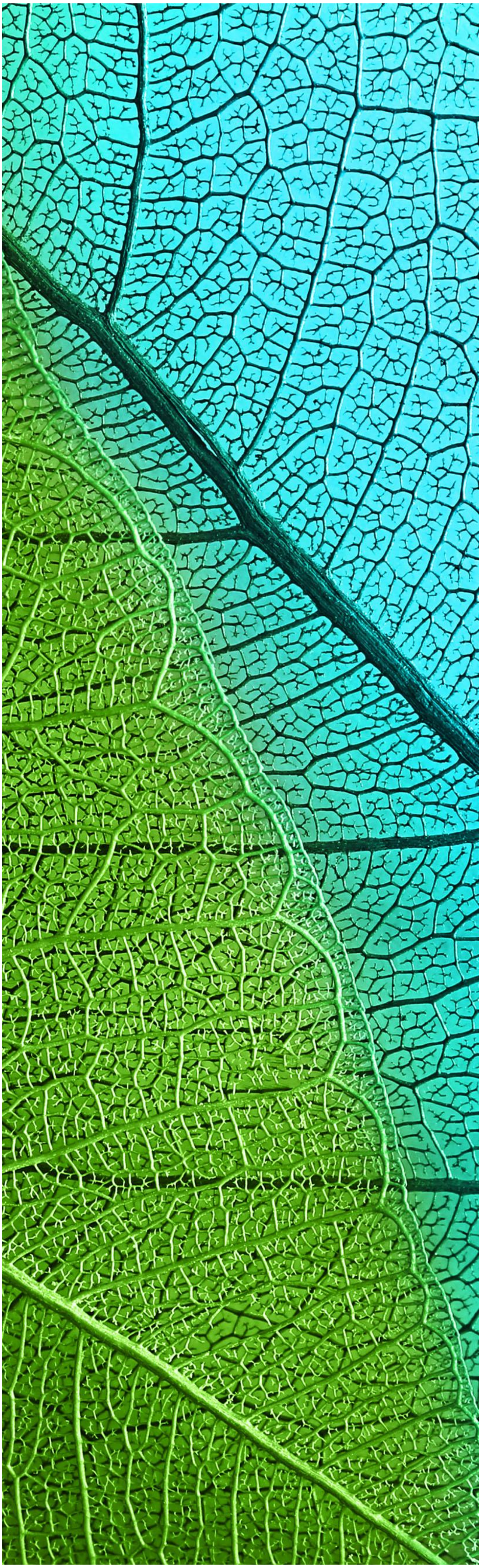

Hexham Wind Farm

Bat Assessment 2025

Prepared for
Hexham Wind Farm Pty Ltd

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

Contents

Tables

Figures

Glossary and acronyms

BAM Plan	Bat and Avifauna Management Plan
BUS	Bird Utilisation Survey
C'wth	Commonwealth
cm	Centimetre/s
CR	Critically Endangered
DCCEEW	Department of Climate Change, Energy, the Environment and Water (C'wth)
DEECA	Department of Energy, Environment and Climate Action (Vic)
DELWP	(former) Department of Environment, Land, Water and Planning (Vic)
DEWHA	(former) Department of the Environment, Water, Heritage and the Arts (C'wth)
EES	Environment Effects Statement under the *Environment Effects Act 1978*
EHP	Ecology and Heritage Partners
EN	Endangered
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (C'wth)
EX	Presumed extinct in the wild
FFG Act	Flora and Fauna Guarantee Act 1988 (Vic)
GLMM	Generalised Linear Mixed Model
GPS	Global Positioning System
GHFF	Grey-headed Flying-fox
HWF	Hexham Wind Farm
km	Kilometre/s
m	Metre/s
min	Minute/s
MNES	Matters of National Environmental Significance
RSA	Rotor Swept Area
RSH	Rotor Swept Height
SBWB	Southern Bent-wing Bat
TSSC	Threatened Species Scientific Committee
VBA	Victorian Biodiversity Atlas
VU	Vulnerable
YBSB	Yellow-belled Sheath-tail Bat

1. Executive summary

Hexham Wind Farm Pty Ltd engaged Nature Advisory Pty Ltd to conduct bat assessments of a 16,104-ha area of land in the Western Victorian localities of Hexham, Caramut, Ellerslie, Minjah and Woolsthorpe for the proposed Hexham Wind Farm (HWF). The wind farm site is bound by the Hamilton Highway to the north, the Woolsthorpe-Hexham and Hexham-Ballangeich roads to the east, Gordons Lane to the south and the Warrnambool-Caramut Road to the west. The proposed HWF site is referred to herein as the 'study area'.

The HWF proposal is to install up to 106 wind turbines, each comprising a tower, nacelle and blades with a maximum blade tip height of 260 m and a minimum blade tip height of 40 m. These parameters were adopted to allow a 'worst case' assessment of environmental and social impacts. The towers will be mounted on concrete foundations with adjacent hardstand areas. The turbines will be positioned with a high regard for landscape amenity, existing land use, ecological constraints and cultural heritage values, and in accordance with relevant planning policies and legislation.

The focus of this investigation was to generate baseline data documenting the spatial presence/absence and temporal activity of bat species, in particular the Southern Bent-wing Bat (SBWB; *Miniopterus orianae bassanii*; Critically Endangered EPBC Act and FFG Act) and Yellow-bellied Sheath-tailed Bat (YBSB; *Saccolaimus flaviventris*; Vulnerable FFG Act) across the study area.

In addition, targeted surveys were undertaken for Grey-headed Flying-fox (GHFF; *Pteropus poliocephalus*; EPBC Act Vulnerable, FFG Act Vulnerable) in February and March 2022, as well as in March 2023 as a temporary camp in a pine forestry plantation was located east of the wind farm site.

1.1. Bat detector survey results summary

- A total survey effort of 4,418 bat detector nights was undertaken at over 80 unique sites on the proposed HWF and its surrounds in various seasons over six years between 2010 and 2023. This included extensive recording at height from two wind monitoring masts.
- Calls from nine species of bats were recorded during these bat detector surveys. Seven of the bats recorded were common, widely distributed species that are not listed under State or Federal conservation legislation.
- Two species recorded were listed threatened bats; namely, the SBWB (EPBC Act Critically Endangered, FFG Act Critically Endangered) and YBSB (FFG Act Vulnerable).
- A further four multi-species complexes were recorded, including the SBWB-complex.
- The vast majority of bat activity was attributed to common and widespread species.
- Out of tens of thousands of recording files from the surveys, 218 were assigned to SBWB (i.e. SBWB-definite). There were 78 SBWB-definite calls recorded in Spring 2010, 15 in Autumn 2011, 5 in Summer 2018, 72 in Summer-Autumn 2019, 8 in Autumn 2020 and 40 in Autumn 2023.
- A further 2,244 calls were assigned to a species complex (i.e. SBWB-complex) that comprise echolocation calls with characteristics that could have been produced by SBWB, Little Forest Bat, or Chocolate Wattled Bat.

- The majority of SBWB-definite calls recorded during surveys from 2010 to 2023 were from treed and wetland habitats; specifically, along Mustons Creek and its treed habitats.
- Overall, SBWB activity (measured as calls per night) tended to be greater close to wetlands and wooded vegetation such as planted eucalypts and forestry plantations for confirmed SBWB calls. SBWB-complex calls, which include Little Forest Bat and Chocolate Wattled Bat calls, were mostly recorded from wooded vegetation such as remnant native woodland (roadside) vegetation, planted eucalypts as well as pine tree rows.
- The overall SBWB activity observed at sites within the boundary of the wind farm was 0.01 to 0.43 average calls per night. SBWB calls were recorded at 33 sites (25%) out of 128 sites. There was one site with 9.85 calls per night outside of the study area boundary.
- The presence of confirmed SBWB in different habitat features showed the highest proportion of sites surveyed with SBWB calls were forestry plantation, remnant trees and wetlands. However, it is noted for each of these categories there were small sample sizes with limited replication. A similar pattern was recorded for the species complex although there was a higher proportion of sites with the call complex in planted eucalyptus, pine tree rows and remnant trees.
- The occurrence of calls across habitat features shows considerable variability and that SBWB can utilise a range of habitats across the landscape. Some patterns observed are partially skewed due to small sample sizes for some habitat features such as remnant trees and forestry plantations and does not indicate a reliable and robust pattern of habitat use when visualising abundance and occurrence (presence/absence) of calls.
- Results of the met mast bat detector survey in the HWF study area showed that overall bat call activity was consistently greater closer to the ground than at height. Gould's Wattled Bat, White-striped Free-tailed Bat and YBSB were recorded at heights of 42 to 50 m above ground level. SBWB-definite or SBWB-complex calls were not recorded at these heights. It is noted that increased background noise, e.g. through wind, can interfere with a bat detector's ability to detect and record bat echolocation calls at height (see Appendix 1).
- Across the bat detector surveys conducted between 2010 and 2023, a total of 610 YBSB calls were recorded. Of these, 561 were in Spring 2010, while lower numbers were recorded in Spring 2018 (4 calls) and Summer-Autumn 2019 (10 calls). None were recorded during the Autumn 2023 survey.

1.2. Grey-headed Flying-fox survey results summary

- The Grey-headed Flying-fox (GHFF; EPBC Act Vulnerable, FFG Act Vulnerable) was recorded during targeted surveys in February and March 2022, as well as in March 2023 from a temporary camp in a pine forestry plantation located east of the study area. No flights towards the study area were observed during the targeted surveys in 2022 and 2023.
- Passive acoustic monitoring of the temporary camp found that GHFFs were highly active throughout March and early April 2023. Activity reduced after this time and the species was not detected during acoustic surveys after 12th April 2023, when the camp appeared to have left the area.
- During the development of the post-approvals Bat and Avifauna Management Plam (BAM Plan) for HWF, the Proponent will consult with DEECA on current, evidence-based industry best-practice monitoring methods and mitigating actions that could be employed to reduce impacts to flying-foxes.

1.3. Avoidance and mitigation

The proponent is developing proactive avoidance, minimisation and mitigation in consultation with DEECA and DCCEEW. This will require a multi-faceted approach that is embedded in the avoidance and mitigation hierarchy but also accounts for the known ecology and behaviour of both species, site features relating to available habitat and foraging opportunities, and the influence of weather and season on bat activity.

This approach includes a minimum rotor swept height (RSH) of 40 m AGL, avoidance of high quality SBWB habitat (creeks, wetlands, remnant native vegetation, forestry plantations) and areas with high SBWB calls, ranking of turbines into higher, moderate and lower risk to SBWB, and micro-siting key turbines to allow for a 269 m buffer (Figure 24).

Further mitigation, such as increasing nighttime low-windspeed cut in and blade feathering for moderate and higher risk turbines during October to April, and an adaptive management regime will be implemented.

1.4. Residual impacts

A comprehensive element of project design has been to selectively place wind turbines in areas that will minimise potential impacts with bats. This highly selective placement of turbines to avoid habitats most used by bats will minimise the likelihood of collisions with turbines. Therefore, no residual impacts are anticipated after implementation of avoidance and mitigation measures. Furthermore, a BAM Plan with specific triggers will be implemented to respond to impacts on these species if impacts are higher than anticipated.

2. Introduction

2.1. Background and scope

Bat utilisation surveys have been undertaken since 2010 to inform the assessment of the potential impacts the construction and operation of the proposed Hexham Wind Farm (HWF) may have on bat species.

To determine the presence of microbat species utilising the study area, particularly that of bat species listed under the EPBC Act and FFG Act, ultrasonic bat detectors were deployed for several weeks at a time in a wide variety of locations.

Surveys were undertaken on or near the proposed HWF site during Spring 2010, Summer-Autumn 2011, Spring 2018 and Summer-Autumn 2019, and for a final survey in Autumn 2023 that was designed to examine the specific habitats utilised by the Southern Bent-wing Bat (SBWB; *Miniopterus orianae bassanii*) and Yellow-Bellied Sheath-tailed Bat (YBSB; *Saccolaimus flaviventris*) across the study area. Recordings were undertaken at ground level and at heights of 50 m using a meteorological (i.e. wind monitoring) mast. The met mast bat detector survey aimed to detect bat flight heights to provide data on which species may be at risk of collision with operating wind turbines at HWF.

Targeted surveys were undertaken for Grey-headed Flying-fox (GHFF; *Pteropus poliocephalus*) in February and March 2022 and in March 2023 after the presence of a temporary camp was noted to the east of the wind farm site (see Section 6).

EES scoping requirements

The EES scoping requirements specify the following evaluation objective and key issues relevant to bat species that have guided this assessment:

To avoid, and where avoidance is not possible, minimise potential adverse effects on biodiversity values within and near the site including native vegetation, listed threatened species and ecological communities, and habitat for these species. Where relevant, offset requirements are to be addressed consistent with state and Commonwealth policies.

The key issues are outlined as the following:

- Direct loss or degradation of habitat for migratory or threatened flora and fauna listed under the EPBC Act and/or the FFG Act.
- Disturbance and/or degradation of adjacent or nearby habitat that may support listed threatened or migratory species or other protected flora, fauna or ecological communities
- Disturbance and increased mortality risk to flora and fauna species listed under the EPBC Act and/or FFG Act.
- Indirect habitat loss or degradation resulting from other effects, such as edge effects, surface hydrological changes, groundwater drawdown, noise, vibration, light or the introduction of weeds/ pathogens.
- Disruption to the movement of fauna between areas of habitat across the broader landscape, including between roosting, breeding and potential foraging sites for the Southern Bent-wing Bat and Grey-headed Flying-fox.
- Potential collision risk for protected bird and bat species with project infrastructure, including with wind turbine blades.

- Potential cumulative effects on relevant listed threatened and migratory species and communities of flora and/or fauna, in particular, but not limited to, Southern Bent-wing Bat and Grey-headed Flying-fox from the project in combination with the construction and operations of other energy facilities.

2.2. Report outline

This report is divided into the following sections.

Section 3 provides a background to the proposed wind farm development.

Section 4 provides information on regulatory requirements.

Section 5 describes the bat detector survey methods used.

Section 6 describes the Grey-headed Flying-fox survey methods.

Section 7 presents and discusses the bat detector results.

Section 8 presents and discusses the Grey-headed Flying-fox results.

Section 9 provides an assessment of threatened bat species recorded.

Section 10 outlines the proposed avoidance and mitigations measures for HWF.

This report was prepared by a team from Nature Advisory comprising Dr Steve Griffiths (Senior Ecologist), Dr Danielle Eastick (Senior Zoologist), Oli Aylen (Senior Ecologist), Curtis Doughty (Senior Zoologist), Kylie Patrick (Senior Ecologist and Project Manager), Maya Zaeim (GIS Analyst) and Dr Inga Kulik (Project Director).

3. Overview

3.1. Site description

3.1.1. Location

The proposed HWF comprises 16,104 ha of land in the Western Victorian localities of Hexham, Caramut, Ellerslie, Minjah and Woolsthorpe, approximately 20 kms west of Mortlake and 200 kms west of Melbourne's CBD. The wind farm site is bound by the Hamilton Highway to the north, the Woolsthorpe-Hexham and Hexham-Ballangeich roads to the east, Gordons Lane to the south and the Warrnambool-Caramut Road to the west. The proposed HWF site is referred to herein as the 'study area'.

3.1.2. Geology and Hydrology

The study area supported basaltic soils derived from newer volcanic flows, with alluvium associated with watercourses. The landscape was gently undulating with a number of permanent watercourses, the most major of which is Mustons Creek in the northern portion of the site, which flows into the Hopkins River to the east of the study area, and Drysdale Creek in the south, which continues to the coast near Warrnambool. Numerous tributaries (many unnamed) of Mustons and Drysdale creeks occur within the study area. Outside of the study area to the east, Salt Creek branches off the Hopkins River between the two pine plantations.

3.1.3. Land-use history

Most of the study area has been used for sheep and cattle farming for over 150 years. The site has been subject to extensive removal of native vegetation in the past. Fertiliser has been extensively applied for many years on the site and, in places, the site has been cultivated for pasture improvement and cropping.

3.1.4. Vegetation

The study area and surrounding land supports agriculture, including dryland cropping and sheep and cattle grazing, with a relatively low density of associated residences. Widespread historical clearing of the study area and surrounds for agriculture has resulted in native vegetation being largely restricted to roadside reserves and watercourses. Numerous windbreaks have been planted on the edge of paddocks consisting of eucalypt species or pines and cypresses. Some of these include native species.

Within private property native vegetation comprised small patches of species depauperate grassland, wetland and woodland along the edges of farm tracks, in lower-lying areas in pasture and along watercourses. Most (if not all) woody vegetation had been removed in these patches. Patches of native vegetation along roadsides included grassland and woodland, which lacked canopy species but did support some woody species (primarily wattles, including Black Wattle and Blackwood). The highest quality native vegetation was found along the wide road reserve of the Hexham-Ballangeich Road.

3.1.5. Fauna habitat

The majority of the study area has been highly modified by past and on-going agricultural practices. Most private properties have been cleared of original native vegetation in favour of grazing and cropping lands and associated planted wind rows.

Native vegetation is primarily restricted to roadsides, waterways and wetland areas. Many of these are also highly modified and contain a high abundance of invasive species vegetation.

The below habitat assessment is based on Nature Advisory field visits described in this report and extrapolated from EHP (2014).

The investigation area supported seven general fauna habitat types described below.

Modified Native Grasslands

Native grasslands occurred in various forms throughout the study area, such as: grasslands of moderate to high quality in patches along roadsides and farming tracks; in remnant patches within grazing lands; in some native woodland windbreak areas where agricultural practices are limited and disturbance does not occur as frequently; and in wetland areas of riparian vegetation or swamps/marches.

These grasslands varied greatly in habitat quality and structure between sites, depending on the ecosystems they existed in and the level of disturbance and modification they experience. These grasslands may provide habitat to some grassland specialists and foraging opportunities to other fauna.

Modified Woodland and scattered trees

Modified woodland patches are scattered throughout the study area and generally support highly modified understoreys for agricultural purposes. They consist typically of open woodlands with trees approximately 20 m tall. These areas occur along roadsides, riparian zones and in patches within agricultural areas. They support limited connectivity but provide an important source of habitat in an otherwise highly modified landscape,

Scattered River Red Gum (*Eucalyptus camaldulensis*) also occur throughout the study area providing limited habitat and foraging opportunities. Many of these provide hollows, an essential habitat component of many bat species, and there is a lack of artificial roosting in the area, such as bridge culverts and old farm structures. As a precautionary measure, it was assumed that all treed habitat within and adjacent to the proposed study area had the potential to have roosting habitat for hollow-roosting bats.

Planted vegetation

Linear windbreaks have been planted throughout the study area, typically bordering paddocks intended for agricultural purposes. These consist of a mix of native tree species, some endemic to the area and others not (mostly Sugar Gums), and non-native species (mostly cypresses and pine trees). Though these typically lack the ecological structure required for high quality habitat, such as understorey and mid-storey or hollows, they provide some shelter and foraging opportunities for bird and microbat species.

Rivers, creek and drainage lines

Waterways occurred throughout the study area. Major waterways include Hopkins River, Mustons Creek and Salt Creek while minor waterways occurred throughout private property consisting of small highly modified drainage lines serving to drain water from naturally occurring wetlands and depressions.

Some of these areas would hold water year-round while other may be ephemeral. They support limited and modified wetland and riparian vegetation but could provide essential habitat for some fauna species, such as water birds, microbats and aquatic species.

Swamps and marshes

These habitats are of moderate value to fauna where they still exist, particularly as much of the original comparable habitat has been modified or drained. Typically lacking floristic diversity, but the hydrology of the habitat still supports many fauna species. Characterised by the growth of sedges and rushes, and the low-lying areas are typically inundated during the wetter months. These areas are mostly grazed when possible.

Artificial waterbodies

A large number of dams occur throughout private property across the study area, supplying water for stock and agricultural purposes. As such many of these lack vegetation, are highly impacted by frequent stock utilisations and therefore provide low quality habitat for native fauna. However, some provide limited fringing and emergent vegetation and are likely to be utilised by microbat species as foraging and drinking resources. Most of the farm dams within the study area are surrounded by agricultural land and lack connectivity with other habitats.

Exotic pasture and crops

This habitat is largely grazed for farming purposes and provides little habitat or shelter for fauna. This habitat covers much of the study area and consists mostly of pasture grass and cereal crops.

