Report

Bird and Bat Adaptive Management Plan

Bonney Downs Wind Farm

17 February 2026

549PG-5692-PL-EN-0002

Rev: 2.1

ABBREVIATIONS

Abbreviation	Definition
AGL	Above Ground Level
BACI	Before–After–Control–Impact
BBAMP	Bird and Bat Adaptive Management Plan
BBSUS	Bird and Bat Site Utilisation Survey
BC Act	*Biodiversity Conservation Act 2016* (WA)
BOM	Bureau of Meteorology
CR	Critically Endangered
Cth	Commonwealth
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DE	Development Envelope
EN	Endangered
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
GPS	Global Positioning System
ha	Hectare
IBA	Important Bird Area
IBRA	Interim Biogeographic Regions of Australia (Version 7)
IDF	Indicative Disturbance Footprint (Bonney Downs Wind Farm)
km	Kilometre
kV	Kilovolt
m	Metre
MI	Migratory
NIW	Nationally Important Wetland
RSA	Rotor Swept Area
VU	Vulnerable
WA	Western Australia

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1 INTRODUCTION

This Bird and Bat Adaptive Management Plan (BBAMP) has been prepared to outline the management and mitigation of risks to bird and bat species known and potentially occurring within the Bonney Downs and Nullagine Pilot Wind Farms. This primarily relates to species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Western Australia's *Biodiversity Conservation Act 2016* (BC Act), or Priority species listed by the Department of Biodiversity, Conservation and Attractions (DBCA) but also includes non-listed species considered to be at-risk of collision. The Nullagine Pilot Wind Farm is bounded by the Bonney Downs Wind Farm boundary and should the Bonney Downs Wind Farm be approved, management of both wind farms would be managed collectively.

This BBAMP forms part of an overarching framework for environmental management for the Project and outlines the management actions to be implemented during construction and operation of the Bonney Downs Wind Farm and operation of the Nullagine Pilot Wind Farm.

1.1 Project Background

Pilbara Energy (Generation) Pty Ltd (PEG), a wholly owned subsidiary of Fortescue Ltd (Fortescue), are seeking approval to construct and operate the Bonney Downs Wind Farm, comprising a wind farm, and supporting infrastructure for power supply.

Separately to this proposal, Fortescue is developing the Nullagine Pilot Wind Farm (the Pilot). The Pilot comprises up to 17 wind turbines, 50 km of 220 kV transmission line to Christmas Creek Mine and associated electrical connection works and has been progressed under separate State approvals. The Pilot is a stand-alone proof-of-concept project with independent purpose and utility. It will generate operational data and learning to inform future decision-making on larger developments, while also replacing the requirement for diesel powered generators at Christmas Creek. The Pilot received approval for construction and operation in 2025.

For the avoidance of doubt, the Pilot is not a staged “first phase” or component of the Bonney Downs Wind Farm and is excluded from the Bonney Downs referral. Notwithstanding this exclusion, the Bonney Downs Wind Farm may connect to the Pilot 220 kV transmission line at the Pilot's nominated grid connection point, subject to the commitments and safeguards described in this BBAMP.

The Bonney Downs Wind Farm and Nullagine Pilot Wind Farm are hereafter collectively referred to as the ‘Project’. The Project is located approximately 9 kilometres (km) southwest of the town of Nullagine in the Pilbara Region of Western Australia. The southern edge of the Project is adjacent to Fortescue's Christmas Creek Iron Ore Mine (as approved under Ministerial Statement 1033) (**Figure 1.1**).

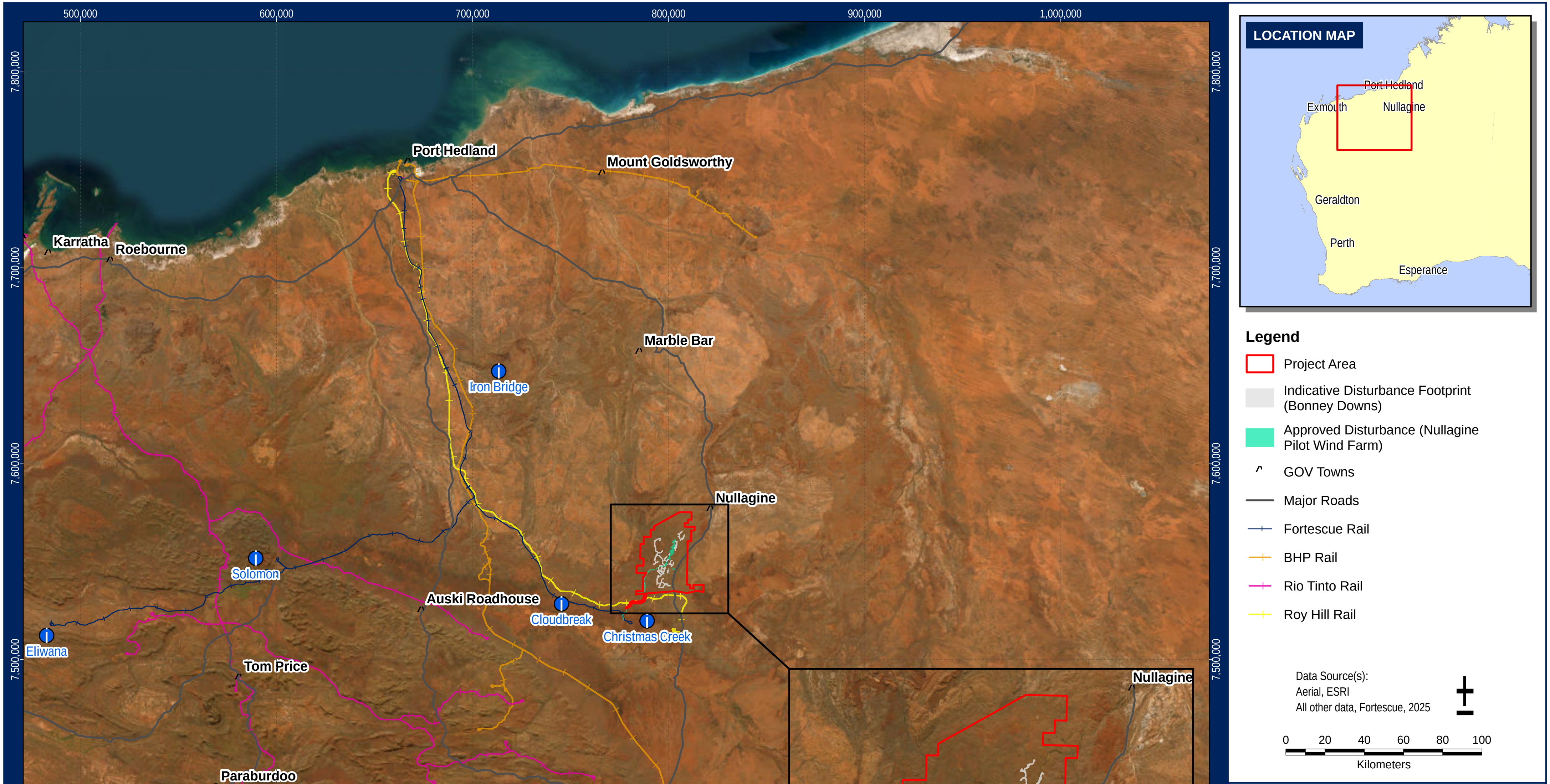


Figure 1-1

Project Location

Requested By: R. Dorji
Date: 10/02/2026
Drawn By: R. Kerr
Size: A4L
Revised By: rykerr
Revision: 1
Approved By:
Confidentiality: 0
Scale: 1:2,750,000
Coordinate System: GDA 1994 MGA Zone 50
Project Name: 4519OP002_MP_EN_0093_BBAMP
Document Name: 4519OP002_MP_EN_0093_038_r0_BBAMP_Location

1.2 Purpose and Objectives

The purpose of this BBAMP is to provide the Project with a framework regarding the adaptive management of potential impacts to birds and bats, attributable to the construction and operation of the Bonney Downs Wind Farm and operation of the Nullagine Pilot Wind Farm.

This BBAMP is also intended to support approvals for the Bonney Downs Wind Farm under both the EPBC Act and Part IV of the *Environmental Protection Act 1986* (EP Act). The Nullagine Pilot Wind Farm received approval in 2025 under the *Mining Act 1978* and this BBAMP only relates to the management of impacts during operation of the Nullagine Pilot Wind Farm.

This BBAMP seeks to detail the mitigation and management procedures to be undertaken for the Project, with a specific focus on reducing impacts to EPBC Act, BC Act and DBCA Priority listed species.

The specific objectives of this BBAMP are to:

- Predict potential impacts to the site utilisation of EPBC Act, BC Act, and DBCA Priority listed bird and bat species and provide suitable mitigation measures.
- Provide impact trigger thresholds for EPBC Act, BC Act, and DBCA Priority listed bird and bat species based on best known ecological thresholds that would trigger a significant impact.
- Present the outcomes of the collision risk assessment, focussing on species which were deemed a high or very high risk of collision impacts.
- Present an overview of post-commissioning monitoring requirements including further bird and bat site utilisation surveys, as well as a carcass search program.
- Present the adaptive management framework to be initiated by Fortescue should an impact trigger be reached or exceeded.
- Outline the pathway for the development of mitigation strategies and management measures, as well as reporting requirements.
- Continue to develop the understanding of the impacts to birds and bats associated with the Project by assessing pre and post commissioning bird and bat data.
- Enable the success of a long-term approach to mitigating and managing potential impacts and potential changes to species' utilisation of the Project Area and its surrounds.

1.3 Statutory Framework

This BBAMP has been developed in accordance with the draft Onshore Wind Farm Guidance (DCCEEW, 2024b) and Environmental Management Plan Guidelines (DCCEEW, 2024a) where appropriate. This BBAMP is also intended to support approvals for the Bonney Downs Wind Farm under both the EPBC Act and Part IV of the *Environmental Protection Act 1986* (EP Act). The legislative framework relevant to this BBAMP is summarised in **Table 1.1**.

Table 1.1: Relevant Legislation

Relevant Legislation	Relevant Agency	Summary	Project Relevance
Commonwealth			
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Department of Climate Change, Energy, the Environment, and Water	The EPBC Act is Australia's key federal environmental legislation instrument. It outlines nine Matters of National Environmental Significance (MNES). Actions that adversely affect MNES may be deemed to be a controlled action under the EPBC Act.	The following MNES are relevant to the Project and this BBAMP: • Listed threatened species. • Listed migratory species. Additionally, the draft Onshore Wind Farm Guidance – Best practice approaches when seeking approval under Australia's national environmental law (DCCEEW, 2024b) was considered in the preparation of this BBAMP.
WA State			
Biodiversity Conservation Act 2016 (BC Act)	Department of Biodiversity, Conservation and Attractions	The BC Act provides statutory protection for species and ecological communities listed as threatened under the Act. The BC Act also provides other listings for species such as Conservation Dependent, Other Specially Protected and Migratory.	The following listed species are relevant to the Project and this BBAMP: • Listed threatened species • Listed migratory species • Listed Other Specially Protected species
Environmental Protection Act 1986 (Part IV) (EP Act)	Environmental Protection Authority	The EP Act serves as the principal State legislative framework for environmental management and protection in Western Australia. The EP Act also focuses on the conservation, preservation, protection, enhancement, and management of the environment. Proposed actions that may result in a significant impact to environmental factors defined by the State Environmental Protection Authority (EPA) must be referred to the EPA under Part IV of the EP Act and may require assessment before proceeding.	The following environmental factors are relevant to the Project and this BBAMP: • Terrestrial fauna
Mining Act 1978	Department of Mines, Petroleum and Exploration	The Mining Act 1978 provides the primary legislative framework for mineral exploration and mining activities in Western Australia. It sets out how mining tenements are granted and managed.	The Nullagine Wind Farm is located across mining tenements granted under the *Mining Act 1978* and received approval for construction and operation in 2025.

1.4 Application of the BBAMP

This BBAMP and the requirements outlined within will be applicable to all employees, contractors and visitors during the construction (inclusive of site preparation) and operation of the Project. Further information regarding the roles and responsibilities of key personnel are outlined in **Section 3.**

1.5 Environmental Outcomes

Specific environmental outcomes to be achieved through the implementation of this BBAMP and the associated components supporting each outcome, are provided in **Table 1.2.**

Table 1.2: BBAMP Environmental Outcomes

Environmental Outcome	Section
Avoid causing a significant impact from turbine collision and barotrauma impacts to conservation listed bird and bat species (and EPBC Act listed migratory species, where relevant)	**Section 6**
Potential changes to species' utilisation of the project site and its surrounds arising from construction and operation are detected, assessed and managed through the BBAMP monitoring program and adaptive management framework	**Section 8.2**
Harm to conservation listed bird and bat species arising from wind turbine impacts (including collision) during commissioning and operation is minimised, detected, reported and adequately responded to, and adaptive management processes are implemented in accordance with the approved triggers/thresholds and corrective actions.	**Section 9**

2 PROJECT OVERVIEW

An overview of the Project description is provided in the following sections.

2.1 Project Description

The spacing and design layout of the Project has been informed by an assessment of existing topography, and the collection of ongoing wind and climate data by Fortescue, specific to the Project. Site data has been used to undertake energy modelling for the wind farm, with wind turbines positioned to optimise efficiency and power output. Turbine placement remains flexible to minimise environmental and social impacts.

Each turbine will have an unsealed access road which will allow for construction and ongoing maintenance of equipment. Turbines will have associated infrastructure to support the transmission of energy from the Wind Farm to Christmas Creek Mine, where the Project will connect into Fortescue's transmission network.

During operations, turbines will have a permanent footprint of up to approximately 1 ha per turbine. Turbines will be arranged in rows that are spaced and orientated to maximise power generation. Indicative footprints for both wind farms are provided in **Figure 2.1**. The final wind farm design will be completed following studies of environmental and heritage constraints. It is anticipated that there will be sufficient flexibility within the wind farm design to enable micro-siting to avoid environmental or heritage constraints additional to those identified in this document. Turbine specifications used to inform this management plan are provided in **Table 2.1**.

Table 2.1: Turbine Specifications

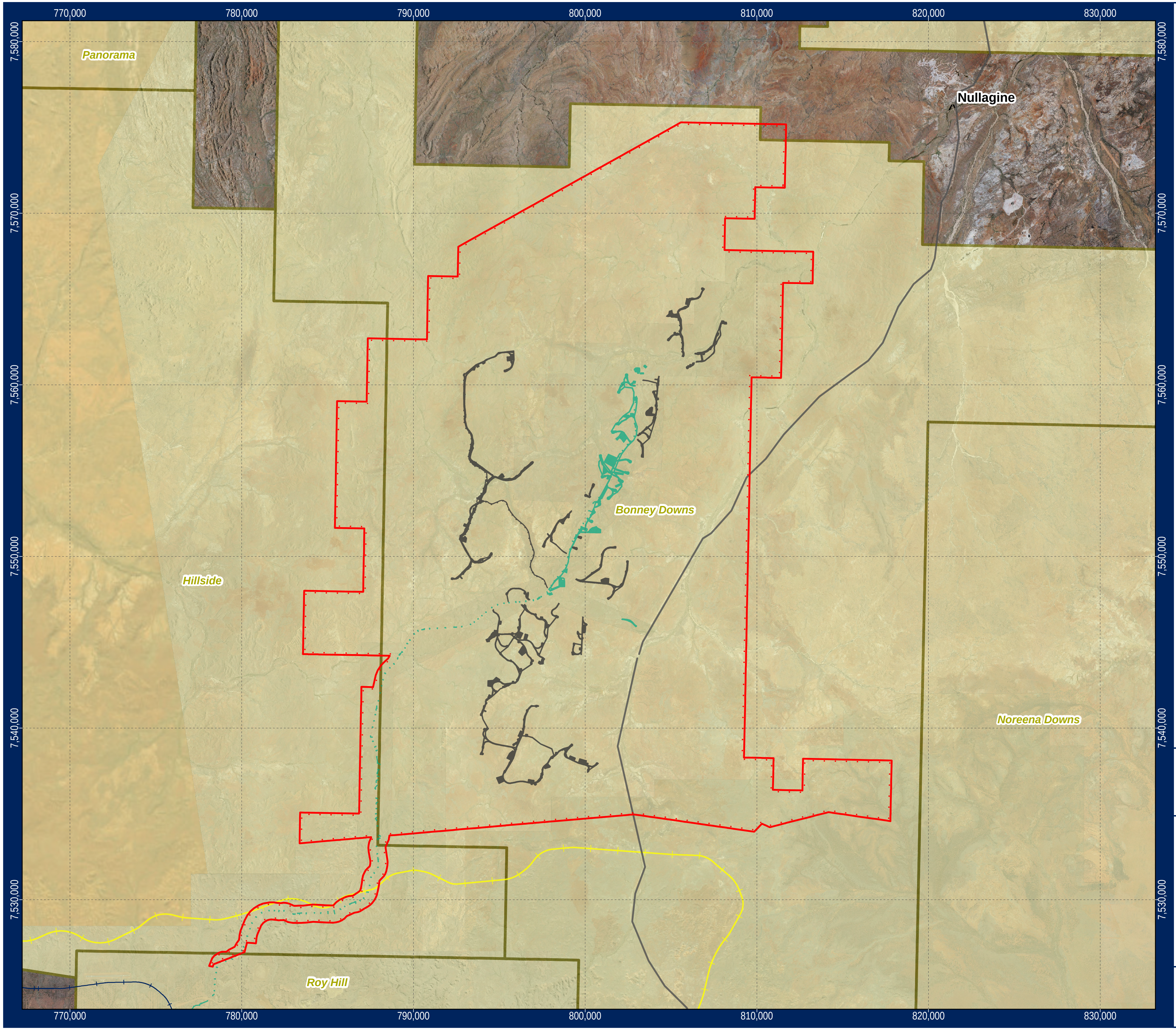
Feature	Maximum Specification
Hub Height	188 m above ground level (AGL)
Rotor Diameter	181.1 m
Blade Length	90.55 m
Maximum Tip Height	278.55 m AGL
Minimum Tip Height	97.45 m AGL
Rotor Swept Area	25,758.9 m²

2.2 Management Boundaries

There is a distinct boundary relevant to this BBAMP for the purposes of managing impacts to bird and bat species from both the Bonney Downs Wind Farm and the Nullagine Pilot Wind Farm. This boundary is presented in **Figure 2.1** as the Project Area.

The Bonney Downs Wind Farm is spatially defined by an indicative disturbance footprint (IDF) which comprises 100 wind turbines and supporting infrastructure.

It should be noted that this BBAMP is intended to provide the management framework for impacts to bird and bat species only during operation of the Nullagine Pilot Wind Farm. The Nullagine Pilot Wind Farm, currently under development, comprises 17 wind turbines and supporting infrastructure which is also presented in **Figure 2.1**. The Nullagine Pilot Wind Farm received approval for construction and operation in 2025 under State approvals.



Legend

- ▢ Project Area
- ■ Indicative Disturbance Footprint (Bonney Downs)
- 🟩 Approved Disturbance (Nullagine Pilot Wind Farm)
- ^ GOV Towns
- — Major Roads
- ┼ Fortescue Rail
- ┼ Roy Hill Rail
- ▭ Pastoral Leases

Data Source(s):
Aerial, Fortescue and ESRI
All other data, Fortescue, 2025

0 2 4 6 8 10
Kilometers

Figure 2-1
Management Boundary

Requested By: R. Dorji	Date: 10/02/2026
Drawn By: R. Kerr	Size: A4L
Revised By: rykerr	Revision: 0
Approved By:	Confidentiality: 0

Scale: 1:300,000
Coordinate System: GDA 1994 MGA Zone 50
Project Name: 4519OP002_MP_EN_0093_BBAMP
Document Name: 4519OP002_MP_EN_0093_039_r0_BBAMP_Boundary

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3 ROLES AND RESPONSIBILITIES

The implementation of this BBAMP requires clear identification of roles and responsibilities. **Table 3.1** specifies the roles and responsibilities associated with this BBAMP.

Table 3.1: BBAMP Related Roles and Responsibilities

Role	Responsibility
Approval Holder	Implementation of a final approved BBAMP and associated decision making.
Site Manager	The Site Manager is responsible to report any incidental bird or bat carcasses including the carcasses of conservation significant species in the Plant and Animal Register to notify the Manager of Nature and Science.
Site Environmental Advisor	Implementation of inductions and training for all site personnel. Collection and storage of opportunistically found carcasses. Implementation of mitigation measures relevant to construction.
Manager of Nature and Science	All correspondence with DCCEEW and/or DBCA. This may include notification of incidents, identification of threatened species and BBAMP associated reporting. Appointing suitably qualified ecologists to implement the technical aspects of the final approved BBAMP, coordination and oversight of the qualified ecologists. Audit and periodic review of the effectiveness of final approved BBAMP and any corrective actions. Implementation of the Adaptive Management Monitoring Program (**Section 8**), management of suitably qualified ecologists, training of site personnel, data analysis and reporting (**Section 10**).
Site Personnel (all)	Undertake site induction on the identification and reporting procedures of incidental finds of potential bird or bat carcasses. Reporting of carcass finds to the Site Manager.

4 ENVIRONMENTAL CONTEXT

The information presented within this section is a summary of two key reports prepared by Ecologia (Ecologia, 2025a, 2026b) and is intended to provide an overview of the site-specific and species-specific characteristics of the Project Area. For more detailed information on the methodology and associated results, refer to Ecologia (2025a, 2026b).

4.1 Site Characteristics

The Project Area is primarily located within the Chichester subregion of the Pilbara bioregion under the Interim Biogeographic Regions of Australia (IBRA) framework. A small proportion also intersects the Fortescue Plains subregion as illustrated on **Figure 4.1**.

Pastoral activities associated with Bonney Downs station along with mining tenements (numerous mines, exploration tenements and historical mining disturbance) are the dominant land uses in the vicinity of the Project Area.

The Chichester subregion (PIL01) comprises 9,044,560 ha of the northern section of the Pilbara Cration and is described as (Kendrick & Mckenzie, 2001):

Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by Acacia inaequilatera over Triodia wiseana (formerly Triodia pungens) hummock grasslands, while Eucalyptus leucophloia tree steppes occur on ranges. The climate is semi-desert-tropical and receives 300 mm of rainfall annually. Drainage occurs to the north via numerous rivers (e.g. De Grey, Oakover, Nullagine, Shaw, Yule, Sherlock).

The Fortescue subregion covers 2,041,914 ha and is described as (Kendrick, 2001):

Alluvial plains and river frontage. Extensive salt marsh, mulga-bunch grass, and short grass communities on alluvial plains in the east. Deeply incised gorge systems in the western (lower) part of the drainage. River gum woodlands fringe the drainage lines. Northern limit of mulga (Acacia aneura). An extensive calcrete aquifer (originating within a palaeo-drainage valley) feeds numerous permanent springs in the central Fortescue, supporting large permanent wetlands with extensive stands of river gum and cadjeput Melaleuca woodlands. Climatic conditions are semi desert tropical, with average rainfall of 300 mm, falling mainly in summer cyclonic events. Drainage occurs to the north-west.

The Pilbara region of WA experiences an arid tropical climate with two distinct seasons: a hot summer from October to April and a mild winter from May to September. Temperatures are generally high, with summer temperatures frequently exceeding 40°C. Light frosts occasionally occur inland during the winter months of July and August. The best available climate data from the nearest long-term Bureau of Meteorology (BOM) weather stations was obtained from Bonney Downs (Station No. 4006, within the Project Area) for rainfall. Temperature data was obtained from Marble Bar (Station No.4106, 78.4 km north of the Project Area).

The closest Nationally Important Wetland (NIW) to the Project Area is the Fortescue Marsh (10 km, southwest), which also intersects the Fortescue Marsh Nature Reserve and is listed as an Important Bird Area (IBA). The only qualifying species for its status as an IBA that are relevant to the Project as conservation significant species is the Grey falcon (*Falco hypoleucos*), listed as Vulnerable under the EPBC Act and BC Act. The next nearest NIWs are Karijini (Hamersley Range) Gorges (100 km, west), Mt Bruce Coolibah – Lignum Flats (~155 km, west), and Lake Disappointment (Savory Creek) System (~150 km, south). Other conservation areas in the broader region include Meentheena (Purungunya) National Park and Meentheena (Purungunya) Nature Reserve (60 km, northeast), Karijini National Park (~100 km, west), and Mungaroona Range Nature Reserve (~120 km, west).

Three major water courses intersect the Project Area including the Nullagine River, the Coongan River and Bonnie Creek. These waterways encompass numerous permanent water bodies including Bonnie Pools (**Figure 4.1**). Bonnie Creek, Bonney Pools, the Nullagine River and the Coongan River provide seasonal habitat for amphibians and fish in addition to water sources for aquatic birds. Ephemeral inundation of these habitats and man-made dams may also provide refuge for migratory birds travelling to the Fortescue Marsh (Ecologia, 2025a).

Ecologia (2025a) described 10 broad fauna habitat types (**Figure 4.1**) within the Project Area based on vegetation types, soil units, and landforms present: Woodland (open), Woodland (closed), Plain (stony/gibber), Plain (cracking clays), Hills/Ranges/Plateaux, Gorges/Gullies, Granite Outcrops (flat dome), Drainage Line/River/Creek (major), Drainage Line/River/Creek (minor) and Rocky Escarpments Ridges/Mesa/Cliffs/Outcrops/Breakaways), and Cleared.

The Plain (stony/gibber) (79.17%) habitat type was the dominant feature of the Project Area, with widespread grazing and trampling disturbances from European cattle documented throughout these areas.

