrounding hardstand of turbines with flood lights to see if LRFF flying through the wind farm would be deterred from the turbine. Unfortunately, the LRFF had vacated the region before the efficacy of the measure could be tested, however this is planned to be trialled again, much sooner, in the event that the species returns. While impacts on LRFF are not technically considered significant based on the BBAMP criteria, any LRFF mortality are to be reported by the Wind Farm personnel in future.

6. Mitigation measures

Mitigation involves the prevention, avoidance and/or reduction of the risk of an impact trigger occurring or continuing to occur. An '*impact trigger*' is defined in Impact triggers as a threshold of impact on birds or bats that triggers an investigation and/or management response. The overall objective of mitigation measures is to ensure that the operation of BWF does not lead to unacceptable impacts on threatened or non-threatened birds and bats.

6.1. Application of mitigation measures during the monitoring period

6.1.1. Removal of Carrion

Regular carrion removal from within 200 metres of turbines will be implemented to assist in reducing the attractiveness of the site to raptors and therefore reduce the chances of fatal collisions by this group of birds. Carrion is defined as the dead and decaying flesh of an animal that often serves as a food source for animals.

To provide for the regular removal of carcasses likely to attract raptors to areas near turbines the procedures below will be adopted.

- Designate a suitable person (such as a wind farm employee or landowner) who will undertake the following activities:

    1. Site personnel shall notify the Site Manager immediately of any identified carrion within 200 metres of an operating turbine.
    2. The Site Manager is responsible for notifying the landowner so that any carcasses and/or remains found that are within 200 metres of turbines, can be collected and disposed of as soon as possible, in a manner that will avoid attracting raptors close to turbines.
    3. The Site Manager shall continue to consult with landowners in relation to the appropriate disposal of collected carrion, to be located at least 200 metres away from the closest turbine, whilst still leaving the carrion available as a food source so as to not reduce the habitat quality for raptors.
    4. Carcass occurrence and removal will be recorded by the Site Manager.

In the 2023 period there were no instances of an animal carcass within 200 metres of a turbine being reported by BWF personnel.

6.1.2. Control of Stock

Grain feeding, trails and spillage from grain trucks, can attract cockatoos and other parrots. Therefore, the Site Manager shall communicate and consult with landowners as required in relation to stop grain feeding practices within 250m of operating wind turbines if it is deemed necessary in reducing the likelihood of the birds colliding with turbines.

During lambing season (usually late autumn / early winter) young lambs are susceptible to death. Therefore, the Site Manager will consult with required landowners to request that consider restricting lambing to paddocks at least 200 metres away from turbines.

These should be undertaken in consultation with landholders. It is acknowledged here that BWF cannot control what landholders do on their property or farming practices.

6.1.3. Pest Management

If many rabbit or other feral animal carcasses or active rabbit presence is incidentally observed, it may be necessary to conduct an integrated rabbit control program (to reduce site attractiveness to WTEs) within 200 metres of turbines. Methods to control rabbits include burrow destruction, and shooting.

During the year 5 (2023) monitoring period, rabbit warrens and activity have not been reported within 200 metres of turbines.

6.2. Supplementary Mitigation Measures

Supplementary mitigation measures will be implemented in consultation with BCS if an impact trigger occurs. The purpose of supplementary mitigation measures will be to prevent a specific impact from continuing to occur. Specific mitigation measures will be implemented depending on the nature, cause and significance of any impact recorded and in response to the results of investigations of the event and of the species concerned on the wind farm site. The purpose of investigations will be to identify clearly the most relevant and effective mitigation measures.

If turbine shutdown is considered necessary by BCS, a species management strategy will be prepared with BCS that sets out:

- The nature of the ongoing unacceptable impacts, including the level of risk to the species' regional and overall populations, where known;
- The findings of detailed investigations undertaken in response to the impact trigger, focussing on the species' use of the immediate area around affected turbines;
- Clear scope for on-going monitoring to identify triggers for turbine shut-down;
- Agreed triggers for turbine shutdown and restart; and
- Reporting and consultation arrangements.

7. Conclusion and Recommendation

The wind farm monitoring from January to December 2023 revealed a total of 101 bird and bat carcasses, including 56 bird strikes and 45 bat carcasses. The most commonly affected bird species were Nankeen Kestrel and Australian Magpie. Bird strikes affected four raptor species including Nankeen Kestrel, Brown Falcon, Black-shouldered Kite and Wedge-tailed Eagle. No threatened bird species were detected in carcass searches. Feather spots were prevalent, indicating scavenging activities, particularly of smaller birds. The overall bird mortality, although not negligible, does not suggest a significant impact on any particular species, particularly when compared to historical data. However, bat mortality remains a concern, with 45 bats recorded, some of which could not be identified due to decomposition or scavenging.

Recommendations

- Continued Monitoring: Due to continuing mortality and significant inter-annual variation in mortality Regular bat-specific carcass searches and raptor monitoring should continue which will help in understanding long-term trends and the effectiveness of mitigation measures.
- Continued Flying-fox camp monitoring outlined in Section 3.1
- Mitigation Measures:
    - Mitigation measures implemented during the monitoring period to be continued (See: Application of mitigation measures during the monitoring period)
    - Consider implementing or enhancing mitigation measures such as adjusting turbine operation during high-risk periods for birds and bats, especially during migration seasons or peak activity times as mentioned in Supplementary Mitigation Measures.
- Further Research: Conduct detailed studies to understand the specific factors contributing to bat mortality, including behavioural studies and acoustic monitoring, to develop targeted mitigation strategies. This could also include deploying Songmeters and seasonal observation of roosting of flying foxes at Wellington Camp. I and prolific flowering of eucalypts on site if there is roosting and feeding activity, mitigation measures described in Section 6.2 could be implemented.
- Stakeholder Engagement: Engage with local wildlife conservation groups and stakeholders to share findings and collaborate on improving wildlife protection measures around wind farms.

8. References

Bernardino J, Bispo R, Martins RC, Santos S & Moreira F 2020, Response of vertebrate scavengers to power line and road rights-of-way and its implications for bird fatality estimates, Scientific Reports 10: Article 15014.

Biodiversity, Conservation and Science Directorate 2022, Bodangora Wind Farm – Bird and Bat Adaptive Management Plan, August 2022 Biodiversity, Conservation and Science Directorate Ref DOC22/667367. Letter to Michael Bullock Site Manager Bodangora Wind Farm. Author Wynn, S

Brett Lane & Associates 2017, *Bodangora Wind Farm Bird and Bat Adaptive Management Program*, Report for Bodangora Wind Farm Pty Ltd. Brett Lane & Associates Pty Ltd, Melbourne. Project No. 15124.

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

Department of Agriculture, Water and the Environment (DAWE) 2021. National Flying-fox monitoring viewer, web-based interactive map, Department of Agriculture, Water and the Environment.

Department of Environment (DoE) 2015. Referral guidelines for 14 birds listed as migratory.

Evans, L.N., 2009. Roosting behaviour of urban microbats: the influence of ectoparasites, roost microclimate and sociality (PhD). University of Melbourne.

Geiser F 2004, 'Energetics, thermal biology and torpor in Australian bats'. In Zubain, A, McCracken, GF, Kunz TH (eds) Functional and Evolutionary Ecology of Bats (pp. 5-22). Oxford University Press Inc. USA.

Godinho, LN, Lumsden, LF, Coulson, G, Griffiths, SR, 2015. Network analysis reveals cryptic seasonal patterns of association in Gould's wattled bats (*Chalinolobus gouldii*) roosting in bat-boxes. *Behaviour* 152, 2079–2105.

Griffiths, SR, Lumsden, LF, Bender, R, Irvine, R, Evans, LN, Visintin, C, Eastick, DL, Robert, KA, Lentini, PE, 2019. Long-term monitoring suggests bat boxes may alter local bat community structure. *Australian Mammalogy* 41, 273–278.

Lumsden, LF, Griffiths, SR, Silins, JE, Bennett, AF, 2020. Roosting behaviour and the tree-hollow requirements of bats: insights from the lesser long-eared bat (*Nyctophilus geoffroyi*) and Gould's wattled bat (*Chalinolobus gouldii*) in south-eastern Australia. *Australian Journal of Zoology* 68, 296–306.