3.1.6. Bat habitat

General key bat habitat features include remnant native woodland, scattered trees, planted tree rows, pine plantations and wetlands and waterways, which are described in Section 3.1.5 and displayed in Figure 2. Threatened species habitat is discussed in more detail below.

Grey-headed Flying-fox (GHFF)

The GHFF feeds primarily of blossoms and fruit in canopy vegetation, and supplements this diet with leaves (Eby, 1995; Hall and Richards, 2000). The major food plants include blossoms of *Eucalyptus*, *Corymbia* and *Angophora* species, melaleucas and banksias (Eby and Law 2008). GHFF movement patterns across the landscape are often dictated by the flowering of different feed species.

A temporary GHFF camp was observed in the pine plantation to the east of the study area (Figure 5), and there are GHFF camps in Warrnambool (permanent; 30 km away), Lismore (new; 55 km away) and Colac (temporary; 85 km away). The pine plantations are the largest treed patches in the vicinity of HWF, however there are narrow patches of remnant woodland and planted eucalypts within HWF. Therefore, there is the potential for GHFF to forage in any flowering eucalypts across the HWF study area.

Southern Bent-winged Bat (SBWB)

SBWB is a nocturnal, aerial hawking insectivorous species with a fast, direct flight pattern (Dwyer, 1965). Where there are trees, SBWBs typically forage in open spaces above the canopy, but can fly closer to the ground in more open areas (Churchill, 2008; Threatened Species Scientific Committee, 2021). Limited radio-tracking studies have shown that SBWBs hunt in a range of habitat types, forested areas, native remnant vegetation, and over cleared agricultural and grazing land (Grant, 2004; Stratman, 2005; Threatened Species Scientific Committee, 2021). SBWB also show a preference for seasonally inundated wetlands (Stratman, 2005). DELWP (2020) state that wetlands with terrestrial vegetation occurring around the fringes and aquatic vegetation within the swamp itself are used extensively, with individuals recorded flying considerable distances from roost caves to reach these foraging areas.

Habitat at HWF which is of higher quality for SBWB includes woodland and wetland areas, rivers and creeks with permanent water sources, and native and planted tree rows which connect to these higher quality areas. The location of nearby SBWB roost caves in proximity to HWF are displayed in Figure 21.

More information on the SBWB foraging behaviour and habitat usage can be found in Section 9.1.2.

Yellow-bellied Sheath-tailed Bat (YBSB)

The YBSB is a wide-ranging species present through tropical and sub-tropical Australia. The species occurs in a wide range of habitats from wet and dry sclerophyll forests to open woodlands. It usually roosts in large tree hollows but sometimes uses buildings (Churchill, 2008; Menkhorst, 1995; NSW Office of Environment and Heritage, 2021). The YBSB is a large (mean body weight = 44 g), open-space adapted species that flies high and fast above the canopy, but has been observed flying lower over open spaces and at the forest edge (Churchill, 2008). It is therefore possible that the YBSB would potentially use all habitat types within the HWF landscape.

More information on the YBSB foraging behaviour and habitat usage can be found in Section 9.2.1.

3.2. Proposed development

HWF proposes to install up to 106 wind turbines, which is reduced from the 109 wind turbines originally proposed in the draft scoping requirements. Each wind turbine will comprise a tower, nacelle and blades with a maximum blade tip height of 260 m and minimum blade tip height of 40 m. The maximum and minimum parameters above have been adopted, allowing a 'worst case' assessment of environmental and social impacts.

Table 1 summarises the planned project infrastructure and associated current design on which this investigation has been based.

Table 1: Specifications for the proposed wind turbines

Number of turbines	Up to 106
Proposed **hub height** (m)	150
Maximum rotor radius (m)	95 (rotor diameter 190)
Minimum rotor swept height (m)	40
Maximum rotor swept height (m)	260

4. Regulatory context

This section presents the relevant Commonwealth and State legislation, policy and guidelines relating to the protection of biodiversity during the planning, construction and operation of wind farm facilities.

4.1. Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC Act)

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) protects a range of Matters of National Environmental Significance (MNES) and matters protected by international treaties. These matters include a list of threatened species, ecological communities and migratory species that are matters of national environmental significance. Any impact on such matters that is considered significant requires the approval of the Commonwealth Minister for the Environment.

Two bat species listed under the EPBC Act are present in the HWF study area:

- Southern Bent-wing Bat (SBWB) - Critically Endangered
- Grey-headed Flying Fox (GHFF) - Vulnerable

A number of specific EPBC Act guidelines and associated species-specific documents have been consulted and directions from these applied during surveys and in formulating the investigations of fauna impacts described in this report. These include:

- Matters of National Environmental Significance - Significant Impact Guidelines 1.1 (Department of the Environment, 2013).
- Onshore wind farm guidance - best practice approaches when seeking approval under Australia's national environment law (Department of Climate Change, Energy, the Environment and Water, Canberra, 2024).
- Survey Guidelines for Australia's Threatened Bats: Guidelines for Detecting Bats Listed as Threatened Under the Environment Protection and Biodiversity Conservation Act 1999 (Department of the Environment, Water, Heritage and the Arts, 2010).
- Department of Environment, Land, Water and Planning, 2020. National Recovery Plan for the Southern Bent-wing Bat *Miniopterus orianae bassanii*. Victorian Government, Melbourne (Department of Environment, Land, Water and Planning, 2020).
- Threatened Species Scientific Committee, 2021. *Miniopterus orianae bassanii* (Southern Bent-wing Bat) Conservation Advice (Threatened Species Scientific Committee, 2021).
- Southern Bent-wing Bat National Recovery Team (SBWBRT) Annual Progress Report 2021 (Southern Bent-wing Bat National Recovery Team, 2021).
- SBWBRT Annual Progress Report 2022 (Southern Bent-wing Bat National Recovery Team, 2022).

4.2. Flora and Fauna Guarantee Act 1988

The Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) lists threatened and protected species and ecological communities (Department of Energy, Environment and Climate Action, 2023a; Department of Environment, Land, Water and Plan, 2019). The Environment Effects Statement (EES) process in Victoria requires that impacts on FFG Act listed species be assessed, even on private land.

Three bat species listed under the FFG Act are present, or can potentially be present in the HWF study area:

- SBWB – Critically Endangered.
- Yellow-bellied Sheath-tail Bat (YBSB) – Vulnerable.
- Grey-headed Flying-fox (GHFF) – Vulnerable.

SBWB Action Statement

The SBWB Action Statement under the FFG Act (Department of Energy, Environment and Climate Action, 2023b), guides the consideration of SBWB and is implemented alongside the FFG Act strategy *Protecting Victoria's Environment – Biodiversity 2037*.

4.3. Other Guidelines

In addition to the foregoing policy and legislative instruments, a number of wind farm specific guidelines have been consulted and key directions from these applied in formulating the investigations of potential impacts to fauna described in this report. These include:

- Guidelines for Bat Surveys in Relation to Wind Farm Developments (Lumsden, 2007).
- Best Practice Guidelines for Implementation of Wind Energy Projects in Australia (Clean Energy Council, 2018).
- Policy and Planning Guidelines - Development of Wind Energy Facilities in Victoria (Department of Environment, Land, Water and Planning, 2021).

DEECA's *Handbook for the development of renewable energy in Victoria* (2025) was released in May 2025. Under the transitional arrangements in the *Handbook*, a proponent will not be expected to apply the Handbook to their project if an assessment under the Environment Effects Act has already commenced for the project. Therefore, the *Handbook* has not been applied to this project.

5. Bat detector survey methods

Best-practice survey techniques were deployed to detect which bat species occur across the study area. Ultrasonic detectors that passively detect and record echolocation calls emitted by free-flying insectivorous bat species were deployed to identify, through expert opinion, the species occurring at the proposed site.

Ultrasonic bat detectors were deployed at HWF across six survey periods. Table 2 outlines the survey effort for each survey period.

Table 2: Date ranges, number of bat detector nights and sites for each survey period

Survey Period	No. of nights	No. of sites	Total bat detector nights
Spring 2010 21 Oct – 23 Nov	7–21	36	298
Summer–Autumn 2011 10 Feb – 31 Mar	7–66	18	413
Spring 2018 25 Oct – 18 Dec	14–53	19	438
Summer–Autumn 2019 5 Feb – 25 Apr	7–79	23	1462
Summer–Autumn 2020 18 Feb – 1 May	92–94	10	930
Autumn 2023 1 March – 2 May	18–61	21	877
Total			4418

5.1. Assumptions and limitations

Acoustic bat surveys have a number of potential limitations. These include:

Detecting capabilities and technical difficulties

- **Technical difficulties** – can result in variation in the number of nights and total hours of recording between the different detectors deployed during a survey. To account for this, the number of calls per night was calculated for each detector location.
- **Detecting capabilities** – bat detectors are only capable of detecting echolocation calls that arrive at the microphone above a critical sound pressure level and at a sufficiently high signal-to-noise ratio. This means that, for an echolocation call to be recorded by a bat detector, it must be louder than background or ambient noise. Furthermore, call data collected is from only a small fraction of the entire three-dimensional airspace in which the turbines will operate. This limitation was taken into consideration when assessing the impacts to bats and designing the avoidance and mitigation hierarchy.
- **Zone of detection** – echolocation calls produced by bats attenuate (reduce in amplitude) as they travel through air, with higher frequency calls attenuating faster than lower frequency calls. This limitation was taken into consideration when assessing the impacts to bats and designing the avoidance and mitigation hierarchy.

Survey variation

- **Survey variation** - There are variables when collecting field data, including variation in the way the detectors are installed, environmental/seasonal conditions, methodology, survey purposes, locations data was collected, personnel collecting the data.
- **Consultant variation** – due to development in survey techniques and surveys being undertaken by different consultancies, the current study contained variation in methodologies. This may influence results as comparison across survey periods has limitations.

An increased survey effort was undertaken by Nature Advisory to counteract for variation in surveys.

Bat behaviour and call characteristics

- **Bat activity levels across weather conditions** – bat activity levels within and between nights may vary in response to weather variables such as air temperature, relative humidity, barometric pressure, wind speed, direction and gusts, and rain. Nature Advisory undertook bat activity weather analysis (see Section 5.8) to better understand these patterns, and used these findings to underpin the avoidance and mitigation process.
- **Overlap in species-specific call characteristics** – calls produced by one bat species may at times closely resemble those of other species. The considerable variability in calls produced by free-flying echolocating bats often makes it difficult, or sometimes impossible, to assign species-level identifications to passively recorded calls. Therefore, all calls that cannot be reliably identified to species level are placed into a call complex. For the purposes of this assessment, all calls within a call complex which contained a threatened species were assumed to possibly be from that threatened species.
- **Relative activity vs abundance** – passively collected echolocation call data cannot be used to quantify numbers of bats present in a given area. Therefore, it is not possible to determine population numbers (abundance), but rather only a measure of relative activity (e.g., calls per night per site).

Potential limitations associated with bat detector surveys and the inferences that can be made from passively recorded echolocation data are described in more detail in Appendix 1.

5.2. Spring 2010 and Autumn 2011 surveys

The 2010-2011 surveys were undertaken at the proposed HWF by Ecology and Heritage Partners (EHP) during October – November (Spring) 2010 and February – March (Autumn) 2011 (Ecology and Heritage Partners, 2014). Detector locations were based on a previous project boundary which has now been superseded; the previous boundary therefore included areas outside of the current HWF project boundary. Anabat bat detectors (Titley Scientific, Queensland) were placed at 32 sites (26 inside and six outside the final HWF boundary) during the Spring 2010 survey and at 15 sites (13 inside and two outside the final boundary) during the Autumn 2011 survey (Figure 1).

The timing of the surveys was chosen to coincide with the Spring and Autumn periods when SBWBs are actively moving across the landscape when leaving from or returning to maternity caves (Ecology and Heritage Partners, 2014). The survey mythology followed that recommended in the *Guidelines for Bat Surveys in Relation to Wind Farm Developments* (Lumsden, 2007). A more detailed description of methodology and survey locations for the 2010-2011 surveys is presented in EHP (2014). Surveys consisted of detector deployed at ground level and one set of paired detectors mounted on the meteorological mast, with a microphone at ground level and at 42 m. These paired detectors were deployed for 5 weeks in spring and 5 weeks in autumn.

Ground detectors were placed in a range of habitat types, including proximate to windrows or remnant trees, dams, watercourses and ridge tops. Open paddock areas were not chosen as EHP determined bat activity in these areas was likely to be low. Sampling sites were spread across the study area, with as many detectors as possible located in the western sections[1]. Detectors were moved weekly during the October – November (spring) sampling period across 32 different locations, and weekly to fortnightly during the February–March sampling period across 15 locations. A total of 559 bat detector nights were undertaken.

The location of maternity and roosting camps relative the HWF site is also presented in EHP (2014; Figure 6b), and in section 9.1.3, Table 19 and Figure 22 of this report.

1 The focus on surveying in the western sections was not clarified in the EHP report.

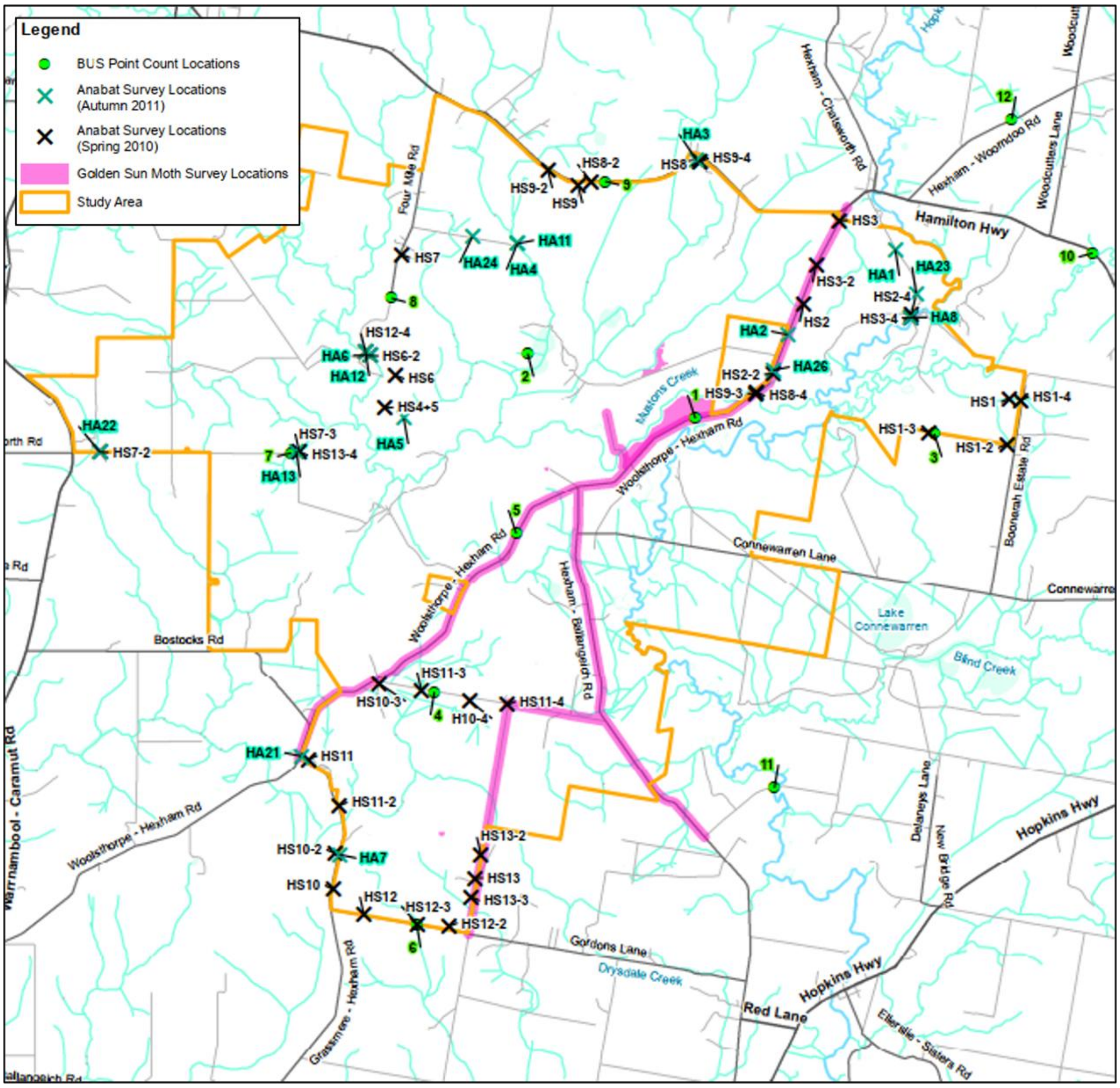

Figure 1: Bat survey sites 2010 – 2011 (source: Ecology and Heritage Partners, 2014).

Note – BUS refers to the Bird Utilisation Surveys (BUS) completed by EHP. Site HA10 is missing from the map and all future mapping as the location is unknown by Nature Advisory.

5.3. Spring 2018, Summer–Autumn 2019, Summer–Autumn 2020 surveys

In a meeting with DEECA Environment (Barwon, SW), an increased survey effort was recommended and subsequently undertaken in Spring (October – November) 2018, Summer – Autumn (February – April) 2019, Summer – Autumn (February – May) 2020, and in Autumn (March – May) 2023 (refer Section 5.3 for Autumn 2023 surveys). This reflected current and evolving best practice survey methodology based on the Survey Guidelines for Australia's Threatened Bats (DEWHA 2010) and on recent advice provided to Nature Advisory by DEECA for pre-commissioning bat detector surveys at other proposed wind farm sites located in south-west Victoria. Surveys conducted during 2019 – 2020 were designed to build upon the previous survey efforts undertaken a decade prior (Ecology and Heritage Partners, 2014). The 2023 survey was designed specifically for the threatened SBWB and sought to target a wider range of areas and habitats across the study area, as opposed to only suitable habitats where, for example, threatened species may occur. This approach aimed to gain a more comprehensive understanding of habitats used by SBWB across the study area.

During the 2018–2020 surveys undertaken by Nature Advisory, Song Meter SM4BAT-ZC and Song Meter SM2+ detectors were used to passively record bat echolocation calls. Detectors were placed approximately 1–2 m above the ground for ground level surveys. Detectors were programmed to commence operation approximately 30 minutes before dusk, and to cease approximately 30 minutes after dawn. Each detector saved bat echolocation call data onto a 64GB SDHC memory card, along with the date and time of each call. Batteries and memory cards were changed in each detector at approximate monthly intervals to maintain consistent recordings.

A habitat description was recorded for each site where a detector was deployed for all Nature Advisory surveys. Table 3 and Table 4 below present the habitat descriptions and the proximity of the detectors to treed habitat and permanent waterbodies for the Spring 2018 and Summer-Autumn 2019 survey periods. Locations of survey sites are shown in Figure 2.

The Summer–Autumn 2020 surveys entailed a more specific approach to understanding how threatened species' habitat preferences may have influenced their presence across the study area. Survey aims and methods are described in more in detail separately in Section 7.4 (height analysis) and Section 7.5 (bat activity across a gradient from wetlands).