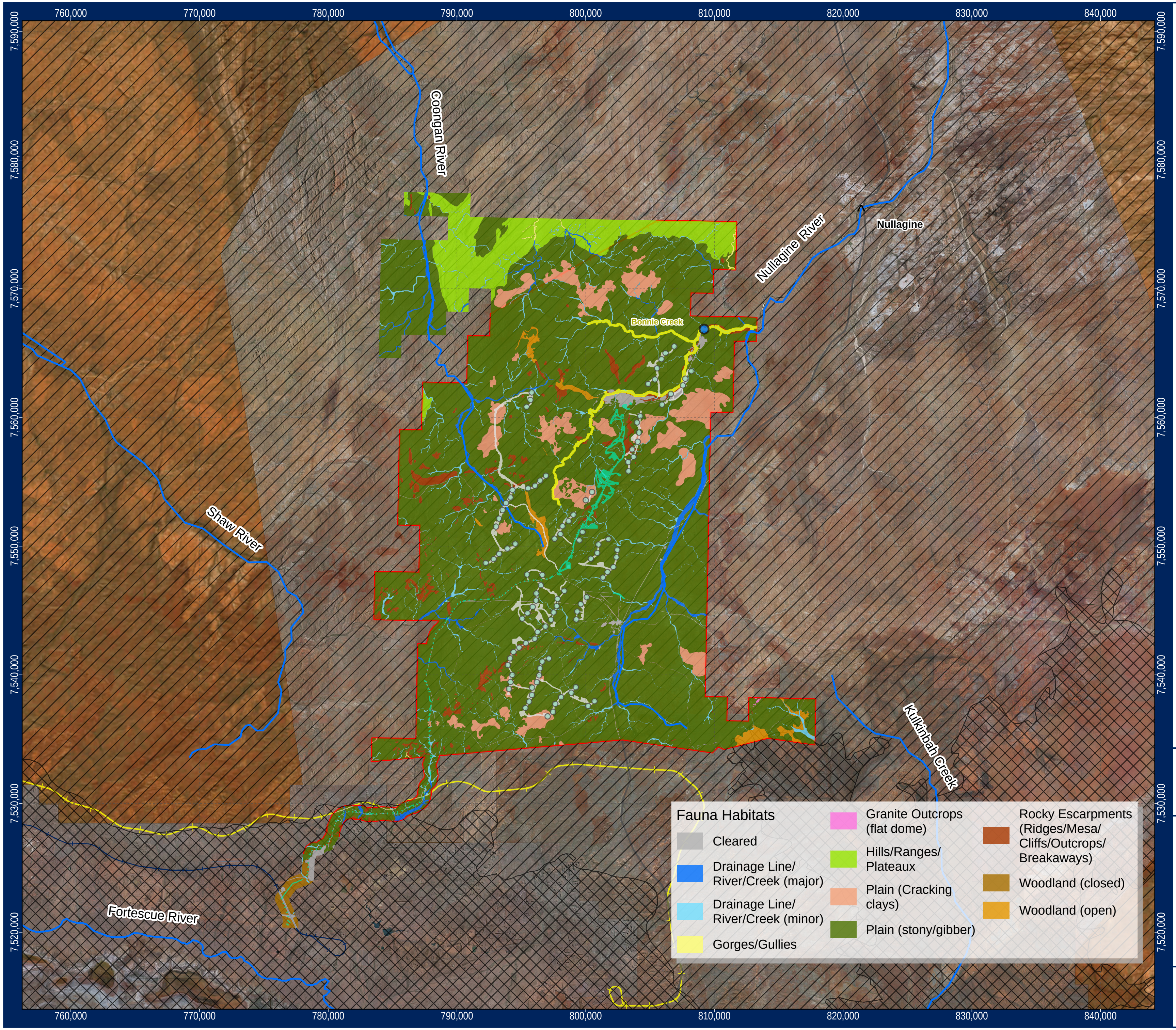

Figure 4-1
Site Characteristics

Requested By: R. Dorji	Date: 16/02/2026
Drawn By: R. Kerr	Size: A4L
Revised By: rykerr	Revision: 1
Approved By:	Confidentiality: 0

Scale: 1:400,000
Coordinate System: GDA 1994 MGA Zone 50
Project Name: 4519OP002_MP_EN_0093_BBAMP
Document Name: 4519OP002_MP_EN_0093_040_r1_BBAMP_Character

4.2 Species Characteristics

4.2.1 Desktop Assessment

A desktop assessment was undertaken to determine the potential for Commonwealth and State listed bird and bat species (i.e. conservation significant) (Ecologia, 2026b), to occur within the Project Area. The desktop assessment was also aimed at identifying the potential occurrence of all other known bird and bat species within the Project Area. The desktop assessment was informed by both species characteristics (behaviour, seasonal occurrence, habitat utilisation, and flight paths and patterns) and site characteristics (habitat features and vegetation, geology and land systems, climatic conditions, wetlands and drainage areas, and conservation areas).

The desktop assessment initially used a 40 km buffer around the Project Area (and a wider buffer of 100 km for DBCA data based on the availability of records) to query biological databases of historical species' occurrences. Biological databases included:

- DCCEEW Protected Matters Database.
- DBCA Threatened and Priority Fauna Database.
- BirdLife Australia's Birdata Database.
- Atlas of Living Australia Database.
- Fortescue Internal Fauna Databases.

Ecological surveys conducted within 100 km of the survey area were also reviewed for the occurrence of conservation significant fauna, specifically birds and bats, and results compiled with the biological database searches. The criteria listed in **Table 4.1** were then utilised to determine the likelihood of occurrence of these species within the Project Area. Consideration was also given to the age and locality of a record, recent taxonomic species revisions, and modelled species' distributions when determining the likelihood of a species' occurrence.

An additional literature review was conducted to assess the characteristics of conservation significant species assessed with a 'High' or 'Moderate' likelihood of occurrence prior to field surveys. In accordance with the Onshore Wind Farm Guidance (DCCEEW, 2024b), the literature was reviewed for the following species characteristics[1]:

- behaviour;
- flight or demographic factors (e.g., species presence [ongoing, transitory/migratory]);
- site use (e.g., transit, roosting, breeding and/or foraging);
- habitat type use;

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[1] Flight height data is not currently available for a number of species identified as part of the desktop assessment.

- movement and flight paths (including nightly foraging and migratory flight paths/patterns);
- flight heights;
- soaring;
- flocking;
- population numbers.

Table 4.1: Likelihood of Occurrence Ratings

Rating	Criterion
Recorded	The species has been recorded within the survey area previously or during the current survey.
High (likely to occur)	The species is likely to occur within the survey area as suitable habitat is known to be present and there are existing records very close to the survey area (within ca. 5-15 km, depending on species mobility).
Moderate (possibly occurs)	The species may occur within the survey area as there are existing records in the vicinity of the survey area, and suitable habitat is likely to be present; OR The species may occur within the survey area as there is insufficient information available to exclude the possibility of occurrence.
Low (unlikely to occur)	The species is unlikely to occur within the survey area as suitable habitat is not present or is not likely to be present; OR Suitable habitat is present within the survey area, but the taxon has not been recorded despite reasonable survey effort.
Does not occur	The species is recognised as being locally extinct or extinct in the wild and does not occur within the survey area; OR Records identified through database searches are associated with a listed subspecies which does not occur within the region.

4.2.1.1 Results

According to database searches and the literature review, 204 bird and bat species have the potential to occur within 100 km of the Project Area, comprising 187 birds and 17 bats.

Of these 204 bird and bat species, 21 conservation significant bird species and 2 conservation significant bat species were anticipated to occur within the Project Area during the field survey program. The additional literature review assessed the site utilisation of these species within the Project Area as (Ecologia, 2026b):

- 17 bird species potentially transitory.
- 4 species (1 bat and 3 birds) potentially breeding, roosting and foraging.
- 1 bat assessed as potentially foraging only.
- 1 bird deemed as unlikely to occur.

The likelihood of occurrence assessment identified 7 conservation significant bird species as having a ‘Low’ likelihood of occurrence within the Project Area due to absence of suitable habitat, age of records, distance of records from the survey area or a combination of these factors. These species were excluded from the totals above and from further consideration within this BBAMP.

4.2.2 Site Specific Assessment

The results of the desktop assessment were validated through a series of comprehensive site-specific field surveys, particularly during the Bird and Bat Site Utilisation Surveys (BBSUS), conducted between 2023 and 2025. Suitably qualified ecologists with expertise in birds and/or bats completed each of the surveys and a summary of the survey effort to date is illustrated on **Figure 4.2.**

The timing of BBSUS undertaken to date is presented in **Table 4.2**. In accordance with DCCEEW (2024b), BBSUS were conducted over two years across all suitable seasons to provide sufficient baseline data about the utilisation of the Project Area and its surrounds by relevant species. BBSUS were scheduled to capture seasonal changes in species presence within the Project Area. The surveys were also aligned with the expected migration periods of conservation-significant birds identified in desktop assessments, such as the Oriental plover (*Anarhynchus veredus*) and Pacific swift (*Apus pacificus*).

The BBSUS program included eight survey events. Bird surveys used 30-minute fixed-point counts across three time periods (early morning, midday, and late afternoon) at 40 sample sites within the Project Area. Fixed-point counts were supported by targeted searches, nest monitoring, and incidental observations. Bat surveys were conducted using Autonomous Recording Units (ARUs) at each sample site to record presence/absence (Ecologia, 2026b).

In addition to the BBSUS program, two multi-phase ecological surveys have been undertaken across the Project Area to assess terrestrial fauna values and collect data on bird and bat species using both systematic survey methods and incidental observations (Ecologia, 2025a). These ecological surveys are listed in **Table 4.2** and are hereafter collectively referred to as the ‘field survey program’.

Table 4.2: Site Specific Assessment Surveys

Survey	Consultant	Description	Dates
Phase 1a Terrestrial Fauna Assessment	Ecologia	Phase 1 Terrestrial Fauna Assessment – Bonney Downs North	22 May – 2 June 2023
Phase 1b Terrestrial Fauna Assessment	Spectrum Ecology	Phase 1 Terrestrial Fauna Assessment – Bonney Downs South	13 – 25 October 2023
Phase 2a Terrestrial Fauna Assessment	Ecologia	Phase 2 Terrestrial Fauna Assessment – Bonney Downs North	9 – 19 October 2023
Phase 2b Terrestrial Fauna Assessment	Spectrum Ecology	Phase 2 Terrestrial Fauna Assessment – Bonney Downs South	4 – 14 April 2024
Phase 3 Terrestrial Fauna Assessment	Ecologia	Phase 3 Terrestrial Fauna Assessment – Bonney Downs North	16 – 29 March 2024
Targeted Fauna Assessment	Spectrum Ecology	Targeted Terrestrial Fauna Assessment – Bonney Downs South	24 July – 2 August 2024
Targeted Fauna Camera Installation	Ecologia	Targeted Camera Installation – Bonney Downs South (46 days duration)	25 – 28 April 2024
BBSUS1	Ecologia	Southward migration	12 – 19 October 2023
BBSUS2	Ecologia	Wet season	5 – 12 February 2024
BBSUS3	Ecologia	Northward migration	21 – 28 March 2024
BBSUS4	Ecologia	Dry season	17 – 24 June 2024
BBSUS5	Ecologia	Southward migration	11 – 17 September 2024
BBSUS6	Ecologia	Wet season	10 February 2025 24 – 27 February 2025
BBSUS7	Ecologia	Northward migration	29 April – 4 May 2025
BBSUS8	Ecologia	Dry season	13 – 19 August 2025

Data Source(s):
Aerial, Fortescue and ESRI
All other data, Fortescue, 2025

Figure 4-2

Bird and Bat Survey Effort
Site Locations

Requested By: R. Dorji	Date: 10/02/2026
Drawn By: R. Kerr	Size: A4L
Revised By: rykerr	Revision: 0
Approved By:	Confidentiality: 0

Scale: 1:300,000
Coordinate System: GDA 1994 MGA Zone 50
Project Name: 4519OP002_MP_EN_0093_BBAMP
Document Name: 4519OP002_MP_EN_0093_042_r0_BBAMP_Survey

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4.2.3 Birds

4.2.3.1 Species Assemblage

A total of 128 bird species were recorded across the field survey program. The avifauna assemblage recorded within the Project Area represents 68.4% of the total avifauna taxa (187) identified as possibly occurring within the region based on the desktop assessment. Sampling effort was deemed adequate based on the modelled species accumulation curve which shows the addition of new species approaches zero (asymptote) after 40 sites suggesting that further site-based surveys are unlikely to increase the number of observed avifauna species at the sampling locations (Ecologia, 2026b).

A total of 45 avifauna families were recorded. The highest recorded species diversity was from the Accipitridae (10 species) and Meliphagidae (8 species) families. The most commonly recorded species during set-time BBSUS included the Yellow-throated miner (*Manorina flavigula* – 345 records), Australian zebra finch (*Taeniopygia castanotis* – 266 records), Australian kestrel (*Falco cenchroides* – 249 records) and White-plumed honeyeater (*Ptilotula penicillata* – 220 records) (Ecologia, 2026b).

4.2.3.2 Observed Bird Utilisation

Species recorded across the field survey program were predominantly woodland/scrubland and raptor species as well as parrots, allies and wetland birds. Example species of the generalised species' groups recorded during surveys are provided in **Table 4.3**. A complete species list is detailed in Ecologia (2026b). Additional information on key bird groups considered to be at-risk of collision due to flight behaviours or records of collision from elsewhere in Australia is provided below.

Table 4.3: Generalised Bird Groups Recorded During Field Surveys

Groups	Example Species in Group*
Aerial feeders	***Pacific swift***, Black-faced woodswallow, Little woodswallow, Masked woodswallow, Welcome swallow
Diurnal raptors	Brown falcon, Wedge-tailed eagle, ***Grey falcon***, Spotted harrier, Nankeen kestrel, Whistling kite
Nocturnal	Barking owl, Tawny frogmouth, Southern boobook, Australian owlet nightjar
Parrots and allies	Galah, Little corella, Cockatiel, Budgerigar, Australian ringneck
Wetland birds	Pacific black-duck, Plumed whistling duck, White-faced heron, Straw-necked Ibis, Black-fronted dotterel, Little black cormorant, ***Oriental plover***
Woodland/Scrubland birds (large)	Australian magpie, Common bronzewing, Torresian crow, Black-faced cuckoo-shrike
Woodland/Scrubland birds (small)	Willie wagtail, Magpie-lark, Rainbow bee-eater, Yellow-throated miner, crimson chat, White-plumed honeyeater

Note. Conservation significant species are italicised and in bold font.

Diurnal Raptors

Eight diurnal raptor species are considered to be permanent residents of the Project Area and have been recorded within the Project Area across 24-months of BBSUS displaying a range of behaviours such as nesting, roosting and foraging (Wedge-tailed eagle [*Aquila audax*], Brown falcon [*Falco berigora*], Nankeen kestrel, Grey falcon [*Falco hypoleucos*], Whistling kite [*Haliastur sphenurus*], Spotted harrier [*Circus assimilis*], Collared sparrowhawk

[*Tachyspiza cirrocephala*] and Brown goshawk [*Tachyspiza fasciata*]) (Ecologia, 2026b). At least 22 Wedge-tailed eagle breeding territories have also been identified within the Project Area, with monitoring in 2024 confirming occupation of 21 territories and breeding evidence at 7 nests (Ecologia, 2026b).

Wetland Birds

Ten families of wetland birds are represented by species recorded within the Project Area across the BBSUS program (Ecologia, 2026b). Wetland bird diversity and abundance appear to fluctuate slightly between seasons; however, the total number of wetland taxa recorded each season remains largely consistent. Abundance of each species appears to decrease during the dry season, but overall species diversity remains high during this period. Seven wetland bird species were recorded nesting in previously known water sources of the Project Area, including Bonney Downs station dam and Bonney Creek (Pink-eared duck [*Malacorhynchus membranaceus*], Black swan [*Cygnus atratus*], Pacific black duck [*Anas superciliosa*], Grey teal [*Anas gracilis*], White-faced heron [*Egretta novaehollandiae*] and Australasian darter [*Anhinga novaehollandiae*]).

Nocturnal Birds

Seven nocturnal bird species have been recorded within the Project Area (Southern boobook [*Ninox boobook*], Barking owl [*Ninox connivens*], Tawny frogmouth [*Podargus strigoides],* Bush stone-curlew [*Burhinus grallarius*], Barn owl [*Tyto javanica*], Australian owlet nightjar [*Aegotheles cristatus*] and Spotted nightjar [*Eurostopodus argus*]) (Ecologia, 2026b). Nocturnal birds have generally been recorded roosting during daytime surveys adjacent in the vicinity of drainage lines, with additional records obtained from motion cameras and spotlighting activities. A pair of Barking owls have been regularly recorded at Bonnie Pools with both birds believed to be permanent residents of this area. A second pair of birds have been heard calling at the Bonney Downs Homestead and these birds are also considered to be permanent residents of the Project Area.

Aerial Feeders (Woodswallows and Swallows)

Three woodswallow species (Masked woodswallow [*Artamus personatus*], Black-faced woodswallow [*Artamus cinereus]* and Little woodswallow [*Artamus minor*]) and the Welcome swallow [*Hirundo neoxena*] were recorded within the Project Area (Ecologia, 2026b). These species spend the majority of their time in-flight foraging on insects. Although the Masked woodswallow and Little woodswallow were infrequently recorded, both species were recorded flying within RSA height (see **Section 4.2.3.4**). The Black-faced woodswallow was recorded more frequently; however, was not recorded flying within RSA during BBSUS. Flight height data was not available for the Welcome swallow, which was incidentally recorded.

4.2.3.3 Conservation Significant Bird Species

Of the 128 bird species confirmed within the Project Area, 3 are conservation significant and listed under the EPBC Act and/or the BC Act. An additional 10 conservation significant bird species were not recorded during the field survey program but are considered as having a ‘High’ or ‘Moderate’ likelihood of occurrence within the Project Area due to the availability of potential habitat and results of the desktop assessment (Ecologia, 2026b).

All ‘Known’ or potentially occurring (‘High’ or ‘Moderate’ likelihood of occurrence) conservation significant species are listed in **Table 4.4**. Conservation significant bird species recorded within the Project Area and their potential site utilisation characteristics are described further in the subsections below and their locations illustrated on **Figure 4.3**.

Table 4.4: Known and Potentially Occurring Conservation Significant Bird Species

Common Name	Scientific Name	WA Status	Cth Status
Known (Recorded)			
Grey falcon	*Falco hypoleucos*	VU	VU
Pacific swift	*Apus pacificus*	MI	MI
Oriental plover	*Charadrius veredus*	MI	MI
High Likelihood			
Peregrine falcon	*Falco peregrinus*	OS	-
Moderate Likelihood			
Night parrot	*Pezoporus occidentalis*	CR	EN
Common greenshank	*Tringa nebularia*	MI	EN & MI
Sharp-tailed sandpiper	*Calidris acuminata*	MI	VU & MI
Australian painted snipe	*Rostratula australis*	EN	EN
Caspian tern	*Hydroprogne caspia*	MI	MI
Common sandpiper	*Actitis hypoleucos*	MI	MI
Glossy ibis	*Plegadis falcinellus*	MI	MI
Gull-billed tern	*Gelochelidon nilotica*	MI	MI
Marsh sandpiper	*Tringa stagnatilis*	MI	MI
Red-necked stint	*Calidris ruficollis*	MI	MI
Wood sandpiper	*Tringa glareola*	MI	MI

Note. VU=Vulnerable; MI=Migratory; OS=Otherwise Specially Protected; CR=Critically Endangered; EN=Endangered.

Grey Falcon

The Grey falcon has been recorded within the Project Area on 23 occasions across the field survey program. Grey Falcons have been recorded across all time periods of the day (morning, midday, and afternoon) on multiple occasions. Flight heights ranged from ground level to 235 m AGL, with seven observations within RSA comprising 30% of records (see **Section 4.2.3.4**). Grey falcons have also been recorded across a range of habitat types and from numerous locations across the Project Area (Ecologia, 2026b).

Grey falcon observations have documented a variety of behaviours, including breeding, roosting, nest defence (interspecific), standing in water, and consumption of prey. Flight observations have likewise included a variety of behaviours, including soaring, gliding and directional flight (Ecologia, 2026b).

Based on the repeated sightings of the Grey falcon, confirmation of breeding behaviours and ongoing utilisation of Drainage Line/River/Creek (major) habitat associated with the Bonnie Creek system, the Project Area is known to support at least one breeding pair of the Grey falcon. It is possible that more than one pair of birds are utilising habitat within the Project Area; however, simultaneous observations of more than one pair of birds have not been recorded to date (Ecologia, 2026b).

Pacific Swift

The Pacific swift was recorded within the Project Area on four occasions during the February 2025 BBSUS, including three records during systematic surveys, and one incidental record. The species was observed overflying the Project Area on each occasion, with a maximum flight height of 37 m AGL (Ecologia, 2026b).

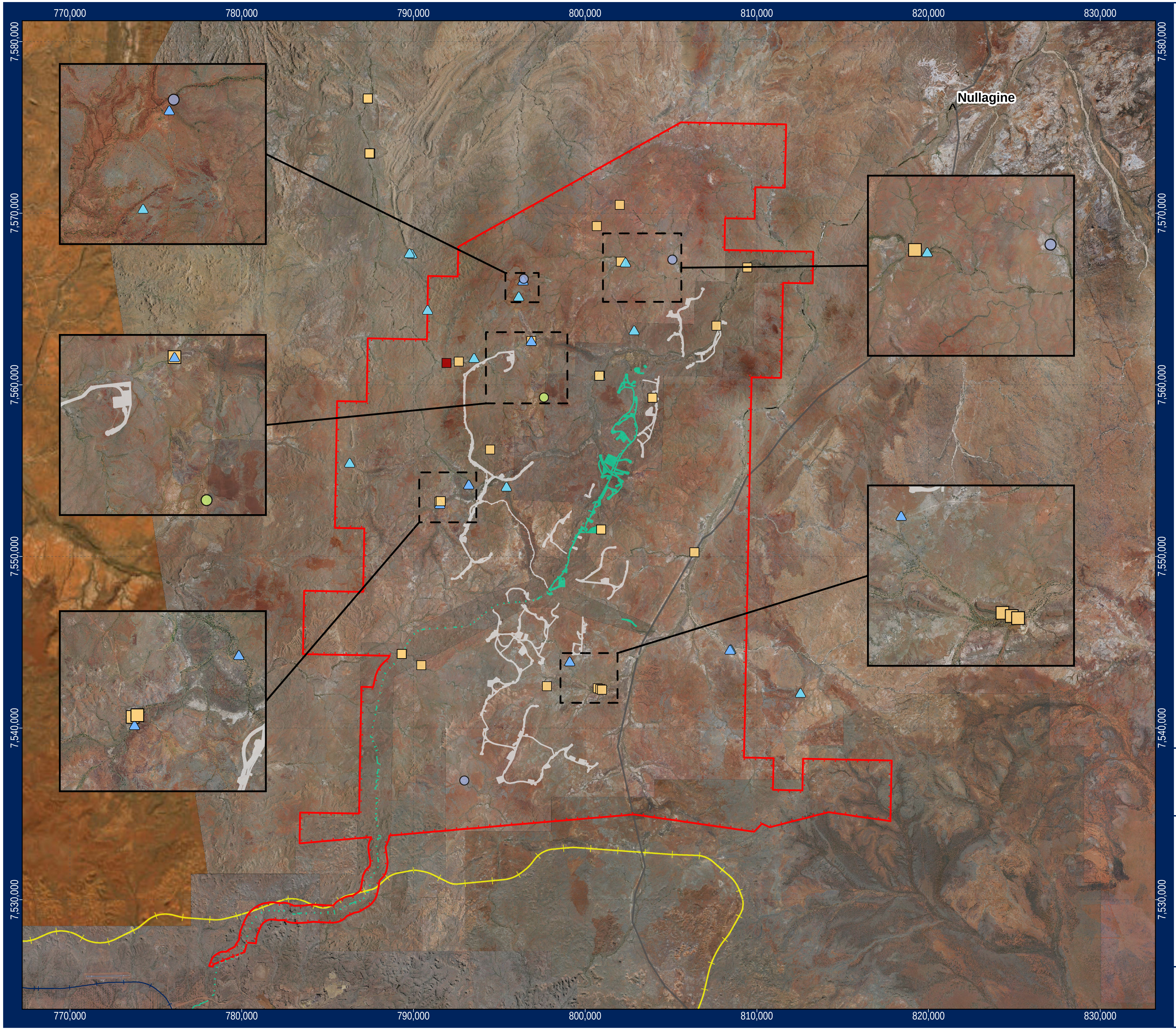
The Pacific swift is almost exclusively aerial and has been observed over inland plains, above foothills and in coastal areas in Australia. They have seldom been observed roosting on trees or the ground and are thought to roost aerially. They often occur in areas of updraughts, such as along cliffs and have been observed from less than 1 m to at least 300 m AGL (Higgins, 1999). This species generally transits south along the coast but have been recorded further inland, particularly during favourable weather conditions such as large storm fronts.

As the Pacific swift does not utilise terrestrial habitats it may only utilise the airspace above the Project Area while transiting or foraging. The species' utilisation of an area is largely dependent on prey abundance which is linked to vegetation, prey habitat, and climatic conditions. The species occurrence is therefore often sporadic and weather dependent, and it is most likely to occur within the Project Area when localised storms and atmospheric pressure variations are more frequent leading to increased food availability, such as during the wet season (Ktitorov et al., 2021).

Oriental Plover

The Oriental plover was recorded within the Project Area on one occasion during the field survey program. One individual was observed during the September 2024 BBSUS overflying the Project Area at a maximum flight height of 7 m AGL (Ecologia, 2026b).

The preferred habitat of the Oriental plover consists of sparsely vegetated plains, including samphire and short-grass flats, where it feeds largely on insects (Johnstone & Storr, 1998). They often forage at night and roost during the day with other waders on beaches or mudflats (Morcombe, 2010). Occurrence of this species is likely to be restricted to a transient presence rather than permanent occupancy as permanent habitat does not occur within the Project Area (Ecologia, 2026b).



Legend

- ⬚ Project Area
- ^ GOV Towns
- — Major Roads
- ⟞ Fortescue Rail
- — Roy Hill Rail
- ▭ Indicative Disturbance Footprint (Bonney Downs)
- 🟩 Approved Disturbance (Nullagine Pilot Wind Farm)
- 🟥 Ghost Bat
- ▲ Grey Falcon
- ■ Pilbara Leaf-Nosed Bat
- ● Oriental Plover
- ● Fork-tailed Swift

Data Source(s):
Aerial, Fortescue and ESRI
All other data, Fortescue, 2025

0 2 4 6 8 10
Kilometers

Figure 4-3
Conservation Significant Fauna within the Project Area

Requested By: R. Dorji
Date: 10/02/2026
Drawn By: R. Kerr
Size: A4L
Revised By: rykerr
Revision: 1
Approved By:
Confidentiality: 0
Scale: 1:300,000
Coordinate System: GDA 1994 MGA Zone 50
Project Name: 4519OP002_MP_EN_0093_BBAMP
Document Name: 4519OP002_MP_EN_0093_041_r0_BBAMP_Fauna

Fortescue

4.2.3.4 At-risk Bird Species

Only 3.3% of flight observations recorded during BBSUS were within the RSA, with an additional 1.1% of flights occurring above the RSA. Limited trends were observed for flights across time of day within and above the RSA, primarily due to low numbers of observations recorded within these zones (Ecologia, 2026b).