Moloney PD, Lumsden LF & Smales I 2019. Investigation of existing post-construction mortality monitoring at Victorian wind farms to assess its utility in estimating mortality rates. Arthur Rylah Institute for Environmental Research Technical Report Series No. 302. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Morcombe M 2021, Morcombe & Stewart Guide to Birds of Australia (Version 1.5) [Mobile App]. Apple App Store.

Nature Advisory 2019, *Bodangora Wind Farm BBAMP Implementation: Grey-headed Flying-Fox Field Investigation – Part II*, Report for Bodangora Wind Farm Pty Ltd. Nature Advisory Pty Ltd, Melbourne. Project No. 15124.

Nature Advisory 2020, *Annual Report on the Implementation of the Bird and Bat Adaptive Management Plan*, Report for Bodangora Wind Farm Pty Ltd. Authors Callan M., O'Meara E., Doughty C., O'Callaghan B., Lane B., Nature Advisory Pty Ltd, Melbourne. Project No. 15124.

Nature Advisory 2021a. Bodangora Wind Farm Nankeen Kestrel Impact Trigger, June 2021. Report No. 19152 (26.0). Prepared for Infigen Australia Pty Ltd.

Nature Advisory 2021a, Bodangora Wind Farm – Impact Trigger Lighting Trial Little Red Flying-fox (*Pteropus scapulatus*) (LRFF), June 2021 Nature Advisory Ref 15124.6 (26.0). Letter to Michael Bullock Manager BWF. Author O'Callaghan, B. Project No. 15124.

Nature Advisory 2021b, *Bodangora Wind Farm: Little red flying-fox Impact Assessment Report*, Report for Infigen Energy Limited. Authors Thomas G., Sebastian M., Clerke J., O'Callaghan B., Lane B., Nature Advisory Pty Ltd, Melbourne. Project No. 15124.

Nature Advisory 2021d, *Bird and Bat Adaptive Management Plan – Second Annual Report*, Report for Bodangora Wind Farm Pty Ltd. Authors Callan M., O'Meara E., Sebastian M., Coutin S., Doughty C., Thomas G., O'Callaghan B., Lane B., Nature Advisory Pty Ltd, Melbourne. Project No. 15124.

Nature Advisory 2022, *Bird and Bat Adaptive Management Plan – Third Annual Report*. Consultant's report to Bodangora Wind Farm Pty Ltd, Authors Clerke. J., O'Callaghan B. Nature Advisory Pty Ltd, Melbourne. Report 15124.8 (1.1).

Nature Advisory 2023, *Bird and Bat Adaptive Management Plan – Fourth Annual Report*. Consultant's report to Bodangora Wind Farm Pty Ltd, Authors Clerke. J., O'Callaghan B. Nature Advisory Pty Ltd, Melbourne. Report 15124.8 (2.1).

Marchant S & Higgins PJ (eds) 1993, *Handbook of Australian, New Zealand and Antarctic Birds, Volume 2: Raptors to Lapwings*, Oxford University Press, Melbourne.

Mathews, et. al., 2013. Wind Energy and Wildlife Conservation, Effectiveness of Search Dogs Compared with Human Observers in Locating Bat Carcasses at Wind-Turbine Sites: A Blinded Randomized Trial, Wildlife Society Bulletin, 37(1): 34-40.

Morcombe M 2021, Morcombe & Stewart Guide to Birds of Australia (Version 1.5) [Mobile App]. Apple App Store.

Paula, et. al., 2011. Dogs as a Tool to Improve Bird-Strike Mortality Estimates at Wind Farms, Journal for Nature Conservation, 19; 2011, 202-208.

Richards GC 2008, *An assessment of bat fauna at the proposed Glenn Innes Wind Farm, NSW.* Report for Connell Wagner Pty Ltd. Author Richards, GC.

Rhodes, M, 2007. Roost Fidelity and Fission–Fusion Dynamics of White-Striped Free-Tailed Bats (*Tadarida australis*), *Journal of Mammalogy*, Volume 88, Issue 5, 18 October 2007, Pages 1252–1260,Smales I 2012, "Fauna Collisions with Wind Turbines: Effects and Impacts, Individuals and Populations. What Are We Trying to Assess?" In *Wind and Wildlife: Proceedings for the Conference on Wind Energy and Wildlife Impacts,* 23 – 40. Springer.

Symbolix 2020. Post-construction bird and bat monitoring at wind farms in Victoria. Public report, 13th Wind Farm Research Meeting 2020.

Appendix 1: Carcass record form

Please fill out details in this form for each bird/bat carcass found. Injured wildlife must be transported to the nearest veterinary and or / wildlife rescue and care.

Term	Definition
Recordable Bird / bat carcass	Birds or bats found on the ground within 200m radius of a wind turbine generator.
Feather spots	Cluster of feathers (minimum 10 feathers or two primary feathers).
Intact	Carcass that is completely intact is not badly decomposed and shows little or no sign of being predated or scavenged.
Scavenged	An entire carcass showing signs of being fed upon by a predator or scavenger or a dismembered carcass in one location.
Injured	Bird or bat found to be alive but injured.

Recordable bird or bat carcass details (If you do not know or are unsure of an answer write "unknown")	
Carcass identified by (name):	
Form completed by (name):	
Wind farm name:	
Date & time:	
Weather conditions in preceding 24 hours: (including wind speed and direction and any unusual weather conditions in last 48 hours. If a waterbird, note the level of water in surrounding water bodies).	
Turbine number:	
Distance (m) and bearing (deg) of carcass from turbine	
Species identification *(type of bird / bat)*	
Description of carcass: Intact, Feather-spot, Scavenged or injured (and any other observations, including description of the injuries)	
How old and what sex is the carcass estimated to be?	
If remains found, indicate type *(body, wings, skeleton, feather spots)*	
Additional comments	
Photos taken of carcass where it is found *(attach photos on page 2)*	Yes ☐ No ☐