Table 3: Habitat descriptions of bat detector survey sites during Spring 2018

Site	Habitat Feature	General habitat description (within 30 metres)	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
HX1	Cleared open land (non-treed)	Open paddocks, scattered planted trees, farm dam	25/10 – 8/11/18	14	10	40
HX2	Remnant native woodland	Scattered remnant and scattered trees, open paddocks	25/10 – 8/11/18	14	20	830
HX3	Cleared open land (non-treed)	Eucalypt windbreak (Sugar Gums), open paddocks	25/10 – 8/11/18	14	30	670
HX4	Likely planted tree	Open paddocks, small patch of acacia.	25/10 – 8/11/18	14	250	1100

Site	Habitat Feature	General habitat description (within 30 metres)	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
HX5	Cleared open land (non-treed)	Pine windbreak, open paddocks	25/10 – 8/11/18	14	50	720
HX6	Cleared open land (non-treed)	Mustons Creek line, riparian woodland, open paddocks	25/10 – 8/11/18	14	200	20
HX7 - air	Cleared open land (non-treed)	Open paddocks	25/10 – 17/12/18	53	500	380
HX7 - ground	Cleared open land (non-treed)	Open paddocks	25/10 – 17/12/18	53	500	380
HX8	Planted eucalypts	Eucalypt windbreak, open paddocks	9/11 – 26/11/18	21	0	400
HX9	Remnant native woodland	Eucalypt woodland, open paddocks	9/11 – 26/11/18	21	0	340
HX10	Planted eucalypts	Eucalypt windbreak, open paddocks	9/11 – 26/11/18	21	0	1020
HX11	Planted eucalypts	Small Eucalypt windbreak, open paddocks	9/11 – 26/11/18	21	0	650
HX12	Remnant native woodland	Large dry wetland/creek line, wind row, open paddocks	9/11 – 26/11/18	21	10	900
HX13	Forestry plantation	Open woodland, farm dam, open paddocks	9/11 – 26/11/18	21	0	100
HX14	Cleared open land (non-treed)	Dry creek, open woodland, open paddocks	27/11 – 17/12/18	20	30	1040
HX15	Cleared open land (non-treed)	Open paddocks	27/11 – 17/12/18	20	80	1200
HX16	Forestry plantation	Scattered trees, open paddocks	27/11 – 17/12/18	20	0	350
HX17	Planted eucalypts	Eucalypt windbreak, open paddocks	27/11 – 17/12/18	20	0	250
HX18	Planted eucalypts	Eucalypt windbreak, open paddocks	27/11 – 18/12/18	21	0	520
HX19	Cleared open land (non-treed)	Open paddocks, scattered trees	27/11 – 18/12/18	21	80	290

Table 4: Habitat descriptions of bat detector survey sites during Autumn 2019

Site	Habitat Feature	General habitat description (within 30 m)	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
HS1	Creek	Open paddock, scattered trees, creek line w/large pools	5/2 – 25/4/19	79	300	0
HS2	Planted eucalypts	Very large dam, scattered trees, open paddock	5/2 – 25/4/19	79	0	30
HS4	Planted eucalypts	Farm dam, treed habitat, open paddock	5/2 – 24/4/19	78	0	20
HS5	Farm dam	Farm dam, open paddocks	5/2 – 25/4/19	79	80	0
HS6	Remnant native woodland	Scattered remnant and scattered trees, open paddocks	5/2 – 24/4/19	78	20	820
[1]HS7 - ground	Cleared open land (non-treed)	Open paddocks	8/2 – 25/4/19	53	460	440
[1]HS7 - 50m	Cleared open land (non-treed)	Open paddocks	8/2 – 25/4/19	53	460	440
HS8	Large scattered tree	Large old tree, open paddocks	28/2 – 28/4/19	59	70	60
HS9	Remnant native woodland	Large dry wetland/creek line, windbreak, open paddocks	28/2 – 27/4/19	58	0	900
[1]HS10	Planted eucalypts	Windbreak, open paddocks	28/2 – 27/4/19	7	0	1200
HS11	Planted eucalypts	Dry creek, open woodland, open paddocks	28/2 – 27/4/19	58	10	1040
HS12	Planted eucalypts	Scattered trees, open paddocks	28/2 – 27/4/19	58	0	360
HS13	Cleared open land (non-treed)	Large old tree, open paddocks	1/3 – 29/4/19	59	300	530
HS14	Planted eucalypts	Windbreak (Sugar Gums), open paddocks	1/3 – 29/4/19	59	0	470
HS15	Planted tree	Open paddocks, small patch of acacia.	1/3 – 29/4/19	59	180	1120
HS16	Pine tree row	Pine and acacia windbreak, open paddocks	1/3 – 29/4/19	59	0	240
HS17	Planted eucalypts	Acacia windbreak, open paddocks	1/3 – 29/4/19	59	0	1100

Site	Habitat Feature	General habitat description (within 30 m)	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
HS18	Cleared open land (non-treed)	Open paddocks	1/3 – 28/4/19	58	550	1100
HS19	Planted eucalypts	Open woodland, farm dam, open paddocks	1/3 – 29/4/19	59	0	90
[2]HG1	Cleared open land (non-treed)	On a fence running parallel to northern section of large lake	28/2 – 27/4/19	58	140	50
[2]HG2	Cleared open land (non-treed)	On a fence running parallel to northern section of large lake	28/2 – 27/4/19	58	170	100
[2]HG3	Cleared open land (non-treed)	On a fence running parallel to northern section of large lake	28/2 – 27/4/19	58	210	160
[2]HG4	Cleared open land (non-treed)	On a fence running parallel to northern section of large lake	28/2 – 27/4/19	58	250	210

[1] Not surveyed for the whole period.

[2] Four detectors were placed in 60 m intervals perpendicular from a lake in a preliminary test of a gradient study (see section 7.5).

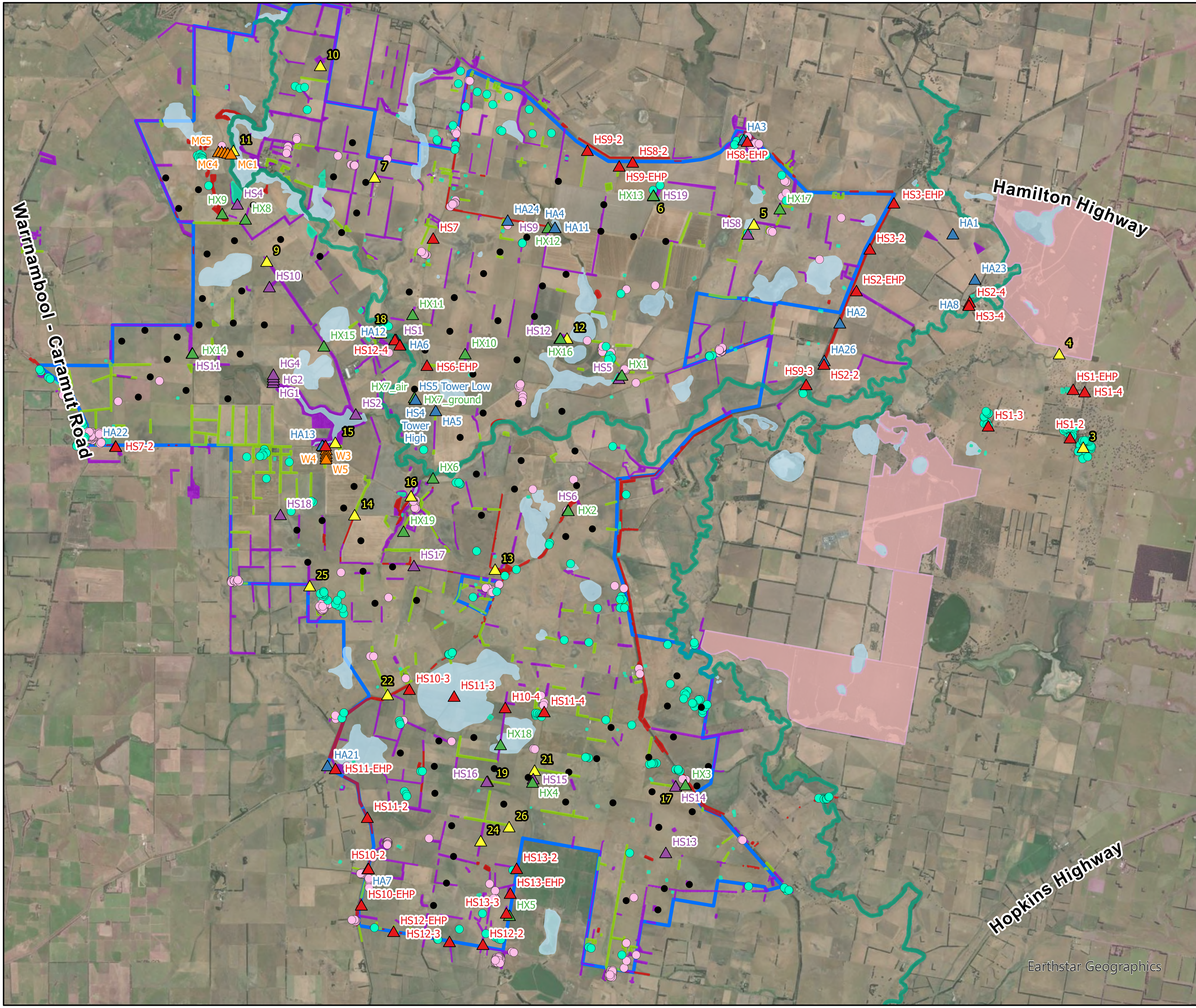

Figure 2: Bat detectors locations and habitat

Project No: 18088.10
Project: Hexham Wind Farm
Date: 11/06/2025

- Wind farm boundary
- Turbine

Bat survey

- Spring 2010
- Autumn 2011
- Spring 2018
- Autumn 2019
- Autumn 2020
- Autumn 2023

Habitat features

- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland
- Planted tree
- Remnant tree

N

Kilometres
0 1 2 3 4
GDA2020 MGA Zone 54

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5.4. Autumn 2023 survey

The Autumn 2023 survey was undertaken by Nature Advisory using Song Meter Mini-bat detectors (Wildlife Acoustics, USA). The timing of the survey was chosen to coincide with the Autumn period when SBWBs are more actively foraging in the landscape and moving across the landscape between maternity and non-maternity caves (Threatened Species Scientific Committee, 2021).

Methods used for the set up and maintenance of the recordings were the same as those described in Section 5.3. Table 5 presents the habitat descriptions at each site where a bat detector was deployed and the proximity of the sites to treed habitat and permanent waterbodies, in addition to deployment dates. Locations of surveys sites are shown in Figure 2.

During the Autumn 2023 survey, 20 sites were sampled. Several of the sites were at locations used during previous bat detector surveys, while some were new locations used to provide a more comprehensive spatial replication across of the wind farm site (Table 5 and Figure 2). The inconsistent detector nights are related to minor variations in employment dates and the functionality of the devices (e.g. battery failure).

Table 5: Habitat descriptions of bat detector sites and survey dates during Autumn 2023

Site ID	Habitat Feature	Habitat description	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
03	Planted eucalypts	Sheep paddock, lots of large old hollow-bearing eucalypts. Detector located about 50m from a farm dam. 69 SBWB calls in 2010 survey.	1/03 - 1/05/23	58	0	100
04	Forestry plantation	Next to the forestry plantation.	1/3 – 2/4/23	34	0	730
05	Wetland	Large farm dam near eucalypt windbreak, surrounded by sheep paddocks.	1/03 - 1/05/23	59	10	0
06	Planted eucalypts	Patch of mixed eucalypt (mostly sugar gum) and pine scattered paddock trees, surrounded by sheep paddocks, about 100m from a farm dam.	1/03 – 2/04/23	32	0	90
07	Planted eucalypts	Eucalypt windbreak surrounded by sheep paddocks.	1/03 – 2/04/23	32	0	960
09	Planted eucalypts	Eucalypt windbreak surrounded by sheep paddocks, about 100m from previous survey site HS10.	1/03 – 2/04/23	32	0	1150
10	Planted eucalypts	Patch of eucalypt (mostly sugar gum), surrounded by sheep paddocks, also a large farm shed.	1/03 - 1/05/23	60	0	900

Site ID	Habitat Feature	Habitat description	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
11	Creek	Permanent pool along Mustons Creek, revegetated riparian zone, lots of aquatic vegetation around edge of pool.	1/03 - 1/05/23	58	140	0
12	Planted eucalypts	Patch of sparse scattered sugar gums, small rubbish tip.	1/03 - 1/05/23	59	0	280
13	Planted eucalypts	Patch of sugar gum surrounded by sheep paddocks, about 100m from a farmhouse.	1/03 – 2/04/23	32	0	220
14	Pine tree row	Pine windbreak surrounded by sheep and cow paddocks.	1/03 – 2/04/23	32	0	970
15	Wetland	Large wetland/lake. Looks like riparian zone has been revegetated, fenced off from cattle.	2/03 – 2/05/23	61	10	0
16	Wetland	Wetland near farmhouse and agricultural buildings. Several permanent pools fed by a tributary off Mustons Creek, looks like riparian zone has been revegetated, fenced off from cattle.	2/03 – 2/05/23	58	80	0
17	Planted eucalypts	Eucalypt windbreak surrounded by cow paddocks. Also, a Pine Windbreak nearby.	2/03 – 2/05/23	58	0	470
18	Creek	Mustons Creek, lots of aquatic vegetation around edges	7/03 – 2/05/23	55	180	0
19	Pine tree row	Pine windbreak surrounded by stock paddocks. Mounted on fence line	6/04 – 2/05/23	26	0	250
21	Pine tree row	Mounted on fence line on western side of Cooramook Lane, 20m from end of Windbreak. Accessed via paddock on western side of lane, as lane not accessible	6/04 – 2/05/23	26	0	1200
22	Pine tree row	End of windbreak in Woolsthorpe-Hexham Road reserve, surrounded by stock paddocks	6/04 – 2/05/23	18	0	540

Site ID	Habitat Feature	Habitat description	Survey period	Detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
24	Planted eucalypts	Mixed *Eucalyptus* Wattle planted windbreak surrounded by stock paddocks. Mounted on fence line	6/04 – 2/05/23	26	0	980
25	Planted eucalypts	Mixed *Eucalyptus* Wattle planted windbreak surrounded by stock paddocks. Mounted on fence line	6/04 – 2/05/23	26	0	310
26	Pine tree row	End of pine windbreak, surrounded by stock paddocks. Mounted on fence line	6/04 – 2/05/23	26	0	920

5.5. Echolocation call identification

5.5.1. Data processing: 2010–2020 survey data

Calls from the bat detectors were downloaded and sent to Rob Gration (Ecoaerial Ecological Services, Newport, Victoria) for identification. The files recorded were first filtered with Anabat Insight software (Titley Scientific, Australia) to exclude those containing only background noise (e.g., wind, rain, insects). The remaining files containing bat calls were then scanned in Insight using Decision Trees to group call sequences based on a combination of pulse characteristics, such as characteristic frequency (Fc), time between calls and pulse curvature. These pulse characteristics were then used to assign each call to a microbat species by comparing the derived metrics and visually comparing call spectrograms (frequency versus time graphs) with those of regionally relevant reference calls and/or with published call descriptions (e.g., Reinhold *et al*. 2001; Pennay *et al*. 2004). Only recordings that contained at least two definite and discrete pulses were classified as bat calls. For most species, a call sequence of several seconds in duration is required before identification can be made confidently. Any calls attributed to a listed bat species were then provided to an external reviewer (Greg Ford, Principal Ecologist, Balance Environmental, QLD) for confirmation of identification to species and/or complex level.

5.5.2. Data processing: 2023 survey data

Bat call analysis was again carried out by Rob Gration. The analysis was undertaken utilising decision trees in Anabat Insight Version 2.0.7 (Titley Scientific, Queensland, Australia) specifically developed for south-west Victoria (also see above paragraph). The decision tree incorporated call metrics derived from SBWB reference calls that were recorded from Panmure Cave free flying bats soon after leaving the cave (R. Gration, pers. comm.). Unlike major caves where large numbers of bats exit at the same time, there was only a couple of hundred bats roosting in Panmure Cave and they did not all exit the cave *en masse* during the period when voucher calls were recorded from free-flying individuals (R. Gration, *pers. comm*.).

The decision -tree for bats in south-west Victoria, utilised for the Autumn 2023 surveys, employed several call parameters, (e.g., duration, slope etc) derived from the Panmure Cave reference calls, published call characteristics and consultation with other bat call analysts. The decision tree for SBWB was created as a species complex that initially incorporates all calls with a characteristic frequency in the range 45–50 kHz.

The search function was run up to a dozen times in “pulse” and “average analysis” mode on the sample data to undertake checks of the species labels assigned to files and to refine call parameters where necessary. All files assigned to the SBWB-complex were manually checked, and all calls confirmed as being SBWB-definite were relabelled. Remaining files were assigned to the species complex, which typically include Little Forest Bat and Chocolate Wattled Bat calls, based on the metrics of the decision tree.

The labelling of a file as containing a SBWB-definite call sequence was based on most pulses (e.g., >4 pulses) having a long characteristic frequency, call duration with a down turning tail within >46kHz to <50kHz i.e., as per the Panmure Cave reference calls and call shape as described by Pennay *et al* (2004) for Eastern Bent-wing Bat.

SBWB-complex calls were assigned only where >4 pulses in a call sequence occurred as described above, but with most pulses in the call sequence associated to other call complex species, e.g., Little Forest Bat or Chocolate Wattled Bat. Calls were discounted as SBWB-complex when the pulses did not meet the call shape, call duration, or slope metrics of SBWB or the call complex species and were a closer match to Large Forest Bat (*Vespadelus darlingtoni*) or other forest bat species (*Vespadelus* spp.).

During the Spring 2018, Summer–Autumn 2019 and 2020 surveys, analysis of the echolocation call data included confirming the presence/absence and distribution of the common bats at all sites in the study area. The actual number of calls of each bat species was only recorded for threatened species.

5.6. Flight height surveys

The height distribution of bats was studied using meteorological masts. Song Meter SMM-U2 ultrasonic microphones connected with mic extension cables to SM4BAT-ZC detectors (installed at ground-level) were installed at two different heights on the first met mast during the 2010/2011 (EHP) and 2018/2019 surveys (Nature Advisory). In 2020, a second met mast was included in the surveys (Table 7). Locations of the two met masts within the HWF study area are shown in Figure 3.

Microphones were placed at the following heights:

- At ground-level at the base of each met mast (all surveys);
- 42 m above ground level (2010/2011 EHP); and
- 50 m above ground level (2018/2019/2020 Nature Advisory surveys).

Recordings were made concurrently at ground-level and at height during each survey period, although it was not clear whether concurrent recordings were made during the Spring 2010 survey (Ecology and Heritage Partners, 2014).

Table 6: Habitat descriptions of met mast bat detector sites between 2011 & 2020

Site ID	Habitat description	Survey year & detector nights	Proximity to nearest treed habitat (m)	Proximity to nearest permanent waterbody (m)
Met mast north (2011 - Tower 2018 – HX7 2019 – HS7 2020 – North)	Open paddock	2011 – 35 2018 – 41 2019 – 76 2020 – 31	465 m	450 m
Met mast south	Open paddock	2020 – 31	320 m	210 m

Note: Met mast north had a different name each survey season.

All bat calls were identified to species or complex level from the echolocation data recorded during the Spring 2018 survey, while only threatened species and species complexes containing threatened species were considered from the data recorded during the Summer-Autumn 2019 and Summer-Autumn 2020 surveys.

However, due to the high frequency of bat calls, they are subject to geometric attenuation and atmospheric attenuation (Voight et al., 2021). Coupled with the limited sensitivity of ultrasonic microphones and the additional noise interference at height, the detection distance of bat calls at height is likely to be less than that of bat calls at ground level, impeding the ability to accurately identify calls to species level.

5.7. Gradient study

In 2020, a gradient survey was undertaken with the aim of investigating appropriate buffer distances from turbine blade tips and areas of higher bat activity. These gradient surveys involved five detectors positioned at 60 m intervals in a straight line from a specific ecological feature, specifically focusing on SBWB activity levels.

Five bat detectors were deployed adjacent to a large dam on private property which would have flowed into Mustons Creek; these sites were labelled MC1–MC5. The dam is located on the north-western side of the proposed HWF development and is situated in cleared agricultural land with some scattered shrubs and trees. The dam generally follows the line of the Mustons Creek forming a linear shape rather than a circular dam. Bat detectors were arranged along a linear transect running east from the north end of the dam, with MC1 being the detector located closest to the dam and MC5 the furthest from the dam.

Another five bat detectors were placed at another large dam on private property closer to the western boundary of the proposed wind farm; these sites were labelled W1–W5. This dam would also have flowed into Mustons Creek and features a narrow band of planted riparian habitat surrounded by cleared agricultural land. Bat detectors were installed starting from the edge of the southern arm of the dam and then running in a southerly direction away from the dam.

'MC' site detectors were placed on the 20th February 2020 and retrieved on 22nd May 2020, whereas 'W' sites were placed 18th February 2020 and retrieved on 22nd May 2020.

The total number of bat calls from each detector was analysed, as was the number of calls of threatened bat species and species complexes as per Section 5.3. Limitations outlined in that section also apply here.

The locations of the gradient study recorders are shown in Figure 3.