A total of 17 bird species were recorded flying within the RSA either during BBUS or via Robin Radar MAX placements, placing them at risk of turbine collision (Hocking et al., 2026). These species are listed in **Table 4.5** along with the total number of sightings recorded and the proportion of time spent at RSA. This includes the Grey falcon, listed as Vulnerable under both the EPBC Act and BC Act.

Table 4.5: Species Recorded Flying at RSA Height

Common Name	Scientific Name	Number of Sightings	Proportion of Records at RSA
Australasian darter	*Anhinga novaehollandiae*	38	0.0526
Australian kestrel (nankeen kestrel)	*Falco cenchroides*	439	0.0182
Australian magpie	*Gymnorhina tibicen*	37	0.03
Australian pelican	*Pelecanus conspicillatus*	10	0.2
Black falcon	*Falco subniger*	1	1
Black kite	*Milvus migrans*	5	0.2
Brown falcon	*Falco berigora*	177	0.079
Grey falcon	*Falco hypoleucos*	33	0.303
Little black cormorant	*Phalacrocorax sulcirostris*	72	0.347
Masked woodswallow	*Artamus personatus*	17	0.411
Spotted harrier	*Circus assimilis*	103	0.0582
Straw-necked ibis	*Threskiornis spinicollis*	43	0.325
Torresian crow	*Corvus orru*	77	0.169
Wedge-tailed eagle	*Aquila audax*	210	0.304
Whistling kite	*Haliastur sphenurus*	151	0.0993
White-necked Heron	*Ardea pacifica*	25	0.12
Yellow-throated Miner	*Manorina flavigula*	453	<0.01

4.2.4 Bats

4.2.4.1 Species Assemblage

A total of 12 bat species were recorded during the field survey program, including 11 microbat species and 1 megabat species. This represents 70.6% of the 17 bat species identified in the desktop assessment as potentially occurring in the region (Ecologia, 2026b). Bat species recorded include the Ghost bat (Megadermatidae), the Pilbara leaf-nosed bat (Rhinonycteridae), two species of Sheath-tailed bat (Emballonuridae), three species of Freetail bat (Molossidae), and at least four species of evening bats (Vespertilionidae). Additionally, the Black flying-fox (*Pteropus alecto*) was recorded roosting opportunistically on a single occasion.

4.2.4.2 Observed Bat Utilisation

Acoustic records show bat activity was concentrated along the creeklines in the north-west, north-east, and central southern parts of the Project Area. Four of the microbat species recorded within the Project Area are known to roost in caves (*Vespadelus finlaysoni, Rhinonicteris aurantia* (Pilbara form), *Taphozous georgianus,* and *Macroderma gigas*) which may restrict their occurrence to key movement corridors that link to suitable roosting habitat. Six microbat species generally make use of tree hollows for roost sites and are therefore less spatially restricted in their movements across the Project Area (*Scotorepens greyii, Chalinolobus gouldii, Ozimops lumsdenae, Chaerephon jobensis, Saccolaimus flaviventris,* and *Austronomus australis*). One microbat call group was identified only to a genus level (*Nyctophilus* sp.) and may represent either the Lesser long-eared bat (*N. geoffroyi*) or Pallid long-eared bat (*N. daedalus)*.

The remaining bat species detected within the Project Area was the Black flying-fox, recorded roosting in a date palm tree. The species may roost within many vegetation types, but usually among dense riparian vegetation and rainforests such as mangroves, swamp forests, and tropical moist forests. Roosts are often occupied intermittently, and the species can travel more than a thousand kilometres annually when travelling between roosts.

4.2.4.3 Conservation Significant Bat Species

Of the 12 bat species confirmed within the Project Area, 2 are listed under the EPBC Act and/or the BC Act (i.e. conservation significant). These species are described further in the subsections below and their locations illustrated on **Figure 4.3**. No additional bat species detected from the desktop assessment are listed as conservation significant.

Ghost bat

The Ghost bat (*Macroderma gigas*) is listed as Vulnerable under the EPBC Act and BC Act. The species was recorded within the Project Area on one occasion during the field survey program via video recording using an acoustic ghost bat lure within Drainage Line/River/Creek (major) habitat in March 2024. Ghost bat calls were not detected at any BBSUS sites across the 24 months of BBSUS; however, as the species does not routinely call while foraging and transiting, this is not a reliable indicator of absence within the Project Area.

This species has the potential to forage in all habitat types and although Rocky Escarpment habitat within the Project Area may provide nocturnal refugia and feeding perches for the Ghost bat, no caves with attributes consistent with roosting habitat were identified during the field survey program.

Species distribution modelling of Ghost bats within the Pilbara region indicates that several roosts are possibly located north and east of the Project Area (< 30 km), in proximity to the Coongan River and Bonnie Creek (Shaw et al., 2025). As only a single record of the ghost bat has been recorded within the Project Area to date, there is insufficient data to discuss specific flight paths and movement corridors within the Project Area for this species. Based on the presence of known roosts within 30 km of the Project Area, it is possible that Ghost bats may utilise Coongan River and Bonnie Creek for foraging and dispersal, potentially creating a movement corridor along the creeks in the northern portion of the Project Area.

Pilbara leaf-nosed bat

The Pilbara-leaf nosed bat (*Rhinonicteris aurantia* [Pilbara form]), is listed as Vulnerable under the EPBC Act and BC Act. The species was detected within the DE via echolocation calls on 25 nights across 10 sites over the 24 months of BBSUS (Ecologia, 2026b). The species was also detected at an additional 8 sites, over 11 nights during terrestrial fauna surveys (Ecologia, 2025a).

The Pilbara leaf-nosed bat has very restrictive habitat requirements, including caves and disused mines with hot to very hot and humid roost sites with temperatures in the 28° to 32°C range and 96% to 100% relative humidity (Armstrong, 2001; Churchill, 2008). During the hotter wetter and more humid summer months, the species has a greater ability to disperse through the landscape. The Pilbara leaf-nosed bat has been observed foraging in a variety of habitats including *Triodia* hummock grasslands covering low rolling hills and shallow gullies, with scattered *Eucalyptus camaldulensis* along the creeks (DCCEEW, 2023b). This species is most commonly encountered over small pools of water in rocky gullies and gorges (DCCEEW, 2023b). No low-time calls (within one hour of sunset) were recorded during the field survey program indicating no roost sites occur within the Project Area. Low activity rates were consistently recorded across the Project Area, suggesting that habitat within the Project Area is utilised for foraging and dispersal only.

Species distribution modelling conducted by Shaw et al. (2025), have identified potential Pilbara-leaf nosed bat roosts within 30 km north of the Project Area, including a combination of disused mine and natural roosts. Habitat modelling indicates that suitable habitat for this species is concentrated to the northern half, and the south-western corner, with the centre of the Project Area representing less suitable habitat. Habitat modelling and the spatial patterning of records within the Project Area suggest that the Coongan River and the Bonnie Creek could be utilised as the main movement corridors in the northern portion of the Project Area, with further dispersal into the surrounding foraging habitat including Gorges/Gullies, Woodland (open) and Plain (stony/gibber) habitats.

4.2.4.4 At-risk Bat Species

Although suitable for detection, the method of species identification via Autonomous Recording Units (ARUs) at approximately ground level is unsuitable for determining detailed species’ flight behaviours.

There is some evidence that a bat species’ propensity for collision risk may be associated with their foraging habitat (i.e. narrow, edge, and open space). Using foraging guilds (comprising foraging habitat and style), Voigt et al. (2024) identified general patterns of threat posed to bat species from turbine collision. Ellerbrok et al. (2022) carried out acoustic surveys at ground and canopy height, and results showed that narrow-space-foraging bats (i.e. forest specialist bats) avoid turbines, but there was no difference for edge or aerial (open) foragers.

In general, narrow-space-foraging bats are considered least likely to encounter wind turbines as they avoid the habitat disturbance and clearing that accompanies a wind farm development, while high and fast-flying migrants are most at risk of wind turbine collision and often recorded in carcass monitoring programs (e.g. White-stripe free-tailed bat). Bat species recorded during the BBUS program and their associated foraging habitat based on Voigt et al. (2024) are presented in **Table 4.6**.

Table 4.6: Foraging Habitats of Bat Species Recorded within the Project Area

Foraging Habitat	Common name	Scientific name
-	Unidentified *Nyctophilus* sp.	*Nyctophilus* sp.
Narrow Space	Ghost bat (VU – EPBC Act & BC Act)	*Macroderma gigas*
Edge Foraging	Gould's wattled bat	*Chalinolobus gouldii*
	Little broad-nosed bat	*Scotorepens greyii*
	Finlayson's cave bat	*Vespadelus finlaysoni*
	Pilbara leaf-nosed bat (VU – EPBC Act & BC Act)	*Rhinonicteris aurantia* (Pilbara form)
Open and Edge Foraging	Black flying-fox	*Pteropus alecto*
Open Foraging	Yellow-bellied sheath-tailed bat	*Saccolaimus flaviventris*
	Common sheath-tailed bat	*Taphozous georgianus*
	Greater northern free-tailed bat	*Chaerephon jobensis*
	White-striped free-tailed bat	*Austronomus australis*
	Northern free-tailed bat	*Ozimops lumsdenae*

Note. VU=Vulnerable.

Collision risk assessments undertaken for these species are summarised in Ecologia (2026b) and results for the Ghost bat and Pilbara leaf-nosed bat presented in **Section 6.1.2**.

5 PROJECT IMPACTS TO BIRDS AND BATS

This section provides a high-level overview of possible impact pathways to bird and bat species from the Project. A higher level of detail on Project-specific impacts and associated quanta is provided in the Bonney Downs Wind Farm – EPBC Act Referral Support Document (Fortescue, 2026) and Nullagine Pilot Wind Project Mining Proposal (Fortescue, 2025).

5.1 Habitat Loss and Barrier Effects

Only potential habitat loss and barrier effects from the Bonney Downs Wind Farm are discussed here. The Nullagine Wind Farm has commenced construction and habitat related impacts are discussed in Fortescue (2025).

No fauna habitat will be significantly impacted on a local or regional scale due to the clearing associated with the Project. The total clearing expected for the Bonney Downs Wind Farm IDF is 910.3 ha (excluding previously cleared areas), including 443.4 ha of permanent clearing and 466.9 ha of temporary clearing. A total of 480.8 ha (this includes 13.9 ha of areas previously cleared by other activities not related to this Project) will be rehabilitated once construction is complete.

Overall, the mapped habitat areas within the Bonney Downs Wind Farm IDF are proportionally small compared to the Project Area. Greater than 95% of each habitat type will remain and habitats are also well represented in the Project Area, indicating that the habitats are also well represented in the surrounding region.

Given the majority of the Project Area will remain undisturbed; the access roads are proposed to only be up to 8 m wide; the turbine structures will be widely spaced with up to 2 km between each turbine and a minimum of 600 m. It is unlikely that clearing and the placement of infrastructure will cause a barrier to species movement within their home ranges. In addition, large areas of undisturbed habitat will remain intact within the Project Area and surrounding area post-disturbance and populations in these areas will not be significantly impacted. Following construction, the rehabilitation of cleared areas can reduce any potential fragmentation or barrier impacts. Overall impacts to habitat are unlikely to be significant.

5.2 Turbine Collision

The majority of bird and bat species recorded during the field survey program are not listed as conservation significant and are typically low-flying and/or canopy-dwelling species which are unlikely to be at risk of collision with turbines (Ecologia, 2026b). Species recorded during the field survey program flying at RSA, and therefore at-risk of collision, were predominantly raptors (8 species) and waterbirds (6 species). These species belong to groups considered to be at greater risk of turbine collision due to flight demographics and behavioural attributes. Only one of these species is listed as conservation significant (Grey falcon – Vulnerable) and is discussed further below.

The Grey falcon is likely to predominantly use the Project Area for foraging across all habitats, with nesting associated with large mature trees in the Drainage Line/River/Creek (major) habitat type. One Grey falcon nest has been confirmed within the northern part of the Project Area in the Drainage Line/River/Creek (major) habitat type during the field survey program. A single, well-developed chick was later observed at this nest with two adult Grey falcons nearby in September 2025 outside of the field survey program (Ecologia, 2026b).

This species is considered prone to collision with wind turbines due to its soaring behaviour within RSA height whilst foraging or dispersing. Flight heights recorded during the field program (Ecologia, 2026b) comprised 68% below RSA, 32% within RSA, and 0% above RSA. Collision Risk Modelling (CRM) was undertaken for this species to quantify potential collision impacts and is detailed further in **Section 6**.

5.3 Barotrauma

Barotrauma is a phenomenon in which rapid air pressure changes from rotating turbine blades are hypothesised to cause tissue damage to air-containing structures, most notably the lungs of bats (Baerwald et al., 2008). It has also been hypothesised that barotrauma can result in non-lethal injuries, such as hearing impairments and other internal injuries that may result in bats succumbing to their injuries away from turbines (Lawson et al., 2020). Due to the unique respiratory anatomy of birds, they are considered less susceptible to barotrauma than that of mammals, specifically bats (Baerwald et al., 2008).

Research conducted in North America on the relative risk of barotrauma compared with direct collisions has resulted in mixed findings regarding the proportion of deaths that have been attributed to each factor (Ellison, 2012), though it appears the majority of fatalities are due to collisions (Grodsky et al., 2011; Rollins et al., 2012). Baerwald et al. (2008) found that barotrauma to the lungs and possibly other organs accounted for 46% of bats killed at turbines with 92% of the barotrauma in those bats displaying as haemorrhaging in the thoracic and/or abdominal cavities. However, Rollins et al. (2012) found that only 6% (5/81) of bats collected at a wind farm in Illinois had lesions possibly consistent with causation by barotrauma, leading the authors to conclude that “traumatic injury is the major cause of bat mortality at wind farms, and, at best, barotrauma is a minor etiology”. Lawson (2020) used computational fluid-dynamics to model changes in air pressure around moving turbine blades to assess the likelihood of bats occurring within areas of extremely high or low pressure. The modelled air pressures were also compared to those associated with mortality in rats to assess the likelihood of barotrauma resulting in lethal or sub-lethal injuries to bats. Barotrauma was determined unlikely to be a leading cause of death supporting the alternative hypothesis that collisions are more likely to be the predominant pathway for bat mortalities as a result of operating turbines.

Due to the difficulty in diagnosing barotrauma unless the carcass is examined immediately after death, it is possible that cases attributed to barotrauma have been confused with traumatic injury associated with direct collisions. There is currently no published information on barotrauma in Australia.

6 BIRD AND BAT RISK ASSESSMENT AND MODELLING

A preliminary overall risk assessment (Ecologia, 2026b) was undertaken for all bird species recorded within the Project Area using the protocol established for onshore wind farms (Reid & Baker, 2025). Collision risk modelling (CRM) was then undertaken to estimate the probability of turbine collision for 13 bird species with sufficient data and is detailed in Hocking et al. (2026). The Grey falcon was the only conservation significant bird species with sufficient data for modelling.

Risk assessments for bat species were undertaken using a range of methods which were then compared with available site-specific information and a literature review to determine final risk ratings.

A summary of the risk assessment results for conservation significant species either known or considered likely to occur within the Project Area is presented in **Section 6.1.2** and **Section 6.2.2**. It should be noted that these results present the inherent anticipated collision risk to bird and bat species and does not account for any mitigation or management measures that may be implemented to reduce potential impacts. The risk assessment results therefore provide a theoretical baseline for which mortalities recorded during the monitoring program can be assessed against (i.e. number and frequency of mortalities) and appropriate measures can then be implemented through the adaptive response procedure (

Figure 9.1) should impacts be greater than anticipated.

6.1 Collision Risk Assessment

6.1.1 Methodology

Key components used to quantify the overall risk score for bird species were based on species' susceptibility to collision (flight height, flight time, flight manoeuvrability, and habitat specialisation) and species' productivity (conservation status and generation time) following the method developed by Reid & Baker (2025). A detailed overview of the methodology and results of this risk assessment are presented in Shephard et al. (2026) and summarised in Ecologia (2026b).

Three risk assessments frameworks were used to assess risk to bats present at Bonney Downs and reviewed against available site data and broader literature available to determine the most suitable site-specific rating for each (Reid & Baker, 2025; Specialised Zoological, 2024, 2025; Voigt et al., 2024). A detailed summary of the methodology and results of the bat risk assessment are presented in Fleming & Dempster (2026) and summarised in Ecologia (2026b).

6.1.2 Summary of Findings

Based on the species' susceptibility to collision and productivity, the avifauna collision risk assessment (Ecologia, 2026b) rated both the Grey falcon and Pacific swift as a 'High' overall risk rating and the Oriental Plover receiving a 'Medium' overall risk rating. The number of flight records and observed proportion of flights at RSA recorded during the BBUS program for these species are provided in **Table 6.1** along with the collision risk category based on the method developed by Reid & Baker (2025). Only the Grey Falcon had sufficient flight data for CRM (see **Section 6.2.2**).

Table 6.1: Avifauna Collision Risk Assessment Results

Common name	Flight records	Below RSA	Within RSA	Above RSA	Risk Category
Grey falcon	25	70%	30%	0%	**High**
Pacific swift	4	100%	0%	0%	**High**
Oriental plover	1	100%	0%	0%	**Medium**

The bat risk assessment (Fleming & Dempster, 2026) rated both the Ghost Bat and Pilbara Leaf-nosed Bat as 'Low' (**Table 6.2**).

Table 6.2: Bat Risk Assessment Results

Common name	Records	Risk Category
Pilbara Leaf-nosed Bat	12	**Low**
Ghost Bat	1	**Low**

6.2 Collision Risk Modelling

6.2.1 Methodology

To tailor the CRM process to the Project, a New Model was developed by the Harry Butler Institute that provided more appropriate estimates based on bird behaviour and spatial separation of wind turbines within the Project Area (Hocking et al., 2026). The New Model is more flexible than traditional models, such as the Band model, and allows increasing levels of site-specific information to be incorporated as more data is obtained. The full CRM report is provided in **Appendix A.**

The New Model is based on three key components: (1) the use of flight height distributions consistent with those required in the Band model, (2) a calculation of strike frequency during passage, comparable to the Band model but slightly simplified, and (3) the simulation of bird movement across the region according to species-specific speeds and travel distances. A detailed description of the method is provided in Hocking et al. (2026).

Modelling was undertaken for the 13 bird species with sufficient and available data for both the Band Model and the New Model to allow a comparison of results using both methods. Species that did not undergo modelling included:

- Species recorded singly or infrequently at RSA across the field survey program and for which there was insufficient flight height data for robust analysis; and
- Species not recorded at RSA, including two conservation significant species (Oriental Plover and Pacific Swift).

6.2.2 Summary of Findings

Modelling was carried out for 13 bird species, including 1 conservation significant bird species (Grey falcon – Vulnerable), using data from the full BBSUS program, the Australian Database of birds (BirdLife Australia, 2025), as well as data from the two Robin Radar MAX units.

Estimated annual mortality rates and likelihood of collision for the Grey falcon are presented in **Table 6.3** for a 90% avoidance rate using the New Model and a 99.5% avoidance rate using the Band Model.

It is currently considered likely that the Grey falcon observations from across the Project Area comprise a single pair. However, even if there were 4 individuals within the Project Area, the New Model estimates 1 bird to be struck every 14 years and the Band Model estimates 1 bird to be struck every 12 years (Hocking et al., 2026; **Table 6.3**). Therefore, the likelihood of collision for this species is considered to be low.

Table 6.3: Estimated Annual Mortality for the Grey Falcon

Species	Taxonomic names	Annual Mortality Rate (%)		Likelihood of collision
		90% Avoid New Model	99.5% Avoid Band Model Option 2	
Grey falcon (VU)	*Falco hypoleucos*	1.61	1.86	**Low**

Note. VU=Vulnerable

Only two species were estimated to have an annual mortality rate >5% under either the Band or New Model (Wedge-tailed eagle and Australian Pelican). The Wedge-tailed eagle annual mortality rate was estimated as 11.67% (Band model) and 4.47% (New Model). If each Wedge-tailed eagle territory mapped within the Project Area is occupied by 2 adults (with an average of one fledged young), then the population size within the Project Area is approximately 54 to 81 individuals. this equates to 6 adults plus 3 fledglings per annum under the Band model or 3 adults plus 2 fledglings per annum under the New Model (Hocking et al., 2026). Annual mortality for the Australian pelican was estimated at 5.25% under the New Model and 2.77% under the Band model (Hocking et al., 2026). The Australian pelican is a dispersive and wide-ranging species which makes the population size difficult to estimate for the Project Area. However, the species has been recorded in relatively low numbers (9 records comprising 35 individuals) during the field survey program (Ecologia, 2026b). Collision impacts for these species will be managed in accordance with **Section 9**. Results for all remaining non-listed species are presented in Hocking et al. (2026).

Modelling was not undertaken for the Pacific swift or Oriental plover despite being recorded during the field survey program as neither species was observed flying within RSA, had insufficient total flight data, or had no suitable proxy species for modelling. All remaining conservation significant bird species not recorded during the field survey program but with a potential to occur within the Project Area did not have suitable proxy species for modelling. Collision impacts for these species will be managed in accordance with **Section 9**.

6.2.3 Collision Risk Model Peer Review

A scientific peer review of the collision risk model report was undertaken by Farrow (2026) in February 2026 and is presented in **Appendix B**. The peer review noted that the approach of undertaking and comparing two CRM methods provided confidence in the results produced. Overall, the review found:

- Presentation of results as accurate and comprehensive;

- Similar rankings in species modelled between both CRM methods despite some differences in estimated annual mortality rates which was to be expected given the difference in methodologies and uncertainties of some parameters; and
- Conclusions of the report as well supported by the results generated from both CRM methods.

7 MITIGATION AND MANAGEMENT MEASURES

This section outlines mitigation measures designed to reduce the risk of significant impacts on bird and bat species from implementation of the Project. Additional measures may be implemented following the investigation of triggers being reached or exceeded and the BBAMP reviewed. Measures may include, but are not limited to, those currently being investigated by Fortescue through trials at the Nullagine Wind Farm and via research projects in collaboration with the Harry Butler Institute. The ongoing, preventative mitigation measures discussed in this plan are provided in **Table 7.1**.

Table 7.1: Project Measures for Avoiding and Reducing Impacts

Measure	Description	Timing
Avoidance: Turbine siting	Siting of Project infrastructure, including turbine locations, has been designed to include: • Where possible, avoid important areas for bird and bat habitats, movement and activity: ○ Avoidance of major drainage/creek lines except where crossing locations are required, ○ Avoidance of direct disturbance of gorges/gullies and hills/ranges/plateaux habitats, which are associated with areas of birds and bats habitats, movement, ○ Avoidance of mesas, which are associated with specific fauna habitats. Additionally, turbine siting has been designed to be widely spaced to reduce the diversionary responses by bird and bat species. Fauna habitat exclusion zones have also been incorporated around critical fauna habitats. Fortescue commits to avoiding all disturbance within the fauna habitat exclusion zones. The only exception is the 500 m buffer surrounding the major drainage line/river/creek habitat, where some small areas of disturbance is proposed. However, despite this allowance, no wind turbines will be placed within this buffer due to its proximity to Grey Falcon breeding habitat.	Design stage
Avoidance: Habitat clearing and collision risk	The Proposal has undergone substantial redesign, resulting in a major reduction in scale, including a decrease in turbine numbers from 200 to 100 and a reduction in the IDF area from approximately 2,044 ha to 944.07 ha.	Design Stage
Mitigation: Vegetation clearing controls	Clearing and ground disturbing activities limited to the defined clearing limits and boundaries described within the approval documentation. The extent of the approved clearing will be clearly communicated in documentation and site inductions. Pre-clearing field demarcation of areas approved to be cleared and post clearing inspections to be undertaken.	Construction
Mitigation: Deterrence	Visual deterrence: Fortescue are investigating the effectiveness of painted turbine blades as a visual deterrence measure. Painted turbine blades will be implemented for the Project should the trial indicate their use provides a significant reduction of carcasses. Acoustic deterrence: Acoustic deterrence devices will be located on Nabralift lattice towers should it be determined birds are roosting.	Operations
Mitigation: Curtailment Protocols	Fortescue may implement additional mitigation measures being trialled at Nullagine windfarm if the adaptive management response outlined in **Section 9** indicates significant risks to conservation significant species may be addressed through these measures. These measures might include: • Blade feathering to <1 RPM for wind speeds below the cut-in speed, • Smart curtailment: Radar and/or camera based smart curtailment system for conservation significant species.	Operations
Mitigation: Lighting controls	Lighting will be designed and managed in accordance with the National Light Pollution Guidelines for Wildlife (DCCEEW, 2023a). These include: • Permanent lighting will be installed only where required, within operational areas, • Permanent and temporary lighting will be shielded to minimise light spill. This includes directional or shielded lighting, the mounting of light fittings as low as practicable, or louvered lighting on low-level bollards,	Operations

Measure	Description	Timing
	• Automatic timers or photovoltaic switches, • Black-out blinds on windows in accommodation camps, and • Permanent and temporary lighting will be directed away from sensitive areas where possible such as areas of critical habitat.	
Carrion removal	A carrion-removal program will operate for the duration of the Project to reduce attraction of raptors and other scavengers to turbine areas. The program applies to all non-bird and non-bat carcasses found within 200 m of accessible turbines. A designated Carrion-Removal Coordinator will oversee periodic inspections by trained personnel, conducted on foot or by vehicle. All staff will be inducted in carcass-removal procedures. Any incidental carrion discovered outside scheduled inspections will be removed promptly, and all removals recorded in a site database with date, location, and species (where known). The program will be reviewed after two years of operation and may be adjusted in consultation with regulators. Annual summaries of carcass detection and removal will be included in compliance reporting.	Operations

8 MONITORING PROGRAM

Survey methods for future additional bird and bat surveys associated with this BBAMP are provided below and are based on current information and industry guidelines. These include continuation of BBSUS, carcass search programs, and ancillary surveys (trials).