Appendix 2: Carcass search detailed data

Year	Season	Month	Date	Common Name	Scientific Name	Carcass type	Threatened Status	*Find Refence	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Year 3	Summer	January	24/01/2023	White-striped Freetail Bat	*Austronomus australis*	Carcass	None	C23.01.01	4	1	166	Forearm 6cm, freetail, fresh 24 hours
Year 3	Summer	January	25/01/2023	White-striped Freetail Bat	*Austronomus australis*	Carcass	None	C23.01.02	9	4	220	Fresh <3 days, visible damage
Year 3	Summer	February	2/03/2023	Australian Noisy Miner	*Manorina melanocephala*	Bird	None	C23.02.02	14	17	250	damage to back; <3 days old
Year 3	Summer	February	2/03/2023	Chocolate Wattled Bat	*Chalinolobus morio*	Bat	None	C23.02.04	30	41	251	4.3cm forearm, damage to back
Year 3	Summer	February	2/03/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C23.02.01	12	35	312	Old >1 week old; male; 2.7cm forearm; damage to left side
Year 3	Summer	February	2/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.02.03	14	19	88	only forearm, 3.7cm forearm
Year 3	Summer	February	3/03/2023	Chalinolobus spp.	*Chalinolobus* spp.	Bat	None	C23.02.06	25	13	222	4.8cm forearm; old; missing bottom half, missing one wing, other wing is deteriorating; very dark brown, almost black fur
Year 3	Summer	February	3/03/2023	Chocolate Wattled Bat	*Chalinolobus morio*	Bat	None	C23.02.07	25	18	193	4.6cm forearm, very dark brown on back and face, stomach is light grey; <24 hours old
Year 3	Summer	February	3/03/2023	Gould's Wattled Bat	*Chalinolobus gouldii*	Bat	None	C23.02.12	25	45	308	2.4cm forearm,< 24 hours old; damage to abdomen; light brown fur on tip, but dark brown close to body, underside is lighter; male
Year 3	Summer	February	3/03/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C23.02.08	25	46	287	> 3 days old; light brown fur on underside and darker brown on back; 2.8cm forearm; damage to back
Year 3	Summer	February	3/03/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C23.02.09	25	34	315	< 24 hours old; same sp as 8 and 13; male; 2.5cm forearm; damage under mouth
Year 3	Summer	February	3/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.02.05	9	42	193	Skull, spine, some wing bones and some fur; 2.5cm forearm
Year 3	Summer	February	3/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.02.10	25	5	105	skeletal remains and some fur; fur is brown and grey; 3.9cm forearm
Year 3	Summer	February	3/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.02.11	25	33	112	skeletal remains; spine, forearm and ear; forearm 3.9cm; fur grey
Year 3	Summer	February	3/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.02.13	19	59	210	part of a skull
Year 3	Autumn	March	28/03/2023	Freetail spp.	*NA*	Bat	None	C23.03.02	14	0	7	<24hours, no damage, forearm 3.6cm
Year 3	Autumn	March	28/03/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C23.03.01	14	3	36	<24hours, no damage, mastiff-like face, forearm 5.8cm
Year 3	Autumn	March	28/03/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C23.03.03	15	45	167	<24hours old, mastiff face, no damage, forearm 5.9cm
Year 3	Autumn	March	28/03/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C23.03.04	20	15	167	<24hours, female, no damage, 5.8cm forearm
Year 3	Autumn	March	29/03/2023	Unknown Bat spp.	*NA*	Bat	None	C23.03.06	25	47	288	skeletal remains, some brown fur, forearm 4.1cm
Year 3	Autumn	March	29/03/2023	Yellow-bellied Sheath-tail Bat	*Saccolaimus flaviventris*	Bat	Vulnerable	C23.03.05	4	11	200	>1 week old, wing membranes deteriorated, face missing fur, white on belly, black on back, teeth visible, forearm 7.6cm
Year 3	Autumn	April	12/04/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	FS23.04.01	5	61	249	feathers spread over 3m, mainly downy feathers, some wing feathers -striped
Year 3	Autumn	April	13/04/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C23.04.01	25	30	88	damage to face, <1 week old, male, 2.5cm forearm
Year 3	Autumn	April	14/04/2023	Brown Falcon	*Falco berigora*	Bird	None	C23.04.02	2	104	248	complete carcass, <3 days old
Year 3	Autumn	April	14/04/2023	Southern Freetail Bat	*Mormopterus planiceps*	Bat	None	C23.04.03	2	39	320	<3 days old, 3.8cm forearm, freetail, male, 7mm penis
Year 3	Autumn	May	24/05/2023	Little Forest Bat	*Vespadelus vulturnus*	Bat	None	C2305-1	25	45	125	Forearm 29mm, <3 days, started to decay
Year 3	Autumn	May	24/05/2023	Musk Lorikeet	*Glossopsitta concinna*	Feather Spot	None	FS2305-1	23	38	270	Feather spot covering ~30cm
Year 3	Autumn	May	12/05/2023	Grey-headed Flying Fox	*Pteropus poliocephalus*	Bat	Vulnerable	INC2305-1	5	20	25	found by BWF staff. Partially scavenged. > 3 days
Year 3	Autumn	May	24/05/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	C2305-3	25	45	219	Spread of 1m, mostly down feathers
Year 3	Winter	June	27/06/2023	Galah	*Eolophus roseicapilla*	Feather Spot	None	FS23.06.1	12	38m	-	Spread of 0.5m, mostly grey down & grey & pink semiplume feathers
Year 3	Winter	June	27/06/2023	Galah	*Eolophus roseicapilla*	Feather Spot	None	FS23.06.2	12	42m	-	Spread of 1m, mostly wing & down feathers (6cm-12cm long)
Year 3	Winter	June	27/06/2023	Musk Lorikeet	*Glossopsitta concinna*	Feather Spot		FS23.06.4	4	70m	-	Spread of 0.2m, 4x wing feathers (8cm long)
Year 3	Winter	June	27/06/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS23.06.3	4	65m	-	Spread of 1.5m, 4x wing feathers (avg. 16cm long)
Year 3	Winter	June	27/06/2023	Unknown Bird spp.	*NA*	Feather Spot		FS23.06.5	4	13m	-	Spread 0.5m, white & grey down feathers, grey & pinky/red semiplume feathers

Year	Season	Month	Date	Common Name	Scientific Name	Carcass type	Threatened Status	*Find Refence	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Year 3	Winter	June	28/06/2023	Unknown Bird spp.	*NA*	Feather Spot		FS23.06.6	5	12m	-	clumped together, 5x white & grey wing feathers, approx. 12cm long
Year 3	Winter	June	28/06/2023	Unknown Bird spp.	*NA*	Feather Spot		FS23.06.7	5	70m	-	Spread 1.5m, predominately grey wing feathers
Year 3	Winter	July	24/07/2023	Australian Magpie	*Gymnorhina tibicen*	Bird	None	C23.07.3	9	36m	175	Partial carcass, 2x pieces of beak (4.5cm long), Feather spread 0.5m, white & black wing and tail feathers, white downing feathers, previously recorded as FS23.07.1
Year 3	Winter	July	24/07/2023	Unknown Bird spp.	*NA*	Feather Spot	None	FS23.07.2	5	38m	243	Spread 1.2m, 2x clumps of white downing/semiplume feathers, found ontop of bunch of sticks
Year 3	Winter	July	24/07/2023	White-striped Freetail Bat	*Austronomus australis*	Bat	None	C23.07.1	9	48m	254	very decomposed, forearm length ~ 65mm, white fur on chest, damage to wing, wedged amongst rocks,
Year 3	Winter	July	25/07/2023	Juvenile Grey Currawong	*Strepera versicolor*	Feather Spot	None	FS23.07.3	15	15m	55	Spread 1.5m, 8x black wing featehrs with light brown tips and grey, brown semi-plumage feathers
Year 3	Winter	July	25/07/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C23.07.2	13	18m	213	Spread 0.3m, 3x wing/tail feathers, 9x bones inlcuding keel/sternum and pelvis
Year 3	Winter	July	25/07/2023	Nankeen Kestrel	*Falco cenchroides*	Feather Spot	None	FS23.07.4	4	86m	246	Spread 1m, 5x wing/tail fathers, 3x semi-plumage, found approx. 10m from the Nakenn Kestrel FS last month
Year 3	Winter	July	27/07/2023	Rainbow Lorikeet	*Trichoglossus moluccanus*	Feather Spot	None	FS23.07.5	2	6m	194	Spread 0.2m, mostly wing feathers
Year 3	Winter	August	22/08/2023	Unknown Bat spp.	*NA*	Bat	None	C23.08.2	20	50m	79	Very decomposed, forearm length ~ 6cm, width of mouth opening 16mm
Year 3	Winter	August	22/08/2023	Unknown Bird spp.	*NA*	Feather Spot	None	FS23.08.1	33	3m	215	Spread of 5m, grey wing & plumage feathers
Year 3	Winter	August	22/08/2023	Yellow-Rumped Thornbill	*Acanthiza chrysorrhoa*	Bird	None	C23.08.1	19	20m	205	Damange to left wing, no eyes
Year 3	Winter	August	23/08/2023	Australian Magpie	*Gymnorhina tibicen*	Bird	None	C23.08.3	14	77m	253	Both wings attached to scapula, part Sternum and vertebrae
Year 3	Winter	August	23/08/2023	Australian Magpie	*Gymnorhina tibicen*	Bird	None	C28.08.5	9	30m	190	Whole wing, downing feathers 0.2m away
Year 3	Winter	August	23/08/2023	Brown Falcon	*Falco berigora*	Bird	None	C23.08.4	13	37m	220	5x wing feathers connected to metacarples
Year 3	Winter	August	23/08/2023	Grey Fantail	*Rhipidura albiscapa*	Feather Spot	None	FS23.08.3	5	34m	114	Spread 0.3m, small grey & white feathers, 3-5cm long wing feathers
Year 3	Winter	August	23/08/2023	Rainbow Lorikeet	*Trichoglossus moluccanus*	Feather Spot	None	FS23.08.4	2	21m	240	Spread 0.3m, located ~6m from last months FS
Year 3	Winter	August	23/08/2023	Southern Freetail Bat	*Mormopterus planiceps*	Bat	None	INC23.08.1	13	53m	358	Bat still alive, blood on nose, collected and given to WIRES
Year 3	Winter	August	23/08/2023	Unknown Bird spp.	*NA*	Feather Spot	None	FS23.08.2	7	77m	33	Spread of 1m, downing feathers
Year 3	Winter	August	24/08/2023	Australian Magpie	*Gymnorhina tibicen*	Bird	None	INC23.08.2	16	50m	NA	<1hr, blood on face, broken wing
Year 3	Winter	August	24/08/2023	Crimson Rosella	*Platycercus elegans*	Feather Spot	None	FS23.08.5	25	40m	100	Clump of downing feathers, 1x 13cm long blue & grey wing feather found ~7m away
Year 3	Spring	September	18/09/2023	Unknown Bird spp.		Feather Spot		FS23.09.1	5	23	188	4x black wing feathers, average length 17cm
Year 3	Spring	September	18/09/2023	Unknown Bird spp.		Feather Spot		FS23.09.2	5	52	137	Spread 0.4m, Grey & light brown semi plumage feathers and downing feathers
Year 3	Spring	September	19/09/2023	Australian Magpie	*Gymnorhina tibicen*	Bird	None	C23.09.7	20	51	62	Spread 0.5m, Part of a wing, grey & white downing feathers, black & white tail feathers, dark brown wing feathers
Year 3	Spring	September	19/09/2023	Brown Falcon	*Falco berigora*	Bird	None	C23.09.8	30	16	171	<48hrs, Spread 0.3m of semi-plumage feathers
Year 3	Spring	September	19/09/2023	Grey Fantail	*Rhipidura albiscapa*	Bird	None	C23.09.6	20	35	290	Beak, spread 0.3m, small grey wing feathers with white spots, average length 7.5cm
Year 3	Spring	September	19/09/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C23.09.10	14	28	215	Spine & lower body with tail & right leg, left leg approx. 0.2m away, Spread 1m, grey & white downing feathers,
Year 3	Spring	September	20/09/2023	Galah	*Eolophus roseicapilla*	Feather Spot	None	FS23.09.3	9	30/44	350/8	Two locations - Spread 0.5m, mostly downing & semi-plumage feathers with 8x grey wing feathers (very windy), Spread 0.5m, all grey (small amounts of pink) wing feathers
Year 3	Spring	October	23/10/2023	Black-shouldered Kite	*Elanus axillaris*	Bird	None	C23.10.1	5	24	200	Claw and leg bones, feathers clumped to leg, 9x white/grey wing/tail feathers. Avg. feather length = 15cm, claw/foot length = 6.1cm
Year 3	Spring	October	23/10/2023	Laughing Kookaburra	*Dacelo novaguineae*	Feather Spot	None	FS23.10.1	5	58	80	1.5m feather spread. First clump brown/black wing/tail feathers. Second clump grey/white semi-plumage feathers. Clumps are 1m apart. Smaller dark feathers with blue tips
Year 3	Spring	October	23/10/2023	Striated Pardalote	*Pardalotus striatus*	Feather Spot	None	FS23.10.2	5	3	300	Small grey wing feathers with white strips. Small orange spot at base. Feathers avg. 6.5cm long and small feahters avg. 3-4cm long