5.8. Weather and bat activity analysis

Due to their small size and reliance on insects as a food source, insectivorous bat activity is linked to weather conditions. Generally, bat activity decreases in unfavourable conditions of low temperatures (Whitaker and Rissler, 1992; Cryan and Brown, 2007; Ruczyński and Bartoń, 2020; Scanlon and Petit, 2008;Turbill, 2008), high wind and rain and changes in barometric pressure (Patriquin et al., 2016; Smith and McWilliams, 2016; Dechmann et al., 2017; Turbill, 2008). SBWB activity patterns with weather can be used to provide species-specific mitigation recommendations which take into consideration active periods of SBWB.

A total of 502 SBWB-definite and SBWB-complex calls were used for analysis, which was the tiotal recorded from a significant sampling effort of 4,418 detector nights. Data was utilised from only sites where SBWB-definite and SBWB-complex calls were recorded to minimise excessive zeros and only used sites where SBWB have been confirmed during 2018–2020 & 2023 surveys. We expanded survey date ranges of each site into individual dates and standardized to the nearest hour from sunset to sunrise. We then assigned bat call records to these blocks by rounding their timestamps to the hour and aggregating counts by site, date, and hour. Environmental data was provided by the proponent collected from the met mast location within the study area, from a level of 1 m above ground level. The environmental data was converted to hourly means for temperature and wind speed and merged the two datasets on common date and time keys. This gave us a full dataset of rounded survey effort for all survey periods, with the average wind speed (at 10 m height) and average temperature for every hour (n = 23,699).

A negative binomial generalised linear mixed model (GLMM) with a log link to bat call counts was fitted using RStudio, with temperature, wind speed at 10 m, and nearest treed habitat (m) as fixed effects, and random intercepts for site and date.

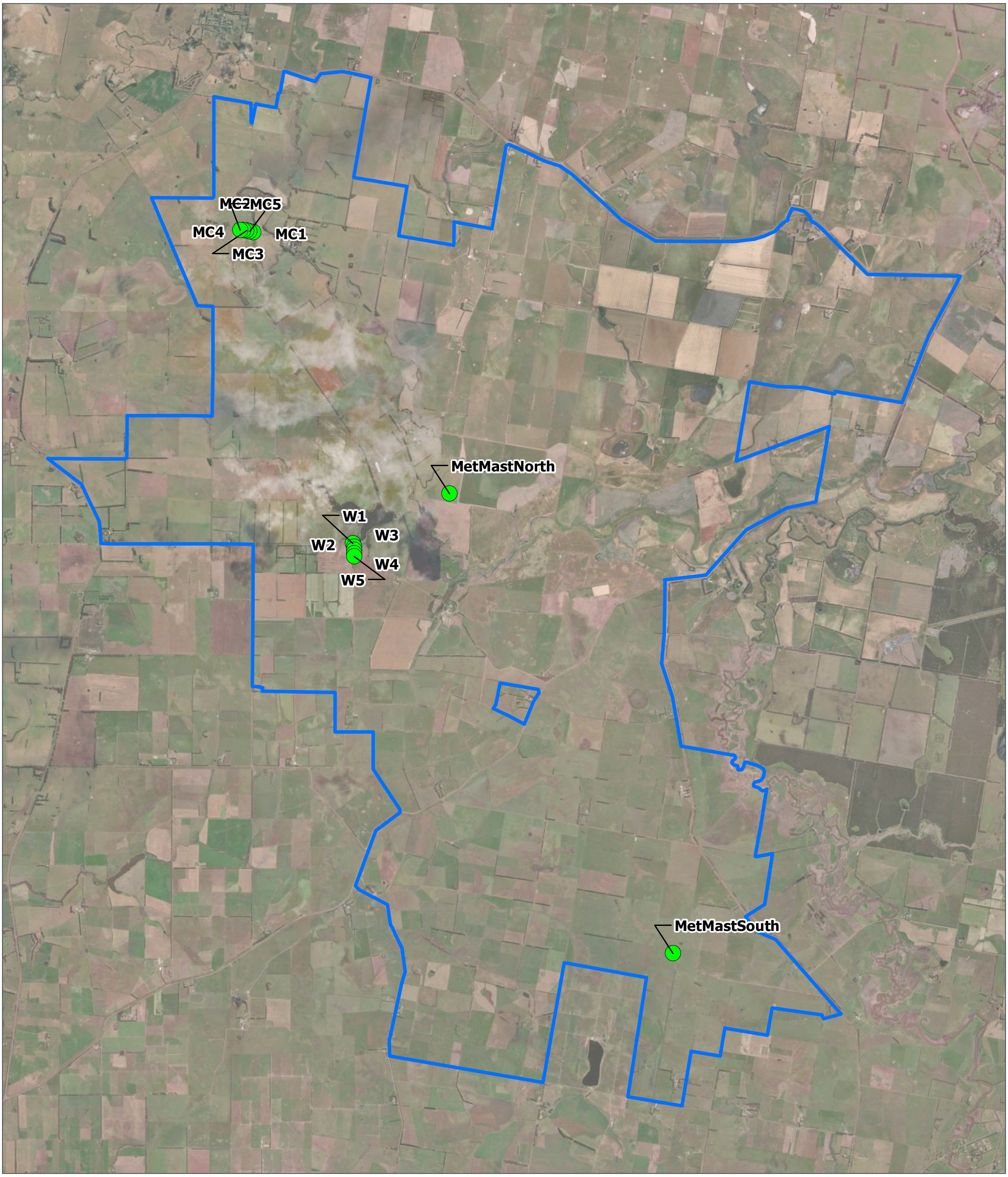

Figure 3: Gradient study and met mast survey locations

Project: Hexham Wind Farm **Client:** Hexham Wind Farm Pty Ltd **Date:** 5/06/2024

Hexham wind farm boundary

Bat detector sites

N

Metres

0 1,400

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Figure 3a: Gradient study "W1" survey locations

Project: Hexham Wind Farm **Client:** Hexham Wind Farm Pty Ltd **Date:** 5/06/2024

Hexham wind farm boundary
Bat detector sites

N

Metres
0 190

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Figure 3b Gradient study "MC" survey locations

Project: Hexham Wind Farm **Client:** Hexham Wind Farm Pty Ltd **Date:** 5/06/2024

Hexham wind farm boundary

Bat detector sites

N

Metres
0 40

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6. Grey-headed Flying-fox survey methods

A temporary GHFF camp was noted in a pine plantation to the east of the study area in 2022, prompting targeted surveys in February and March 2022 and in March 2023 when the bats where present. In addition, two audible Song Meter Minis were deployed adjacent to the camp from early March to the end of April 2023 to record audible vocalisations made by members of the camp that could be used to estimate the date when the bats left the temporary camp in 2023.

6.1. Field surveys – flyout counts

Dawn and dusk surveys were undertaken to determine the presence, number and flight direction of GHFFs flying and feeding.

Surveys were undertaken during the following dates:

- 14th to 16th February 2022;
- 15th and 16th March 2022;
- 22nd March 2022;
- 1st March 2023;
- 7th and 8th March 2023; and
- 16th and 17th March 2023.

While undertaking the dawn and dusk surveys, one to two observers scanned the sky looking for and listening for GHFFs. The observers undertook visual searches of the area with their eyes, binoculars and when it became too dark to see GHFFs with these, used thermal binoculars. Searches consisted of the observer scanning the sky from the horizon vertically and horizontally in all directions. The survey sites selected provided an unobstructed view of the landscape.

After finding GHFF during the first survey, the remaining surveys were located in similar areas around the pine plantation (Figure 4).

After the initial aerial GHFF searches, roaming surveys by car and on foot were undertaken, listening and spotlighting for feeding bats.

Evening surveys commenced 30 minutes prior to sunset and were completed two hours after sunset, while morning surveys commenced at least an hour prior to sunrise and were completed ten minutes after sunrise. Weather conditions during the surveys were conducive to GHFF foraging, i.e. no rain, low wind.

6.2. Acoustic monitoring

After determining the location of the temporary GHFF camp within the plantation, two automated acoustic recorders (Song Meter Mini – Wildlife Acoustics Inc.) were deployed adjacent to the camp on 7th March 2023. The recorders were set to record for two hours at a time, one hour before and after sunset and sunrise, and data was stored in an SD card. The acoustic recorders and data were retrieved on 30th April 2023, after the GHFF camp had left the area (Figure 5).

The data was analysed using the software Kaleidoscope Pro (Wildlife Acoustics Inc.). A call of the GHFF was identified in the data and its parameters (220-4500 Hz frequency range, duration 0.5-1.5 seconds) were assessed. Once the parameters were set, a basic cluster analysis was run in Kaleidoscope Pro. Cluster analysis scans the recordings and pulls out detections of the above frequency and duration, and groups them in clusters of sounds that have common features.

A subsample of each cluster was manually checked, visually and/or acoustically, and the cluster was discarded if the first 30-40 detections did not match the species. When the first 20-30 detections of a cluster showed calls from GHFF, further calls were checked to examine the dates that the camp was active. When manually checking a cluster, the user scrolled down, briefly viewing the call features in the spectrogram viewer. If necessary, the call was played to confirm. Most common calls were able to be quickly identified at a quick glance, only having to play outliers or dubious calls.

After determining an approximate date that GHFF activity began to decrease, the data beyond this date was examined again through a second cluster analysis of a subset of the data after this date. As this yielded few GHFF calls due to low activity, manual examination of audio files was used as a final check for the presence of the species.

6.3. Limitations

Detection of GHFF via acoustic analysis became more difficult as activity at the camp reduced. This is unlikely to have affected the aim of this study as activity of the camp was still able to be monitored effectively. Individual calls were also able to be detected via manual viewing of acoustic data. It is possible that a small number of individuals remaining at the site may not have been detectable due to infrequent calling.

Figure 4: Grey-headed Flying-fox survey points

Project: Hexham Wind Farm **Client:** Hexham Wind Farm Pty Ltd **Date:** 4/07/2023

Wind farm boundary

Survey date

- 14-Feb-22
- 15-Feb-22
- 16-Feb-22
- 22-Mar-22
- 1-Mar-23
- 7-Mar-23
- 8-Mar-23
- 16-Mar-23

N

Metres

0 400

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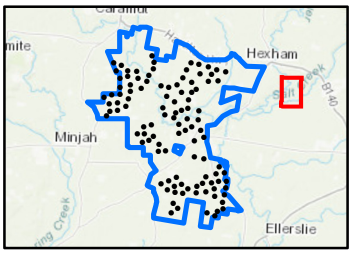
16087 - Created by: EL - M:\2018 Jobs\18088\18088_11 FIG3 GHFF survey 230704.mxd

Figure 5: Location of Grey-headed Flying Fox Camp and Acoustic Recorders

Project: Hexham Wind Farm **Client:** Hexham Wind Farm Pty Ltd **Date:** 28/06/2023

- Wind farm boundary
- Turbines
- GHFF camp
- Songmeters



N

Metres
0 190

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7. Bat detector survey results

The following section outlines all bat utilisation surveys undertaken to date at the proposed HWF.

Southern Bent-winged Bat calls are displayed as both a total number of calls, and as relative activity (calls per night). Relative activity is a more representative measure of species occurrence than activity per site, as the number of bat detector nights varied between survey sites. However, the limitation of 'calls per night' is that it does not take into account conditions when bat activity may be lower, such as lower temperatures and higher wind or rainfall.

7.1. Spring 2010 and Autumn 2011

The EHP (2014) surveys identified nine bat species and five species complexes (Table 7). Two threatened species were observed: the EPBC Act and FFG Act listed SBWB, and the FFG Act listed YBSB. As minor discrepancies occur within the EHP (2014) report, Nature Advisory has presented the information to the best of their understanding.

Table 7: Summary of results for Hexham Wind Farm bat species for the 2010-2011 survey

Common name	Scientific name	Conservation status	Total no. of calls	
			Spring 2010	Autumn 2011
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*	Vulnerable, FFG Act	561	35
Southern Bent-wing Bat	*Miniopterus orianae bassanii*	Critically Endangered, EPBC Act and FFG Act	78	15
Chocolate Wattled Bat	*Chalinolobus morio*	Common, secure	86	2
Eastern Falsistrelle	*Falsistrellus tasmaniensis*	Common, secure	27	1
Gould's Wattled Bat	*Chalinolobus gouldii*	Common, secure	528	16
Large Forest Bat	*Vespadelus darlingtoni*	Common, secure	1,286	46
Little Forest Bat	*Vespadelus vulturnus*	Common, secure	61	0
Southern Free-tailed Bat	*Ozimops planiceps*	Common, secure	3	0
White-striped Free-tailed Bat	*Austronomus australis*	Common, secure	240	33
Forest Bat sp.	*V.darlingtoni/V. regulus/V. vulturnus*	(Species complex)	196	32
Gould's Wattled Bat/Free-tailed Bat sp.	*C. gouldi/O. planiceps/O. ridei*	(Species complex)	24	0
Southern Bent-wing Bat/Chocolate Wattled Bat/Little Forest Bat	*M. orianae bassanii/ C. morio/V. vulturnus*	(Species complex)	14,74	282
Long-eared Bat sp.	*Nyctophilus geoffroyi/N. gouldi*	(Species complex)	173	1
Free-tailed Bat sp.	*Ozimops. planiceps/O. ridei*	(Species complex)	1	0

SBWB-definite calls were recorded from seven locations during Spring 2010, with a total of 78 calls, and from two locations during Autumn 2011 surveys, with a total of 15 calls (Table 8). The majority (95%) of the calls recorded in Spring 2010 calls were from one detector site (Site HS1-2, 69 calls) located to the east of the current wind farm site in a sheep grazing paddock with many large, scattered trees and a farm dam. Due to limitations with bat acoustic data and limited information presented in the EHP (2014) report, it is unknown whether these 69 calls were recorded within a short duration and therefore may be the same bat circulating the area, or if this was data collected from several bats or over a longer time period. The remaining SBWB-definite calls were recorded in the north-eastern section of the initial study area between Boonerah Estate Road and Woolsthorpe-Hexham Road around the Hopkins River and its tributaries (Table 8), which is also outside the study area. These locations included linear strips of remnant riparian woodland and grazing paddocks with a relatively high density of large, old scattered trees, predominantly River Red Gums; these treed areas were likely to provide ideal foraging opportunities for Southern Bent-wing Bat. None of these sites are within the updated HWF site and study area (Figure 6).

During the Autumn 2011 survey, calls assigned as SBWB-definite were recorded at sites in the western area of the wind farm, around a farm dam and on Mustons Creek (Table 8). Waterbodies such as this may provide good foraging opportunities for SBWBs.

Calls assigned to SBWB-complex, which could possibly have been produced by either SBWB, Little Forest Bat or Chocolate Wattled Bat, were recorded at 14 other locations (Table 8).

The YBSB was detected at 16 sites during the Spring 2010 survey and seven sites during the Autumn 2011 survey, with an unusually large overall number of calls (e.g., over 590 calls). The locations of these records were widely distributed across the HWF study area, with some clustering around the southern sections of the study area (Table 8 and Figure 6).

Table 8: Threatened bat species recording location Hexham Wind Farm Spring 2010 and Autumn 2011

Season	Survey dates	Survey location	Southern Bent-wing Bat (SBWB-definite)	SBWB-complex (SBWB/Little Forest Bat /Chocolate Wattled Bat)	Yellow-bellied Sheath-tailed Bat
Spring 2010	21/10/10-28/10/10	HS1*	1	71	
		HS2*		301	
		HS3	2	157	
		HS6		2	
		HS8			105
		HS9			19
		HS12			1
		HS13			48
	28/10/10-4/11/10	HS1-2*	69	273	
		HS2-2*	3	145	
		HS3-2*	1	118	3
		HS6-2		3	
		HS7-2		25	
		HS10-2			6
		HS11-2			22
		HS12-2			3
		HS13-2		2	109
	4/11/10-/11/11/10	HS1-3	1	27	
		HS7-3		8	
		HS9-3			32

Season	Survey dates	Survey location	Southern Bent-wing Bat (SBWB-definite)	SBWB-complex (SBWB/Little Forest Bat /Chocolate Wattled Bat)	Yellow-bellied Sheath-tailed Bat
		HS10-3		59	4
		HS12-3		25	
		HS13-3			17
	11/11/10-18/11/10	HS1-4	1	258	
		HS2-4			
		HS9-4			100
		HS10-4			27
		HS7-3			
	18/11/10-23/11/10	HS1-4			
		HS10-4			
		HS8-4			10
		HS12-4			3
		HS13-4			52
Autumn 2011	10/2/11-17/2/11	HA5		59	
		HA6		25	
	17/2/11-25/2/11	HA8			26
		HA10			4
		HA11		8	
		HA12	2	49	
		HA13	4	65	
		HA7			
	25/1/11-4/3/11	Tower low		2	
		HA3			
		HA12		53	
	4/3/11-11/3/11	HA11			
		HA21			
		HA22		21	
	11/3/11-31/3/11	Tower high			
		HA21			5
		HA13	9		
Total			92	1756	596

*Bat detector survey sites that are located outside the current HWF project area.

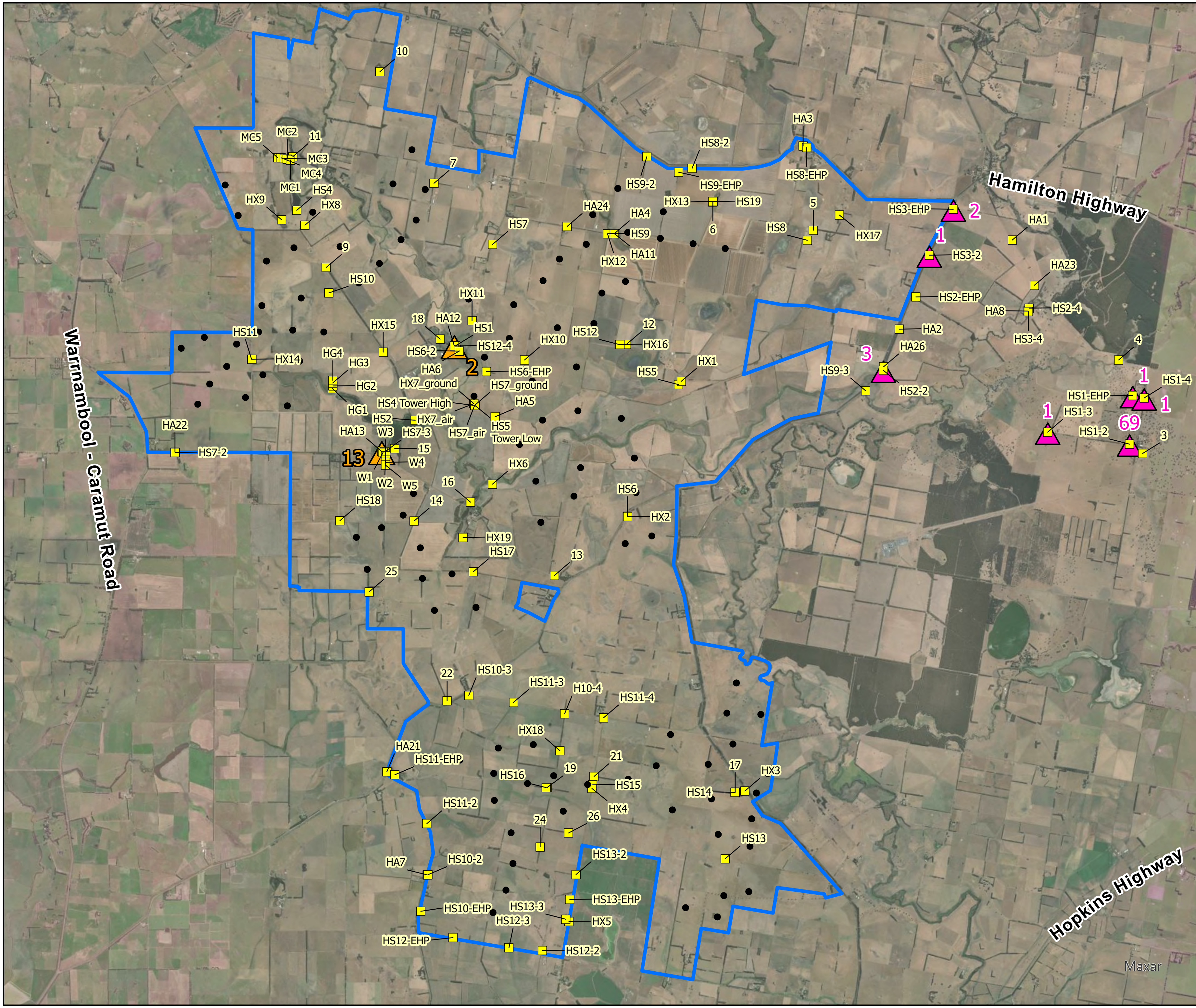

Figure 6: Southern Bent-wing Bat calls - Spring 2010 - Autumn 2011 (EHP)

Project No: 18088.10
Project: Hexham Wind Farm
Date: 11/06/2025

Wind farm boundary
Turbine
Bat survey location

Southern Bent-wing Bat calls (EHP)

Spring 2010
Autumn 2011

Kilometres
0 1 2 3 4
N
GDA2020 MGA Zone 54

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7.2. Spring 2018

Eight bat species were recorded during the Spring 2018 survey (Table 9); six of these were common, widespread and secure and usually occur in farmland and other habitats throughout south-eastern Australia, and two were threatened species: SBWB and YBSB.