8.1 Monitoring Program Schedule

An overview of the schedule for the different components of the bird and bat monitoring program is provided in **Table 8.1**.

Timing of the bird monitoring program has been determined based on the southward (September - November) and northward (February-April) migration of conservation significant species known or potentially occurring within the Project Area. Specifically, this timing is based on the migration staging for these species in northern Australia and includes a month on either side to account for variability across years. Timing of the bat monitoring program has been scheduled to coincide with the bird monitoring program and is considered appropriate timing for detecting species expected to occur within the Project Area.

Table 8.1: BBAMP Monitoring Schedule

Survey	Project Phase	Timing	Duration	Reference
Bird Site Utilisation Surveys	Construction / Operation	Twice annually, in October/November and February/March. Commencing within 6 months of the first 25% of turbines being operational.	2 years	**Section 8.2.1**
Bat Site Utilisation Surveys	Construction / Operation	Twice annually, in October/November and February/March. Commencing within 6 months of the first 25% of turbines being operational.	2 years	**Section 8.2.2**
Carcass Search Surveys	Construction / Operation	Surveys will occur every 2 months for an initial two-year period. Commencing within 3 months of all turbines being operational.	2 years	**Section 8.3**
Carcass Detectability Trial	Construction / Operation	Once every 6 months following construction and full commencement of operation, beginning with or prior to the first carcass search survey.	2 years	**Section 8.4.1**
Carcass Persistence Trial	Construction / Operation	Once every 6 months following construction and full commencement of operation, beginning with or prior to the first carcass search survey.	2 years	**Section 8.4.2**

8.2 Bird and Bat Site Utilisation Surveys

The purpose of post-commissioning BBSUS is to continue to develop the understanding of the impacts to birds and bats associated with the construction and operation of the Project by assessing post commissioning bird and bat data against baseline data. This information can then be used to inform adaptive response measures and enables the success of a long-term mitigation and management. A summary of the post-commissioning BBSUS program is provided in the following sections.

8.2.1 Bird Site Utilisation Surveys

Post-commissioning, bird site utilisation survey methods will follow those of BBSUS conducted between 2023 and 2025. Methods will be adapted should new techniques become available, provided the changes meet the overall objective of the monitoring program. For the purpose of reporting, any observations of birds flying at RSA height constitutes ‘at-risk behaviour’.

Bird site utilisation surveys will be conducted within six months of the first 25% of turbines being commissioned and having passed reliability testing. Surveys will be expanded to incorporate additional areas once new turbine groups have been commissioned, and the area is considered safe to do so. Survey timing will be aligned with that of pre-commissioning BBSUS (**Table 4.2**) to coincide with the seasonal migration of EPBC Act and BC Act listed birds.

The requirement for further post-commissioning bird site utilisation surveys will be reviewed by a third-party expert ecologist after the initial two years of surveying. To be consistent with previous bird site utilisation data collected between 2023 and 2025 and facilitate the BACI framework, the methods utilised will follow those employed previously. In addition to the bird site utilisation surveys, flight data may continue to be collected during both the construction and operational phases of the Project using a variety of automatic detection units (including radars, cameras, and acoustic monitoring technologies). These data will be used for ongoing analyses of flight heights and behaviour to inform updates to collision-risk assessments and the development of appropriate mitigation strategies.

8.2.2 Bat Site Utilisation Surveys

Post-commissioning, bat site utilisation survey methods will follow those of BBSUS conducted between 2023 and 2025. Methods will be adapted should new techniques become available, provided the changes meet the overall objective of the monitoring program. For the purpose of reporting, any observations of bats flying at RSA height constitutes ‘at-risk behaviour’.

Bat site utilisation surveys will be conducted in conjunction with bird site utilisation surveys, twice annually, and will continue for the first two years of operation.

The requirement for further post-commissioning bat site utilisation surveys will be reviewed by a third-party expert ecologist after the initial two years of surveying. To be consistent with previous bat utilisation data collected between 2023 and 2025 and facilitate the BACI framework, the methods utilised will follow those employed previously.

In addition to the bat site utilisation surveys, flight data may continue to be collected during both the construction and operational phases of the Project using a variety of automatic detection units (including radars, cameras, and acoustic monitoring technologies). These data will be used for ongoing analyses of flight heights and behaviour to inform updates to collision-risk assessments and the development of appropriate mitigation strategies.

8.3 Carcass Search Program

The key objective of the carcass search program is to monitor the frequency of bird and bat mortality due to collision or barotrauma associated with the Project from which the total number of mortalities can be estimated. Estimated frequency of mortality due to collision or barotrauma will be modelled and reported annually using inputs from the carcass search program to determine the range of actual mortalities that have occurred. These outputs can then be used to assess the accuracy of mortalities/featherspots/injured individuals recorded by the carcass search program and inform appropriate responses or extension of the program's implementation.

The methods to be employed as part of this program are detailed throughout the following subsections. Reporting requirements relevant to the carcass search program are summarised in **Section 10**.

8.3.1 Turbine Selection

The same subset of 40 of turbines will be searched during each sampling event over the life of the program. Turbines selected for searching will be randomised across the Project Area with consideration for spatial coverage and accessibility as all turbines are currently assumed to be of equal risk.

Where annual monitoring via the BBSUS or carcass search program indicates that some turbines or areas may be at higher risk of collision than others, turbines selected for searching may be modified with consideration of the following factors:

- Turbines where prior mortality events of threatened or migratory species have been confirmed.
- Turbines that overlap or occur in proximity with habitat for threatened or migratory birds and bats.
- Turbines representative of different habitat types and landscape positions.

Modifications may involve additional searches at select turbines to bolster detection rates or changes to the subset of turbines searched using proportionate stratified randomisation according to habitat type. Additional searches may be undertaken at any time during the monitoring program while changes to the subset of turbines searched will only be reviewed as part of annual compliance reporting. Any modifications made will be summarised in the Annual Compliance Report (**Section 10**).

It should be noted that turbines searched in addition to the subset of regularly searched turbines can not be used to generate annual mortality estimates as that would bias estimations. Data gathered from additional searches would be used to improve carcass detectability for monitoring against trigger levels (**Section 9**) and allow timely implementation of the adaptive response procedure (

Figure 9.1).

8.3.2 Survey Timing and Frequency

The carcass detection program will commence within 3 months of all turbines being commissioned and continue for a period of two years.

Carcass searches will be undertaken once every two months, and the search program will be reviewed for efficacy after two years by a third-party expert ecologist, with the possibility of extension, pending review results. The efficacy requirement for extension will be based on a circumstance where there is a clear discrepancy between the anticipated and realised frequency of bird and bat mortality due to the operation of the wind turbines or where deemed necessary as part of adaptive management measures (**Section 9**).

Incidental carcasses collected by operational staff between scheduled surveys will be stored in an on-site freezer, along with collection details and photographs being provided to the Site Environmental Advisor for identification. Details on how to collect specimens, record observations and the best way to store carcasses in a freezer will be provided to operational staff during site inductions as specified in **Section 8.3.6**.

8.3.3 Search Area

The final search area engaged for the carcass search program will be determined based on the confirmation of final specifications of the proposed turbines and the method employed for carcass searches.

Based on the proposed RSA as well as the findings of Hull and Muir (2010), Huso and Dalthorp (2014) and Prakash and Markfort (2020), an indicative area with a radius of 120 m around the base of each turbine comprising an inner and outer search area (80 m radii, respectively) will be utilised. Based on fall zone distributions for bat and bird carcasses (Hull & Muir, 2010), this radius would provide full coverage of the bat fall zone and 85% of the bird fall zone. A search radius of 160 m would be required to achieve 100% of the bird fall zone and involve 9 km of transect walked per turbine which would limit the number of turbines searchable during each survey event. A 120 m search radius equates to approximately 5 km of transect walked per turbine and allows a greater number of turbines to be searched while still accounting for a majority of the possible bird fall zone.

8.3.4 Search Method

There are two potential search methods proposed, including a human detection search method and the use of detection dogs, which are detailed in **Section 8.3.4.1** and **Section 8.3.4.2**. The human detection method will be used in the first instance wherever suitable due to logistical and safety issues with utilising detection dogs in the climate and environment of the Project Area.

8.3.4.1 Human Detection Method

Carcass searches will be conducted by ecologists experienced in bird and bat carcass identification. At each turbine search area, the observer will walk transects comprising an inner and outer search area (60 m radii respectively) at each of the selected turbines (**Figure 8.1**).

Carcass searches will be conducted as follows:

- The inner and outer search areas will be surveyed at each selected turbine with the intensity of searches varying based on distance from the wind turbine base with as follows:
    - Inner zone = transects to be spaced every 6 m to 60 m from base of turbine.

- Outer zone = transects to be spaced every 12 m from 60–120 m from base of turbine.

Following the initial inner and outer zone searches, a follow-up ‘pulse search’ will also be conducted at surveyed turbines. The pulse search will occur within several days of the initial searches and involves a repeat of the aforementioned ‘inner zone’ search, to detect additional small and medium-sized bird and bat mortality. Pulse searches bolster turbine collision rate data for small birds and bats as their carcasses persist for a shorter time in comparison to larger species (which may still be present and able to be detected during a future carcass search).

The frequency of carcass search surveys may be altered if the findings of the carcass persistence trial indicate that it would be necessary or appropriate.

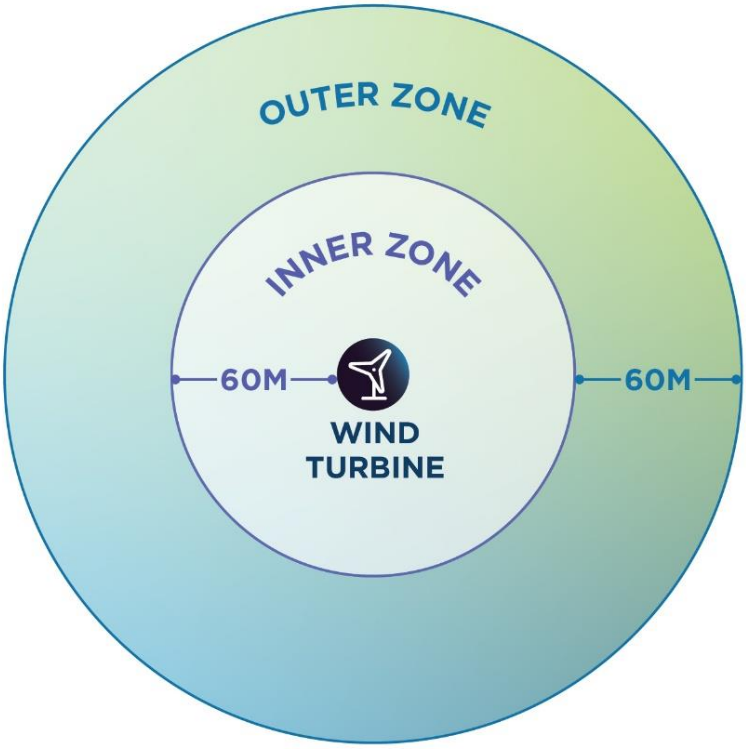


Figure 8.1: Human Detection Method Search Areas

8.3.4.2 Detection Dog Method

Trained detection dogs may be used if they are available and if the climatic conditions and terrain of the search areas are suitable for a safe and effective canine search effort. As such, surveys conducted during summer months may need to be scheduled to avoid extreme weather. The terrain of the search areas may present some limitation to the detection dog and trainer, where dense vegetation and steep, rocky terrain occurs. A detection dog team is comprised of at least one ecologist and detection dog whereby both will undertake surveys as early and/or late in the day as possible to avoid heat stress, so that the health and safety of the dogs and handlers is prioritised.

Dog handlers will be trained ecologists and experienced in identification of all bird and bat species that may occur within the Project Area. The detection dog will be highly trained with recall and always be within sight or within audible distance of the handler. Detection dog teams will generally work from downwind to upwind across the 120 m radius (Search Area). Depending on the wind speed at the time of sampling, the width between transects used by the detection dog team will vary. This is because the scent cone being emitted by the carcass will become narrower during stronger wind and wider during lighter wind. As such, the distance between transects will vary from between 10 m and 30 m at the discretion of the trained detection dog handler (**Figure 8.2**).

The detection dog team will walk across the direction of the wind, allowing the dog to freely move across the search transect, while responding to commands of the handler. A GPS collar will be attached to the detection dogs to allow the handler to track movements in real time and ensure the entire search area has been sufficiently covered by the dog. Once the distance travelled by the dog is adequate and there are no clear coverage gaps, the team will move to the next wind turbine and repeat the process.

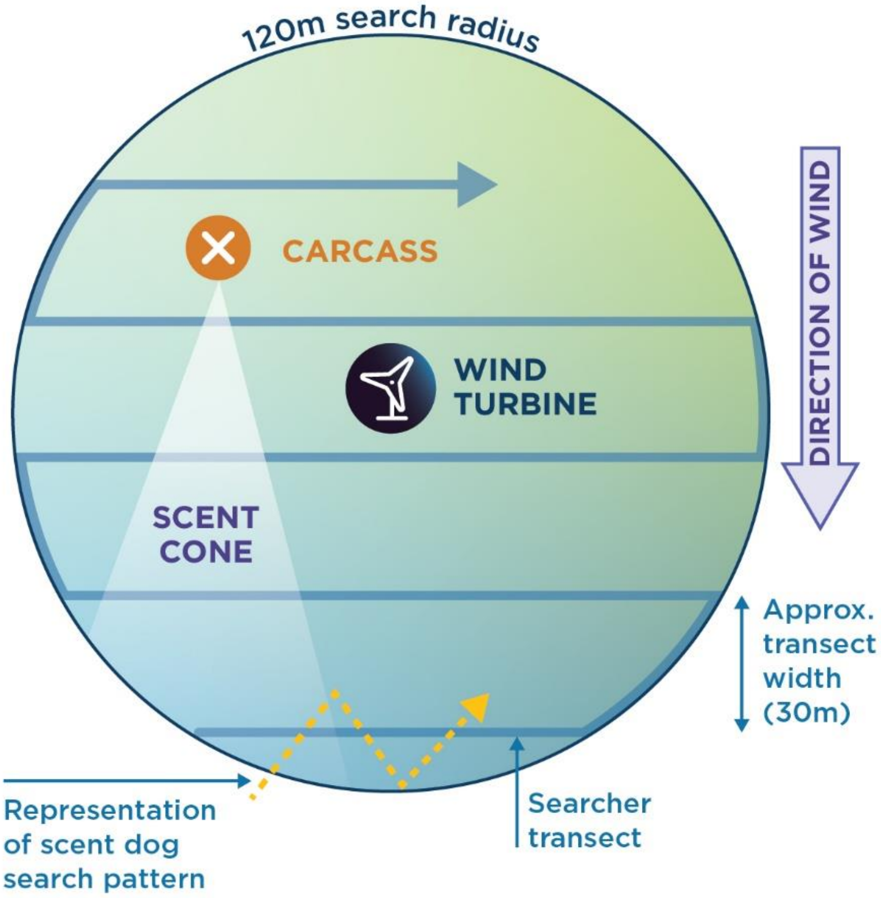


Figure 8.2: Detection Dog Method Search Area

8.3.5 Unsearchable Areas

In certain situations, the topography surrounding wind turbines may present challenges to effective search and monitoring activities. Terrain such as steep slopes, dense vegetation, or rocky areas can limit access for both human surveyors and trained detection dogs. At turbines within such areas, searcher efficacy or carcass detectability (particularly if humans are used to search for carcasses rather than dogs) may vary.

Areas deemed as unsearchable for each turbine included in the carcass search program will be marked/mapped and a corrective factor equivalent to the remaining area unable to be surveyed will be applied to produce total bird and bat mortality estimates. Prior to implementing the searches, a statistician will be consulted regarding the corrective factor and the preferred method for recording the data for use in the mortality estimation.

8.3.6 Data Collection and Carcass Find Protocol

During the carcass search surveys and the carcass persistence trials (**Section 8.4**), data will be collected and recorded on predefined survey sheets, including online applications if appropriate.

The data will include (but is not limited to) general information such as basic survey and weather information, location-specific information including ground cover/substrate, and the extent of the search area that is accessible/searchable.

If a bird or bat carcass or featherspot is detected during a carcass search survey, the carcass or featherspot must be collected, photographed and stored (if a carcass), its location must be recorded on a GPS device, and the relevant data collection form completed. The carcass will then be placed in an on-site freezer dedicated to this purpose and clearly labelled as such, with the carcasses to be used in carcass detectability trials and carcass persistence trials (**Section 8.4**). Handling and collection of carcasses should consider the following:

- The carcass must be removed from the site by a person wearing rubber gloves and double bagged in clear plastic bags.

- The carcass must be photographed in such a way that it can be further identified, i.e. on a white background with an item or measuring tape for scale and adequate lighting.

- A label with the date, turbine number, species name (if known) and a unique specimen code must be placed in the second bag to allow cross-reference to the corresponding completed datasheet.

- The carcass will be transported to a dedicated on-site freezer where it will be retained for the purpose of either a second opinion on its identification, or for use in carcass persistence trials or carcass detectability trials.

- In cases where featherspots or carcasses cannot be identified, the following process will be undertaken:

    - Photos of the featherspot or carcass will be analysed by the Site Environmental Advisor (including any colleagues) to definitively identify the find, including circumstances where the Site Environmental Advisor allocated the identification to likely or probable confidence levels.

    - Methods to further definitively identify the featherspot or carcass could then involve sending photos of the find and/or the find itself to a species specialist or museum, or for DNA testing. DNA testing is not proposed to be used for carcasses or featherspots unless there is the potential it could be a threatened species.

All data collected during the carcass search program will be entered into a database. Data pertaining to incidental finds must also be retained in this database.

All carcasses collected must be kept (frozen) until the completion of all ancillary surveys as outlined in **Section 8.4**.

8.4 Ancillary Surveys

The purpose of ancillary surveys (trials) is to test and measure both carcass persistence and searcher efficiency during the monitoring program. These trials will help calibrate inputs for the calculations of mortality estimates and allow survey methods to be adjusted where appropriate.

8.4.1 Carcass Detectability Trials

The efficacy of the carcass detection program will be investigated using carcass detectability trials which aim to detect the degree of error present as a calibration factor for mortality estimates.

The detectability of carcasses under turbines can vary depending on a range of factors such as the efficacy of the observer, the size of the carcass, and the type of ground cover. Given this, carcass detectability trials will be undertaken to determine the efficacy of finding carcasses within different areas of the Project Area. These trials will correspond with periods of low and high grass or cropping cover as carcass detection by humans is limited by these visual restrictions.

Carcass detection trials will be undertaken twice across a 12-month period and commence immediately prior to or with the first carcass search survey. The trial can be undertaken concurrently with the carcass persistence trials and/or the carcass search surveys to maximise survey efficiency. If the carcass detection team undertaking the carcass search program (**Section 8.3.4**) changes, then new carcass detectability trials will be implemented to account for changes in detectability by personnel.

The broad methodology for carcass detectability trials includes:

- Birds and bats collected during the carcass detection program will be stored in an on-site freezer, suitable for storage during the carcass detectability trial. Where local deceased bird or bat carcasses are not available, other mammal and bird carcasses of similar size classes will be ethically sourced (e.g. from a pet food supply store or animal rehabilitation clinic).

- Carcasses of varying size and species (both bird and bat) will be randomly placed around the search zone of the turbines (**Figure 8.1** and **Figure 8.2**). The number of carcasses placed and associated turbines selected will be determined using a randomisation tool, though will total a minimum of 10 large birds (e.g. raptors), 10 medium sized birds, and 10 small sized birds, and 10 microbats per trial/season (**Table 8.2**). The location of the carcasses will be captured using a GPS.

- The ecologists or detector dog team, without the knowledge of the calibration survey, will undertake the carcass detection program as per the methodology described above.

This method enables results of the carcass detection program to be corrected using a calibration factor, derived from the number of placed carcasses found, divided by the number of carcasses placed. For example, if five carcasses of the original ten are found by the surveying team, the calibration factor of 0.5 (5/10) would apply to the results of the carcass detection program. In this example, it is assumed that 50% of the carcasses were missed and should be accounted for.

Table 8.2: Minimum Trial Replicates per Season/Trial

Season/Trial	Large Birds	Medium Birds	Small birds	Microbats
Dry Season	10	10	10	10
Wet Season	10	10	10	10

8.4.2 Carcass Persistence Trials

Birds and bats injured or killed through collision with turbines may be removed from search areas by scavengers such as varanids, raptors, ravens, dingoes, or introduced mammals. Carcass persistence trials allow the persistence rates of different-sized carcasses to be estimated and improve the estimation of mortality rates of birds and bats impacted via turbine collision.

The persistence trials will be undertaken once every six months for a period of two years. To assess variation in scavenging rates across carcass sizes, three different size classes for birds will be used with an equal number of replicates per trial (Table 8.2). The various carcasses will be placed within the search zone of a selection of turbines within the DE and their location recorded via GPS. Each carcass will have a motion-detecting camera placed nearby to identify the species potentially scavenging the carcass and record the date and time that the carcass is removed as recommended by Ravache et al (2024).

The motion-detecting cameras will be supplemented by physical carcass checks by suitably qualified ecologists or trained on-site personnel. The Site Environmental Advisor/on-site personnel will manually check the carcasses at 3 days and between 7-14 days following carcass placement. These checks will record whether the carcass is “intact” (i.e., does not appear to have been scavenged by a vertebrate predator) or “partially scavenged” (i.e., flesh and skeletal remains are found). Feather-spots will also be recorded, however will not contribute to the persistence correction factor as this may bias results (as scavenging has likely already occurred by the time feather-spots are found). Other relevant notes relating to scavenging (e.g. scavenger scats, feathers, bones, type of scavenging) will also be recorded.

Quantifying the mean and confidence interval of the time until the removal of carcasses is required for input into the calculation of mortality estimates. Carcass persistence will be examined through survival analysis using statistical analysis to estimate the survival function.

9 IMPACT TRIGGERS AND ADAPTIVE MANAGEMENT

This section defines impact trigger levels for threatened and migratory species, as well as the adaptive management process which is to be engaged if trigger levels are met or exceeded.

The objective of the impact trigger level is to prevent the operation of the wind farm resulting in adverse impacts to bird and bat populations.

This is intended to achieve the overarching environmental outcome of avoiding direct and indirect impacts to threatened bird and bat populations or otherwise minimising these to as low as reasonably possible.

Trigger levels to be implemented under this BBAMP are provided in **Table 9.1**.

Table 9.1: Impact Trigger Levels

Trigger Category	Definition	Trigger[2]	Basis of Categorisation
Trigger 1 – Threatened Species	Threatened bird or bat species listed under the EPBC or BC Act as: • Critically Endangered • Endangered • Vulnerable	confirmation **of one carcass, featherspot, or injured individual**	EPBC Act Significant Impact Guidelines 1.1 (Commonwealth of Australia, 2013) consider any mortality or disturbance to listed Threatened species as potentially significant.
Triger 2 – Migratory Species	Bird or bat species listed as Migratory under the EPBC or BC Act	confirmed **annual mortality of 0.05%** of the national population or East Asian-Australasian Flyway population for migratory shorebirds[3]	EPBC Act Significant Impact Guidelines 1.1 and Wind Farm Industry Policy Statement 2.3 (Commonwealth of Australia, 2009), which indicate that impacts affecting >0.1% of a population may be significant. A conservative trigger level under this has been used.
Trigger 3 – Other Conservation Significant Species	Bird or bat species listed as Priority by DBCA or Other Specially Protected under the BC Act	confirmation of **two carcasses, featherspots, or injured individuals** across two consecutive months	Locally significant species may not trigger EPBC referral but warrant adaptive management to avoid population-level decline.
Trigger 4 – Non-listed Species	Bird or bat species not listed under the EPBC Act, BC Act, or as Priority species by DBCA[4]	**confirmation of four carcasses, featherspots, or injured individuals** recorded at the same or adjacent turbines within two consecutive months	Threshold considered adequate to capture reoccurring impacts or non-stochastic mortality trends.

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[2] Trigger refers to a confirmed mortality or injured individual within the designated search area either during the carcass search program, within 200 m of Project infrastructure as part of carrion removal procedures, or within 200 m of Project infrastructure incidentally during other activities. If expert identification (including DNA testing) is required to determine the species of a carcass or featherspot, then the impact trigger will occur from the date the species identification is confirmed.

[3] Population estimates to be revised annually during annual compliance reporting with the latest available data. Trigger levels based on current population estimates are provided in **Table 9.3**.

[4] Excludes the 10 most abundant bird species recorded during the field survey program: Budgerigar, Little corella, Australian zebra finch, Galah, White-plumed honeyeater, Yellow-throated miner, Painted finch, Masked woodswallow, Spinifex pigeon, Cockatiel.

Conservation significant species known or considered likely to occur within the Project Area are listed in **Table 9.2** along with their associated trigger category.

Table 9.2: Trigger Categories for Conservation Significant Species Known or Likely to Occur

Common Name	Scientific Name	WA Status	Cth Status	Trigger Category
Known (Recorded)				
Grey falcon	*Falco hypoleucos*	VU	VU	Trigger 1
Pacific swift	*Apus pacificus*	MI	MI	Trigger 2
Oriental plover	*Charadrius veredus*	MI	MI	Trigger 2
Ghost bat	Macroderma gigas	VU	VU	Trigger 1
Pilbara leaf-nosed bat	Rhinonicteris aurantia (Pilbara form)	VU	VU	Trigger 1
High Likelihood				
Peregrine falcon	*Falco peregrinus*	OS	-	Trigger 3
Moderate Likelihood				
Night parrot	*Pezoporus occidentalis*	CR	EN	Trigger 1
Common greenshank	*Tringa nebularia*	MI	EN & MI	Trigger 1
Sharp-tailed sandpiper	*Calidris acuminata*	MI	VU & MI	Trigger 1
Australian painted snipe	*Rostratula australis*	EN	EN	Trigger 1
Caspian tern	*Hydroprogne caspia*	MI	MI	Trigger 2
Common sandpiper	*Actitis hypoleucos*	MI	MI	Trigger 2
Glossy ibis	*Plegadis falcinellus*	MI	MI	Trigger 2
Gull-billed tern	*Gelochelidon nilotica*	MI	MI	Trigger 2
Marsh sandpiper	*Tringa stagnatilis*	MI	MI	Trigger 2
Red-necked stint	*Calidris ruficollis*	MI	MI	Trigger 2
Wood sandpiper	*Tringa glareola*	MI	MI	Trigger 2

Note. VU=Vulnerable; MI=Migratory; OS=Otherwise Specially Protected; CR=Critically Endangered; EN=Endangered.