Year	Season	Month	Date	Common Name	Scientific Name	Carcass type	Threatened Status	*Find Refence	Turbine number	Distance from turbine (m)	Bearing from turbine (°)	Notes
Year 3	Spring	October	24/10/2023	Musk Lorikeet	*Glossopsitta concinna*	Feather Spot	None	FS23.10.6	12	62	159	Dark brown wing feathers with strip of green. Green downing feathers attached at base, small grey/green downing feathers. Wing feathers length = 9cm - 9.5cm.
Year 3	Spring	October	24/10/2023	Rock/Feral Pigeon	*Columba livia*	Feather Spot	None	FS23.10.7	30	60	75	Grey/white wing/tail feathers, dark brown downing feathers have sparkle of blue/green, avg feather length = 5.5cm - 7.5cm.
Year 3	Spring	October	24/10/2023	Unknown Bird spp.		Feather Spot		FS23.10.3	14	23	175	3m feather spread, downing and semi-plumaghe feathers, grey with dark brown/black tips.
Year 3	Spring	October	24/10/2023	Unknown Bird spp.		Feather Spot		FS23.10.4	13	66	199	Dark brown/white wing/tail feathers, length between 5.5cm - 10cm
Year 3	Spring	October	24/10/2023	Unknown Bird spp.		Feather Spot		FS23.10.5	13	26	327	Grey/dark brown feathers, some appear broken, avg. length = 7.5cm - 11cm. Small pink downing feather
Year 3	Spring	October	24/10/2023	Wedge-tailed Eagle	*Aquila audax*	Bird	None	C23.10.3	14	58/76	131/75	Cut in half and found in two locations. First location, broken spine, wing and leg, tow claw missing, organs gone. Second location, head, neck and one wing
Year 3	Spring	October	25/10/2023	Australian Magpie	*Gymnorhina tibicen*	Feather Spot	None	FS23.10.9	9	68	188	0.3m feather spread, dark brown long wing/tail feathers
Year 3	Spring	October	25/10/2023	Eastern Rosella	*Platycercus eximius*	Feather Spot	None	FS23.10.8	25	41	194	0.3m feather spread, grey downing feathers with green tips, 2x grey/yellow semi-plumage feathers, blue/dark brown wing and tail feathers
Year 3	Spring	October	26/10/2023	Crested Pigeon	*Ocyphaps lophotes*	Feather Spot	None	FS23.10.11	33	10--18	263	8m feather spread, grey/white downing feathers, some with green or pink sparkle. Light grey feathers with white tips, dark brown wing/tail feathers with white tips and bases.
Year 3	Spring	October	26/10/2023	Unknown Bird spp.		Feather Spot	None	FS23.10.10	20	100	357	1m feather spread, brown/white wing/tail feathers and semi-plumage feathers, some with green tinge on right side
Year 3	Spring	November	20/11/2023	Black-shouldered Kite	*Elanus axillaris*	Bird	None	C23.11.2	5	22	206	One wing, black, grey and white feathers
Year 3	Spring	November	21/11/2023	Galah	*Eolophus roseicapilla*	Feather Spot	None	FS23.11.2	15	58	219	0.3cm feather spread, grey, white and black small/short feathers
Year 3	Spring	November	21/11/2023	Little Friarbird	*Philemon citreogularis*	Feather Spot	None	FS23.11.1	19	40	172	0.1cm feather spread, small grey wing feathers with thin light brown stripe down side, lengths between 4-7cm
Year 3	Spring	November	21/11/2023	Nankeen Kestrel	*Falco cenchroides*	Bird	None	C23.11.4	14	22	212	One wing, white feathers underside, dark brown feathers with orange feathers near wing base
Year 3	Spring	November	21/11/2023	Superb Fairywren	*Malurus cyaneus*	Bird	None	C23.11.5	14	57	142	small body, no head, only a few tail feathers, brown wings, black and white body feathers, avg. feather lengths = 7.2cm
Year 3	Spring	November	21/11/2023	Wedge-tailed Eagle	*Aquila audax*	Bird	None	C23.11.3	30	60	0	Decomposed back, most tail feathers missing
Year 3	Summer	December	19/12/2023	Robin spp.		Bird		C23.12.5	12	28	46	Decomposing, wing feathers dark brown with beige stripes, wing feather length = 4.8cm, grey with white tips downing feathers
Year 3	Summer	December	19/12/2023	Unknown Bird Spp.		Feather Spot	None	FS23.12.1	7	64	140	Feather spread 0.1m, clumped together on rock, bottom half grey top half dark drown downing/semi plumage feathers

symbolix

Bodangora Wind Farm Mortality Estimate - Year 3

Prepared for Nature Advisory, 27 August 2024, Ver. 1.0

This report outlines an analysis of mortality at Bodangora Wind Farm (BWF) from 2019-05-18 to 2023-12-20 (excluding 2021-05-30 to 2022-12-24 as there were no surveys over this period). The analysis is broken into the three related components below:

- Searcher efficiency / detectability – estimated from human trials in March 2021 and July 2021, and dog trials in September 2023 and November 2023.
- Scavenger loss rates – estimated from trials from July 2020 to May 2021
- Mortality estimates - based on surveys by humans at 33 turbines, from 2019-06-18 to 2021-05-30 and surveys by dogs at 17 turbines, from 2023-01-24 to 2023-12-20

1 Available data

Survey data was collected and provided by Nature Advisory on behalf of Iberdrola. A brief summary of the data is provided below, and the ultimate focus of this report is a discussion of the potential mortality.

Turbine parameter data (rotor diameter and height) was provided by Nature Advisory.

Species archetype data was taken from Hull and Muir (2010).

1.1 Data cleaning

Survey data:

- Surveys in June 2023 had been mislabelled as “Pulse” surveys and were updated to be “Initial” survey type.

Carcass finds and detectability data:

- Species names were updated to make capitalisation and hyphenation consistent.
- Unknown or unidentifiable birds were recoded to “Unidentified Bird”.
- Unknown or unidentifiable bats were recoded to “Unidentified Bat”.