SBWB was detected in the central and north-eastern sections of the HWF site, with five SBWB-definite calls across five different sites (Figure 7). Habitat across these sites included open space (HX7 & HX15), eucalypt windbreaks within open paddocks (HX11 & HX17), and open woodland with a farm dam (HXHX13).

Four YBSB calls were detected across two sites in the south-eastern corner and central areas of the site. Habitat across these sites included eucalypt windbreaks within open paddocks (HX3 & HX11),

In addition to the calls positively identified to species-level, four multi-species complexes were also identified (Table 9). Results are displayed by presence at each site given the low numbers of threatened species calls recorded. Three of the species complexes included common species and the fourth included the SBWB-complex.

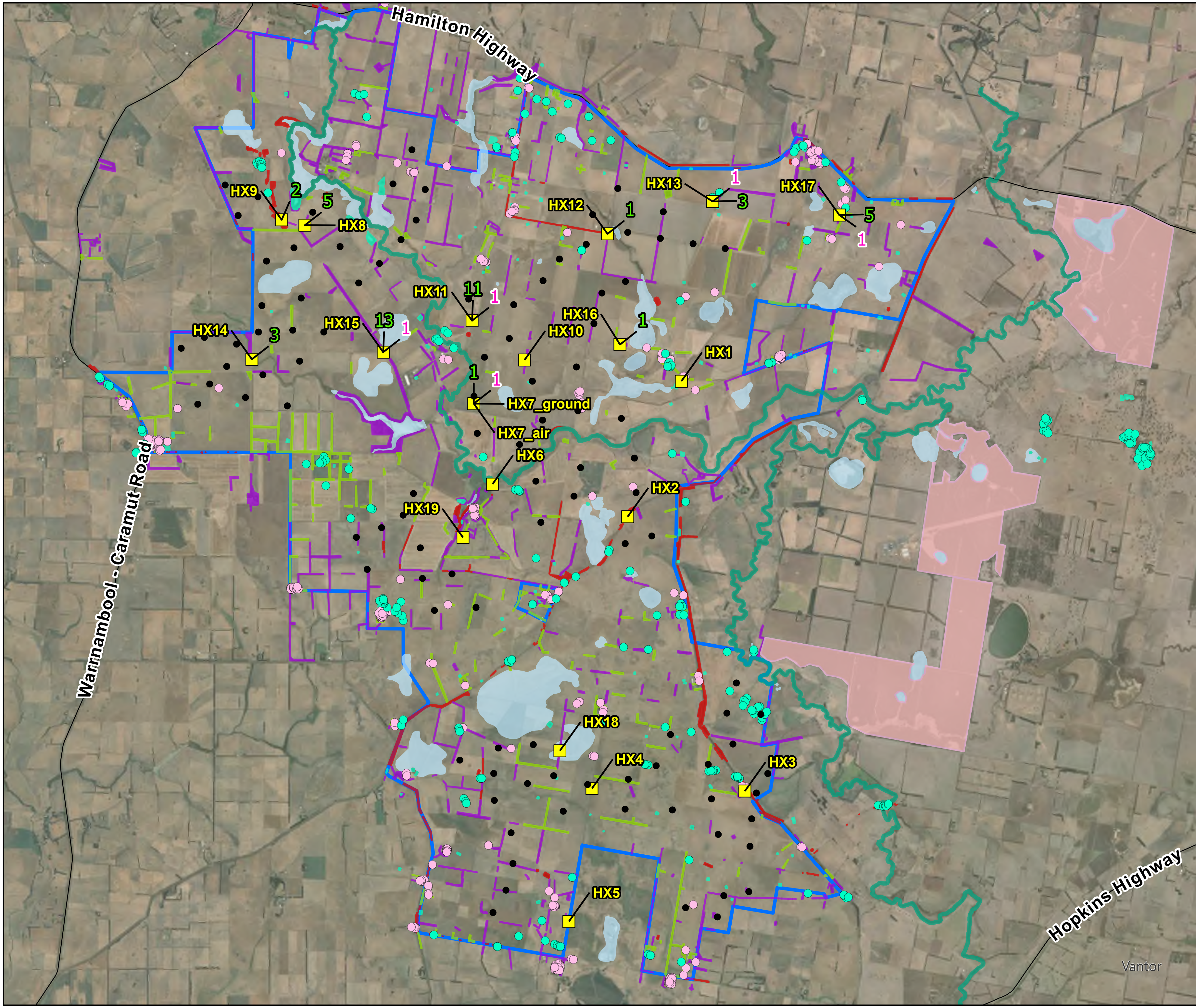
Table 9: Bat occurrence at the proposed Hexham Wind Farm during the Spring 2018 surveys

Common name	Scientific name	Conservation status	Sites of records
Southern Bent-wing Bat (5 calls)	*Miniopterus orianae bassanii*	Critically Endangered EPBC Act and FFG Act	HX7-ground, HX11, HX13, HX15, HX17
Yellow-bellied Sheath-tailed Bat (4 calls)	*Saccolaimus flaviventris*	Vulnerable FFG Act	HX3, HX11
White-striped Free-tailed Bat	*Austronomus australis*	Common, secure	HX1, HX2, HX3, HX7-air, HX7-ground, HX11, HX14, HX15, HX16
Southern Free-tailed Bat	*Ozimops planiceps*	Common, secure	HX7-ground, HX11, HX13, HX15, HX17
Gould's Wattled Bat	*Chalinolobus gouldii*	Common, secure	HX1, HX2, HX3, HX4, HX5, HX6, hX7-air, HX7-ground, HX8, HX9, HX11, HX12, HX13, HX14, HX15, HX16, HX17, HX18
Chocolate Wattled Bat	*Chalinolobus morio*	Common, secure	HX1, HX2, HX3, HX7-ground, HX8, HX9, HX10, HX11, HX12, HX13, HX14, HX15, HX16, HX17, HX19
Eastern Falsistrelle	*Falsistrellus tasmaniensis*	Common, secure	HX1, HX3, HX9, HX17
Large Forest Bat	*Vespadelus darlingtoni*	Common, secure	HX1, HX2, HX3, HX4, HX5, HX6, HX7-ground, HX8, HX9, HX10, HX11, HX12, HX13, HX14, HX15, HX16, HX17, HX19
Little Forest Bat	*Vespadelus vulturnus*	Common, secure	HX1, HX3, HX7-ground, HX9, HX11, HX12, HX13, HX14, HX16, HX17, HX19
Species Complexes			
Southern Bent-wing Bat/ Chocolate Wattle Bat/Little	*M. orianae bassanii/ C. morio/V. vulturnus*	(Species complex)	HX7-ground, HX8, HX9, HX11, HX12, HX13, HX14, HX15, HX16, HX17

Common name	Scientific name	Conservation status	Sites of records
Forest Bat (27 calls)			
Free-tailed Bat species complex	*O. planiceps/O. ridei*	(Species complex)	HX1, HX2, HX3, HX5, HX7-ground, HX10, HX11, HX13, HX14, HX15, HX16
Long-eared Bat species complex	*Nyctophilus geoffroyi/N. gouldi*	(Species complex)	HX1, HX3, HX7-ground, HX11, HX13, HX14, HX15, HX16, HX19
Forest Bat species complex	*V. darlingtoni/V. regulus/V. vulturnus*	(Species complex)	HX1, HX2, HX3, HX4, HX5, HX6, HX7-ground, HX8, HX10, HX11, HX12, HX13, HX14, HX15, HX16, HX17, HX19

Figure 7: Southern Bent-wing Bat calls-Spring 2018

Project No: 18088.10
Project: Hexham Wind Farm
Date: 17/11/2025



Wind farm boundary
Turbine
Bat detector sites

Habitat features

Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Bat call numbers

1: SBWB definite bat call
1: SBWB complex bat call

Kilometres
0 1 2 3 4
N
GDA2020 MGA Zone 54

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7.3. Summer–Autumn 2019

During the Summer–Autumn 2019 survey, two species of threatened bats were recorded in the study area: SBWB and YBSB. In addition, calls assigned to the SBWB-complex* were also recorded.

A total of 72 calls were positively identified as SBWB-definite calls, recorded from 11 sites. There were 254 SBWB-complex calls recorded from 17 sites (Table 10 and Figure 8), and ten YBSB calls recorded from four out of the 24 sites (Table 10).

Table 10: Threatened bat species recorded at the study area during the Summer–Autumn 2019 survey

Site	Total recording nights	SBWB-definite		SBWB-complex*		Yellow-bellied Sheath-tailed Bat	
		Total calls per site	Average calls per night	Total calls per site	Average calls per night	Total calls per site	Average calls per night
HG1	58	1	0.02	5	0.09	1	0.02
HG2	58	1	0.02	17	0.29	0	0
HG3	58	1	0.02	0	0	0	0
HG4	58	0	0	0	0	0	0
HS1	79	0	0	3	0.04	0	0
HS2	79	0	0	1	0.01	0	0
HS3	79	6	0.08	26	0.33	0	0
HS4	78	0	0	6	0.08	0	0
HS5	79	1	0.01	1	0.01	1	0.01
HS6	78	1	0.01	2	0.03	0	0
HS7-ground	76	1	0.01	0	0	0	0
HS7- 50m	76	0	0	0	0	0	0
HS8	59	25	0.42	18	0.31	0	0
HS9	58	0	0	0	0	0	0
HS10	58	0	0	0	0	0	0
HS11	58	0	0	1	0.02	0	0
HS12	58	22	0.38	47	0.81	6	0.1
HS13	59	0	0	3	0.05	0	0
HS14	59	10	0.17	82	1.39	2	0.03
HS15	59	0	0	3	0.05	0	0
HS16	59	3	0.05	35	0.59	0	0
HS17	59	0	0	3	0.05	0	0
HS18	59	0	0	1	0.02	0	0
HS19	59	0	0	0	0	0	0
Totals	1560	72	0.05	254	0.16	10	0.01

*SBWB-complex – includes calls that could have been produced by SBWB, Little Forest Bat or Chocolate Wattled Bat

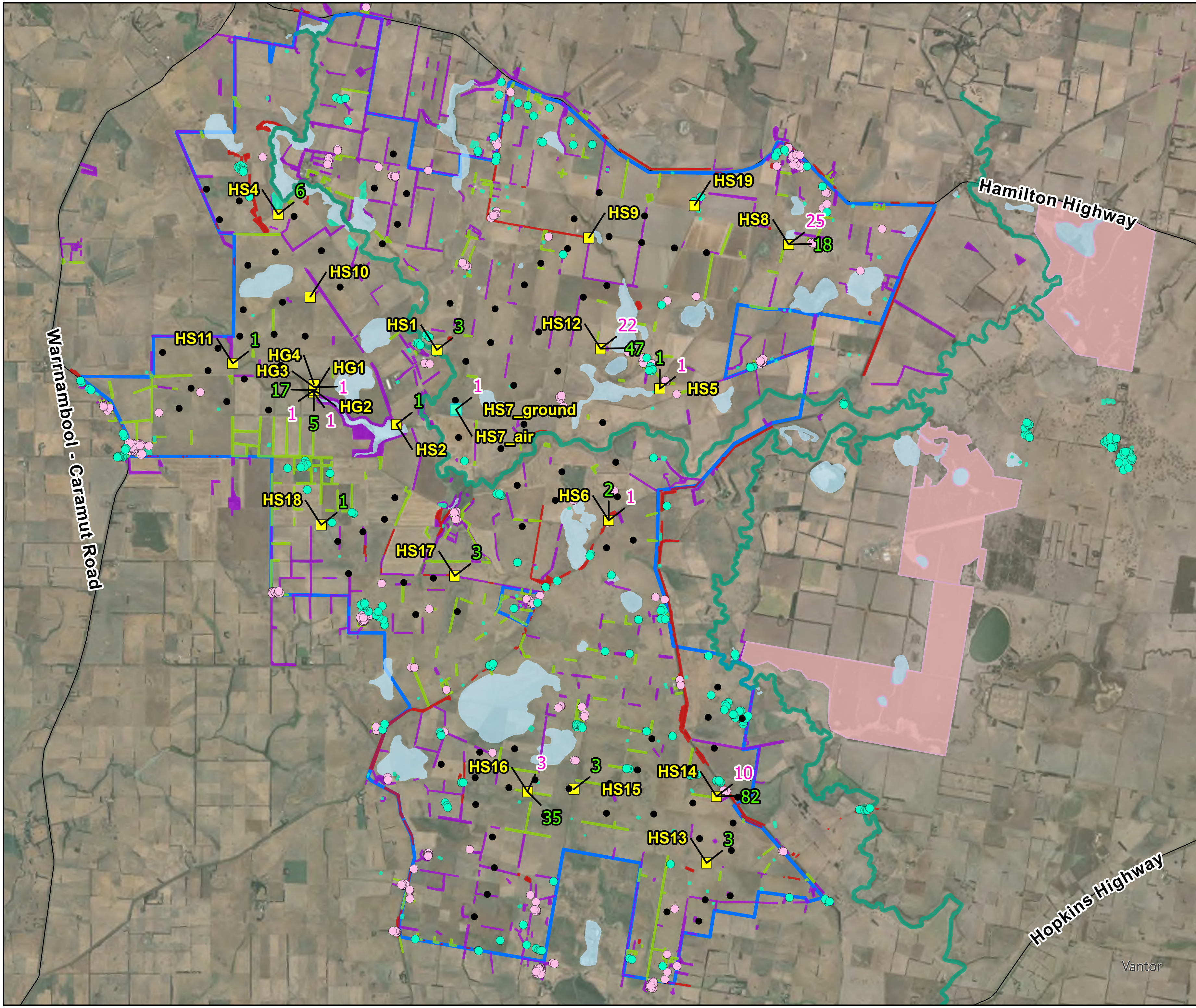

Figure 8: Southern Bent-wing Bat calls_Summer-Autumn 2019

Project No: 18088.10
Project: Hexham Wind Farm
Date: 17/11/2025

- Wind farm boundary
- Turbine
- Bat detector sites

Habitat features

- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland
- Planted tree
- Remnant tree

Bat call numbers

1: SBWB definite bat call
1: SBWB complex bat call

Kilometres
0 1 2 3 4
N
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7.4. Height distribution of bats

The distribution of the frequency of bat calls and heights at which they were recorded are shown in Table 11. As previously mentioned, all species were analysed from the call data recorded during the Spring 2018 survey, while only threatened species were considered in the Summer–Autumn 2019 and Summer–Autumn 2020 call datasets.

Calls recorded at ground-level during Spring 2018 were mostly common species, such as Gould's Wattled Bat and White-striped Free-tailed Bat. A single SBWB-definite call was identified from the ground-level detector in both the Spring 2018 and Autumn 2019 surveys. In addition, four species complexes were recorded, with the Forest Bat spp. complex being the most frequently recorded during Spring 2018. The SBWB-complex was recorded only at ground level, with two calls in Autumn 2011, one call in Spring 2018 and one call in Summer–Autumn 2020.

At 50 m above ground-level, only Gould's Wattled Bat and White-striped Free-tail Bat were recorded during Spring 2018. These two species are edge and open-space adapted taxa, respectively, which often fly above the canopy, and have been regularly recorded flying at Rotor Swept Area (RSA) heights at other wind farms in similar settings by Nature Advisory. No threatened species or associated complexes were recorded at 50 m above ground level during surveys in Summer–Autumn 2019 or Summer–Autumn 2020.

Table 11: Bat calls recorded at ground-level and 42m/50m height at Hexham Wind Farm

Species	Autumn 2011		Spring 2018		Summer-Autumn 2019		Summer-Autumn 2020			
	Tower 42m (35 nights)	Tower ground (35 nights)	HX7 50m (41 nights)	HX7 ground (40 nights)	HS7 50m (76 nights)	HS7 ground (76 nights)	North 50m (31 nights)	North ground (69 nights)	South 50m (31 nights)	South ground (69 nights)
Chocolate Wattled Bat	0	0	0	0	0	0	0	X	0	X
Gould's Wattled Bat	0	**2**	**11**	**11**	0	0	0	0	0	0
Large Forest Bat	0	**1**	0	**2**	0	0	0	0	0	0
Little Forest Bat	0	0	0	**1**	0	0	0	0	0	0
Southern Bent-wing Bat	0	0	0	**1**	0	**1**	0	0	0	0
Yellow-bellied Sheath-tailed Bat	X	0	0	0	0	0	0	0	0	0
White-striped Free-tail Bat	0	**14**	**7**	**3**	0	0	0	0	0	0
Identified to call complex										
Free-tail Bat complex	0	0	0	**5**	0	0	0	0	0	0
Southern Bent-wing Bat/ Little Forest Bat/Chocolate Wattled Bat complex	0	**2**	0	**1**	0	0	0	0	0	**1**
Long-eared Bat complex	0	0	0	**5**	0	0	0	0	0	0
Forest Bat complex	0	0	0	**15**	0	0	X	X	0	X

X - Denotes presence (numbers not provided in EHP (2014) report or the 2020 bat call analysis)

Note – Sites Tower, HX7, HS7 and North are the same met mast location.

7.5. Gradient study

Gradient surveys in 2020 positioned five detectors at 60 m intervals in a straight line from specific ecological features, specifically focusing on the activity levels of SBWB.

The gradient study did not yield sufficient data to indicate a trend in habitat preference at either site for SBWB. No SBWB-definite calls were recorded from the Mustons Creek (MC) sites and eight calls were recorded from the wetlands (W) sites (Table 12). These numbers of calls per site are insufficient to statistically model the relationship between SBWB activity and distance from habitat. More calls were recorded from the SBWB-complex, but overall activity was not high enough to statistically model the relationship between SBWB activity and distance to habitat.

Table 12: Summary of gradient study results

Site	Detector nights	Distance from wetland (m)	SBWB-definite calls	SBWB-complex calls
MC1	94	0	0	15
MC2	94	60	0	0
MC3	94	120	0	0
MC4	94	180	0	0
MC5	94	240	0	0
Total	**470**		**0**	**15**
W1	92	0	0	0
W2	92	60	2	7
W3	92	120	6	9
W4	92	180	0	3
W5	92	240	0	0
Total	**460**		**8**	**15**

Section 9.1 provides further insight into habitat preference of SBWB. Table 14 shows all SBWB-definite calls recorded during each survey period, the habitat in which they were located and the general distance to the nearest waterbody (waterway, dam, creek).

The results show that SBWB was recorded in a variety of habitats not necessarily adjacent to water sources. Higher numbers tended to be more frequently recorded at treed habitat, occasionally hundreds of metres from water.

7.6. Weather and bat activity analysis

The weather and bat activity analysis results indicate that SBWB and SBWB complex activity increases with temperature, decreases with wind speed, and is slightly reduced with greater distance to treed habitat, with significant variation across sites and dates (Figure 9a & 9b, Table 13).

The model (AIC = 3262.7, BIC = 3319.2, log-likelihood = −1624.3, dispersion = 0.0814) revealed that temperature had a significant positive effect (estimate = 0.104, p = 8.17e-05), meaning that each 1°C increase was associated with an approximately 10.97% increase in expected calls (exp(0.104) ≈ 1.11). Wind speed had a significant negative effect (estimate = −0.308, p = 2.70e-09), indicating that each unit increase in wind speed reduced the expected call count by about 26.44% (exp(−0.308) ≈ 0.74). Nearest treed habitat had a small but significant negative effect (estimate = −0.0062, p = 0.0421), suggesting that for every meter increase in distance to treed habitat the expected call count decreased slightly (exp(−0.0062) ≈ 0.99). The random intercept variance was estimated to be 1.518 (SD = 1.232) for site and 2.287 (SD = 1.512) for date, indicating considerable variation in baseline call counts across sites and dates.