The 0.05% thresholds for migratory species under Trigger 2 are listed in **Table 9.3**.

Table 9.3: Migratory Species Annual Trigger Levels

Common Name	Scientific Name	Annual Trigger Level (0.05% of Population)	Population Data Source
Caspian tern	*Hydroprogne caspia*	125*	(BirdLife International, 2018b)
Common sandpiper	*Actitis hypoleucos*	95	Van Swinderen (2025)
Glossy ibis	*Plegadis falcinellus*	60*	(BirdLife International, 2025)
Gull-billed tern	*Gelochelidon nilotica*	12.5*	(BirdLife International, 2018a)
Marsh sandpiper	*Tringa stagnatilis*	65	Van Swinderen (2025)
Oriental plover	*Charadrius veredus*	115	Van Swinderen (2025)
Pacific swift	*Apus Pacificus*	50	(Department of the Environment, 2015)
Red-necked stint	*Calidris ruficollis*	300	Van Swinderen (2025)
Wood sandpiper	*Tringa glareola*	65	Van Swinderen (2025)

Note. Where a population estimate range is provided for a species, the lower estimate has been used to calculate the species' threshold. *National population estimates are not available, and global population has been used.

9.1 Response and Reporting Requirements

If an impact trigger level is met or exceeded under trigger levels 1, 2, or 3 (conservation significant species), a further investigation and reporting response is required as per the process depicted in

Figure 9.1 (also refer to **Section 10**). It is the responsibility of the person who discovered the carcass, injured individual, or featherspot to notify the responsible personnel immediately upon discovery, to ensure the response plan outlined in

Figure 9.1 can be promptly initiated.

If an impact trigger level under trigger level 4 (non-listed species) is met, a further investigation is required to determine if a revised risk assessment of the species should be initiated as per **Section 9.2.**

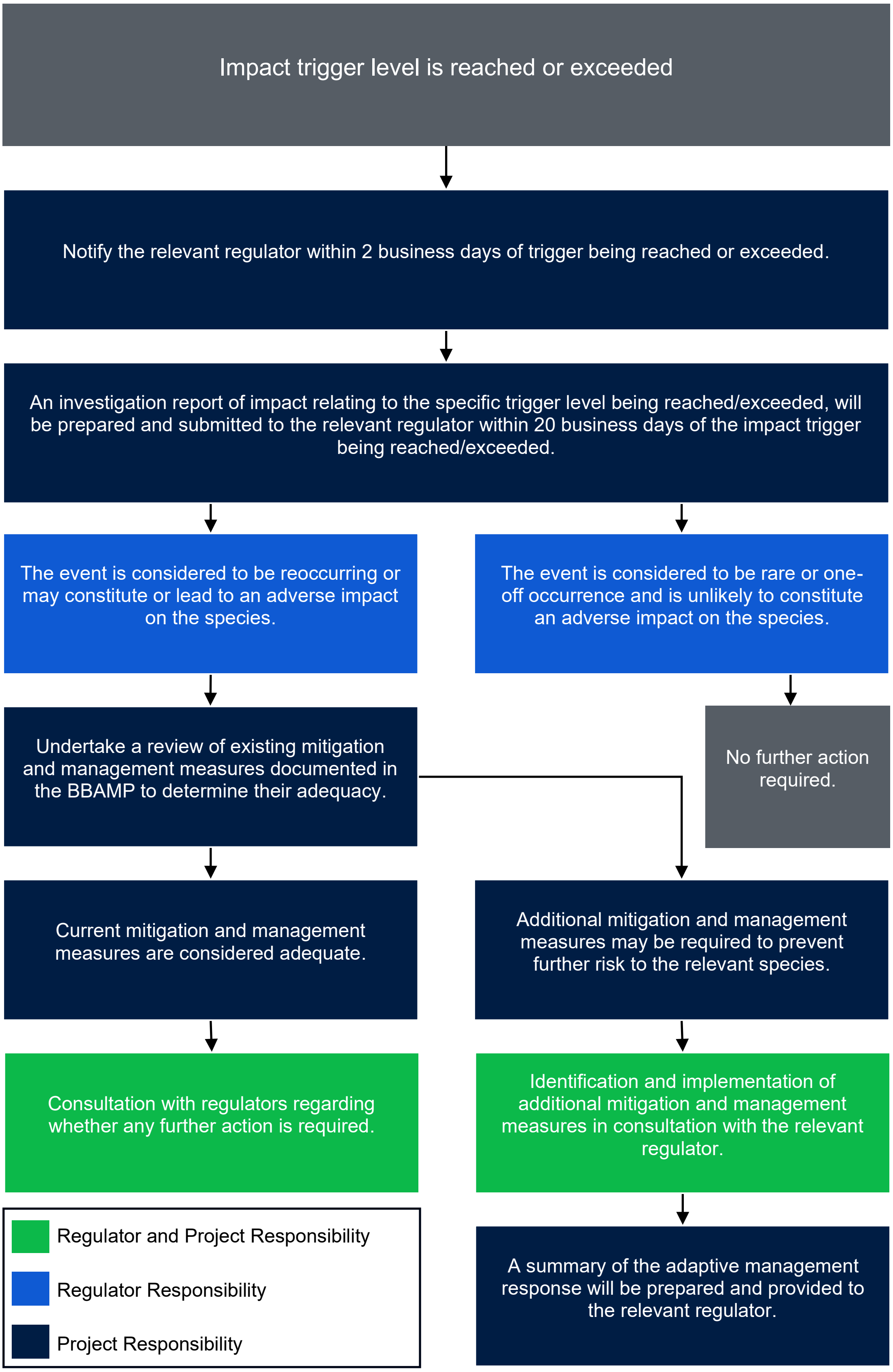

Figure 9.1: Decision Making Framework and Adaptive Management Approach

9.2 Revised Risk Rating Management

Data collected during the bird and bat monitoring program will be assessed against the collision risk assessment methods presented in **Section 6.1** to build upon the understanding of the turbine collision and/or barotrauma impacts. The collision risk assessment will be updated upon the two-year review and, if suitable, incorporated into the annual compliance report as specified in **Section 10**.

The risk assessment may also be revised on an ad-hoc basis in specific circumstances. If a new conservation significant bird or bat species is observed during the monitoring program resulting in a change in the likelihood of occurrence (e.g. from 'Moderate' or 'High' to 'Known'), a species' conservation listing is changed by the relevant department, or an investigation into a non-listed species trigger exceedance recommends risk rating management, the following process will be initiated:

- Commissioning of a revised collision risk assessment to determine the revised risk rating for the species.
- Undertake a review of the current mitigation and management measures identified in the BBAMP and determine their adequacy to prevent significant impacts to the species.
- Identify further mitigation and management measures to reduce the risk to the species based on turbine collision and barotrauma if required.
- For any listed species with a risk rating revised to 'Very High', where possible a CRM will be commissioned to determine the estimated number of collisions per year based on current Project operation.

Where the outcomes of the response involves changes to this BBAMP, those changes will be reported to the relevant regulator within three months in accordance with **Table 10.1**.

10 REPORTING REQUIREMENTS

The proposed reporting requirements of this BBAMP are detailed in **Table 10.1**.

Table 10.1: BBAMP Reporting Requirements

Report	Description	Timing
Annual Compliance Report	Following each year of the carcass search program, an Annual Compliance Report (ACR) will be submitted to the relevant regulators within 3 months of survey completion. The report will detail the species impacted including: • Total carcasses/featherspots detected of each species. • Locations of carcasses/featherspots detected. • Dates carcasses/featherspots were detected. • Details of any carcass/featherspots detections that triggered impact levels. The ACR will also include a turbine collision summary outlining: • Supporting evidence from case studies of listed species carcass size classes used in ancillary trials, where available. • Survey methods including carcass searches, ancillary trials, and survey effort. • Environmental/meteorological conditions. • Results of persistence trials and searcher efficiency trials. • Annual probability of detection and monthly strike monitoring. • Associated statistical analyses for estimations of mortality rates. • Annual mortality rates for all species (including non-listed species) which have recorded mortality in association with the Project. These calculations must consider and factor in the search area and associated effort, searcher efficiency, and carcass persistence rates. Additional information may also be included in the ACR such as: • Updates to species' risk assessments based on actual turbine strike impacts to date, including monitoring data and incidental species sightings. • Re-analysis of flight path and habitat predictions to identify potentially high-risk areas as required, compared against actual turbine strike impacts to date (including monitoring data and incidental species sightings). • Re-analysis of individual turbine strike risk based on monitoring data and incidental species sightings, including justification for any proposed changes to risk ratings based on ongoing monitoring and survey efforts. • Referencing improvements and updates to the monitoring program, including the methods applied. • The incorporation of adjustments to impact thresholds and the provision of details of associated adaptive management actions taken, including a review of the effectiveness of any implemented BBAMP mitigation measures. • Referencing ongoing process improvement and incorporation of new information and technology; for example, improved turbine strike mitigation measures and strike detection technology. • The outlining of unforeseen limitations or issues identified during Project's operation, and any other matters requested by the relevant regulators. A second report detailing the findings of the full 2-year carcass search program must be submitted to relevant regulators within 3	Annually for 2 years, with final report provided within 3 months of annual monitoring completion.

Report	Description	Timing
	months of completion of 24 months of surveys. In addition to the above information, the second report will include recommendations for the continuation of the monitoring program, length of continuation, and any changes to monitoring frequency or survey effort.	
Summary of Adaptive Management Response	A summary report outlining the monitoring and effectiveness of any adaptive management response is required to be submitted to relevant regulators where changes to the adaptive management approach outlined in this BBAMP have been made in consultation with those regulators.	Within 3 months of approved changes being made to this BBAMP.
Impact Trigger Reporting	Relevant regulators must be notified within **two business days** from when the impact trigger is met. The report outlining the investigation of the impact causing a specific trigger level to be reached/exceeded must then be submitted to relevant regulators within **20 business days**. The impact trigger report will include: • The impact trigger level that was reached. • The species and number of individuals involved in the impact trigger. • The date/s and location/s of recovered carcasses/featherspot. • Any identified ecological factors contributing to the impact trigger such as climate, presence of prey species/foraging opportunities, seasonal factors (i.e. migration). • Whether the event is likely to be rare or regular or may constitute an adverse impact on the species at the local, regional or total population scale. In cases where further monitoring or implementation of mitigation measures is deemed necessary through consultation with relevant regulators, the findings and effectiveness of such will be reported.	If an impact trigger occurs in accordance with **Section 9**, relevant regulators will be notified within 5 business days. An investigation report will be provided within 20 business days of the impact trigger being reached/exceeded.

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DOCUMENT CONTROL

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Checked or Squad Review# (if applicable)	Vlad Rios Vera	vlad.riosvera Digitally signed by vlad.riosvera DN: cn=vlad.riosvera, email=vlad.riosvera@fortescue.com Date: 2026.02.18 14:42:13 +08'00' Signature
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Next Review Date (if applicable)	Enter a date	

APPENDIX A COLLISION RISK MODEL REPORT

Bird and Bat Management Plan science for wind energy developments

Project 2.2.3 Collision Risk Modelling Outcomes
Final Report

Harry Butler Institute
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Murdoch University is on Noongar Boodjar and the bird observations have been carried out on Palyku Country. Thanks to Ecologia Environment and Spectrum Ecology and & Spatial for sharing unpublished data. The authors of this report would like to thank the other members of the overarching project for valuable insights and discussion.

Project 2.2.3 Collision Risk Modelling Outcomes

1 Executive summary

The Bonney Downs Generation Hub (BDGH) is proposed to be located at Bonney Downs Station in the Pilbara region of Western Australia. The proposed wind farm consists of up to 100 Wind Turbine Generators. A major concern is the potential impact on bird life due to the presence of large wind turbines; not only from the proposed BDGH but also the combined impact from the nearby Nullagine Pilot Wind Farm currently under development (17 turbines). An analysis of the combined risk to bird life via collision from both the proposed BDGH and the Nullagine Pilot Windfarm (total of 117 turbines) was performed.

A study of existing collision risk models (CRM) was undertaken. Data from the Bird and Bat Site Utilisation Surveys (BBSUS) conducted as part of this project (*ecologia* Environment 2025) and the Australian Database of Birds (BirdLife Australia 2025) were used in this project. Statistical modelling was used to cover missing data in flight height distribution (visual observations). Where possible, data from the two Robin Radar MAX units on site was analysed and prepared for use in the simulation models.

A publicly available CRM, the Band model (Band *et al.* 2007, Band 2012, Band 2024) was implemented. Additionally, a new 3D flight analysis model was developed especially for this project, mitigating identified shortcomings recognised for the Band model. The New Model uses a 3-dimensional approach to predict bird location and WTG interaction.

Simulations were run for 13 bird species that were observed at BDGH flying at heights that would be within the rotor sweep area (RSA) of the proposed WTGs. Using a conservative estimate of birds avoiding the WTG, results from the two models (Band Option 2 with 99.5% avoidance, New Model with 90% avoidance) were consistent and indicate relatively high (11.67%, 4.47%) collision risk for the Wedge-tailed eagle (with resident animals commonly recorded at the site), Australian pelican (2.77%, 5.25%), Straw-necked ibis (7%, 2.75%), Litte black cormorant (2.04%, 1.35%) and Masked woodswallow (2.19%, 1.55%). All other species were classified as having <2% collision risk. The Grey falcon (listed as Vulnerable **VU** under the IUCN, EPBC Act, and BC Act) was estimated to have a relatively low risk of collision under both models (1.86%, 1.6%).

It should be noted that the collision risk estimates presented below represent inherent (unmitigated) collision risk and do not account for the potential reduction achievable through management and design measures that may be adopted during project development or operations (e.g., curtailment, deterrent/monitoring systems, or blade marking/painting).

2 Key outcomes

- Both the Band and the New Model identified the same bird species at risk and at similar levels, providing verification of the methodology.

- The Band model has been calibrated over many years to improve consistency of results with field studies (fatality records). This calibration was obtained by comparing carcass numbers after the installation of the wind farm with predictions of the model (Urquhart, & Whitfield, 2016; Smales 2023), not with direct measurement or observation of birds avoiding the WTG (Hull & Muir 2013). The Band model therefore routinely uses high avoidance rates (99.5%). A 'worst-case' scenario was calculated using the Band model option 2 with 98% avoidance. By contrast, because it uses a three-dimensional approach, the New Model calculations predicted similar outcomes using lower numerical values for avoidance.

- The species with highest collision risk was identified as the Wedge-tailed eagle (11.67% for the Band Option 2 model with 99.5% avoidance rate, and 4.47% for the New Model with 90% avoidance rate). This raptor was commonly recorded at the site. This species also had the most BBSUS and radar records, and so the modelling estimates for flight height were most reliable.

- Straw-necked ibis (7.0%, 2.75%), Australian pelican (2.77%, 5.25%), Little black cormorant (2.04%, 1.35%) and Masked woodswallow (2.19%, 1.55%) were estimated as next in terms of collision likelihood.

- All other species were computed to have relatively low collision risk, with estimates <2% for both models.

- The Grey falcon (listed as a Vulnerable species) was identified as having predictions of 1.86% (Band Option 2) or 1.61% (New Model) of the population at risk of collision per year from the two models.

- Worst-case results with Band option 2 with 98% avoidance identified the same species as having higher rates of collision. The Straw-necked ibis and Wedge-tailed eagle stand out as having higher predicted collision risk than other species, with all other species at below 10%, even in this worst-case scenario.

Table 1. *Comparison of the predicted collision risk for 13 Pilbara bird species for the Band Model (Option 2 with 99.5% avoidance) and the New Model (assuming 90% avoidance). Cells are coloured from greatest (red) to least (green) collision risk. Bold values are >2%. Three further species were noted but insufficient data was available for CRM.*

Species		Nº· of BBSUS records ‡	**Band model 2** 99.5% Avoidance	**Band Model 2** 98% Avoidance 'Worst-case'	**New Model** 90% Avoidance
Australasian darter	*Anhinga novaehollandiae*	48	1.98	**5.46**	1.12
Australian kestrel	*Falco cenchroides*	250	0.44	1.18	0.57
Australian pelican	*Pelecanus conspicillatus*	4	**2.77**	**7.6**	**5.25**
Brown falcon	*Falco berigora*	91	1.44	**3.89**	1.52
Grey falcon **(VU)**	Falco hypoleucos	9	1.86	**5.05**	1.61
Little black cormorant	*Phalacrocorax sulcirostris*	113	**2.04**	**6.6**	1.35
Masked woodswallow	*Artamus personatus*	17	**2.19**	**6.03**	1.55
Spotted harrier	*Circus assimilis*	64	0.73	1.96	1.25
Straw-necked Ibis	*Threskiornis spinicollis*	33	**7**	**19**	**2.75**
Torresian crow	*Corvos orru*	86	0.01	0	0.03
Wedge tailed eagle	*Aquila audax*	133	**11.67**	**31.66**	**4.47**
Whistling kite	*Haliastur sphenurus*	90	1.75	**4.75**	1.98
White-necked heron	*Ardea pacifica*	27	0.55	1.49	1.2
Black-necked stork **(NT)**	*Ephippiorhynchus asiaticus*	2	Insufficient data		Insufficient data
Oriental plover **(MI)**	*Charadrius veredus*	1	Insufficient data		Insufficient data
Pacific swift **(MI)**	*Apus pacificus*	12	Insufficient data		Insufficient data

Conservation listings *† Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) Act:* ***VU*** *Vulnerable,* ***MI*** *Migratory species protected under international agreement,* ***EN*** *Endangered. IUCN:* ***NT*** *Near Threatened. Others are not listed as conservation-significant.*

‡ total across 480 hours of BBSUS observations.

Note that the collision risk estimates presented in this report represent ***'inherent (unmitigated) collision risk'*** *and do not account for the potential reduction achievable through management and design measures that may be adopted during project development or operations (e.g., curtailment, deterrent/monitoring systems, or blade marking/painting).*

3 Introduction

Fortescue Ltd (Fortescue) has set the ambitious industry-leading target to be carbon neutral by 2030. To reach this commitment to decarbonise its Pilbara mining operations, Fortescue are pursuing wind and solar energy developments to eliminate fossil fuel use from iron-ore operations. Fortescue is investigating options for wind and solar energy developments lying within the Chichester IBRA subregion of the Pilbara IBRA region.

This project represents a collaboration between the Harry Butler Institute at Murdoch University (HBI) and Fortescue for Collision Risk Modelling (CRM) for species identified at potential risk of wind turbine collision at Bonney Downs Station (Bonney Downs Generation Hub and Nullagine Pilot Wind Farm), as per the Onshore Wind Farm Guidance (DAWE 2021, DCCEEW 2023b, 2024). This work recognises the need to identify effective mechanisms for mitigation of potential unintended impacts that will undermine both climate and biodiversity goals, and to apply these from the earliest planning stages, in alignment with Fortescue's Biodiversity Strategy (2023).

In what follows, we discuss the choice of birds for simulation, the data preparation, the Band model and the development of the New Model. Simulations were performed on 13 species, and the probability of a collision was computed for each.

3.1 Scope of work

This project has addressed six key aims (**Table 2**). The aims were identified in the original scope of work and the right-side column is the outcome for that aim.

Table 2. *Collision Risk Modelling Assessment Outcomes as proposed in the Scope of Works.*

Aim	Achievement
1. **Identify which species are most likely to be impacted by wind turbine strike** (based on presence, population size, location of their preferred habitat and therefore, predicted presence, flight height and characteristics).	Achieved. The results are as shown in **Tables 1 and 7**.
2. Where possible, **calculate collision risk windows** (i.e., the likelihood of collision) **for species or species groups of interest** dependent on flight height and/or 'style'. Collision risk windows are an important input parameter for CRM.	Achieved. Using the two models we obtained consistent results for those birds that were at risk of colliding with the WTG and the probability that such an event might occur given the flight speed and height. See **Sections 5 and 6.**
3. **Estimate worst case collision risk**, based on Band CRM (Band *et al.* 2007) "Worst-case" assumes a lower value for avoidance (birds diverting away from the WTG), but within the expected avoidance behaviour.	Achieved. This was completed using the Band model with 98% avoidance. Given the data available, all assumptions were made as general as possible, leading to worst-case scenarios. See **Sections 5 and 6.**
4. **Evaluate published CRMs** to determine which are useable prior to the wind farm construction phase. For example, a more sophisticated model may be possible if suitable data collected from an existing windfarm can be used to inform the model [e.g., Biosis modelling has been used in Wedge-tailed eagle and White-bellied sea-eagle (Smales *et al.* 2013) and Bayesian modelling in other raptor species (Adachi *et al.* 2015)], or where aerodynamic parameters can be derived through flight modelling.	Achieved. This was completed and is reported in **Section 4.1**
5. **Incorporation of site-specific environmental factors** (e.g., wind direction, velocity, temperature) within CRM for significant species with justification of the choice of the model used including a statement of all assumptions and uncertainties.	Achieved. Site specific data for bird behaviour was used, including measured wind speed and temperature. Wind speed is important in the turbine management and operational strategy.
6. **Inform CRM with actual flight behaviour of the species** (derived from radar traces, on-ground observations and other relevant data collected as part of stage 2.1), as well as relative abundance and significance of species (conservation listed, culturally significant or otherwise).	Achieved. BBSUS data were used to fit flight height distributions to most species. The Grey falcon is listed as Vulnerable. Simulation results for this case showed low-medium threat.

4 Methods

The Band model (Band *et al.* 2007) has long served as a standard framework for collision risk estimation (Cook *et al.* 2025), either directly or through derivative models. The Band model uses a vertical plane to estimate passage of a particular species along a single two-dimensional line across the wind farm. This neglects the three-dimensionality of the wind farm and therefore overestimates the likelihood of a bird passing through the RSA. Although there is a "large array" correction in the model it does not sufficiently compensate for the third dimension. However, the Band model has been benchmarked against post-construction collision datasets and is retained here as the benchmark method alongside the site-specific New Model.

To consider the particular situation at Bonney Downs Station and to implement a fully three-dimensional study to compare with the Band model, a New Model was developed that includes a fully three-dimensional simulation and provides estimates based on bird behaviour and spatial separation of the WTG. The New Model allows more site-specific information to be incorporated as more data is obtained.

In what follows there is a summary of the history of collision risk models, information on how the bird species were chosen for simulation, and how the data were prepared. We modelled collision likelihood using the Band model and also developed a novel CRM. Due diligence dictates that both models be used to consider the Bonney Downs Generation Hub and Nullagine Pilot Wind Farm, so summaries of both the Band model and the new model are given. Simulations were performed using both models and the results were compared to provide a final assessment.

4.1 Collision Risk Models

Cook *et al.* (2025) published a review of 52 CRM models that have been published over the last 40 years. These models include a total of 75 input parameters (**Table 3**), with increasing complexity over time, moving from collision with individual turbines, to impacts of whole wind farms. The total number of parameters used ranges from 4 to 22 (median 15) (Cook *et al.* 2025). Whilst the original CRM used only 5 input parameters (Manning 1983), an increasing number of parameters is typical of more recent CRM, with the widely used Band *et al.* (2007) model – the model that we have applied on first principle – requiring 20 parameters.

Next to specifications of the wind turbines (rotor diameter capturing the rotor swept area, maximum width of blade, rotation period, number of turbines, hub height, pitch, number of blades), aspects of bird behaviour around wind turbines (avoidance rate, body length, flight speed, wingspan, % time at Critical Risk Height) are central to CRMs (**Table 3**).

Table 3. *Parameters included in 52 Collision Risk Models (CRM) (calculated from data presented in Cook et al. 2025). Colours reflect parameters included in few to many (blue to red) models.*

		CRMs including this parameter	
Category of parameter	**Parameter**	**Count**	**%**
Bird behaviour and morphology	Avoidance Rate	36	69%
	Body length	34	65%
	Flight speed	32	62%
	Wingspan	30	58%
	% time at Critical Risk Height	28	54%
	Flap or glide	18	35%
	Continuous flight height distribution	10	19%
	Collision rate	8	15%
	Flight Direction	7	13%
	Number of Turbines encountered	6	12%
	Flight behaviour (e.g. Foraging, commuting etc)	5	10%
	Flight angle to headwind	3	6%
	Probability of safe passage	2	4%
	Point of Entry	1	2%
Parameters used to estimate bird flux	Bird Flight Activity	20	38%
	Population Size	16	31%
	Time Flying per Day	11	21%
	Nocturnal Activity	10	19%
	Bird Density	8	15%
	Distance to Nest	5	10%
	length of breeding season	5	10%
	% Time in Wind Farm	5	10%
	% time in different habitats	3	6%
	Distance to Conspecific Nest	2	4%
	Body Mass	2	4%
	Foraging range	2	4%
	Departure direction	1	2%
	Distance to coast	1	2%
	Distance to Fishing Harbour	1	2%
	Movement Probability	1	2%

Category of parameter	Parameter	CRMs including this parameter Count	%
	Basal Metabolic Rate	1	2%
	Foraging Efficiency	1	2%
	Energy Density of Prey	1	2%
Weather and landscape parameters	Wind Speed	12	23%
	Wind Direction	5	10%
	Terrain Altitude	5	10%
	Air Density	3	6%
	Land use and habitat	3	6%
	Terrain Slope	3	6%
	Water Depth	2	4%
	Human population density	2	4%
	Distance to Slope	2	4%
	Precipitation	1	2%
	Visibility	1	2%
	Temperature	1	2%
	Heat flux	1	2%
	Surface pressure	1	2%
	Humidity	1	2%
	Solar Radiation	1	2%
	Boundary Layer Height	1	2%
	Fishing vessel presence	1	2%
	Terrain Aspect	1	2%
Wind farm parameters	Number of Turbines	31	60%
	Operational time	23	44%
	Wind Farm Area	18	35%
	Turbine Locations	10	19%
	Distance between turbines	3	6%
	Number of Turbine Rows	2	4%
	Distance to Wind farm	1	2%
	Distance between Turbine rows	1	2%
Wind turbine parameters	Rotor diameter	39	75%
	Maximum width of blade	32	62%
	Rotation period	32	62%
	Hub height	29	56%
	Pitch	28	54%
	Number of Blades	27	52%
	Maximum rotor tip height	23	44%
	Minimum rotor tip height	20	38%
	K (1D or 3D)	18	35%
	Turbine surface area	8	15%
	Blade thickness	3	6%
	Cut in speeds	2	4%
	Nacelle Width	2	4%
	Power coefficient	1	2%
	Monopole diameter	1	2%

Of the 52 models reviewed by Cook *et al.* (2025), it was observed that only 23 out of 52 contained sufficient information to recreate the model; in some cases, this was because the model is regarded as proprietary software and commercially sensitive (e.g., Smales *et al.* 2013). This observation highlights the importance of CRM models that can be run in an efficient and transparent manner, with the process and results accessible to all stakeholders including regulators, developers and their consultants.