2 Statistical 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 method to achieve this.

Best practice estimators project the number of found carcasses (C) up to the number of actual mortalities (M), by accounting for:

- The probability a carcass will be detected by the searcher (p)
- The probability a carcass is not lost to scavenging or decay prior to the search (r)
- The probability a carcass falls within the searched area (a) - also known as the "coverage factor"
- The fraction of turbines searched (f)

Most mortality estimators, e.g. (M. M. Huso 2011), can be conceptualised as a ratio estimator:

$$\hat{M} = \frac{C}{\hat{p} \cdot \hat{r} \cdot \hat{a} \cdot f} \tag{1}$$

The terms in the denominator provide a "boost factor" to the number of carcasses found, C.

However, a limitation of analytical methods, is estimating r, 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, designs to targeting specific species, or the use of a pulsed design in which the turbine is searched monthly with a return visit a few days later. Additionally, ratio estimators cannot handle the cases when zero carcasses are found, as zero multiplied by any number still gives zero. This limits their ability to provide an estimate for very rare species that may collide infrequently.

To address this, Symbolix have developed a Monte Carlo algorithm. We have used this method for mortality estimates at over forty 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 survey protocol, and sampling from empirical distributions for scavenge loss and searcher efficiency. This method allows us to directly sample the probability a carcass was lost before each survey, negating the need to calculate r analytically for each survey round.

We then estimate how many carcasses were truly generated, 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 (number of carcasses found).

This method has been benchmarked against analytical approaches (M. M. 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).

Figure 1 provides an overview of the methodology. A detailed explanation can be found in Stark and Muir (2020).

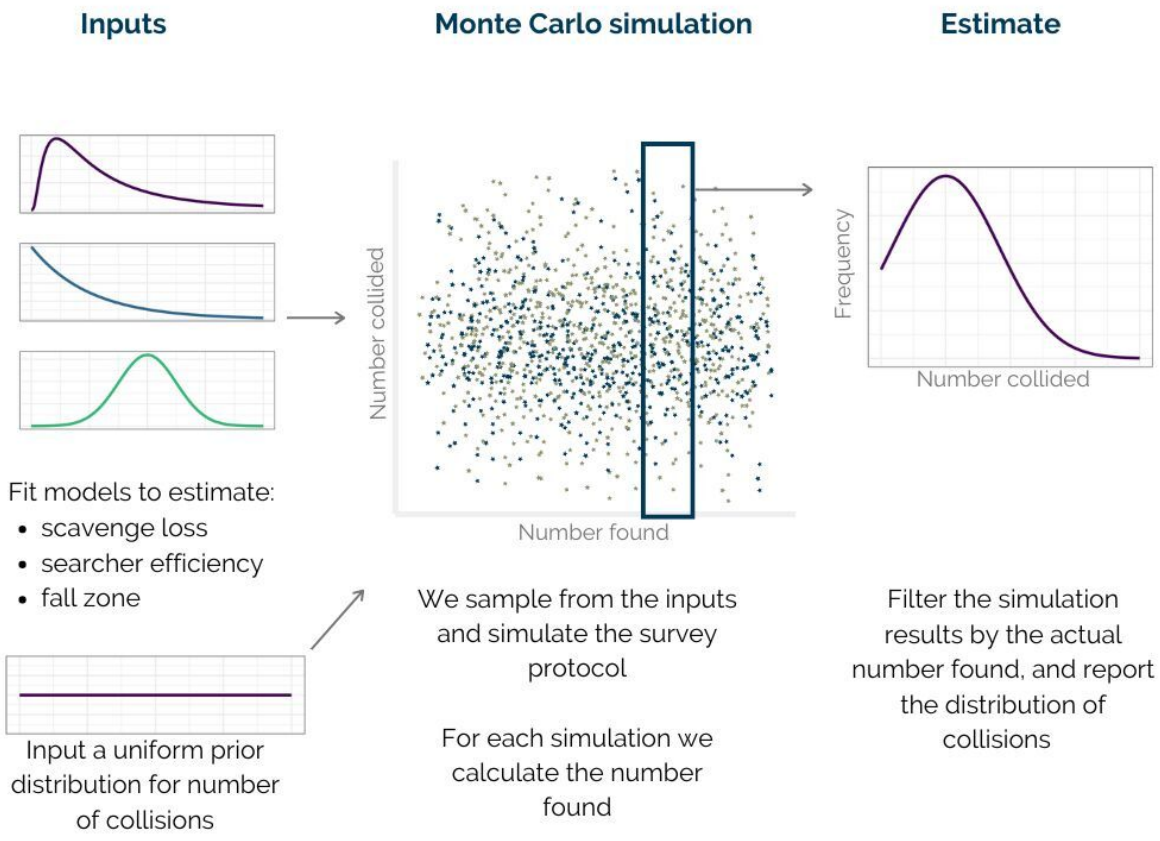

Figure 1: Overview of how the mortality estimation works.

The following sections outline how we estimate p, r and a. C is given by the field observation data for this site, and f is defined by the survey design.

3 Analysis and modelling

The survey program consisted of carcass searches, and adjunct scavenger and detection trials. We summarise the methods, field data and analysis results for each below.

3.1 Carcass search data

The carcass searches provide the C and f terms in Section 2.

3.1.1 Survey effort

Carcass searches were undertaken in accordance with the Bird and Bat Management Plan (BBMP)[1].

In Years 1 and 2 these were human surveys, an ecologist would search along circular transects spaced 6 metre apart out to a radius of 60 metres. Between 60 and 100 metres, transects were spaced at 12 metres. For the dog surveys in Year 3, the detection dog with a trained handler would start downwind of the turbine and search in a sweeping pattern within a 100 metre radius from the turbine.

The mortality estimate was based on a dated list of turbine surveys. The survey frequency is summarised in Table 1.

100% of turbines were searched in Years 1 and 2, and 52% were searched in Year 3. In Years 1 and 2, 16 turbines were randomly selected to be surveyed twice each month. These turbines were surveyed out to a radius of 100 metres in standard surveys and to 60 metres in pulse surveys. The remaining 17 turbines were surveyed once every two months, with eight or nine surveyed each month. These turbines were searched out to a radius of 100 metres.

Approximately 18 months after the first two years of surveys, a third year of surveys was undertaken by trained detection dogs. This included monthly surveys at 17 turbines out to 100 metres. In the Monte Carlo algorithm, we explicitly simulate the survey design. The proportion of turbines sampled (f) is therefore accounted for in the simulation.

[1] Report 15124 (3.6) Bodangara BBAMP approved.pdf

Table 1: Number of surveys per month and section.

Date	Human surveys		Dog surveys
	Initial	Pulse	Initial
2019 Jun	24	17	
2019 Jul	17	17	
2019 Aug	17	17	
2019 Sep	17	14	
2019 Oct	17	16	
2019 Nov	17	16	
2019 Dec	18	16	
2020 Jan	17	16	
2020 Feb	16	16	
2020 Mar	31	18	
2020 Apr	33	16	
2020 May	24	14	
2020 Jun	22	16	
2020 Jul	27	16	
2020 Sep	16	14	
2020 Oct	30	16	
2020 Nov	39	14	
2020 Dec	17	15	
2021 Jan	41	30	
2021 Feb	39	17	
2021 Mar	33	14	
2021 Apr	30	11	
2021 May	32	15	
2023 Jan	1		15
2023 Mar			32
2023 Apr			16
2023 May			17
2023 Jun			17
2023 Jul			17
2023 Aug			16
2023 Sep			17
2023 Oct			17
2023 Nov			17
2023 Dec			17

3.1.2 Carcass finds

The breakdown of found carcasses per species are summarised in Table 2.

Table 2: Carcasses found during formal surveys.