Random effects showed notable variability among sites (SD = 1.23) and dates (SD = 1.51), indicating substantial heterogeneity. DHARMa diagnostics confirmed the model's adequacy, with no evidence of over- or under-dispersion (p = 0.424), no problematic excess zeros (p = 1.000), and uniformly distributed residuals (p = 0.503).

Cumulative percentages were chosen to display at which wind speeds the highest activity of SBWB occurred, to inform decisions around mitigation measures such as turbine cut-in speed. Table 13 displays the cumulative percentage of observed and fitted bat calls. Fitted values show the GLMM modelled values. Both the observed and modelled calls highlight that <90% of calls occur under a wind speed of approximately 6 m/s, and <77% of calls occur under a wind speed of approximately 4.5 m/s (Table 13, Figure 9b top).

Furthermore, 80% of observed SBWB calls were recorded between night-time temperatures of 10.2 and 17.8 °C and 90% were recorded between 9.5 and 19.9 °C (Figure 9b bottom).

Table 13: Cumulative percentage of observed and fitted bat calls at wind speeds of 4.5 m/s to 6.5 m/s.

Wind speed (m/s)	Observed values (%)	Fitted values (%)
4.5	75.05	77.27
5.0	79.72	82.39
5.5	84.38	86.42
6.0	90.06	89.39
6.5	96.55	93.62

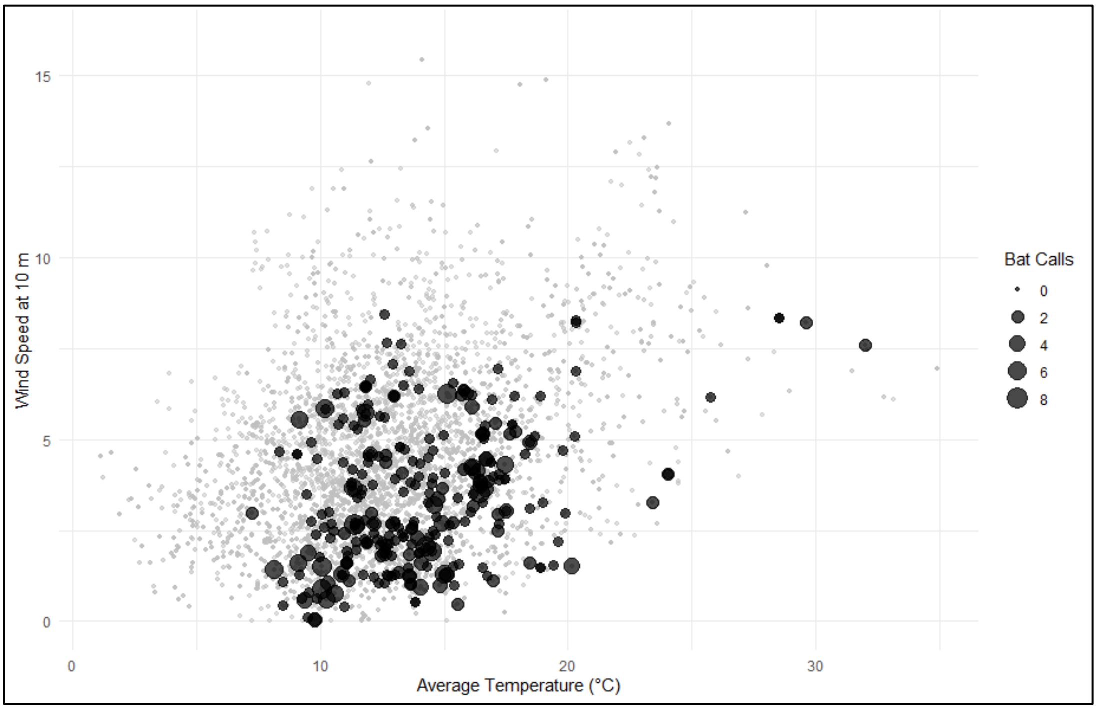
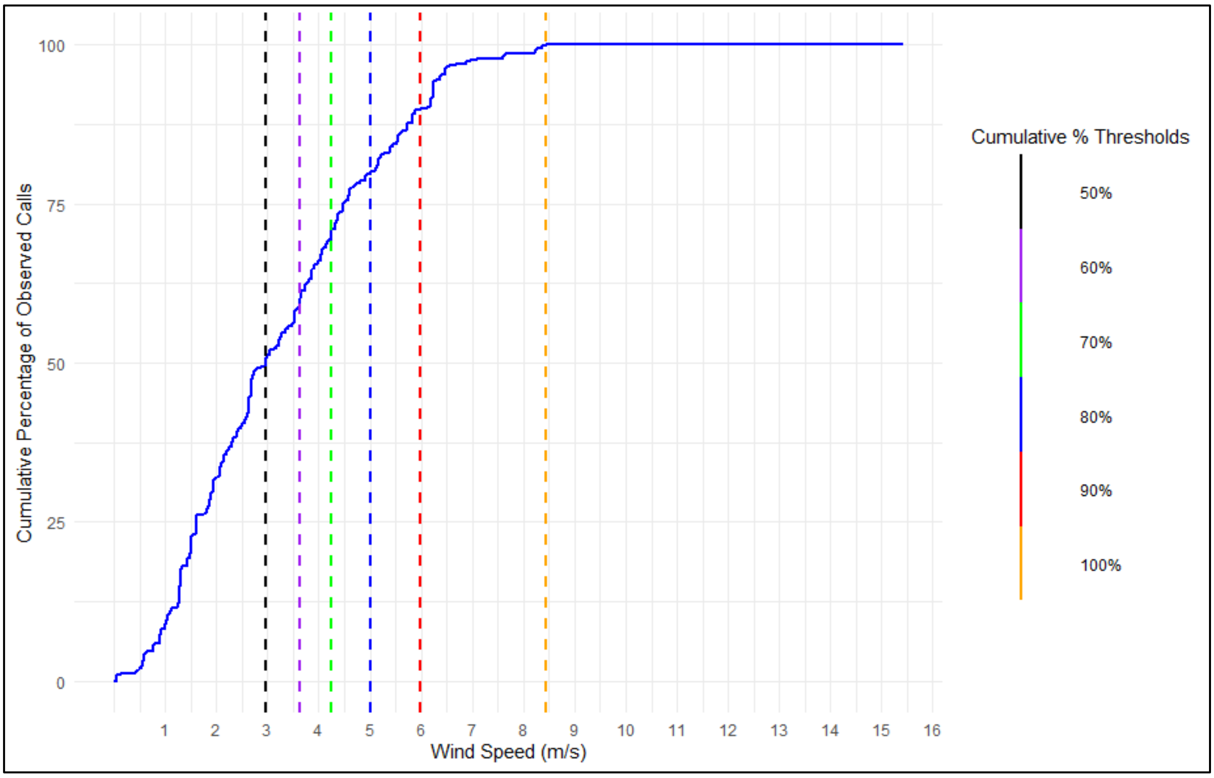


Figure 9a: Results of the SBWB and SBWB complex activity and weather condition analysis.

Number of observed SBWB-definite and SBWB-complex calls with wind speed (m/s) and average nightly temperatures (°C). Plot shows zero counts (sampled but no SBWB calls) in light grey to highlight the actual observed bat calls in black (n = 493).



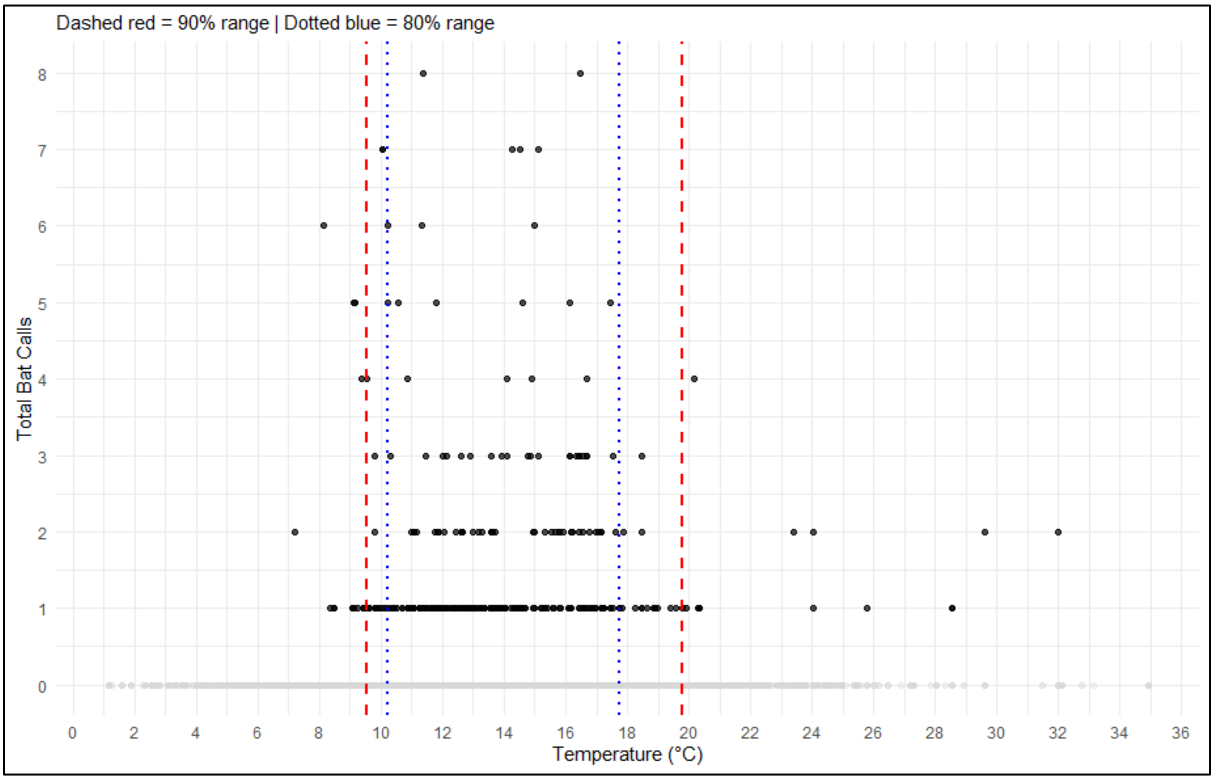


Figure 9b: Results of the SBWB and SBWB complex activity and weather condition analysis.

Top: Cumulative percentage of observed SBWB-definite and SBWB-complex calls for mean hourly wind speeds (m/s) at HWF, with the dashed lines indicating the wind speed at the cumulative percentage thresholds. Bottom: Total observed SBWB-definite and SBWB-complex calls at each observed night-time temperature (°C) at HWF, with the dashed lines indicating the range where 80% (blue) and 90% (red) of SBWB calls are recorded.

Information about weather and bat activity highlights the importance of implementing an appropriate mitigation strategy that has the ability to be adaptive post-construction if impacts are detected through post-constriction monitoring,

The data presented in this report provides a snapshot of bat activity from the monitoring data that indicates that SBWB are present across the proposed wind farm landscape.

7.7. Autumn 2023 Bat Surveys

During the Autumn 2023 survey, analysis of echolocation call data recorded from 20 sites over 877 bat detector nights was limited to identifying calls from threatened bat species.

Both SBWB-definite and SBWB-complex calls were recorded in the study area.

The YBSB, which was recorded in all previous surveys (2010, 2011, 2018 & 2019), was not recorded in the Autumn 2023 survey. More information on YBSB site usage can be found in Section 9.2.

7.7.1. Southern Bent-wing Bat activity

A total of 40 calls were positively identified as SBWB-definite calls. These were recorded across 28 nights at 6 out of the 21 bat detector sites (Figure 10). Average relative activity for SBWB-definite calls across all sites was 0.05 calls per night, ranging from no calls at 15 of the 21 sites to a maximum of 0.31 calls per night at Site 5 (Table 14). This includes 10 calls from site 4, which was located outside of the site boundary, next to the pine plantation.

In addition, a further 155 calls identified as SBWB-complex were recorded across 63 nights at 14 out of the 21 bat detector sites. Average relative activity of SBWB-complex calls across all sites was 0.18 calls per night and ranged from no calls at 7 of the 21 sites, to maximum of 0.98 calls per night at Site 16 (Table 14, Figure 14).

Table 14: Southern Bent-wing Bat definite and species complex calls identified in Autumn 2023

Site No.	SBWB-definite calls	SBWB-complex calls*	No. nights with SBWB-definite calls	No. nights with SBWB-complex calls	Total No. recording nights	SBWB-definite relative activity (calls/night)	SBWB-complex relative activity (calls/night)
3	0	5	0	5	58	0	0.09
4	10	12	6	9	34	0.29	0.35
5	18	31	12	20	59	0.31	0.53
6	0	2	0	2	34	0	0.06
7	2	2	2	2	33	0.06	0.06
9	0	1	0	1	35	0	0.03
10	0	0	0	0	60	0	0
11	0	1	0	1	58	0	0.02
12	2	14	2	5	59	0.03	0.24
13	0	0	0	0	33	0	0
14	0	2	0	2	34	0	0.06
15	1	4	1	4	61	0.02	0.07

Site No.	SBWB-definite calls	SBWB-complex calls*	No. nights with SBWB-definite calls	No. nights with SBWB-complex calls	Total No. recording nights	SBWB-definite relative activity (calls/night)	SBWB-complex relative activity (calls/night)
16	7	57	5	12	58	0.12	0.98
17	0	0	0	0	58	0	0
18	0	0	0	0	55	0	0
19	0	0	0	0	26	0	0
21	0	1	0	1	26	0	0.04
22	0	0	0	0	18	0	0
24	0	4	0	4	26	0	0.15
25	0	2	0	2	26	0	0.08
26	0	0	0	0	26	0	0
Total	40	155	28	70	877	0.05	0.18

*This includes all files containing calls that could have been produced by SBWB, Little Forest Bat or Chocolate Wattled Bat.

The spatial distribution of SBWB-definite and SBWB-complex calls recorded across the study area was patchy, with an overall tendency for greater activity levels at a small sub-set of sites.

During the Autumn 2023 bat detector survey, 76.3% of SBWB-definite and SBWB-complex calls combined were recorded from three of 21 sites close to wetlands. Two wetlands accounted for 72.4% of all SBWB-definite and SBWB-complex calls. Site 16 (41% of SBWB-definite and SBWB-complex calls combined) is a wetland fed by a tributary off Mustons Creek that comprises several permanent pools (Figure 11). This wetland has been fenced to remove access to cattle and the property managers have undertaken extensive restoration of the riparian vegetation surrounding the wetland. Site 05 (31.4% of SBWB-definite and SBWB-complex calls combined) is a large farm dam close to large windbreaks comprising mature eucalypt and pine trees (Figure 12).

Apart from bat detector sites close to wetlands, the remaining calls were mostly at sites with either patches of *Eucalyptus* or planted windbreaks comprised mainly of mature eucalypt trees (21.8% of SBWB-definite and SBWB-complex calls combined, Figure 13). Only 1.9% were recorded close to planted windbreaks comprising exotic pine trees, with three calls attributed to the SBWB-complex, and no SBWB-definite calls.

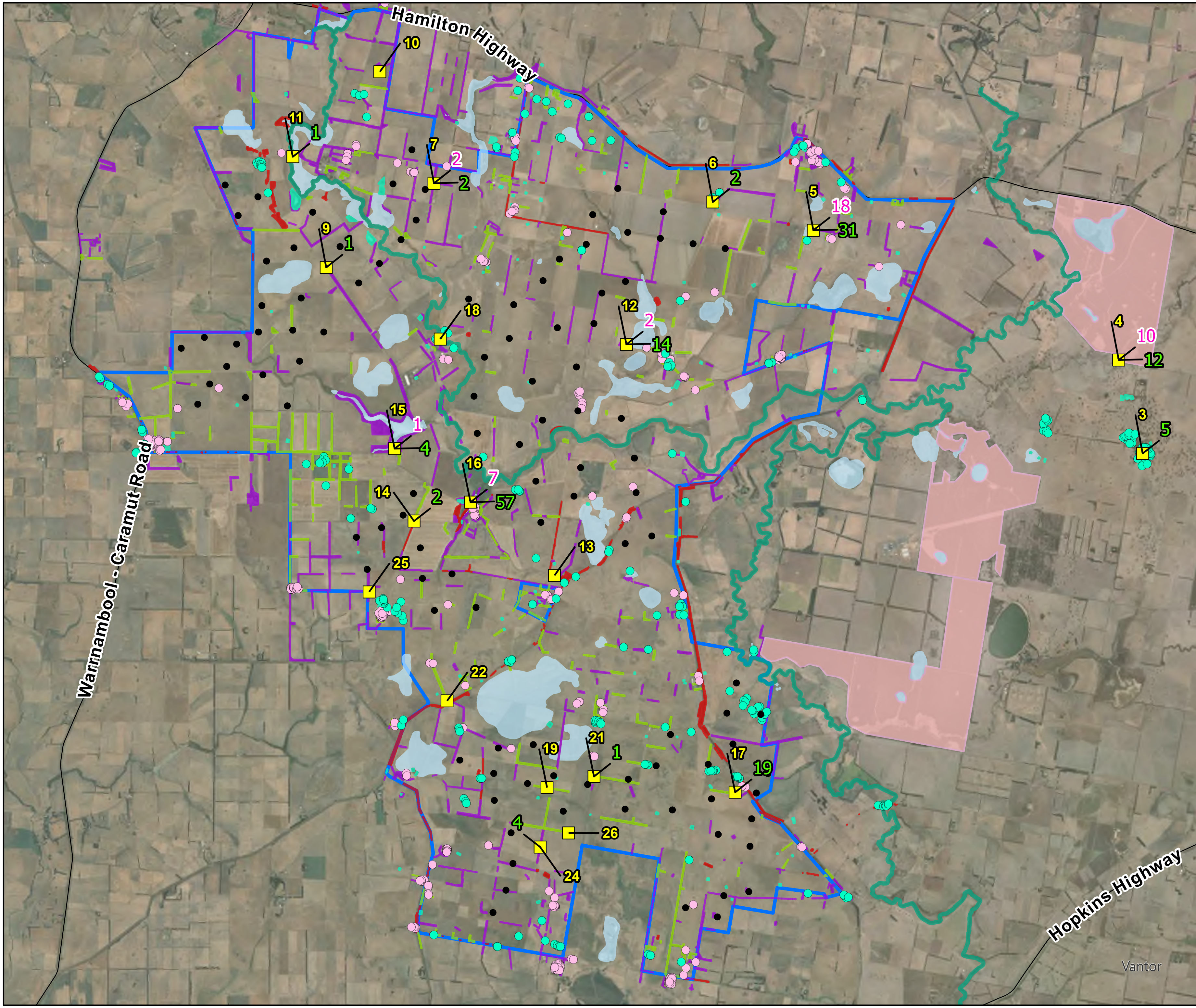


Figure 10: SBWB definite and complex calls Autumn 2023

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

- Wind farm boundary
- Turbine
- Bat detector sites

Habitat features

- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland
- Planted tree
- Remnant tree

Bat call numbers

1: SBWB definite bat call
1: SBWB complex bat call

N

Kilometres
0 1 2 3 4
GDA2020 MGA Zone 54

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Figure 11: Large, permanent pool in a tributary off Mustons Creek (Site 16)

Figure 12: Large Farm Dam close to *Eucalyptus* and pine windbreaks (Site 05)

Figure 13: Typical planted *Eucalyptus* windbreak at the wind farm site

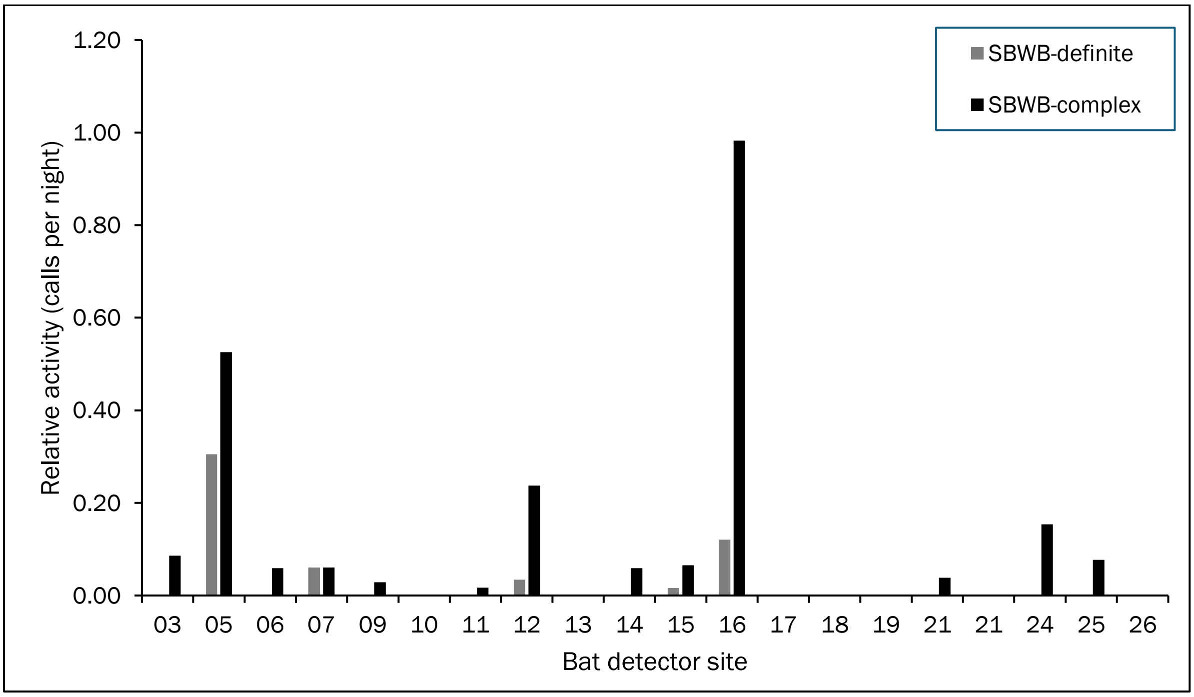

Figure 14: Southern Bent-wing Bat calls at each bat detector sites during the Autumn 2023 survey

7.7.2. Temporal activity patterns

The time of the night when each of the SBWB-definite and SBWB-complex calls were recorded is plotted in Figure 15. Calls were grouped into 15-minute time blocks after sunset.