All these different models have a common methodology, and the differences are in the level of detail and sophistication. Each model includes evaluation of three components:

(1) what is the likelihood of a bird being in the danger region close to the turbine,

(2) what is the likelihood they will fly through the rotor sweep, and

(3) what are the chances of being hit if they do?

The earliest models (e.g., Band *et al.* 2007) used very simple probabilistic arguments, for example dividing the volume of the region very close to the turbine by the volume of the birds' expected daily travel and using that as a probability of being co-located with the turbine. This requires very little in the way of data, but only knowledge of the bird's daily habits. However, even this is sometimes difficult to obtain and may vary greatly between bird species.

Later models began to incorporate data on expected flight height for each species, and GPS data were used to map behaviour to present a clearer picture of activity. For example, Hull and Muir (2013) used extensive data on the movement of Tasmanian Wedge-tailed eagles (*Aquila audax*) and White-bellied sea eagles (*Haliaeetus leucogaster*) to determine their flight heights and locations, and were able to quantify turbine avoidance. The decision on whether a bird would be struck began with calculations of given bird size and speed compared to rotor speed and thereby computed likelihood of direct collision (Band 2007). This aspect has also been improved to include the direction of flight and wind speed calculations and how they modify the likelihood of collision (Holmstrom *et al.* 2011, Christie & Urquhart 2015).

If there is sufficient data about a particular species, the likelihood of being in the vicinity of the rotors can be estimated with more confidence. For example, Murgatroyd *et al.* (2021) analysed GPS data for the behaviour of Verreaux's eagle (*Aquila verreauxii*) and found their most favoured habitat was in countryside with slopes to assist in soaring. They were able to make more confident predictions of the best locations for the turbines to avoid encroaching on areas preferred by the eagles. Therefore, they were able to recommend safer places for the turbines and buffer zones to minimise bird-turbine interactions.

A more sophisticated model is possible if suitable data collected from an existing windfarm can be used to inform the model [e.g., Biosis modelling has been used in Wedge-tailed eagle and White-bellied sea-eagles (Smales *et al.* 2013) and Bayesian modelling in other raptor species (Adachi *et al.* 2015)], or where aerodynamic parameters can be derived through flight modelling.

However, these enhancements and improvements require a very large data collection exercise that is not always feasible. Throughout this historical evolution, because of its fundamental importance in the field and its simpler data requirements, the Band model has consistently remained central to many analyses. It has continually improved and kept up with the latest developments. In 2012, a stochastic component was introduced to each phase of the Band Model algorithm, so that both inputs and outputs include statistical variation. For example, mean flight height as a determinant of interaction with the rotor sweep was replaced by a distribution with mean and variance determined from field data. Several options for the shape of this distribution were employed in the Band model.

Due to its widespread use, the decision was made that the collision risk modelling should include the use of the Band (2012) model. However, after implementation we found that there were some limitations in the model in terms of predicting proximity of birds to turbines. As a result, a new model was developed to address this issue. The implementation of the Band model and the New Model are described below.

4.2 Choice of Species for modelling

Of 128 bird species recorded at Bonney Downs, 17 have been recorded flying at heights that would place them within the RSA; this total includes 8 raptor species (**Table 4**). This relatively low number is partly due to the very high RSA of the proposed turbines (>100m), with many species never recorded flying at or above that height. Another 3 raptor species were reported at the site (although none of the observations put them at RSA height) (**Table 4**). Modelling was carried out for 13 bird species using data from the eight Bonney Downs BBSUS conducted as part of this project (*ecologia* Environment 2025) and data from the two Robin Radar MAX placements. The choices made were dictated by the available data. CRM analysis was not carried out for some species where:

(1) There were insufficient flight height data records for robust analysis; for example, records of the Black falcon (n=1 sighting) and Black kite (n=5 sightings) were insufficient to generate accurate estimates of flight height. The low numbers of records during BBSUS (*ecologia* Environment 2025) suggests their presence at Bonney Downs Station is very low. In the case of Australian magpie and Yellow-throated miner, there was insufficient records of flight heights within the RSA for modelling.

(2) All of the data showed a species to be below the proposed RSA, including two migratory species: Oriental plover and Pacific swift. We note that 7 of these species recorded at Bonney Downs Station (Black-necked stork, Pacific swift, Australian hobby, Little eagle, Little woodswallow, Square-tailed kite, White-bellied sea-eagle) have been identified as having 'high' overall risk of wind turbines (assessment includes collision risk, habitat displacement, and population effects) according to the Reid analysis (Reid & Baker 2025, Reid *et al.* 2025), see **Table 4**. However, this assessment estimated threat of collision for an RSA between 30 to 275 m, and their assessment was largely based on expert elicitation. We have no records of these species flying at heights that would place them at risk of the proposed wind turbines (100–280 m RSA).

Thus, the final set of 13 bird species modelled was chosen based on the available BBSUS data.

Table 4. *Data for 33 bird species observed at Bonney Downs Station and some of their characteristics, and information on modelling status.*

Species			Body mass average (g)†	Mortalities recorded across Australian wind farms [1]	Number of sightings	Proportion of flight records within RSA	Sufficient data to model collision risk †	Reid overall risk CATEGORY‡
Bird species recorded at RSA height								
1	Australasian darter	*Anhinga novaehollandiae*	1630		38	0.0526	Y	high
2	Australian kestrel	*Falco cenchroides*	180	54	439	0.0182	Y	high
3	Australian pelican	*Pelecanus conspicillatus*	5426		10	0.2	Y	high
4	Brown falcon	*Falco berigora*	587	48	177	0.079	Y	high
5	Grey falcon **(VU[1])**	*Falco hypoleucos*	471		33	0.303	Y	high
6	Little black	*Phalacrocorax sulcirostris*	967		72	0.347	Y	high
7	Masked	*Artamus personatus*	35	1*	17	0.411	Y	high
8	Spotted harrier	*Circus assimilis*	570	1	103	0.0582	Y	high
9	Straw-necked ibis	*Threskiornis spinicollis*	1353	1*	43	0.325	Y	high
10	Torresian crow	*Corvos orru*	555	41*	77	0.169	Y	medium
11	Wedge-tailed eagle	*Aquila audax*	3558	58	210	0.304	Y	high
12	Whistling kite	*Haliastur sphenurus*	745	5	151	0.0993	Y	high
13	White-necked heron	*Ardea pacifica*	893		25	0.12	Y	high
	Species with too few records for flight height (required for CRM analysis)							
14	Black falcon	*Falco subniger*	744	1	1	1	N_L	high
15	Black kite	*Milvus migrans*	825		5	0.2	N_L	high
16	Australian magpie	*Gymnorhina tibicen*	275	115	37	0.03†	N_L	medium

Species			Body mass average (g)†	Mortalities recorded across Australian wind farms [1]	Number of sightings	Proportion of flight records within RSA	Sufficient data to model collision risk †	Reid overall risk CATEGORY‡
17	Yellow-throated	*Manorina flavigula*	57		453	<0.01	N-L	medium
Other species that have been identified at risk of turbine collision risk (either published mortalities or expert elicitation: Reid & Baker 2025, Reid et al. 2025), but were not recorded at RSA flight heights at Bonney Downs								
18	Australian bustard	*Ardeotis australis*	5238		23	0	N(RSA)	medium
19	Australian hobby	*Falco longipennis*	247	1	22	0	N(RSA)	high
20	Black-necked stork [2]	*Ephippiorhynchus*	4197		2	0	N(RSA)	high
21	Black-faced	*Coracina novaehollandiae*	115		38	0	N(RSA)	medium
22	Black-shouldered kite	*Elanus axillaris*	272		10	0	N(RSA)	medium
23	Budgerigar	*Melopsittacus undulatus*	28		1937	0	N(RSA)	medium
24	Horsfield's bush lark	*Mirafra javanica*	23		99	0	N(RSA)	medium
25	Little eagle	*Hieraaetus morphnoides*	812	1	1	0	N(RSA)	high
26	Little woodswallow	*Artamus minor*	17		4	0	N(RSA)	high
27	Magpie-lark	*Grallina cyanoleuca*	79	13	111	0	N(RSA)	low
28	Oriental plover **(MI)**	*Charadrius veredus*	95		1	0	N(RSA)	medium
29	Pacific swift **(MI)**	*Apus pacificus*	42		12	0	N(RSA)	high
30	Painted finch	*Emblema pictum*	11		466	0	N(RSA)	low
31	Rainbow bee-eater	*Merops ornatus*	29		106	0	N(RSA)	medium
32	Square-tailed kite	*Lophoictinia isura*	647		1	0	N(RSA)	high
33	White-bellied sea-	*Haliaeetus leucogaster*	2900		1	0	N(RSA)	high

***† Data for collision risk modelling** Y: yes sufficient data to model collision; N(RSA) no records of flights within the RSA; N: insufficient flight height data, no CRM carried out; N-L: insufficient numbers of flight height data within the RSA to carry out CRM.*

‡ Reid used an RSA of 30 to 275 m for their evaluations.

***Conservation listings** Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) Act (**VU** Vulnerable, **MI** Migratory species protected under international agreement).* [1] This species is specially protected under international, Federal and State legislation – the species is listed as Vulnerable under the IUCN Red List, 'Vulnerable' under the Commonwealth EPBC Act, and Criterion 4 ('Vulnerable') under the Western Australian Biodiversity Conservation Act 2016. [2] Globally listed as Near Threatened (NT) by the IUCN Red List.

It is possible to use the simulation model to consider bat collision, but at the time of writing there was insufficient data to perform this. An analysis of the threat to bats based on habitat and behaviour is considered in *Project 2.1.3 Literature review and bat traits analysis* (Fleming & Dempster 2026), providing an indication of which species may be under threat of collision.

4.3 Data Sources and Preparation

The input data required for the models includes bird physical characteristics (body length, wingspan, etc.), bird behaviour (flight height distribution, flight speed, active time, etc., see **Table 5**) as well as the turbine characteristics (hub height, blade length, rotor size, pitch and speed) and operational details of the wind farm (number of turbines, size of the farm and operational strategy – see **Tables A9** and **A10**). The most difficult to obtain are bird flight characteristics, particularly flight height distribution, i.e. time spent at rotor swept height and time in the air.

Table 5. *Input data for the models.*

	Body Length (m)		Wingspan (m)		Flight Speed (m/s)		Proportion in RSA	
Species	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australasian darter	0.900	0.020	1.220	0.003	15.252	3.870	0.062	0
Australian kestrel	0.320	0.020	0.720	0.030	9.358	2.530	0.047	0.026
Australian pelican	1.700	0.0625	2.450	0.075	15.221	2.106	0.183	0
Brown falcon	0.445	0.008	1.015	0.068	11.770	3.396	0.090	0.043
Grey falcon **(VU)**	0.365	0.033	0.915	0.033	11.787	3.360	0.132	0.034
Little black cormorant	0.600	0.0275	1.000	0.025	13.894	4.179	0.1171	0
Masked woodswallow	0.190	0.00625	0.330	0.005	9.290	4.039	0.151	0
Spotted harrier	0.555	0.028	1.340	0.065	8.337	2.459	0.050	0.041
Straw-necked ibis	0.650	0.050	1.100	0.050	14.631	3.912	0.183	0
Torresian crow	0.490	0.0175	1.000	0.1675	11.348	3.708	0.002	0
Wedge-tailed eagle	0.955	0.053	2.013	0.086	15.409	4.922	0.266	0.092
Whistling kite	0.550	0.020	1.330	0.065	10.799	3.203	0.137	0.050
White-necked heron	0.910	0.075	1.550	0.06	10.196	3.110	0.072	0

Bird dimensions are taken from the Australian Database of birds, and the flight speed from modelling (Klein Heerenbrink 2023). The proportion of time at risk height is computed from the BBSUS observations.
Conservation status *(DBCA 2025):* ***VU*** *Vulnerable (IUCN, EPBC Act, WA BC Act).*

Having detailed flight height data allows us to fit statistical distributions to identify the best fit for flight height. The preparation of the flight height data can be summarised in two examples. The Grey falcon had far fewer recorded sightings than the Wedge-tailed eagle. Using the estimated heights of the records for the Grey falcon (**Figure 1**), simulations provide log-normal flight height distribution (green line in **Figure 1**). For the Wedge-tailed eagle, the log-normal distribution also provided an excellent fit (**Figure 2a**) and was more reliable because of the availability of more data. Knowledge of the underlying distribution is valuable because it enables estimation of the likelihood of birds being at risk of collision using only the distribution parameters (mean and standard deviation).

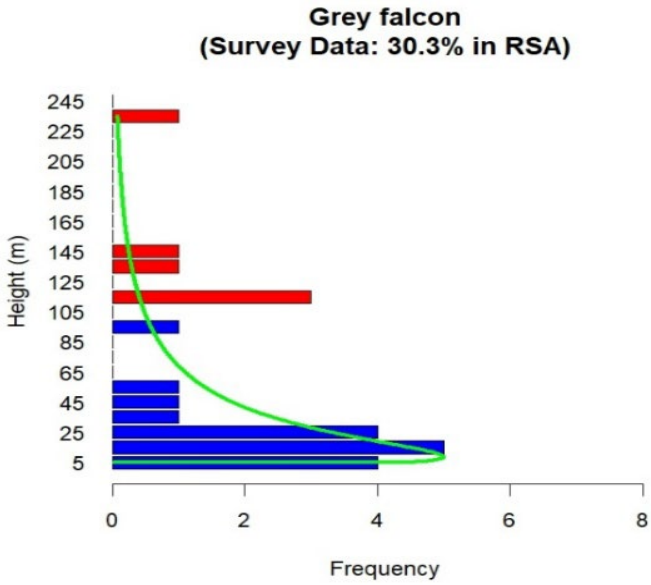

Figure 1. Histogram of flight height data for the Grey falcon taken from BBSUS data, along with the corresponding fitted log-normal distribution used for the simulation model flight heights.
Blue bars represent flight heights below, and red bars flight heights that would fall within the rotor swept area (RSA) (i.e., 'at risk' of turbine collision).

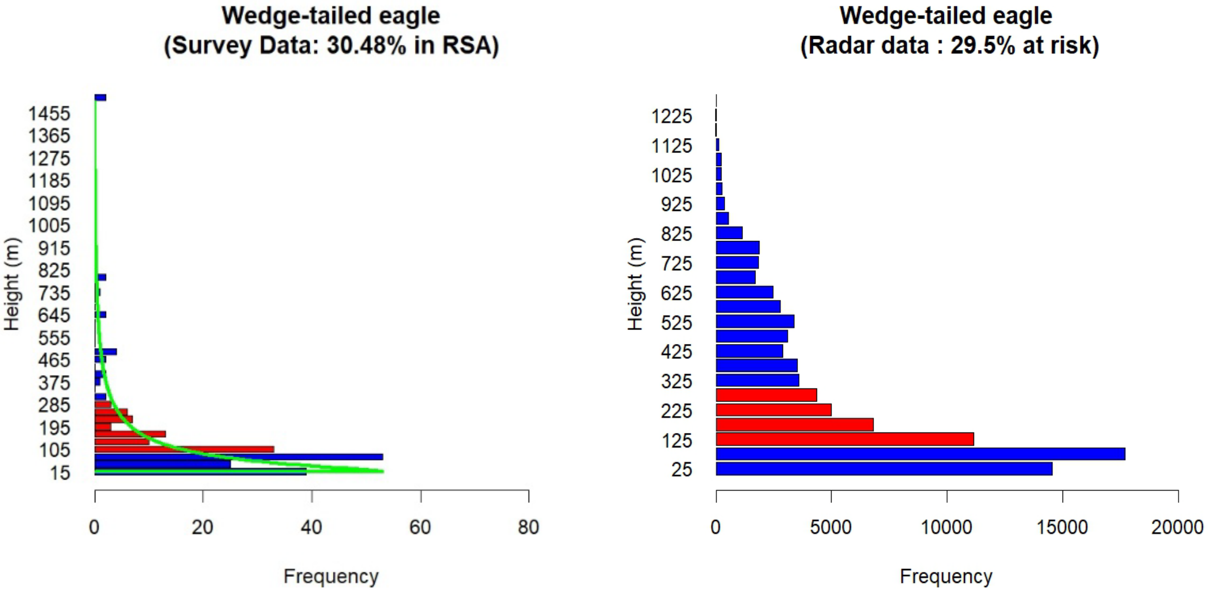

Figure 2. Histograms of data from BBSUS (left) and radar data (right) for the Wedge-tailed eagle.
These data were used to fit distributions that reflect flight heights. Blue bars represent flight heights below or above, and red bars flight heights that would fall within the rotor swept area (RSA). Indication is for time at RSA (i.e., 'at risk' of turbine collision).

A similar process to obtain time in the rotor swept area (RSA) of the proposed wind turbines (100–280 m) was used for all other species for which there was sufficient data (see **Table 5**). For each species, histograms of the flight heights from all recorded sightings across eight Bonney Downs BBSUS (*ecologia* Environment 2025) were plotted to estimate the likelihood of birds flying within the proposed turbine RSA. Statistical summaries of the parameters of flight height distributions were then used to generate a distribution of flight heights using multiple simulations.

As a comparison and test of the approach, radar data collected over one week, including various bird classes was analysed. We focused on daytime records for the 'medium bird' radar category, which includes species such as the Wedge-tailed eagle (visual observations match this radar category with Wedge-tailed eagles for the majority, >95%, of instances). For birds in this category, it was possible to extract key flight parameters, namely, elevation and airspeed, to characterise their flight height distribution. These data were collated and fitted with a log-normal distribution (**Figure 2b**) for comparison with direct visual observations from the Bonney Downs BBSUS data. The radar data indicates that approximately 29.5% of the flying time for the birds in this category (most likely Wedge-tailed eagles) lies within RSA, a result that is close to the survey-based estimate (which was 30.48%) but is more accurate due to the higher temporal resolution of the radar observations. This serves as a verification of the fitting of flight heights to the available BBSUS data. Radar data for other species are not available as this requires substantial field validation through direct observation.

4.4 The Band Model

The Band model was originally developed to calculate the collision rate for greylag geese (*Anser anser*) and hen harriers (*Circus cyaneus*) at an individual wind farm near Dounreay, Scotland. The 2012 model (Band 2012) was an update of the model to facilitate application in the offshore environment, given that direct observations of birds from key vantage points – in respect to gathering information on flight activity – are not usually possible in the marine environment. As it is noted that the flight height distribution for many species is not uniformly distributed (e.g., Schaub *et al.* 2023, Schaub *et al.* 2024b), the model was extended to make use of data on the distribution of bird flight heights (Band 2012). The model includes stochastic variation in all parameters, and a multi-simulation approach is used. The code is written in the statistical package 'R' and comes with a set of default parameters that can be used in the absence of data for a particular site.

Monthly wind speed averages are used in the Band model to estimate WTG rotor speeds, and these have a distribution, making the simulation more like the reality of wind variability throughout time. Inputs are mean and variance for each factor. Multiple simulations (often thousands) representing data over a year are conducted using different distributed input parameters. Thus, the output is not a single number for each bird species, but a distribution of probability of collision. In this report, only the mean percentage chance of collision in the Bonney Downs Station per year is reported.

For any collision risk model, there are three essential components: (1) the likelihood of a bird being near a wind turbine, (2) the chance the bird will fly within the RSA, and (3) the likelihood of a direct collision if the bird does fly through the RSA. The second and third components involve calculations that involve the bird's behaviour, flight height distribution and speed and how these are related to the speed and size of the rotors and pitch of the blades. It is the first two components that require the most intense data collection. The Band model uses an extended two-dimensional plane for the first component, resulting in a higher number of interactions with the WTG than a fully three-dimensional simulation.

To be generally applicable, the Band model makes assumptions of uniformity across the wind farm. For example, the turbines are assumed to be evenly distributed across the area of the farm, birds of all species are assumed to be evenly spread, and most meteorological inputs are taken as monthly averages. Bird flights are assumed to fly across the line of the turbines and include upwind and downwind calculations.

The likelihood of being in the vicinity of the rotors is estimated using a line-of-sight survey to determine birds flying across this line during the survey. Once this is determined, the calculation of likelihood of actual collision is computed using flight speed and direction, rotor speed, time the rotor is in operation (given various power generation strategies and wind speed), and time for passage through the RSA.

Avoidance is a crucial factor in determining the final turbine collision rate but is an unknown quantity for most birds. The Band model has been "calibrated" over many years to improve consistency of results with field studies (fatality records). This calibration was obtained by comparing carcass numbers after the installation of the wind farm with predictions of the model (Urquhart & Whitfield 2016, Smales 2023), not with direct measurement or observation of birds avoiding the WTG (Hull & Muir 2013). The Band model is therefore routinely applied using high avoidance rates (99.5%). A 'worst-case' scenario for the Band model option 2 was carried out with 98% avoidance. Section 4.6 discusses this choice of avoidance rate in more detail.

There are three options for flight height distribution in the Band model (Band 2012, Masden *et al.* 2021):

- **Option 1:** This option uses a distribution about the mean flight height for each bird species to compute time at the danger level between the top and bottom of the RSA. The risk of collision is termed the Basic model, and no differentiation is made between the different heights within the RSA. Option 1 does not include wind direction, and a simple, direct avoidance is included. It produces much higher estimates of collision numbers because of the uniform flight height distribution.

- **Option 2:** The computation of flight height is based on detailed data collection for many species, that has been used to generate a generic shape function for flight height using a bootstrapping technique (Johnston *et al.* 2014). This distribution is then fitted for each bird using estimates of their flight height mean and variance. The direct collision risk is then integrated over the range in height of the rotor swept (e.g. near the base of the RSA is much less than at the height of the hub due to the greater width). Wind direction is not included. Avoidance is included as a percentage.

- **Option 3:** This option is very similar to Option 2, including the same factors, but with a more sophisticated calculation of the passage through the RSA, including wind direction and more detail of the rotor geometry and flight direction. The flight height data in options 2 and 3 can be modified for a particular species Simulations revealed that the results of Option 3 were very similar to Option 2 for all species modelled, so only the results of Option 2 are quoted in this report.

For each option, the output of the Band model is a monthly display of a distribution of collision likelihood as well as a total risk. Variation in the monthly output is due to changes in wind strength and bird density (both inputs are averaged for each month). In this report we have included only mean collision percentages, rather than the full plots.

Calculations of likelihood of passing through the RSA are based on a two-dimensional, vertical plane through which all birds must pass. The area of RSA of all turbines is then divided by the total area of this plane, providing an estimate of the number of passages. It was determined that the Band model over-estimates the number of passages through the turbines. This calculation is not appropriate for farms with a very large number of turbines.

4.5 The New Model

Limitations of the Band model are in the computation of the number of interactions that a particular bird species has with the WTG. The method overestimates the number of interactions because it assumes an extended two-dimensional plane in which the WTG are situated. This approximation therefore omits the third horizontal dimension. This approximation is reasonable for small numbers of turbines but breaks down when there are large numbers of WTG, as in the proposed wind farm at Bonney Downs. Historical records and calibration of the Band model (Urquhart & Whitfield 2016, Smales 2023) allow it to produce good estimates when compared to collision data. However, in order to compare with a more three-dimensional approach, a new model was developed with an improvement in this aspect of the methodology. Simulations were performed with a full three-dimensional model of the region, thus giving a more accurate representation of the density of bird flights in the vicinity of the WTG.

The new collision likelihood model is, like all others, based on three key components: (1) the use of flight height distributions consistent with those required in the Band model, (2) a calculation of strike frequency during passage, comparable to the Band model but slightly simplified, and (3) the simulation of bird movement across the region according to species-specific speeds and travel distances. Together, these components provide a framework analogous to that of the Band model but item (3) provides a full three-dimensional representation of the wind farm.

Statistical simulations were used to represent random movement of birds across both wind farms at Bonney Downs Station. Turbines were positioned approximately in their planned locations, and bird flights of varying lengths were generated according to species-specific flight speeds and travel distances, uniformly distributed across a reconstructed map of the Bonney Downs Station including approximate WTG locations (see **Figure 3**). Simulations with the New Model included 15,000 random flights of length ranging from 10 to 40 km, estimated from flight speeds and time in the air. These were randomly simulated across the Bonney Downs Station and a small buffer area around it to take account of nearby bird populations. The starting points and travel directions of the flights were chosen randomly from a uniform distribution. The proportion of these ‘flights’ that crossed the 200 m-long lines representing the WTG were then counted, allowing determination of the number of times there would be an intersection of the bird with a WTG per distance travelled. Thus, for each species, the speed and flight characteristics were used to compute the likelihood of an interaction with the WTG.

Extensive trial simulations show that if the motion is completely random (i.e., **Figure 3**), then the likelihood of being in any location is equal to any other. Therefore, the likelihood of a collision depends mainly on distance travelled, and only slightly on the length of each individual flight. As a result, one of the most important factors for each bird species is the distance an individual bird would need to travel before it would be struck. For example, given certain parameters, a Wedge-tailed eagle might travel close to 10,000 km before being struck. While this sounds like a long distance, it is less than the approximate distance an eagle travels in a year (Cherriman 2024), which may be up to 25,000-30,000 km.