Species	Year 1	Year 2	Year 3
Apostlebird	1		
Australian Hobby	1		
Australian Magpie	7	3	5
Australian Raven		1	
Australian Wood Duck		1	
Black-shouldered Kite			2
Brown Falcon	3	8	3
Chocolate Wattled Bat	1		2
Corvid sp.	4	4	
Crested Pigeon		1	1
Crimson Rosella			1
Domestic Pigeon			1
Eastern Rosella	2	1	1
Freetail Bat sp.			9
Galah	2	12	4
Gould's Wattled Bat	10	8	1
Grey Butcherbird	1		
Grey Currawong			1
Grey Fantail	1	1	2
Grey-headed Flying-fox		4	
Inland Forest Bat	3		
Large Forest Bat		2	
Laughing Kookaburra			1
Lesser Long-eared Bat	1	1	
Little Forest Bat		4	5
Little Friarbird			1
Little Red Flying-fox		201	
Magpie-lark	1	1	
Musk Lorikeet			3
Nankeen Kestrel	7	30	7
Noisy Miner	5		1
Pied Currawong	2		
Rainbow Lorikeet			2
Red-rumped Parrot	2		
Robin sp.			1
Rufous Songlark		1	
Sacred Kingfisher		1	
Southern Forest Bat	4	1	

Table 2: Carcasses found during formal surveys. *(continued)*

Species	Year 1	Year 2	Year 3
Southern Freetail Bat	8	8	6
Striated Pardalote		1	1
Superb Fairy-wren			1
Unidentified Bat			11
Unidentified Bird		5	13
Wattled Bat sp.			1
Wedge-tailed Eagle	4	2	2
White-striped Freetail Bat	7	3	7
Willie Wagtail		1	
Yellow-bellied Sheathtail Bat	1	1	1
Yellow-rumped Thornbill			1

A number of carcasses were also found incidentally. These carcasses are not included in the data that produces the mortality estimate; however we report them here for completeness (Table 3).

Table 3: Incidental carcass finds.

Species	Number found
Australian Magpie	4
Australian Raven	1
Australian Wood Duck	1
Black Falcon	1
Crested Pigeon	1
Galah	1
Gould's Wattled Bat	1
Grey-headed Flying-fox	5
Inland Forest Bat	1
Little Red Flying-fox	97
Musk Lorikeet	1
Nankeen Kestrel	11
Pied Currawong	1
Southern Forest Bat	1
Southern Freetail Bat	2
Wedge-tailed Eagle	2
White-striped Freetail Bat	1

3.2 Searcher efficiency

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

3.2.1 Field methods

The searcher efficiency data was collected in accordance to the specification in section 3.2.5 of the BBMP.

The human searcher efficiency data is sourced from trials conducted in March 2021 and July 2021, and the dog searcher efficiency data is sourced from trials conducted in September 2023 and November 2023. Carcasses were laid out, searches for the carcasses were undertaken using the same protocol as the main mortality survey (i.e. using a human observer in the human trials and a trained detection dog (with a human handler) in the dog trials). If the carcass was found, "success" was recorded, else "failure" was the searcher missing the carcass.

The carcasses deployed for searcher efficiency trials included birds (54 replicates), bats (29 replicates) and 5 mice as bat proxies. We also note that two bat carcasses were removed from analysis (and not included in the count of replicates) since they could not be found when cleaning up after the trials and therefore we have no evidence that they were there to be found during the trials.

The number of carcasses for each group are summarised in Table 4.

Table 4: Count by species class and observer used during the detection trials.

Species type	Human	Dog
Bird	14	40
Bat	16	13
Bat Proxy		5

3.2.2 Statistical methods

We estimated searcher efficiency by fitting binomial generalised linear models (GLMs). The optimal model was determined, guided by the small-sample corrected Akaike Information Criterion (AICc) (Anderson and Burnham 2004).

The theory of AICc is complex, the details of which are beyond the scope of this report. However, fundamentally AICc is a method for choosing the best approximating (i.e. best model fit) and parsimonious (a simpler model is preferable to a more complex model) model. For each model we fit to the data, we calculate the AICc. We compare the differences in AICc between models, which in turn informs us of the weight of evidence for that particular model.

We also consider the reliability and applicability of parameters in the model. For example, cloud cover may affect detection rates, but the ability of observers to accurately and consistently

record cloud cover is likely to be poor and it is not feasible to incorporate cloud cover into a mortality estimate.

AICc is not the same as significance testing. We do not aim to state anything is significant at the 5% level, instead we aim to find a good model fit for the data.

3.2.3 Results

The dogs found 100% of carcasses laid out, and therefore we assume all carcasses have the same searcher efficiency, while the human searcher efficiency model is split by species type.

The outputs of these models are presented in Table 5.

Table 5: Detection efficiencies for bats and birds.

Variable	Dogs (Birds & Bats)	Human (Bats)	Human (Birds)
Number found	58	9	12
Number placed	58	16	14
Mean detectability proportion	1	0.56	0.86
Detectability lower bound (95% CI)	0.94	0.3	0.57
Detectability upper bound (95% CI)	1	0.8	0.98

Overall detectability of bats and birds by dogs is 100%, with a 95% confidence interval of [94%, 100%].

Overall detectability of bats by humans is 56%, with a 95% confidence interval of [30%, 80%]. Overall detectability of birds by humans is 86%, with a 95% confidence interval of [57%, 98%].

3.3 Scavenger efficiency

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.

This section estimates the r term in Section 2.

3.3.1 Field methods

The scavenger efficiency data was collected in accordance to the specification in section 3.2.4 of the BBMP. This included trials conducted in different seasons to account for seasonal changes in scavenging rates.

Scavenger efficiency trials were conducted from July 2020 to May 2021. The trials ran over approximately 30 days. In total, 37 carcasses were used (including 18 birds and 19 bats). Trials used human checks in order to record the times of scavenge events. Checks were

completed every in the morning and afternoon for the first two days after they were placed then approximately daily for the rest of the trial.

Table 6 summarises the species used in the trials.

Table 6: Count by species class used in the carcass persistence trials.

Species	Bat	Bird
Apostlebird		3
Australian Magpie		3
Australian Raven		1
Australian Wood Duck		1
Brown Falcon		2
Crested Pigeon		2
Nankeen Kestrel		3
Noisy Miner		1
Red-rumped Parrot		1
Rufous Songlark		1
Gould's Wattled Bat	5	
Grey-headed Flying-fox	2	
Little Red Flying-fox	8	
Southern Freetail Bat	3	
Yellow-bellied Sheathtail Bat	1	

3.3.2 Statistical methods

Survival analysis (Kaplan and Meier (1958), Kalbfleisch and Prentice (2011)) was used to determine the distribution of time until complete loss from scavenge (or decay). Survival analysis was 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, ∞] (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 (M. M. P. 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. Generally, the best distribution is the log-normal

distribution (Stark and Muir 2020).

3.3.3 Results

The best model for scavenger efficiency was the model with birds and bats aggregated.

Figure 2 shows the survival curve fitted to the carcasses. The survival curve (smooth solid line for fitted regression curve, jagged step function for empirical removal rate) shows the estimated proportion of the set remaining at any given time. The shaded portions are the 95% confidence intervals on the estimate.

Under these assumptions, the median time to bat carcass removal via scavenge is 0.8 days, with a 95% confidence interval of [0.3, 1.9] days. The median time to bird carcass removal via scavenge is 2.3 days, with a 95% confidence interval of [0.9, 5.8] days.

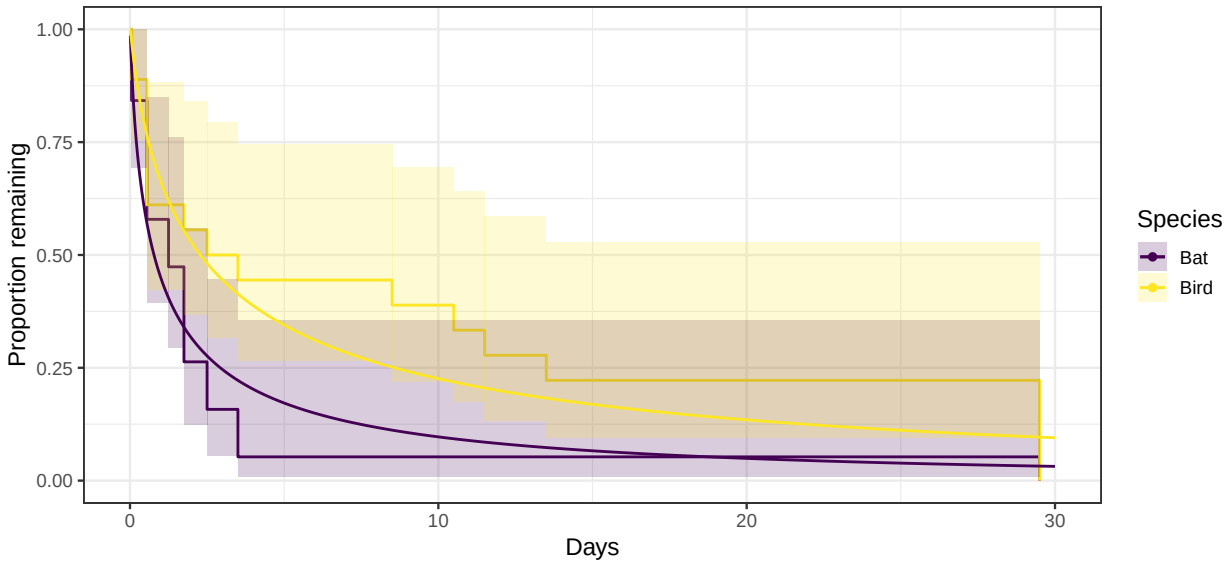

Figure 2: Empirical survival curve (the step function), with 95% confidence intervals shaded. The smooth curve presents the fitted model.