Figure 15 shows that the spread of calls (temporal activity) in relation to time after sunset had a well-defined pattern. Apart from two SBWB-definite and five SBWB-complex calls recorded in the first hour after sunset, the bulk of the activity occurred between 1.5 to 6 hours after sunset, with peak activity centered around 2 to 5 hours after sunset (Figure 15).

The small amount of SBWB activity recorded at the wind farm within one hour of sunset compared to later during the night suggests that bats travelled for some distance from locations outside the study area. No roosting sites are known to occur within the HWF study area. It is therefore presumed that foraging SBWBs travelled to the HWF site from other locations. SBWBs are known to travel an average of 35 km per night from roosting caves to their foraging grounds (Bush et al., 2022), with longer nightly intercave movements of 70 km occurring less frequently (van Harten et al., 2022a). The maximum straight-line distance travelled by a SBWB in a single night is 85 km (Bush et al., 2022). The nearest roosting caves to the wind farm site are Grassmere (25 km) and Panmure (30 km), both are within the known range of nightly movements and could therefore be the source of SBWBs recorded travelling across the HWF site during the Autumn 2023 survey.

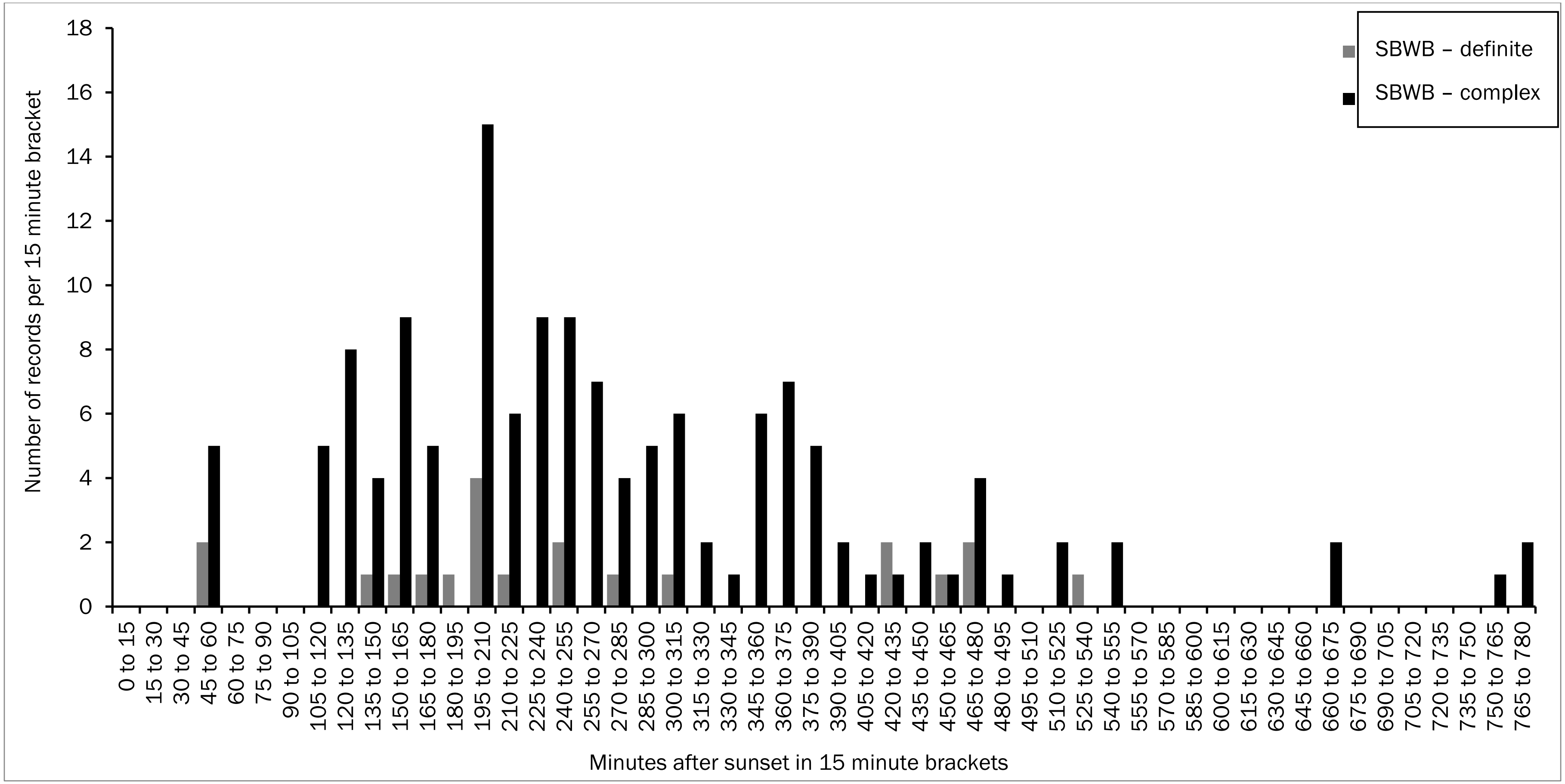

Figure 15: Timing of Southern Bent-wing Bat calls in relation to sunset during March-April 2023

8. Results of targeted Grey-headed Flying-fox surveys

8.1. Field surveys – fly out counts

8.1.1. Summer-Autumn 2022

GHFF were observed in flight on both nights of the February 2022 survey, however no GHFF were observed during the morning March 2022 surveys (Table 15). Five GHFF were observed on the 14th February 2022 flying along the western boundary of the plantation, in a northerly direction from the south. Three of the GHFF landed in an apple tree nearby. While the two remaining GHFF continued flying to the north. One in a northerly direction from the plantation and the second in a northerly direction along the course of the Hopkins River.

On the 15th February 2022, ten GHFF were observed flying in a north-westerly direction from the pine plantation (Figure 16).

The timing of the first observations (just after sunset) of the GHFF (Table 13) indicated that they had come from a camp in close proximity to HWF and likely not the known GHFF camp that is located in Warrnambool a distance of more than 30km away. These observations back up the observation made by the member of the public, who said that the camp is in the plantation south of the Hamilton Hwy.

Four separate observations of feeding GHFF were recorded. The GHFF were observed feeding in a non-native apple tree and a non-indigenous planted Sugar Gum (*Eucalyptus cladocalyx*). The locations of these feeding observations were all to the east of the proposed Hexham Wind Farm.

It was apparent GHFFs were utilising the area east of Hexham Wind Farm, however their presence in the area varies throughout the year. It appears that the GHFF are relocating to the area to take advantage of the abundant resources available to them when the Sugar Gums of the area are flowering, which begins in the middle to end of March.

8.1.2. Autumn 2023

Between the survey period of 2022 and 2023, it was confirmed that a GHFF colony was roosting in the pine plantation 2.8 km to the east of the proposed HWF. The following GHFF observations were made during surveys undertaken in March 2023. On the 1st March, approximately 290 GHFF were recorded leaving the pine plantation heading in a south-easterly direction and approximately 80 flying toward the south. Again, on the 7th March, GHFF were recorded leaving the pine plantation and travelling in a southerly direction with six individuals observed. On the 8th March approximately 235 GHFF were recorded leaving the pine plantation and heading to the north and approximately 40 to the south, and finally on the 16th March 2023, 19 GHFF were observed travelling in a north-north-westerly direction and 17 GHFF were observed leaving the camp in an north-east direction (Table 15).

Table 15: Grey-headed Flying-fox observations during Summer-Autumn 2022 and Autumn 2023 surveys

Date	Time Start	Time End	Time of first sighting	Location	Number of GHFF	Flight Direction	Visibility	Wind Direction	Wind Speed	Temp. C°	Cloud Cover %	Moon
14/02/22	9:42 PM	9:17 PM	9:01 PM	Hamilton Hwy @37.997322 S, 142.700744 E	5	N	Good	SW	Gentle	20	0	Full
15/02/22	5:24 AM	7:00 AM	NA	Hamilton Hwy @37.997322 S, 142.700744 E	0	NA	Good	SE	Gentle	16	100	Full
15/02/22	7:43 PM	9:20 PM	8:58 PM	Boonerah Rd @38.001724 S, 142.691048 E	10	NNW/NW	Good	S	Gentle	20	0	Full
16/02/22	5:50 AM	7:00 AM	NA	Woolsthorpe-Hexham Road @38.009241 S, 142.675843 E	0	NA	Good	NA	NA	13	100	Full
22/03/22	7:20 PM	8:10 PM	NA	Boonerah Estate Rd @ 38.03179055 S, 142.72664262 E	0	NA	Good	NA	NA	15	60	3rd Qtr.
1/03/23	7:30 PM	8:50 AM	8:15 PM	Boonerah Estate Rd @ 38.030920 S, 142.72664262 E	370	SE	Good	SSW	Gentle	15	95	3rd Qtr.
7/03/23	7:30 PM	9:15 PM	NA	Woolsthorpe-Hexham Road @38.010407 S, 142.675843 E	0	NA	Good	W	Strong	13	80	Full
7/03/23	7:30 PM	9:15 PM	8:35 PM	Hardys Lane @38.041787 S, 144.704843 E	6	S	Good	W	Strong	13	80	Full
8/03/23	7:20 PM	9:00 PM	8:31 PM	Hamilton Hwy @37.997322 S, 142.700744 E	235	NNW	Good	W	Fresh	14	60	Full
8/03/23	7:20 PM	9:00 PM	8:40 PM	Boonerah Estate Rd @ 38.030920 S, 142.72664262 E	40	S	Good	W	Fresh	14	60	Full
16/03/23	7:10 PM	8:40 PM	8:25 PM	Hamilton Hwy @37.997322 S, 142.700744 E	19	NNW	Good	WNW	Fresh	15	70	1st Qtr.
16/03/23	7:10 PM	8:40 PM	8:25 PM	Boonerah Estate Rd @ 38.030920 S, 142.72664262 E	17	E/NE	Good	WNW	Fresh	15	70	1st Qtr.

Figure 16: Grey-headed Flying-fox flight paths and number observed

Project No: 18088.10
Project: Hexham Wind Farm
Date: 17/11/2025

Wind farm boundary

Observation date and direction

- 14/02/2022
- 15/02/2022
- 01/03/2023
- 07/03/2023
- 08/03/2023
- 16/03/2023

370: Number of GHFF observed

Kilometres
0 0.5 1 1.5 2
GDA2020 MGA Zone 54

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8.2. Acoustic monitoring

The GHFF camp activity was detectable via recording the species' calls on acoustic recorders. Two call types of the GHFF were detected: (i) colony squabbling and shrieking, and (ii) in-flight calls (Figure 17). Additionally, the sound of 'wing beats' as the species flew in and out of the camp were occasionally detectable.

The GHFF was highly active through March to early April 2023. Following sounds of activity in the morning of 8th April 2023, activity then reduced with noticeably fewer detections of the species in the following days. Analysis detected only occasional calls from a few individuals and the sounds of wing beats until the last acoustic detection of the species was recorded on the 12th April 2023 at 06:54am. From 13th April 2023, the sounds of trucks and machinery were detected operating within the plantation, and common bird species continued to call, but no GHFF calls were recorded. It can be derived that the Flying-fox colony left the camp by the 13th April 2023.

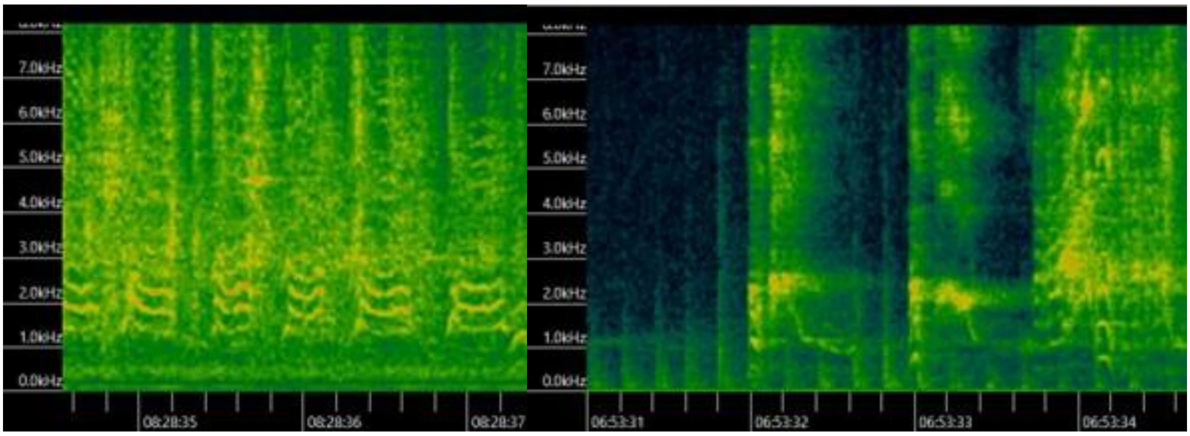

Figure 17: Spectrogram of GHFF colony shrieking and squabbling (left) and wing beats and flight calls (right)

8.3. Potential impacts

Impact rating criteria

A set of impact rating criteria, from very low to very high, was developed specific to biodiversity and used to qualitatively describe the level of potential impact expected to bats at HWF (Table 16).

Table 16: Biodiversity impact rating criteria framework

Impact rating	Qualitative description of impact
Very low	The impact is localised (immediate vicinity) and / or short-term, and changes to the receptor are unlikely to be detectable above natural conditions. Having negligible effect on the known population or range of the receptor
Low	The impact is at the site scale and / or is medium-term, and results in reversible changes (i.e. to conservation status / population viability / genetic resource etc.) to the receptor once the activity has ceased. Having a minor effect on the known population or range of a receptor.
Medium	The impact is local scale and / or is medium term, and results in reversible changes to the receptor once the activity has ceased.

	Loss of a moderate proportion of the known population or range of a receptor.
High	The impact is regional scale and long-term, and results in reversible changes to the receptor once the activity has ceased. Loss of a high proportion of the known population or range of the receptor.
Very high	The impact is regional (or up to international) scale, and / or long-term, and results in substantial and possibly irreversible change (permanent), or total loss, to the receptor. Loss of a very high proportion of the known population or range of the receptor.

Grey-headed flying-fox potential impacts

Grey-headed Flying-fox has the potential to re-use a camp and occasionally fly over the wind farm site which may put it at risk of collision with turbines.

The closest known roost of this species is located in pine forest plantation to the east of the site. A total of 290 GHFF were recorded leaving the camp on the 1st March 2023. The Warrnambool camp has had up to 2,500 – 10,000 individuals recorded at the camp. The usual numbers at the camp are between 1 and 2,499 individuals (DAWE 2022b). In the past few years, a temporary camp has established itself at a pine plantation northwest of Mortlake. Numbers at this camp are estimated between 2,500 and 9,999 (DAWE 2022b).

Each night the GHFF leave their roost and spread out across the landscape in search of food resources which include fruit and nectar from blossoms. They will usually travel within 15 km of its roost in search of food each night (Tideman 1998) though they have been reported moving out to 50 km (DAWE 2021b). The absence of GHFF observations heading in a westerly direction from their roost in the pine plantation supports the conclusion that there are limited food resources within the boundary of the proposed HWF that would attract the GHFF to the area. Food resources at the HWF include blossoms of remnant eucalypts and planted Sugar Gums and the fruit of any planted fruit trees that may be around farmhouses (Figure 2).

It is considered unlikely that the GHFF would visit the proposed HWF regularly to feed. However, there may be flights across the site. Consequently, it is considered unlikely that the proposed wind farm will result in levels of mortality sufficient to cause a significant impact on the species. . However, specific measures will be included in the BAM Plan to address impacts to these species.

There are very few records of this species in the region and the nearest confirmed permanent roost is situated in the Warrnambool Botanic Gardens, approximately 35 km south. The colony hosts around 500 individuals on average which leave to forage in the surrounding region, though the proposed HWF area is likely beyond their nightly foraging range. The species are considered to be capable of long-distance movements to new colonies throughout the entirety of their range, which extends from Victoria to Queensland.

The habitat of HWF is generally not considered preferable to the species thus they would be unlikely to occur regularly, however the temporary GHFF camp noted in a pine plantation to the east of the HWF in 2022 prompted investigations into their nightly fly-out patterns. These camps form when temporary foraging resources in an area become available, such as blossoming Eucalyptus trees which provide nectar for the species to feed on. The species will move in and 'camp' temporarily while the resources are available and then move on when they are depleted. Data displayed on the Australian Flying-fox monitor (2025) from 2022 identifies flight paths consistently in a north-east direction from the pine plantation camp, with only two flight paths over the northern-most section of the HWF study area. However, the camp was recently discovered to active during surveys for another project on 23 September 2025, with 218 individuals flying out in a north-westerly direction (*Nature Advisory, internal data*). When the camp is active, it is possible that GHFF may move through the HWF site on occasion, or forage on Eucalypts in the study area when flowering.

The absence of GHFF observations heading in a directly westerly direction towards the wind farm site from their roost in the pine plantation supports the conclusion that there are limited food resources within the boundary of the proposed HWF that would attract the GHFF to the area.

Impacts from disturbance are unlikely, but GHFF's may collide occasionally with turbines if passing through the wind farm site. Therefore, the impact rating for this species prior to implementing avoidance and mitigation measures is very low.

9. Overview of threatened microbat species recorded across the study area

Two threatened species were confirmed as occurring in the study area during this investigation. SBWB (confirmed and/or species complex) calls were recorded during every survey period. YBSB calls were recorded during every survey period except for Autumn 2023. The occurrence across the study area and related implications for each species are discussed in the following section.

9.1. Southern Bent-wing Bat

The SBWB is an obligate cave-roosting species with a restricted distribution (19,452 km^2) in south-eastern Australia that spans an area from Robe, Naracoorte and Port MacDonnell in south-east South Australia, extending eastwards to Lorne and Pomborneit in south-west Victoria (Churchill, 2008; Threatened Species Scientific Committee, 2021). There is a small area of overlap in the distribution of the SBWB and Eastern Bent-wing Bat in western Victoria, where individuals of each subspecies may roost together in some non-maternity caves (Threatened Species Scientific Committee, 2021). In this region, SBWB and Eastern Bent-wing Bat cannot be reliably distinguished using traditional field-based techniques, such as comparing morphometrics (Department of Environment, Land, Water and Planning, 2020).