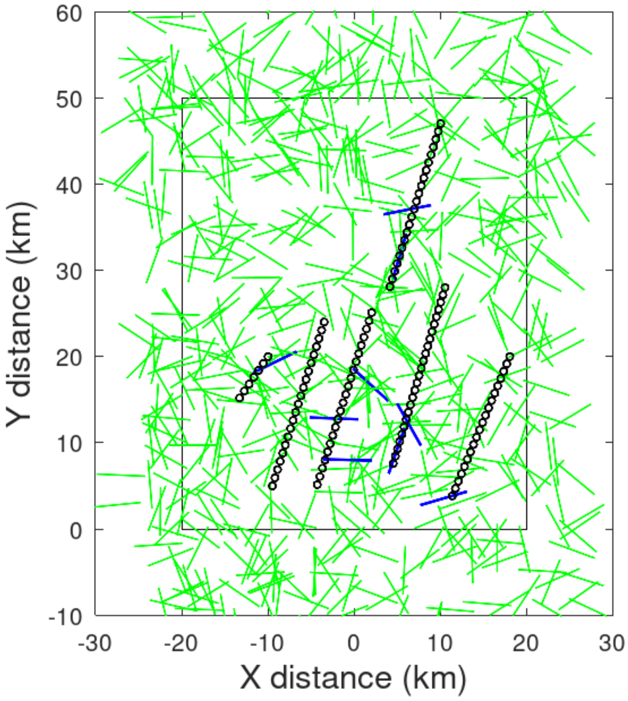

Figure 3. *Simulated random bird flight paths.*

The small circles indicate turbine locations and the green, lines are simulated bird flights. The blue lines close to the turbines are cases in which the flight crosses the location of a turbine. Not every flight that crosses the line of WTG will involve a potential collision as they may pass between them. This example has a uniform distribution of flights and shows only 500 “flights”. Simulations for each bird species involved 15,000 flights.

4.6 Choice of Avoidance Rates

Collision risk models first estimate potential collisions assuming no avoiding action, then apply an avoidance rate to account for behavioural responses that reduce exposure and collision probability. Accordingly, the avoidance rate used for modelling should be interpreted as an overall, pragmatic correction factor capturing multiple processes (e.g., displacement and evasive behaviour) that are not explicitly represented in the geometric collision calculation, rather than a single observed avoidance mechanism at one spatial scale. NatureScot’s updated onshore CRM guidance explicitly states that avoidance rates used in collision risk estimates should be characteristic of overall avoidance (including both behavioural displacement and behavioural avoidance) and recommends presenting outcomes across a high avoidance range (e.g., 98%, 99% and 99.5%) where species-specific information is limited (NatureScot 2025). On this basis, the Band Model is retained as the benchmark, with 99.5% as the base case and 98% as a conservative “worst case” that remains within plausible overall avoidance values, while still providing a strong stress test (a four-fold increase in the non-avoidance multiplier relative to 99.5%). This is consistent with guidance that many species exhibit avoidance ⩾98% and that 98% is an appropriate default where species-specific evidence is unavailable (NatureScot 2025), and with Australian synthesis for species such as Wedge-tailed eagles indicating avoidance is likely to be very high (Biosis 2006).

The New Model adopts 90% as the conservative comparability scenario for calibration/sensitivity testing. However, avoidance inputs must remain within scientifically plausible ranges because they function as correction factors during model calibration. Extremely low overall avoidance values should not be treated as candidate inputs without strong, site-specific empirical evidence demonstrating such low overall avoidance is realistic (Smales 2023).

5 Results

5.1 How to interpret this report

- This report provides an assessment of the likelihood of birds of different species colliding with the WTG at the proposed BDGH and the Nullagine Pilot Wind Farm (currently under development). The assessment is based on BBSUS data collected on site and on simulations using two models: the Band model commonly used in international studies and a new model developed for this project.

- Results are presented as an estimate of *the percentage of the local population that may be struck by the turbine blades over a one-year period* within two wind farms at Bonney Downs Station and a surrounding 5 km zone. For example, a value of '10%' indicates that an estimated 10% of the local population may collide with the blades in one year. In other words, if there are 100 birds in the region, then the modelling suggests 10 may be struck during the year. It is unlikely that most bird species would survive direct impact, and so these numbers represent predicted fatalities. Since the calculation is a percentage, it automatically adjusts as the population changes (so in the next year, assuming no replacement, 9 bird collisions are predicted).

- For birds in very low numbers, such as the Grey falcon, this percentage can be read as the likelihood of collision within the year. For example, if there are 4 individuals and the predicted collision risk is 1.86% (Band Option 2 model), it suggests that, on average, you might expect 1 bird to be struck every 12 years. Under the New Model with 90% avoidance (1.6% collision risk), you might expect 1 bird to be struck every 14 years.

- Birds that are not considered herein were deemed to be at low chance of collision because they were never observed at the height of the rotor swept area (RSA), or there were insufficient data to predict their probability of collision.

5.2 Results of simulations

Simulations were performed for 13 bird species identified in the BBSUS surveys as described in **Table 4**. Comparison of the model outcomes for the 13 bird species are shown in **Table 1**.

It should be noted that the collision risk estimates presented below represent inherent (unmitigated) collision risk and do not account for the potential reduction achievable through management and design measures that may be adopted during project development or operations (e.g., curtailment, deterrent/monitoring systems, or blade marking/painting).

Results of the Band model using Option 2 (avoidance rate of 99.5%) for each species are indicated. The Band model results are quite sensitive to avoidance rates. A worst-case is simulated with 98% avoidance. A high-avoidance sensitivity set is commonly presented where species-specific avoidance data are limited. As the Band avoidance factor is applied as a single multiplier to the pre-avoidance collision estimate, the 98% case primarily scales predicted mortality magnitudes rather than changing the relative risk ranking between species; therefore, species-by-species discussion focuses on the base case, with 98% retained as a bounding sensitivity (Smales 2023; NatureScot 2024).

The New Model had a more consistent methodology for computation of time interaction with the WTG. For these calculations, 90% avoidance is used as a conservative sensitivity value to support comparability with Band outputs; it should not be interpreted as a definitive species-specific overall avoidance rate for the wind farms at Bonney Downs Station. Using the 90% avoidance factor, these collision likelihood values were such that only the Australian pelican (5.25%), Straw-necked ibis (2.75%) and Wedge-tailed eagle (4.47%) were found to be above 2% mortality per annum (**Table 1**).

A summary of the results for the **Band Option 2 model (99.5% avoidance)** and the **New Model with 90% avoidance** are discussed separately for the 13 species modelled.

Australasian darter – CRM models produced estimates of less than 3% mortality of the local population per year (1.98%, 1.12%). While the Australasian darter was only recorded in the RSA on 6% of occasions and is predicted to fly quickly (so would pass through the rotor zone in a relatively shorter time, reducing the chance of collision), this is a relatively large bird, with an average body length of around 90 cm, which would increase its collision risk. We note that this is likely a conservative estimate for Australasian darter which would likely spend only a small proportion of their time in flight (as they forage around water), as 29% of flight height records included instances where the birds were flushed when disturbed; their amount of flight time would therefore be less without such disturbance.

Australian kestrel – Collision likelihood is rated at less than 1% of population per year at Bonney Downs Station. This is a small bird species at around 30 cm body length, recorded spending less than 5% of its time at RSA. Although the result was a low risk of collision (0.44%, 0.57%), the kestrel was the most commonly recorded of the 13 species modelled (**Table 6**). Because they are a common species, Australian kestrel mortalities are frequently recorded at operational wind farms across Australia (**Table 4**), leaving little dispute regarding vulnerability to wind turbines for this species.

Australian pelican – This large bird averages 1.7 m in body length, flies at the RSA for around 18% of the time, and consequently has relatively high risk of turbine collision, the second highest of the species modelled. The Band Option 2 model produced lower percentage chance of collision (2.77%) than the New Model, which was about double this value (5.25%). This is an unusually large difference between the two models and depends on the slightly different computation of the passage through the WTG given the flight height distribution. The Band model has a more subtle approach to the passage calculation depending on the elevation within the RSA, so if the flight height distribution is weighted at the lower heights of the RSA, there is a lower risk of collision due to the narrowing of the blades.

Brown falcon – CRM models predict similar risk of 1.44% to 1.52% collision. These falcons are a small-medium bird of length around 50 cm. They have extremely rapid flight and regularly hover, but spend an estimated 9% of flight time at RSA, putting them at risk. Because they are a common species, Brown falcon mortalities are frequently recorded at operational wind farms across Australia (**Table 4**), leaving little dispute regarding vulnerability to wind turbines for this species.

Grey falcon (VU) – Listed as Vulnerable (EPBC Act), the Grey falcon is known to exist in small numbers at Bonney Downs Station. From the distribution of observations (**Figure 4**) and records of flight and nesting behaviour, there is likely one or two pairs of these birds present[1]. The Grey falcon is slightly smaller in size but has similar flight characteristics to the Brown falcon. However, direct visual observations identified Grey falcons flying at RSA height (13% of records at RSA heights) more often than Brown falcons (9% RSA), reflected in higher estimates of collision risk for Grey falcon (1.86%, 1.61%). This species has not been reported as a mortality at Australian wind farms to date, which could reflect non-overlapping geographic range with current operational wind farms, or strong avoidance behaviour.

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[1] *observers positioned ~8 km apart reporting the same individual bird – identified from a missing tail rectrice – flying between hunting grounds and nest site.*

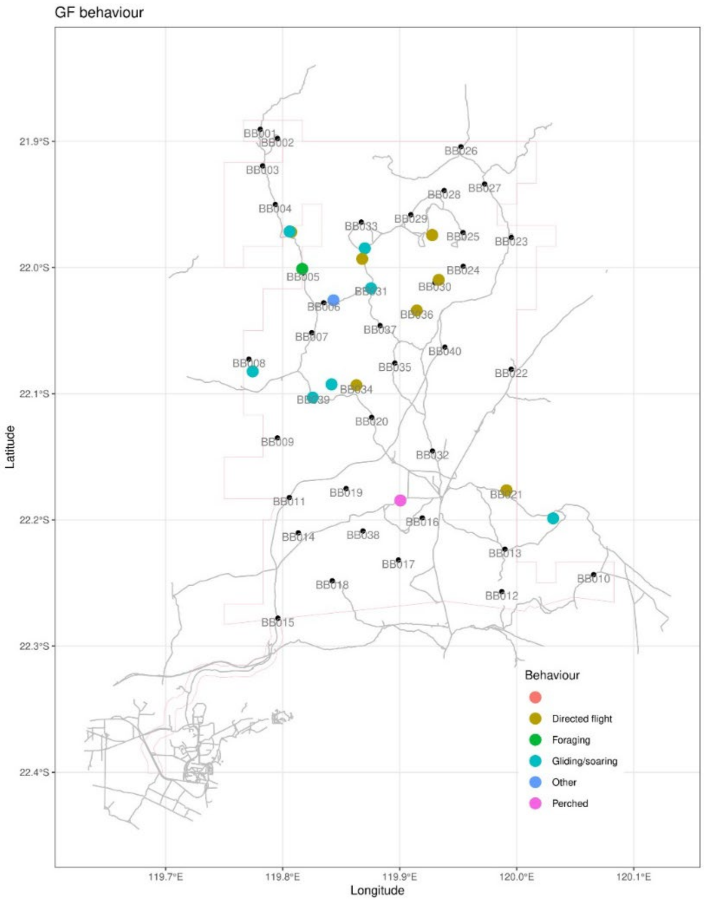

Figure 4. *Sightings of the Grey falcon (coloured dots representing different behaviour records) across Bonney Downs Station.*

Little black cormorant – This bird species was observed at RSA flight height on ~12% of occasions. It is a bird with body length ~60 cm and flies relatively swiftly. The larger time at RSA led to collision risk estimates of 2.04% and 1.35%. We note that this is likely a conservative estimate for Little black cormorant which would likely spend only a small proportion of their time in flight (as they forage around water), and 41% of flight height records included instances where the birds were flushed when disturbed; their amount of flight time would therefore be less without such disturbance.

Masked woodswallow – Spending around 15% of its time in the RSA places this bird species at high risk of collision. It is a smaller bird (at 20 cm) but flies more slowly than some of the others in this list. It spends the majority of its time foraging in flight. This combination of factors led to a probability of collision of 2.19% or 1.55%.

Spotted harrier – At around 50 cm in length, spending a large portion of each day quartering (foraging flight), and flying relatively slowly, Spotted harriers would be at high risk of turbine collision. However, these birds usually fly close to the ground – records identified these birds as spending only ~5% of time at RSA. These raptors were therefore modelled as having much lower probability of collision than the other raptors considered in this work (0.73%, 1.25%).

Straw-necked ibis – A medium-large bird (body length ~65 cm) that flies relatively quickly, these birds were commonly recorded at RSA heights (18% of records), placing them at risk of collision. This is reflected in the simulated percentage collisions per year, which was the third highest of the species modelled at 7.0% and 2.75%. We note that this is likely a conservative estimate for Straw-necked ibis which would likely spend only a small proportion of their time in flight (as they forage around water), and 18% of flight height records included instances where the birds were flushed when disturbed; their amount of flight time would therefore be less without such disturbance. For this species, the Band Option 2 model produced a value that was double that of the estimate derived from the New Model. This ibis has a lower collision probability than the Australian Pelican, which has been recorded with similar times at the RSA, because it flies at a similar speed but is much shorter, thereby spending less time in passing through the rotor blades.

Torresian crow – Very low risk of collision given its time in the RSA was observed at less than 1% of the time. As a result, the mean percentage of collisions was rated as less than 1% (<0.01%, 0.03%). Corvids have been commonly reported as collision mortalities at operational wind farms across Australia, which likely reflects small ground clearance for many currently operational wind farms (**Table 4**). The low collision predictions in the present study likely reflect the greater ground clearance to the proposed wind turbines (RSA 100–280 m) compared with current operational wind turbines (RSA from 30 m).

Wedge-tailed eagle – Collision predictions for the Wedge-tailed eagle are the highest of the 13 species modelled (11.67%, 4.5%). Hull and Muir (2013) give avoidance rates, from direct observation, 81-97% for Wedge-tailed eagles in Tasmania. In the Band model, recalibration of the data (see Section 4.4; Smales 2023) gives the equivalent range to be 96-99%. Despite high avoidance rates, this medium-large bird (body length ~1 m) spends around 30% of its flight time in the RSA and spends a large proportion of the day in flight. There are 27 territories mapped at Bonney Downs Station (**Figure 5**). If each territory is occupied by 2 adults (with an average of one fledged young), then the population size for the site is about 54 to 81 individuals. At 11.67% risk (Band Option 2 model), this equates to 6 adults plus 3 fledglings at risk per annum. At 4.47% risk (New Model with 90% avoidance), this equates to 3 adults plus 2 fledglings at risk per annum. Wedge-tailed eagle mortalities are commonly recorded at operational wind farms across Australia (**Table 4**), leaving little dispute regarding vulnerability to wind turbines for this species.

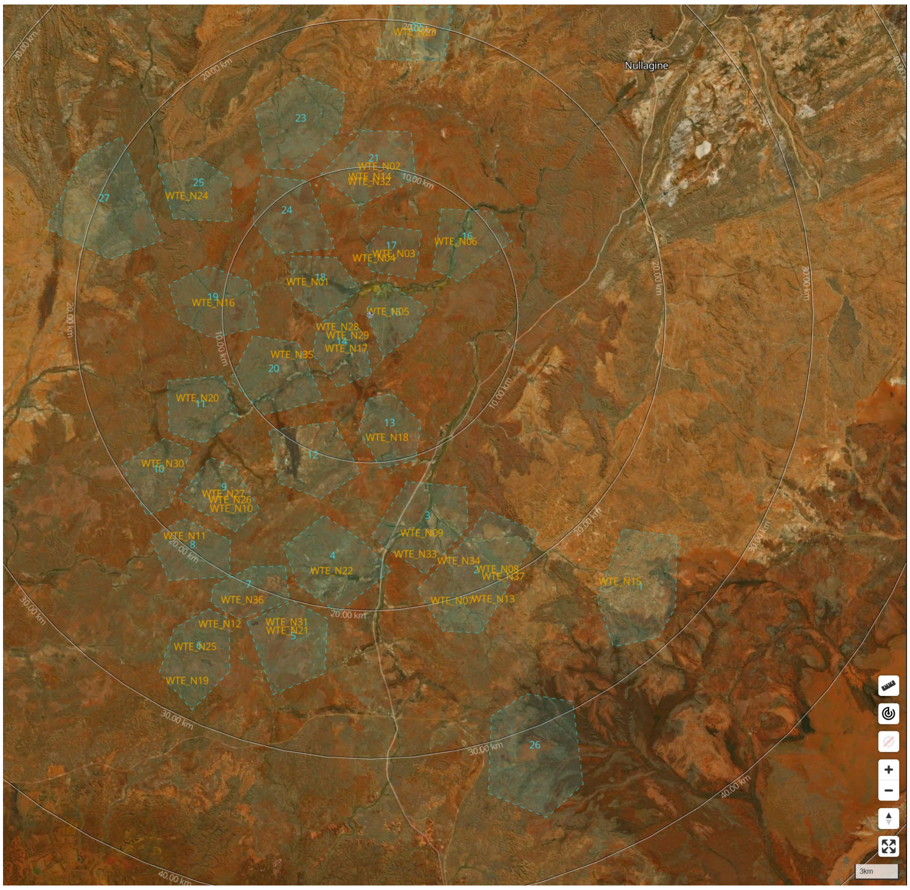

__Figure 5.__ 27 Wedge-tailed eagle territories mapped across Bonney Downs (Ecologia).

Whistling kite – This medium-sized raptor (body length ~50 cm) was commonly observed flying at RSA height (14% of records) and spends a large proportion of the day in flight. Consequently, this species has a predicted probability of collision of 1.75% or 1.98%. Whistling kites have been recorded as mortalities at Australian operational wind farms, although not commonly (**Table 4**).

White-necked heron – A relatively large bird (body length ~90 cm) that flies slowly compared to the others modelled in this study, but was observed at RSA less than 7% of the time. Predicted collision percentages were 0.55% and 1.20%. We note that this is likely a conservative estimate for White-necked heron which would likely spend only a small proportion of their time in flight (as they forage around water), as 21% of BBSUS flight height records included instances where the birds were flushed when disturbed; their amount of flight time would therefore be less without such disturbance.

5.3 Comparison of the Band model with the New Model

The Band model with Option 2 and the New Model used similar flight height distributions and bird characteristics, along with likelihood of collision during the passage of the bird through the RSA. However, the method of computing the number of transects through the RSA were differed between the two models. The models correlated strongly, as can be seen in **Figure 6**, which compares the Band model Option 2 with 99.5% avoidance against the New Model with 90% avoidance. **Figure 7** shows the correlation between the Band model with option 2 and the New Model with 90% avoidance. The New model generally estimates a lower number of collisions (despite including a lower turbine avoidance coefficient than required for the Band model) but the correlation is good.

Table 6 provides a detailed comparison of the different aspects of the Band model, used extensively in Wind Farm assessment, and the New Model which uses a different methodology to determine WTG proximity.

Collision risk for Bonney Downs has been assessed using both the widely accepted Band model and a project-specific three-dimensional collision risk model. The new model uses the same underlying collision calculation as the Band model but incorporates explicit turbine locations and simulated bird movement as well as a 3-dimensional representation of the wind farm. Under equivalent conservative assumptions, both models identify the same species as being of relatively higher likelihood of collision, and the New Model produces collision estimates that are similar to the Band Option 2 model.

In summary, the new 3-D collision risk model is at least as robust as the standard Band model, reproduces Band's species risk patterns under equivalent conservative assumptions, but provides a more realistic representation of the Bonney Downs wind farm. Comparison of the two models provides confidence in the integrity of both models and the reliability of the outcomes given the available input information.

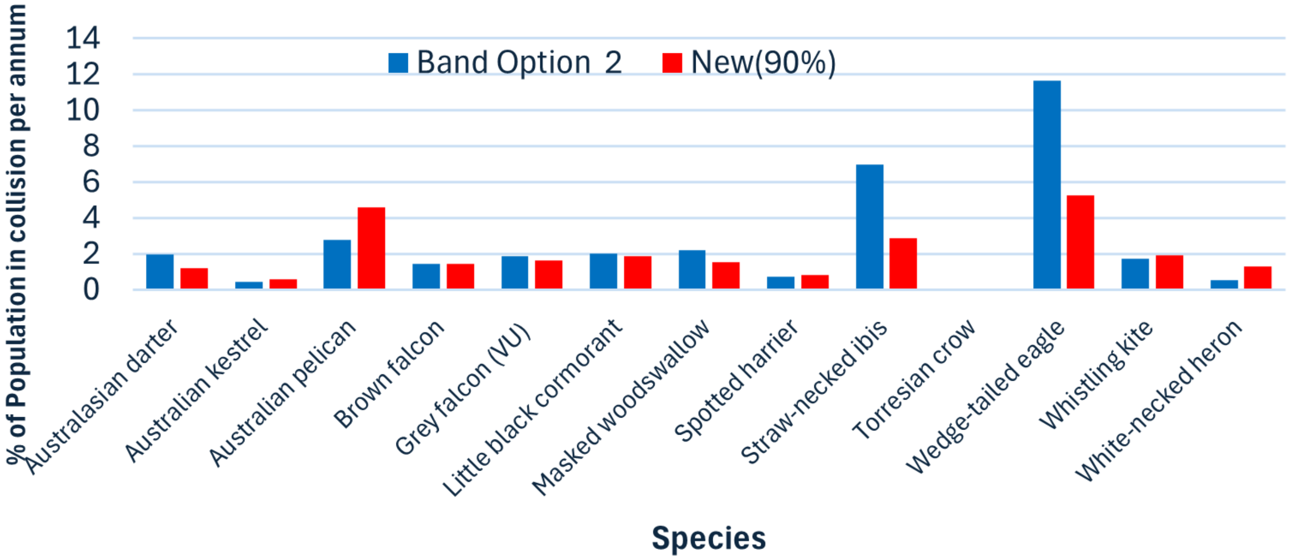

Figure 6. *Turbine collision predictions for 13 birds (expressed as a percentage of the population present at the site in a single year), showing Band model Option 2 (with 99.5% avoidance) and the New Model (with 90% avoidance).*

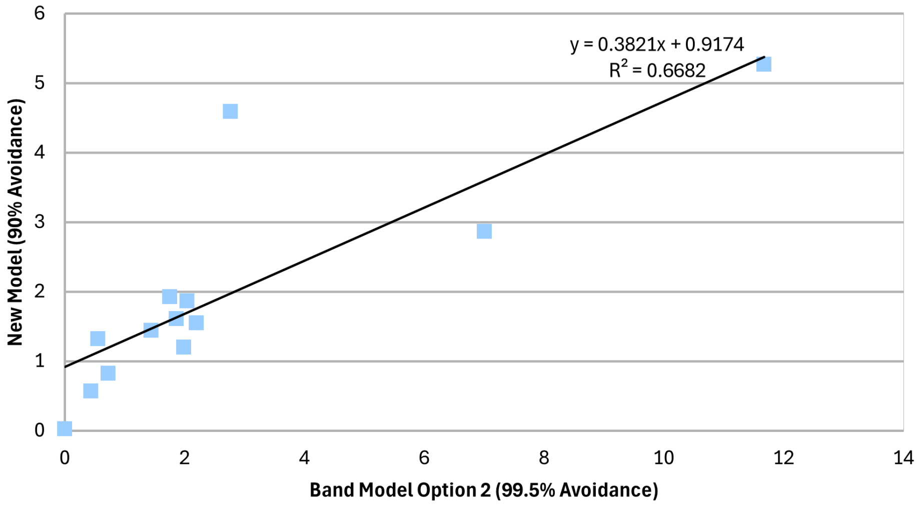

Figure 7. *Comparison of Band model Option 2 (99.5% avoidance) with the New Model (90% avoidance). The correlation is strong (R^2=0.67). There is greater variation for large birds with higher collision percentages.*

Table 6. *Comparison of the Band model and the New Model.*

Aspect	Band model	New 3-D collision risk model (Bonney Downs)	Assessment (New vs Band)
Role & purpose in this assessment	Provides a transparent, conservative estimate of bird–turbine collision risk and acts as the benchmark method.	Uses the same collision geometry as Band but in a 3-D, simulation tailored to the Bonney Downs layout; run in parallel with Band.	At least as good – provides context for Bonney Downs rather than a generic site. Keeps Band as the benchmark.
Regulatory status	Widely used and accepted in wind farm assessments; *strong regulatory precedent*.	New, project-specific tool presented in addition to Band, designed to be fully compatible with Band.	Band leads on precedent, but the New Model is clearly framed as an extension rather than a replacement. Includes more site specific details.
Core collision geometry	Analytical calculation of collision probability for a bird crossing the rotor disc using turbine and bird dimensions and speeds.	Uses the same geometric logic to calculate collision probability whenever a simulated bird overlaps a moving rotor.	At least as good – same physics and transparency, implemented in a more flexible engine.
Bird movement & layout representation	Birds represented as straight-line crossings of a 2-D rotor disc; turbine layout and topography are highly simplified.	Simulates individual 3-D bird trajectories through the actual turbine array, allowing repeated passes and complex paths, and can incorporate topography/habitat as data allow (this feature was not implemented in the present report due to a lack of data).	Better – more realistic spatial and movement representation, especially for a large, complex wind farm.
Treatment of time & operations	Typically assumes constant turbine operation and steady bird activity over time.	Very similar operation but capable of more time dependent analysis if data allows.	At least as good – capable of extension with better data input.
Inputs on bird use of airspace	Uses observed flight activity (e.g. flights/hour at rotor height) extrapolated across turbines.	Uses estimates of time that birds spend in the rotor-swept volume across the array, informed by site data and refinable with radar/other sources.	Comparable in data uncertainty, but better structured around time in the risky airspace.
Avoidance behaviour	Applies a single avoidance rate (e.g. 95–99%) as a scalar; results are highly sensitive to this assumption. *This value is a calibration of the model rather than a field measurement*.	Gives equivalent results to Band with lower numerical values of avoidance such as those measured in Hull and Muir (2013).	Currently "as good as" (same dependence on assumed rates) with clear potential to become better if real avoidance can be quantified in the field. Band avoidance is calibrated using post installation wind farm mortality (Urquhart and Whitfield, 2016, Smales, 2023)
Uncertainty & transparency	Uncertainty explored via scenarios (activity, avoidance); model structure is simple and well understood by regulators.	Uses the same scenario approach but within a more realistic spatial and temporal framework; key uncertainties are explicitly identified and tested.	At least as good – similar transparency, plus improved structural realism; still precautionary where data are limited.
Outputs & strengths	Species-level annual collision/mortality estimates; good for relative risk ranking and broad comparison between species.	Produces directly comparable species-level outputs and can additionally support parameter sensitivity analysis and future turbine- or habitat-level risk mapping.	Better – delivers all Band-style outputs needed for assessment, plus extra capability for future refinement and mitigation design.
Overall regulatory assurance	Provides continuity with past assessments and a familiar reference point.	Complements Band by reproducing its key patterns under equivalent assumptions while offering a more realistic and flexible site-specific framework.	Suitable alongside Band – New Model is at least as robust as Band and generally more conservative/realistic under shared assumptions.