3.4 Coverage factor

The probability a carcass falls within the searched area (i.e. the "coverage factor") is calculated to provide the a term (Section 2).

3.4.1 Statistical methods

3.4.1.1 Fall zone simulation We generated a carcass fall-zone distribution for for each species class given the turbine size at the wind farm.

The fall-zone distribution is the end result of the simulation method detailed in Hull and Muir (2010). The simulation method is a ballistics model describing bird and bat strikes by turbine blades.

3.4.1.2 Coverage factor calculation 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.

3.4.2 Simulation inputs

The fall zone simulation requires a set of turbine and bird specifications.

Table 7 displays the dimensions and RPM of the turbines at Bodangora Wind Farm. Table 8 shows the bird and bat physical parameters used. These archetypes were used as they represent a medium sized species for each species type and produce an estimate of the average fall zone.

Table 7: Turbine specifications for Bodangora Wind Farm

Rotor Diameter (m)	Tower Height (m)	RPM
130	85	8

Table 8: Species parameters used per group.

Species type	Archetype	Mass (kg)	Min. area (sq m)	Max. area (sq m)
Bat	Gould's Wattled Bat	0.014	0.0028	0.014
Small to medium Bird	Raven	0.680	0.0450	0.100

3.4.3 Results

Figure 3 displays the simulation results, given the factors specified above. We display the cumulative density function (CDF) on the y axis versus the distance from turbine on the x axis for each species type. The CDF describes the expected proportion of carcass which fall less than or equal to a certain distance from the turbine.

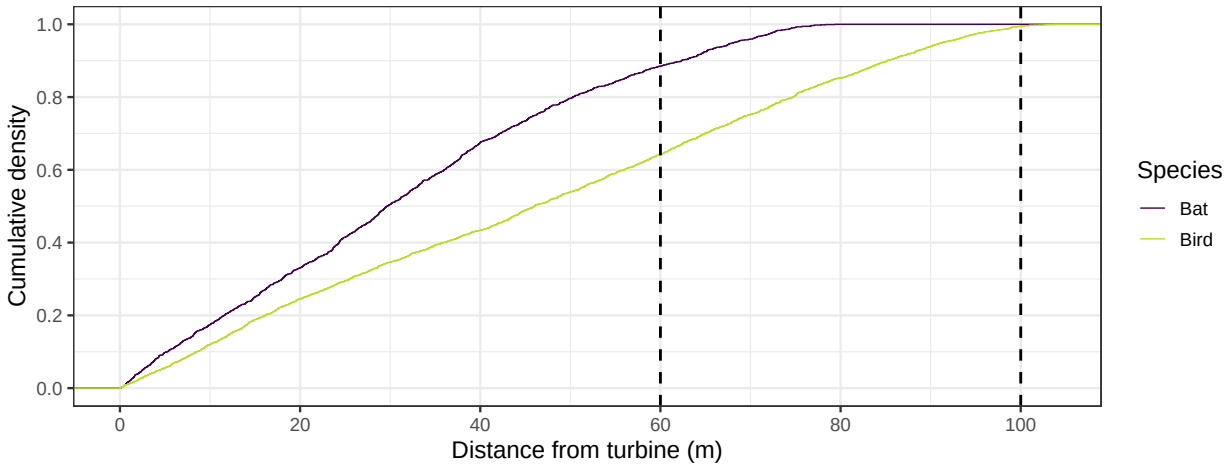

Figure 3: Cumulative distribution function of the fall zone simulation output for birds and bats. Vertical lines indicate the Pulse and Initial survey radii.

Once the fall zone distribution is calculated, we generate a "coverage factor". The coverage factor represents the expected proportion of carcasses which fall within the searched area, given the search protocol.

On average, we expect about 88% of bats and 64% of birds to fall within 60m of the turbine, and 100% bats and 99% of birds fall within 100m.

4 Mortality estimate

With estimates for scavenge loss, searcher efficiency, and survey coverage for BWF, we then converted the number of bat and bird carcasses detected into an estimate of overall mortality from 2019-05-18 to 2023-12-20 (we allow for collisions to occur up to a month prior to the first survey). Our analysis excludes the period from 2021-05-30 to 2022-12-24 during which no surveys were conducted.

The mortality estimation is done via a Monte Carlo algorithm. We used 25000 simulations for the Year 3 estimate and 40000 for the cumulative estimate, 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 model assumptions are listed below:

- There were 33 turbines on site available to strike bats and birds.
- Of these, 33 were searched as described in section 3.1.1.
- Search frequency for each turbine was taken from a list of actual survey dates (see Table 1 for a summary).
- Mortalities were allowed to occur from 2019-05-18 (approximately one month from the first survey), until the final surveyed date, 2023-12-20 (excluding 2021-05-30 to 2022-12-24) for the cumulative estimate. For the Year 3 estimate, mortalities were allowed to occur from 2022-12-24 (approximately one month from the first year 3 survey), until the final surveyed date, 2023-12-20.
- Bats and birds are on-site at all times during this period.
- Bats and birds that are struck are immediately replaced (i.e. strikes one day do not affect the chance of strikes the next).
- We assume 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 was equal chance of any turbine being involved in a collision / mortality.
- Scavenger loss and searcher efficiency rates are calculated as outlined above.
- We assumed a log-normal scavenge shape.
- We assumed coverage factors as outlined above.

4.1 Bats

During the three years of surveys, 311 bats were found during formal surveys. The resulting (median) estimate of total mortality is 5990 Bats lost on site over the three years of surveys. The (median) estimate of mortality in Year 3 is 1093 Bats.

Table 9 and Figure 4 display the percentiles of the distributions, to show the confidence on the mortality estimate.

Based on the detected carcasses, measured detectability, scavenge rate, and survey effort, we expect that there was a total site loss of around 5990 Bats, and are 95% confident that fewer than 1.0127×10^4 individuals were lost, in the three year period (this excludes the unsurveyed period).

Table 9: Percentiles of estimated total bat losses in the three years of surveys (excluding the unsurveyed period).

Estimate	0%	50% (median)	90%	95%	99%
Cumulative	2528	5990	9590	10127	11839
Year 3	436	1093	2230	2682	2974

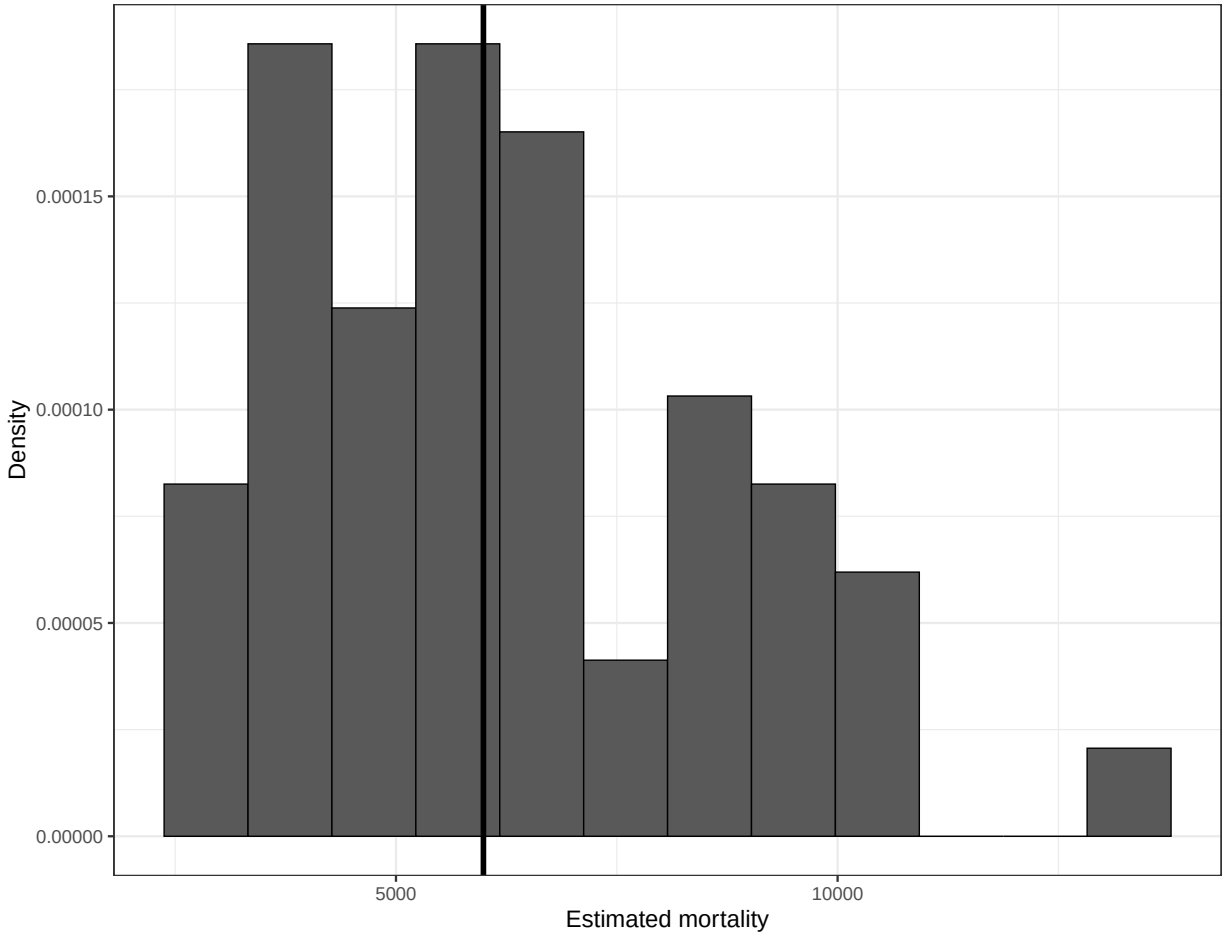

Figure 4: Histogram of the total losses distribution (bats) during 2019-05-18 to 2023-12-20 but excluding 2021-05-30 to 2022-12-24. The black solid line shows the median.

4.2 Birds

During the three years of surveys, 172 birds were found during formal surveys. The resulting (median) estimate of total mortality is 1441 Birds lost on site over the three years of surveys. The (median) estimate of mortality in Year 3 is 639 Birds.

Table 10 and Figure 5 display the percentiles of the distributions, to show the confidence on the mortality estimate.

Based on the detected carcasses, measured detectability, scavenge rate, and survey effort, we expect that there was a total site loss of around 1441 Birds, and are 95% confident that fewer than 2327 individuals were lost, in the three year period (this excludes the unsurveyed period).

Table 10: Percentiles of estimated total bird losses in the three years of surveys (excluding the unsurveyed period).

Estimate	0%	50% (median)	90%	95%	99%
Cumulative	717	1441	2014	2327	2868
Year 3	288	639	994	1098	1470

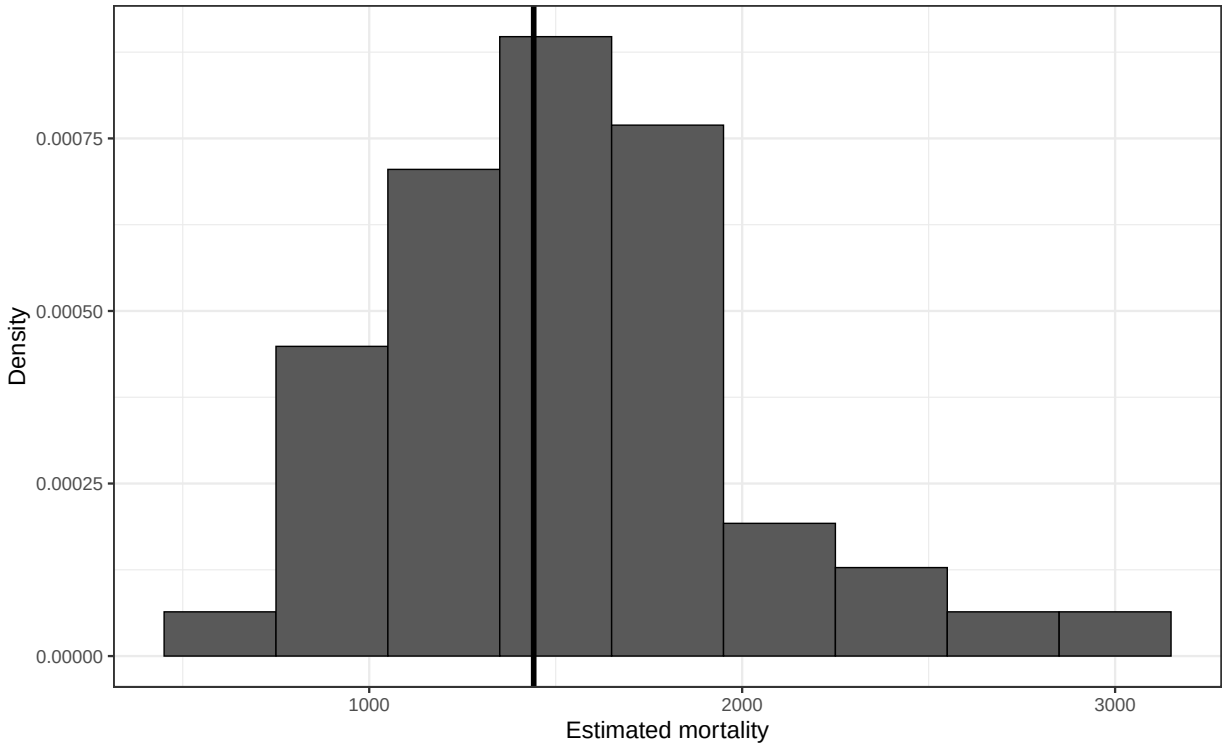

Figure 5: Histogram of the total losses distribution (birds) during 2019-05-18 to 2023-12-20 but excluding 2021-05-30 to 2022-12-24. The black solid line shows the median.

References

Anderson, D, and K Burnham. 2004. "Model Selection and Multi-Model Inference." *Second. NY: Springer-Verlag* 63 (2020): 10.

Hull, CL, and Stuart Muir. 2010. "Search Areas for Monitoring Bird and Bat Carcasses at Wind Farms Using a Monte-Carlo Model." *Australasian Journal of Environmental Management* 17 (2): 77–87.

Huso, Manuela M. P., Dan Dalthorp, and Fränzi Korner-Nievergelt. 2015. "Statistical principles of post-construction fatality monitoring." In *Wildlife and Wind Farms - Conflicts and Solutions, Volume 2*, 227–37. Pelagic Publishing.

Huso, Manuela MP. 2011. "An Estimator of Wildlife Fatality from Observed Carcasses." *Environmetrics* 22 (3): 318–29.

Kalbfleisch, John D, and Ross L Prentice. 2011. *The Statistical Analysis of Failure Time Data*. John Wiley & Sons.

Kaplan, Edward L, and Paul Meier. 1958. "Nonparametric Estimation from Incomplete Observations." *Journal of the American Statistical Association* 53 (282): 457–81.

Korner-Nievergelt, Fränzi, Pius Korner-Nievergelt, Oliver Behr, Ivo Niermann, Robert Brinkmann, and Barbara Hellriegel. 2011. "A New Method to Determine Bird and Bat Fatality at Wind Energy Turbines from Carcass Searches." *Wildlife Biology* 17 (4): 350–63.

Ripley, Brian D. 1987. *Stochastic Simulation*. USA: John Wiley & Sons, Inc.

Sawilowsky, Shlomo S. 2003. "You Think You've Got Trivials?" *Journal of Modern Applied Statistical Methods* 2 (1): 218–25. https://doi.org/10.22237/jmasm/1051748460.

Stark, E, and S Muir. 2020. "Post Construction Bird and Bat Monitoring at Wind Farms in Victoria."