5.4 Conservation listed species

A total of 27 conservation-significant have been listed for the Pilbara Bioregion under ALA records (**Table 7**). Fifteen of these have medium to high likelihood of being present at Bonney Downs Station.

Three conservation-significant species have been recorded to date at Bonney Downs Station:

- The Grey falcon (*Falco hypoleucos*) **(VU)** is listed as Vulnerable under the EPBC Act and BC Act. There are 83 records of the species in the Pilbara (ALA 2025), and 33 recorded sightings of the Grey falcon during the first 8 BBSUS surveys. Of these, about one third identified the flight height as being sufficient to place the bird in the RSA. **Figure 4** provides the locations at which the Grey falcon was seen. It is likely that some of these may be a single pair. The diagram shows the sightings to be reasonably evenly spread across Bonney Downs site. Both models rated the Grey falcon of being in danger of losing less than 2% of the local population each year due to modelled collision with the WTG. This is a relatively low value (estimated 1 bird collision every ~12 years for the adult population of ~2 pairs), which if correct would mean the population would maintain sustainable levels.

- The Pacific swift (*Apus pacificus*) is a migratory species protected under federal and state legislation **(MI)**. There are 51 records of the species in the Pilbara (ALA 2025), and 12 records at Bonney Downs, all flying below RSA height. We have therefore not carried out CRM for this species as it was never recorded at RSA.

- The Oriental plover (*Charadrius veredus*) is a migratory species protected under federal and state legislation **(MI)**. There are 65 records of the species in the Pilbara (ALA 2025). There has been only one record of this species at Bonney Downs, with the bird flying below RSA height. These data are too few to predict likelihood of turbine collision and we have not carried out CRM for this species.

One conservation-significant species not recorded has a **high** likelihood of occurring at the site, based on habitat suitability (*ecologia* Environment 2025):

- The Peregrine falcon (*Falco peregrinus*) **(OS)** — listed under Western Australian *Biodiversity Conservation Act 2016* as a specially protected species – a species otherwise in need of special protection (other specially protected). There are 120 records of the species in the Pilbara (ALA 2025), but none at Bonney Downs as part of BBSUS. Consequently, without flight height data, we have not carried out CRM for this species.

Two conservation-significant species not recorded have a **medium** likelihood of occurring at the site, based on habitat suitability (*ecologia* Environment 2025).

- Night parrot (*Pezoporus occidentalis*) is protected under international, national and state legislation **(CR)**. These birds usually stay just above vegetation, flying low and fast when flushed, often in zigzag patterns, but have been recorded covering significant distances (18-41 km in a night, Murphy *et al.* 2017) between roosting/feeding sites. There is only 1 record of the species in the Pilbara (ALA 2025) and none at Bonney Downs as part of BBSUS, and we have no flight height data to work from.

- The Glossy ibis (*Plegadis falcinellus*) is a migratory species protected under federal and state legislation. There are 102 records of the species in the Pilbara (ALA 2025), but none at Bonney Downs as part of BBSUS, and we have no flight height data to work from.

Nine migratory waterbird species have been recorded in association with the Fortescue Marsh, but were not recorded at Bonney Downs Station during the BBSUS. These birds have **medium** likelihood of presence at Bonney Downs Station *en route* to the Fortescue Marsh (*ecologia* Environment 2025).

- Australian painted snipe (*Rostratula australis*, **EN**)
- Common greenshank *Tringa nebularia*, **MI**)

- Common sandpiper (*Actitis hypoleucos,* **MI**)
- Sharp-tailed sandpiper (*Calidris acuminata*, **MI**)
- Red-necked stint (*Calidris ruficollis*, **MI**)
- Gull-billed tern (*Gelochelidon nilotica*, **MI**)
- Caspian tern (*Hydroprogne caspia*, **MI**)
- Wood sandpiper *Tringa glareola,* **MI)**
- Marsh sandpiper (Tringa stagnatilis, **MI**)

Other conservation-significant species not recorded have **low** or **no** likelihood of occurring at the site (*ecologia* Environment 2025).

- Southern giant petrel (*Macronectes giganteus*, **EN**)
- Eastern osprey (*Pandion haliaetus*, **MI**)
- Red goshawk (*Erythrotriorchis radiatus*, **EN**)
- Curlew sandpiper (Calidris ferruginea, **CR**)
- Grey wagtail (*Motacilla cinerea*, **MI**)
- Yellow wagtail (*Motacilla flava*, **MI**)
- Princess parrot (*Polytelis alexandrae*, **VU**)
- Letter-winged kite (*Elanus scriptus*)
- Sandhill grasswren (*Amytornis whitei whitei*)
- Barn swallow (*Hirundo rustica*, **MI**)
- Oriental cuckoo (*Cuculus optatus*, **MI**)
- Barking owl (*Ninox connivens*)

Table 7. *List of conservation-significant bird species present in the Pilbara (excluding marine, shorebirds and waders) that are listed under the Threatened and Priority Fauna List (DBCA 2025). The Reid risk rating is based on a much lower RSA (minimum height 30m) and so may inaccurately represent risk for the WTG in this proposal (RSA>100m).*

Common name	**Scientific name**	**National listing†**	**WA listing§**	**ALA records in Pilbara§**	**Likelihood of occurrence at Bonney Downs (Number BBSUS records)**	**CRM modelled**	**Reid overall risk CATEGORY**
Grey falcon	*Falco hypoleucos*	VU	VU	83	Recorded (33)	Yes	High
Pacific swift	*Apus pacificus*	MI	MI	51	Recorded (12)	No (<RSA)	High
Oriental plover	*Charadrius veredus*	MI	MI	65	Recorded (1)	No (<RSA)	Medium
Peregrine falcon	*Falco peregrinus*	Not listed	OS	120	High (0)	No	High
Night parrot	*Pezoporus occidentalis*	EN	CR	1	Moderate (0)	No	High
Glossy ibis	*Plegadis falcinellus*	MI	MI	102	Moderate (0)	No	High
Australian painted snipe	*Rostratula australis*	EN	EN	320	Moderate (0)	No	High
Common greenshank	*Tringa nebularia*	MI	EN	15678	Moderate (0)	No	High
Common sandpiper	*Actitis hypoleucos*	MI	MI	22877	Moderate (0)	No	Medium
Sharp-tailed sandpiper	*Calidris acuminata*	MI	MI	11307	Moderate (0)	No	High
Red-necked stint	*Calidris ruficollis*	MI	MI	11041	Moderate (0)	No	Medium
Gull-billed tern	*Gelochelidon nilotica*	MI	MI	7177	Moderate (0)	No	High
Caspian tern	*Hydroprogne caspia*	MI	MI	14407	Moderate (0)	No	High
Wood sandpiper	*Tringa glareola*	MI	MI	9017	Moderate (0)	No	Medium
Marsh sandpiper	*Tringa stagnatilis*	MI	MI	7127	Moderate (0)	No	NA[2]
Southern giant petrel	*Macronectes giganteus*	EN	MI	28	Low (0)	No	NA[3]
Eastern osprey	*Pandion haliaetus*	MI	MI	134	Low (0)	No	High
Red goshawk	*Erythrotriorchis radiatus*	EN	VU	584	Low (0)	No	High
Curlew sandpiper	*Calidris ferruginea*	CR	CR	5146	Low (0)	No	High
Grey wagtail	*Motacilla cinerea*	MI	MI	126	Low (0)	No	NA
Yellow wagtail	*Motacilla flava*	MI	MI	0	Low (0)	No	NA
Princess parrot	*Polytelis alexandrae*	VU	P4	1	Low (0)	No	high
Letter-winged kite	*Elanus scriptus*	Not listed	P4	15	Low (0)	No	High
Sandhill grasswren	*Amytornis whitei whitei†*	Not listed	P4	415 (all subspp)	Low (0)	No	Low
Barn swallow	*Hirundo rustica*	MI	MI	11	Low (0)	No	NA
Oriental cuckoo	*Cuculus optatus*	MI	MI	2	Low (0)	No	Medium
Barking owl	*Ninox connivens*	Not listed	P3	7476	Does not occur	No	Medium

Conservation listings

*† Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) Act (**VU** Vulnerable, **MI** Migratory species protected under international agreement, **EN** Endangered).*

*§ Western Australia Biodiversity Conservation (BC) Act 2016 (**VU** Vulnerable, **MI** Migratory species protected under international agreement, **OS** Species otherwise in need of special protection (other specially protected) under the Biodiversity Conservation Act 2016, **P4** DBCA Priority species, **CR** Critically Endangered).*

***§ ALA Records** Data were downloaded from the Atlas of Living Australia (ALA 2025, 26 December 2025) for the IBRA 6 Pilbara Region (DCCEEW 2023a).*

† sub-species naming according to Black et al. (2020).

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[2] *There are 3 other Tringa spp. listed, two with a Medium risk score and one with a High risk score. The ssp with the Medium score are both listed as Least Concern, whereas the spp with the High score is listed as Vulnerable (this is the Common Greenshank). Marsh sandpiper is Least Concern, so in the absence of a Reid 2025 score, Medium would be a best estimation*

[3] *Southern giant petrel is not listed in Reid 2025. However, there are 10 members of the Procellariidae family listed, all with a High risk score*

6 Discussion

The results of two models were compared for 13 bird species that have been determined to spend some time within the height range of the RSA. The Band model has been calibrated to include a bird avoidance of 99.5% (Urquhart & Whitfield 2016). Option 2 of the Band model compared well with the new model with 90% avoidance. This number is obtained from the measured "avoidance" of between 80-95%, described in (Hull & Muir 2013) for the Tasmanian Wedge-tailed eagle. These avoidance factors calibrate to 97-99% avoidance in the Band model (Smales 2023). Similar avoidance calibrations were obtained in Urquhart and Whitfield (2016) for other species.

The two factors that would improve the predictive capability of **all** models are accurate flight height and avoidance information; however, collecting these data would take a considerable amount of time and in many cases may not be possible since it would require GPS or radar tracking of many individuals of each species. This is especially true for those species that are rarely recorded at Bonney Downs Station. Confidence in the outcomes is provided by the fact that the results are consistent between the two models for the number of collisions that might be expected for each species.

There were 15 conservation-significant species with moderate to high likelihood of being present at the site, based on habitat suitability (*ecologia* Environment 2025).

- The Grey falcon (*Falco hypoleucos*) **(VU)** is in danger of losing less than 2% of the local population each year due to modelled collision with the WTG. This is a relatively low value (estimated 1 bird collision every ~12 years for the adult population of ~2 pairs), which if correct would mean the population would maintain sustainable levels. Based on expert elicitation, Reid and Baker (2025) attributed the highest risk profile (class 5) for flight height and second-highest (class 4) for the amount of time spent in flight for this species, with a high overall turbine risk categorisation. However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

- We have not carried out CRM for Pacific swift (*Apus pacificus*) as this species as it was never recorded at RSA. Based on expert elicitation, however, Reid and Baker (2025) attributed the highest risk profile flight height and amount of time spent in flight for this species, with a high overall turbine risk categorisation for this species. However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

- There was a single record of Oriental plover (*Charadrius veredus*) and therefore insufficient data to carry out CRM for this species. Although this species has been attributed by Reid and Baker (2025) attributed 'class 2' for flight height (noting that class 1 was attributed to flightless and resident obligate ground foraging birds), the Oriental plover has been given a score of class 4 for flight time, in recognition of its migration behaviour, with an overall risk categorisation of medium. However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

- Habitat suitability suggests high likelihood of Peregrine falcon (*Falco peregrinus*) **(OS)**, although there were no records as part of BBSUS. Consequently, without flight height data, we have not carried out CRM for this species. Based on expert elicitation, Reid and Baker (2025) attributed the highest risk profile flight height (class 5) and second-highest categorisation (class 4) for amount of time spent in flight for this species, with a high overall turbine risk categorisation. However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

- Night parrot (*Pezoporus occidentalis*) have not been recorded at Bonney Downs as part of BBSUS, and we have no flight height data to work from. From expert elicitation, Reid and Baker (2025) classed this species as likely to have a low chance of flying within RSA height (class 2, noting that class 1 was attributed to flightless and resident obligate ground foraging birds). Based on these assessments, the species would have low likelihood of turbine collision. However, Night parrots have been classed as having high risk of wind energy developments, overall, largely due to their habitat specialisation and conservation ranking (Reid & Baker 2025). However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

- The Glossy ibis (*Plegadis falcinellus*) have not been recorded at Bonney Downs as part of BBSUS, and we have no flight height data to work from. From expert elicitation, this ibis has been grouped as class 4 for habitat specialisation and class 4 for flight height, classified as high overall turbine risk (Reid & Baker 2025). However, this assessment estimated threat of collision for an RSA between 30 to 275 m, while the wind farms at Bonney Downs have a much higher RSA (100–280 m) and therefore greater ground clearance (~100m).

For nine migratory waterbirds associated with Fortescue Marsh (but not recorded at Bonney Downs during the BBSUS), Reid and Baker (2025) Appendix 4 outlines the following overall risk categories:

    - Australian painted snipe (*Rostratula australis*) – High
    - Caspian tern (*Hydroprogne caspia*) – High
    - Common greenshank (*Tringa nebularia*) – High
    - Common sandpiper (*Actitis hypoleucos*) – Medium
    - Gull-billed tern (*Gelochelidon nilotica* [incl. *G. n. affinis*]) – High
    - Marsh sandpiper (*Tringa stagnatilis*) – was not assigned an overall risk category in Appendix 4; so no Reid & Baker overall risk category is available for this species.
    - Red-necked stint (*Calidris ruficollis*) – Medium
    - Sharp-tailed sandpiper (*Calidris acuminata*) – High
    - Wood sandpiper (*Tringa glareola*) – Medium

These nine migratory birds have **medium** likelihood of presence at Bonney Downs Station *en route* to the Fortescue Marsh (*ecologia* Environment 2025).

The Reid and Baker (2025) Appendix 4 risk categories are a national, trait-based screening outcome that relies heavily on susceptibility attributes such as time spent flying and flight height relative to the rotor-swept area, and Reid & Baker note that empirical Australian flight-altitude data are limited for many taxa. At Bonney Downs, the lower bound of the rotor-swept area is substantially higher than the minimum rotor heights assumed in many generic onshore wind assessments (e.g., commonly spanning ~30 to >130 m in guidance examples), which means the proportion of flights occurring within the rotor-risk height band could be lower for some wetland-associated species if their local movements are predominantly at low altitude (NatureScot 2025). More broadly, studies using the Band framework show that increasing ground clearance can materially reduce collision risk for species whose flight-height distribution is concentrated below the lower rotor sweep (Schaub *et al.* 2024a). In addition, these Fortescue Marsh-associated taxa may be encountered at Bonney Downs primarily during intermittent commuting or passage movements rather than regular foraging/loafing activity within the development envelope; accordingly, their site-specific collision risk category may differ from national screening categories once site-specific data on passage frequency and flight-height distributions (including commuting trajectories) are available.

6.1 Conclusions

HBI developed and applied a three-dimensional, time-explicit collision risk model (the New Model) in parallel with the Band model to assess turbine-collision risk at the Bonney Downs Wind Farm. The New Model preserves Band's core collision geometry but simulates individual bird trajectories in three dimensions across the actual turbine layout and explicitly quantifies time spent in the rotor-swept airspace (RSA). Run for 13 bird species recorded flying within the RSA, the New Model reproduces the Band model's relative risk ranking (strong correlation reported between

Band Option 2 and the New Model under comparable avoidance scenarios) while providing improved structural realism for a large, spatially complex array.

HBI's analysis and Bonney Downs survey outputs indicate that the following conservation-listed taxa are present within the study area and warrant targeted attention:

- Grey falcon (*Falco hypoleucos*) **(VU)**. Band Model results: ≈1.86% p.a. (99.5% avoidance) or New Model results: ≈1.61% p.a. (90% avoidance). The worst-case prediction is 5.05% (98% avoidance), which would equate to 1 adult every 5 years. These are relatively low values, which if correct would mean the population would maintain sustainable levels. The values are reported as conservative inherent (unmitigated) collision risk estimates given the deliberately precautionary inputs used where species-specific data are limited.

HBI emphasises that these numerical results should be treated with caution. The New Model's structural advances (explicit array layout and 3-D movement) give it at least equivalent — and in relevant respects superior — inferential capacity compared with the Band model, but both approaches remain dependent on a small number of influential inputs (notably: proportion of time in the RSA, time in the air and avoidance behaviour). Under equivalent inputs the New Model produces species-level outputs that are comparable with those from Band; consequently, the two models together provide an appropriately cautious basis for assessment of the listed taxa.

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8 Appendix

8.1 Turbine Data

The configuration proposed for the Bonney Downs project, and used as the basis of simulations, is given in **Table A7** and **Table A8**. The potential locations of the 117 turbines are given in **Figure A8**.

Table A8. *Specifications of the proposed Bonney Downs Wind Farm and the Nullagine Pilot Wind Farm.*

Technical Information and Wind Farm Component	Data used/Scenario Modelled
Turbine model	Envision Energy EN182-7.8
Number of turbines	17 for Nullagine pilot project, 100 for Bonney Downs wind farm
Number of blades per turbine rotor	3
Rotor blade maximum chord (m) (i.e., depth of blade)	4.897 m
Blade Length (m)	89 m
Rotor Radius (m)	91 m
Rotor Diameter (m)	182m
Circumference of blade tip (m) (Pi x Rotor Diameter)	571.77 m
Swept area (m^2) (Pi x Rotor Radius^2)	26,015.53 m^2
Turbine height (m)	279 m
Hub height (m)	188 m
Swept height (m)	182 m
Maximum height to blade tip (m)	279 m
Minimum height to blade tip (m)	97 m
Max Tip Speed (m/s)	89.58 m/s
Rotation speed (rpm)	Varies from 3.3 rpm at 3 m/s to 9.4 rpm at 9.5 m/s and then constant at 9.4 rpm up until cut-out (25 m/s)
Rotation period (s) (i.e., seconds per rotation)	6.38 s for 9.4 rpm, 18.18 s for 3.3 rpm
Turbine operation time	Operate between 95-98% of the time.
Mean pitch angle of the blade during normal operation (degrees)**	Probably -5 deg up until rated wind speed at 14 m/s and then steadily increases to around 25 deg at cut-out (25 m/s). Parked at 90 degrees.

*** The pitch angle of the turbine blade is determined by wind speed, which is variable depending on several factors including, location, local topographic, landscape etc. To maintain a constant operating speed the pitch angle of the blade is altered. The pitch angle of the turbine blade is greater in stronger winds to "feather" the blades to control rotation speed.*

Table A9. *Rotor speed as a function of wind speed for the proposed turbines. Given wind data, the average speed of the rotor over the year can be incorporated into the model.*

Hub height wind speed [m/s]	Rotor speed [RPM]
3	3.3
3.5	3.8
4	4.3
4.5	4.9
5	5.4
5.5	5.9
6	6.5
6.5	7.0
7	7.6
7.5	8.1
8	8.6
8.5	9.0
9	9.3
9.5	9.4
Greater than 10	9.4

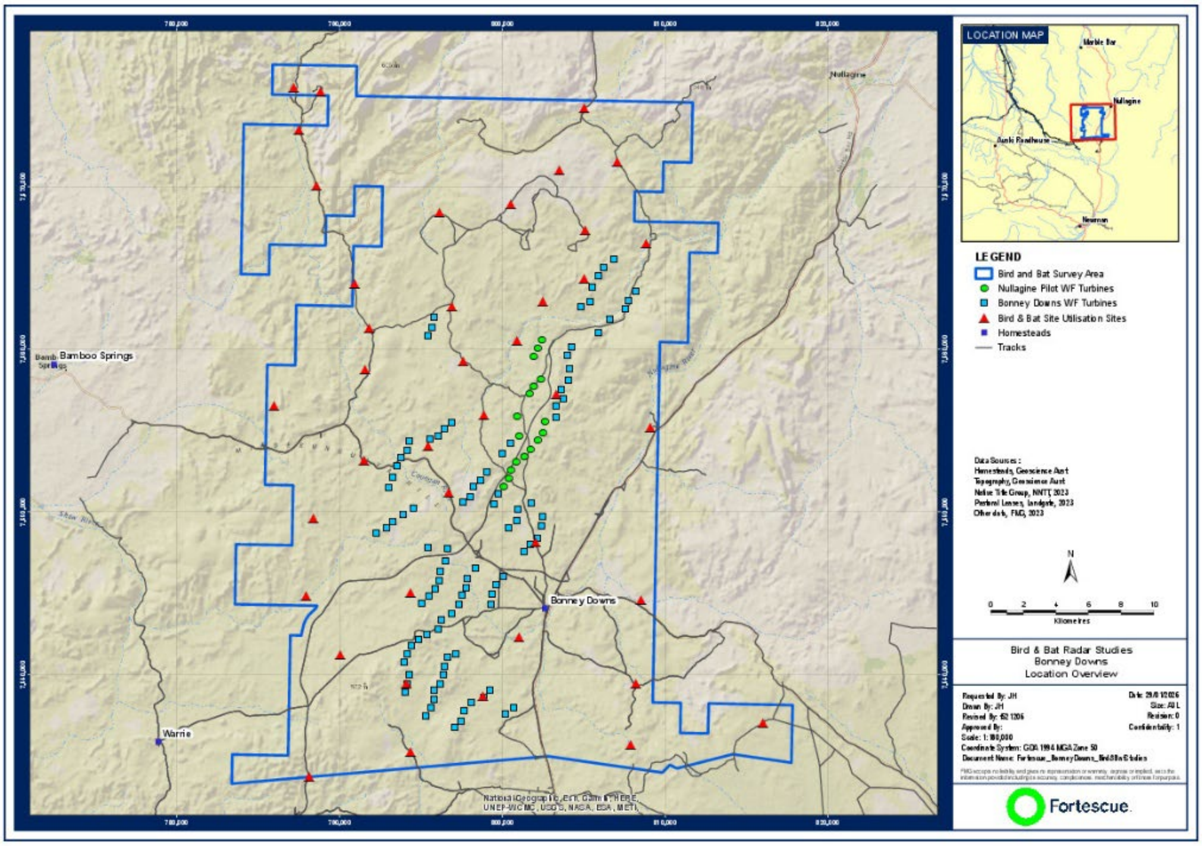

Figure A8. *Proposed location of turbines (blue) and BBSUS sites(red) with Pilot WTG (green).*

APPENDIX B COLLISION RISK MODEL PEER REVIEW

Scientific Peer review of:

Bird and Bat Management Plan Science for Wind Energy Developments Project 2.2.3 Collision Risk Modelling Outcomes Final Report

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Introduction

This review is of the scientific component of the report named above. The report presents the outcomes of collision risk model (CRM) calculations for two separate wind farms: Bonney Downs Generation Hub and Nullagine Pilot. The modelling addresses the impact of the wind farms on local bird populations with a particular emphasis on endangered and vulnerable species.

The report uses two different approaches for modelling the impact of the wind farms on local bird populations. The key output of the modelling is an estimate of the *Collision Risk* which is defined as the percentage of a local bird population that may be struck by turbine blades over a one year period. This output is estimated for a several (but not all) bird species present in the vicinity of the wind farms.

Methods

Choice of Bird Species. The report lists 33 species observed in the wind farms' vicinity. A collision risk is calculated for 13 of these species. The omitted species have either too few data of their behaviour to be included in the CRMs or are known to fly too low to interact with turbines at the wind farms. This decision is clearly stated and supported by the evidence presented in the report.

The Band Model. This model methodology has a near two decade history of use in CRM estimation. Within the general approach of this methodology there are a number of different sub-approaches that vary in sophistication, generality and parameter scope. The report includes a comprehensive review of these different approaches and carefully delineates the model appropriate for the wind farms. All the parameters used for the model are presented in tables in the report.

The "New Model". All Band models assume a 2-D geometry in their construction. This is a reasonable but significant simplifying assumption that can be mostly compensated for by adjusting some model parameters, particularly the *avoidance rate* that has been calibrated so that Band models match field studies.

The above limitation motivates the *new model* where a 3-D framework is used. This allows for measured or estimated bird flight height distribution and wind turbine distribution to be more realistically incorporated into the model.

The model is well motivated and formulated. It uses simulated random bird flights to estimate collision risk. In this report this is scientifically well justified.

A key parameter used in both models is the *avoidance rate.* The same term is used in both models however the parameter has a slightly different technical (quantitative) meaning in the two models. This is largely a consequence of the 2-D vs 3-D framework. This means that the numerical value of this parameter (which is expressed as a percentage) is different between the two models even though both models are modelling the same situation and produce similar results. It would help if a different name was used for this parameter for the two models to more clearly differentiate their different meanings.

Both models incorporate field study data on bird behaviour (particularly flight height distributions). The methodology for incorporating these data in the models is well explained, motivated and scientifically justified. The report incorporates a detailed comparison between the two models (Table 7).

Results, Discussion & Conclusions

Both models are run for each of the 13 species of birds and the results are presented and compared. This is an excellent modelling approach. Since each model uses different a methodology, one can can be used validate the other. From a scientific perspective, this is the main strength of the report engendering confidence in the results.

Results are presented for each species separately with a brief discussion to put the results for each species in context. The presentation here is accurate and comprehensive.

It is particularly noteworthy that both modelling approaches result in the same ranking of species in terms of risk. There is some differences in the estimated values of collision risk which is to be expected given the different methodologies and uncertainties around some parameters.

The conclusions in the report are supported by, and consistent with, the modelling results. The results have not been “over interpreted” and there is an appropriate level of caution recommended to the reader.

Conclusions

The work in this report is competently done. A particular strength is the use two methodologies for estimating collision risk.

The methods used are clearly described, motivated and appropriate for the study.

The survey of the relevant literature is thorough.

The presentation of the results is clear and the conclusions are well supported by the results.