In 2000, the SBWB was recognised as a subspecies distinct from the Northern (*Miniopterus orianae orianae*) and Eastern (*Miniopterus orianae oceanensis*) Bent-wing Bats (Cardinal and Christidis, 2000). There is one other Australian Miniopterid, the Little Bent-wing Bat (*Miniopterus australis*); this species' distribution spans south-eastern NSW to north-east Queensland and does not overlap with SBWB (Australasian Bat Society, 2024). With a mean weight of 15.7 g, head and body length of 52–58 mm, and forearm length of 45–49 mm, the SBWB is slightly larger than the other two *Miniopterus orianae* subspecies, however the three subspecies are morphologically very similar (Churchill, 2008).

The SBWB has undergone serious population decline since the 1960s (Department of Environment, Land, Water and Planning, 2020). Consequently, in 2007 the SBWB was listed as Critically Endangered under the EPBC Act. In Victoria, the species is listed as Critically Endangered under the FFG Act. A draft national recovery plan for the SBWB was issued in 2015 (Lumsden and Jemison, 2015), and a revised plan was formally adopted under the EPBC Act in 2020 (Department of Environment, Land, Water and Planning, 2020).

Recent population modelling predicted an 84% to 97% reduction in population size from 2020-2056 (van Harten et al., 2022b). Continued population decline is suspected to be driven primarily by historical and ongoing loss of foraging habitat via the conversion of wetlands and native vegetation for agricultural purposes. Drought and the introduction of White-nose Syndrome to Australia both pose significant threats to SBWB (Holz et al., 2019; Southern Bent-wing Bat National Recovery Team, 2022).

9.1.1. Definite and complex calls

SBWB definite, complex and combined calls during each survey season are displayed in Figures 18, 19 and 20, respectively. These figures display all SBWB calls by year (different colours) and rate of calls per night (size of circles) with some sites showing results over multiple survey years, resulting in overlap of data points in some instances. Due to the presence of three species within the species complex, two of which are common, and the expected higher volume of calls, the *rate* *of calls per night* categories are larger than those for SBWB alone. Surveys where no calls were recorded during all or some of the survey years are displayed with a square.

There were 218 SBWB-definite calls recorded from 33 of the 128 sites across the study area from 2010 to 2023 (Table 17). The area with the highest activity of SBWB-definite during the Spring 2010 survey was site HS1-2, with 90.8% (69 calls) of the 2010 calls. This site was located off Boomerah Estate Road, approximately 700 m from a large farm dam with multiple large, scattered paddock trees and small patches of planted eucalypt windbreaks nearby. The proposed development footprint has been revised since this survey and site HS1-2 is no longer within the development area (Figure 2, Figure 6).

During Autumn 2011, 86.7% (13 calls) of SBWB-definite calls were recorded at site HA13, which is located approximately 300 m south of a large farm dam towards the centre of the HWF study area. There were also patches of linear planted windbreaks in the vicinity (Figure 6).

Single SBWB-definite calls were recorded at five sites during Spring 2018, which were all generally located in the centre (within a few kms of a large farm dam or Mustons Creek) or north-east of the HWF study area, near a small creek and several small- to medium-sized farm dams (Figure 7, Figure 18).

During Autumn 2019, 34.7% (25) of SBWB-definite calls were recorded at HS8, which is in the north-east section of the HWF study area, approximately 100 m from a farm dam and planted wind breaks. HS12 also had a comparatively high number of calls (30.6%, 22 calls) and is in a small patch of trees approximately 300 m from a medium-sized farm dam in the north-east portion of the HWF study area (Figure 8, Figure 18).

During the gradient studies in autumn 2020, 100% (8) of the SBWB-definite calls were recorded at in cropped land up to 120 m south of a large wetland in the centre of the wind farm site.

In 2023, 60% of the SBWB-definite calls (18 calls) were recorded at a large farm dam close to a eucalypt wind break in the northeast of the HWF study area (site 05). While 23% of SBWB-definite calls (7 calls) were recorded at a large wetland close to Mustons Creek (site 16; Figure 14, Figure 18).

In addition to the SBWB-definite calls, 2244 calls were attributed to the SBWB-complex, which includes calls with characteristics that could have been produced by SBWB, Little Forest Bat or Chocolate Wattled Bat (Figure 19 & Figure 20).

From extensive bat detector surveys Nature Advisory has conducted at a range of sites over the last decade, plus publicly available results from bat detector surveys done by multiple other consultants and studies, Forest Bat spp. and Chocolate Wattled Bats often comprise a large proportion of the total number of calls recorded during surveys conducted across south-eastern Australia. However, it is assumed that a proportion of the SBWB-complex calls recorded would have been SBWB.

Table 17: Numbers and average of Southern Bent-wing Bat calls per recording night by site (2010-2023)

Site	Habitat ID	No. of recording nights	No. calls	Ave. calls per night
Spring 2010				
HS1	Creek	7	1	0.14
HS3	Remnant native woodland	7	1	0.14
HS1-2	Remnant tree	7	69	9.85
HS2-2	Remnant native vegetation	7	3	0.42
HS3-2	Remnant native woodland	7	1	0.14
HS1-4	Planted eucalypts	12	1	0.08
Total		**298**	**78**	**0.20**
Autumn 2011				
HA13	Planted eucalypts	35	13	0.97
HA12	Creek	35	2	0.06
Total		**413**	**15**	**0.04**
Spring 2018				
HX7-ground	Cleared open land (non-treed)	53	1	0.02
HX11	Planted eucalypts	21	1	0.05
HX13	Planted eucalypts	21	1	0.05
HX15	Cleared open land (non-treed)	20	1	0.05
HX17	Planted eucalypts	20	1	0.05
Total		**438**	**5**	**0.01**
Summer-Autumn 2019				
HS8	Remnant tree	59	25	0.42
HS12	Planted eucalypts	58	22	0.38
HS14	Planted eucalypts	59	10	0.17
HS3	Remnant native woodland	79	6	0.08
HS16	Pine tree row	59	3	0.05
HG1	Cleared open land (non-treed)	58	1	0.02
HG2	Cleared open land (non-treed)	58	1	0.02
HG3	Cleared open land (non-treed)	58	1	0.02
HS5	Farm dam	79	1	0.01
HS6	Remnant native woodland	78	1	0.01
HS7-ground	Cleared open land (non-treed)	53	1	0.02
Total		**1,462**	**72**	**0.05**
Autumn 2020				
W2	Cleared open land (non-treed)	92	2	0.02
W3	Cleared open land (non-treed)	92	6	0.07
Total		**930**	**8**	**0.00**
Summer-Autumn 2023				
4	Forestry plantation	34	10	0.29
5	Wetland	59	18	0.31
7	Planted eucalypts	33	2	0.06
12	Planted eucalypts	59	2	0.03
15	Wetland	61	1	0.02
16	Wetland	58	7	0.12
Total		**877**	**40**	**0.05**
Grand Total		**4,418**	**218**	**0.05**

Note - Greg Ford (Principal Ecologist of Balance Environmental, QLD) peer-reviewed the 2018 and 2019 SBWB-definite calls) and confirmed the results via email (21/7/2020).

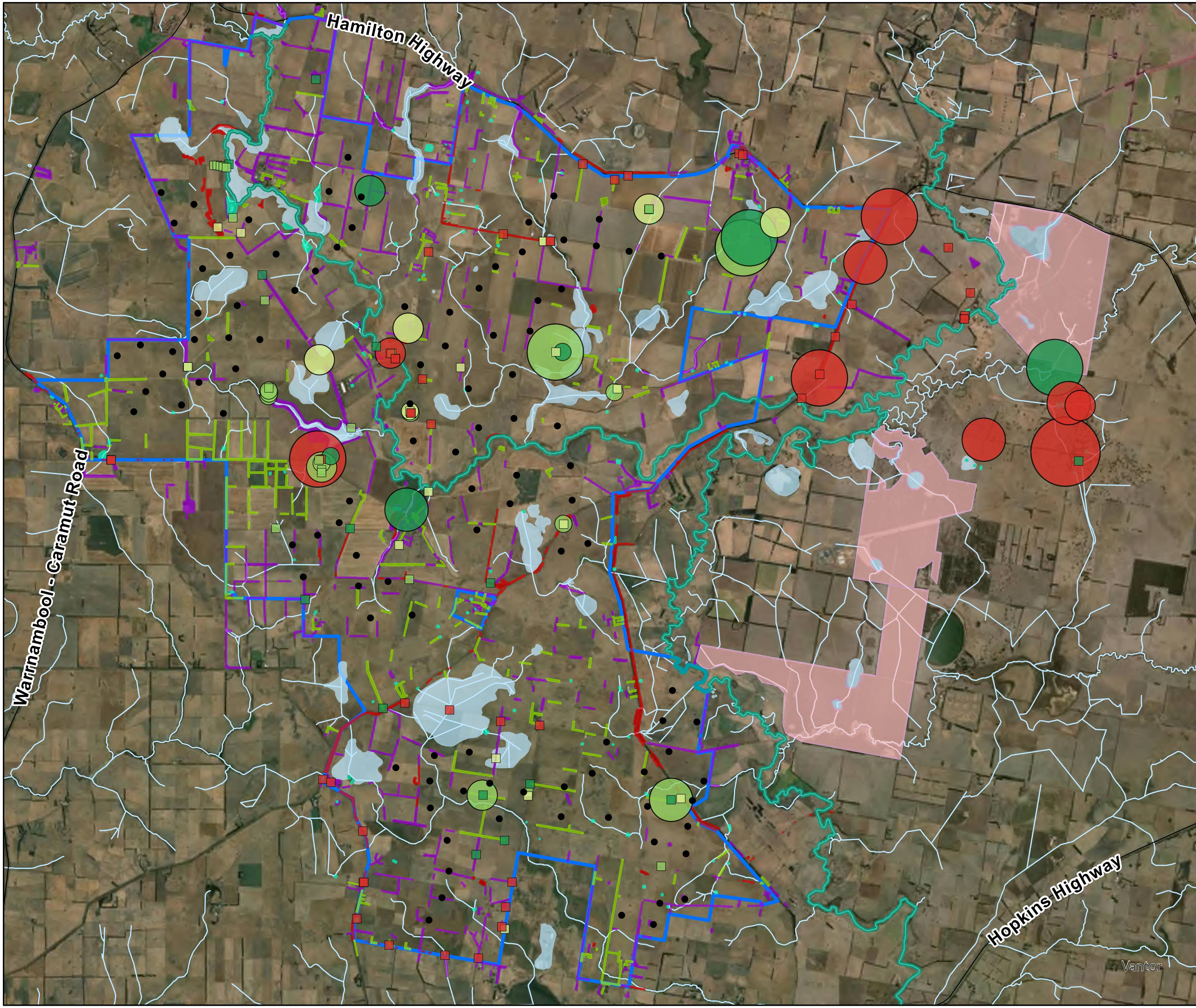

Figure 18: SBWB calls with habitat

Project No: 18088.10
Project: Hexham Wind Farm
Date: 19/11/2025

Wind farm boundary
Turbine
Watercourse

Habitat features

Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland

Survey year

2010 2011 2018 2019 2020 2023

Rate of calls per night

No calls recorded
Very Low (≤0.04)
Low (0.04 to 0.1)
Medium (0.1 to 0.2)
High (0.2 to 0.5)
Very high (>0.5)

N
Kilometres
0 1 2 3 4
GDA2020 MGA Zone 54

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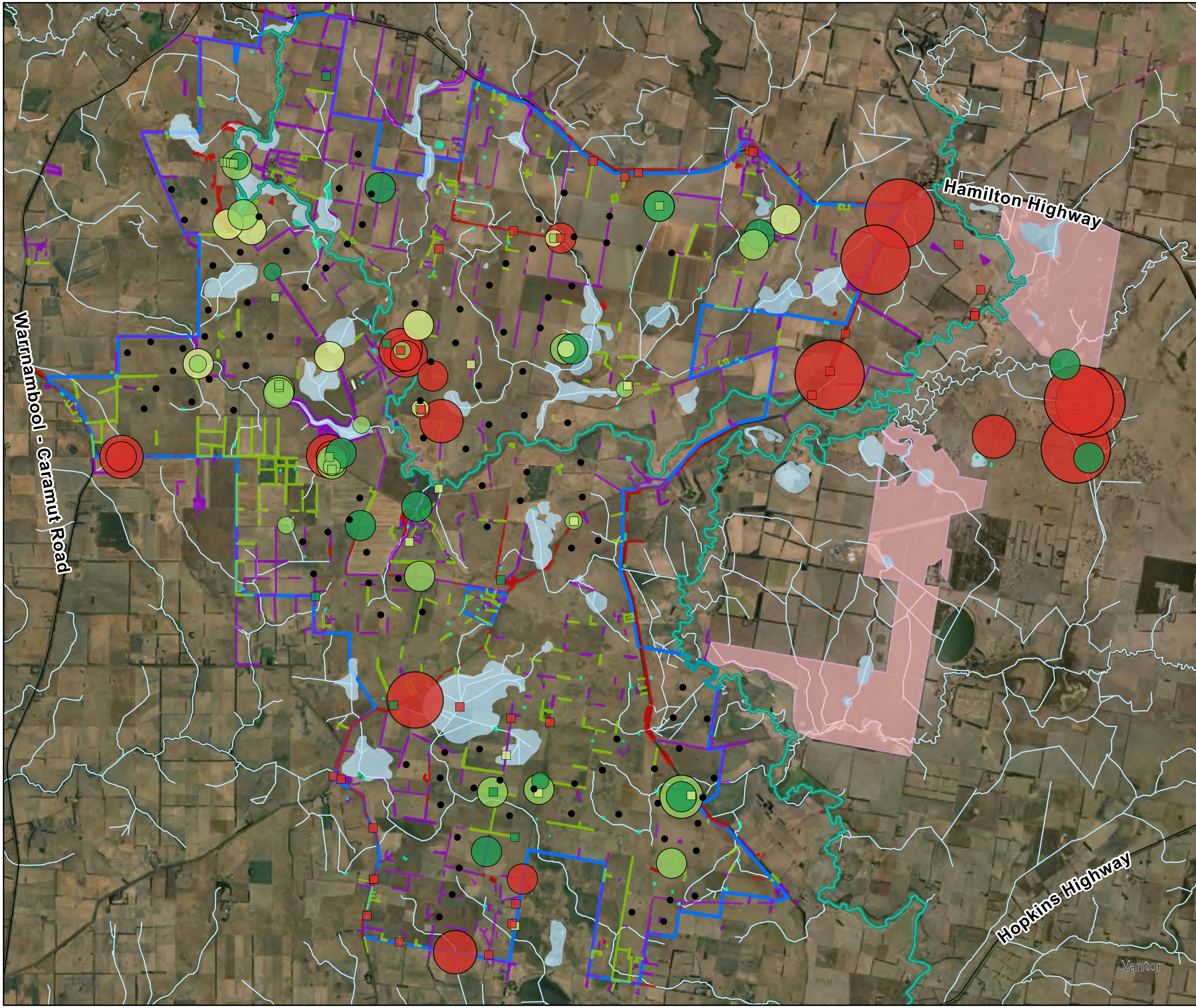
Figure 19: SBWB complex calls with habitat



Project No: 18088.10
Project: Hexham Wind Farm
Date: 19/11/2025

Wind farm boundary
Turbine
Watercourse

Habitat features

Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland

Survey year

2010 2011 2018 2019 2020 2023

Rate of complex calls per night

No calls recorded
Very Low (<0.05)
Low (0.05 to 1)
Medium (1-5)
High (5-10)
Very high (>10)

N

Kilometres
0 1 2 3 4
GDA2020 MGA Zone 54

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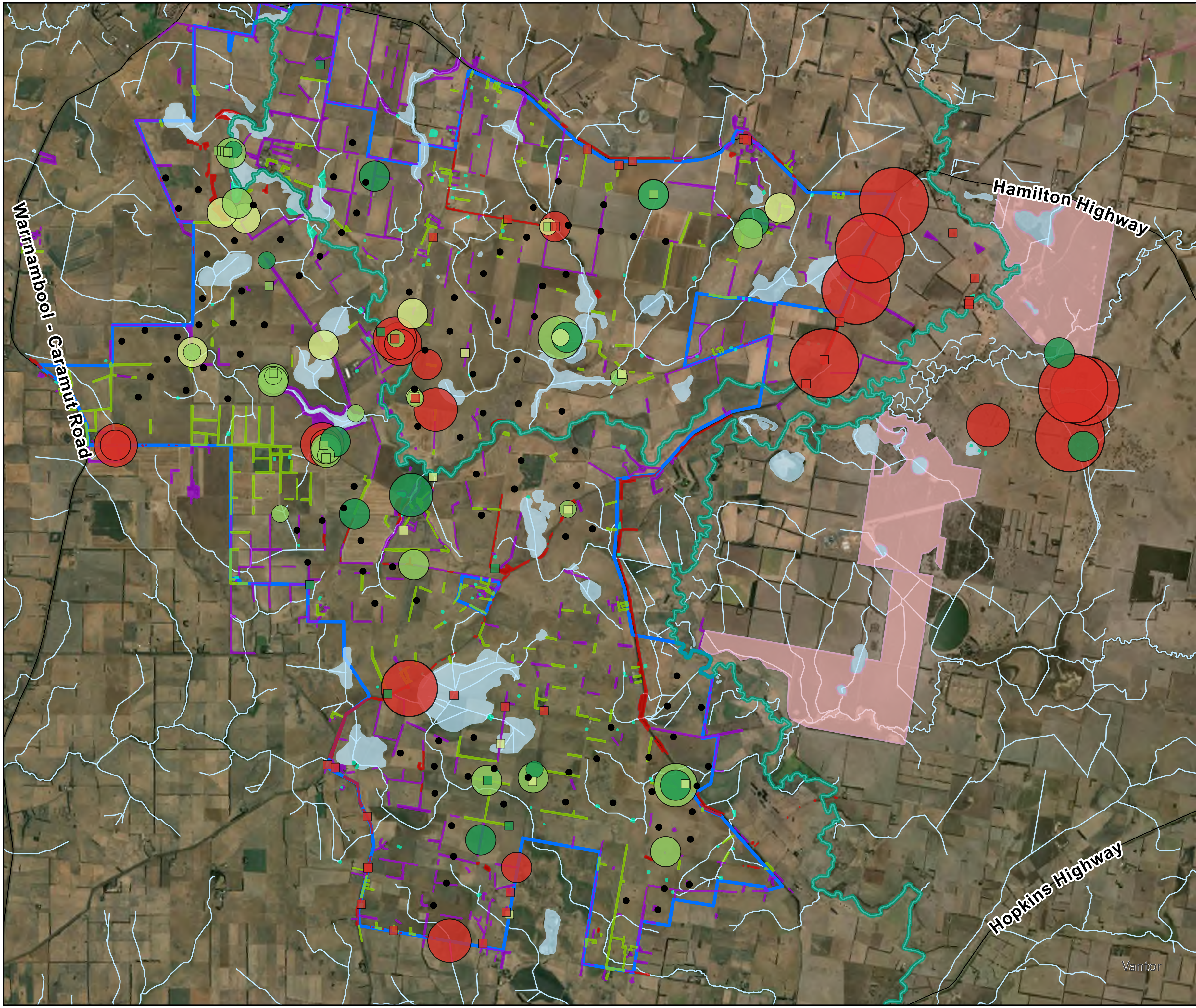
Figure 20: SBWB combined calls with habitat

Project No: 18088.10
Project: Hexham Wind Farm
Date: 19/11/2025



Wind farm boundary
Turbine
Watercourse

Habitat features
Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland

Survey year
2010 2011 2018 2019 2020 2023

Rate of combined calls per night
No calls recorded
Very Low (<0.05)
Low (0.05 to 1)
Medium (1-5)
High (5-10)
Very high (>10)

Kilometres
0 1 2 3 4
GDA2020 MGA Zone 54

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9.1.2. Foraging and habitat usage

SBWB is a nocturnal, aerial hawking insectivorous species with a fast, direct flight pattern (Dwyer, 1965). Where there are trees, SBWBs typically forage in open spaces above the canopy, but can fly closer to the ground in more open areas (Churchill, 2008; Threatened Species Scientific Committee, 2021). Limited radio-tracking studies have shown that SBWBs hunt in a range of habitat types, forested areas, native remnant vegetation, and over cleared agricultural and grazing land (Grant, 2004; Stratman, 2005; Threatened Species Scientific Committee, 2021). SBWB also show a preference for seasonally inundated wetlands (Stratman, 2005). DELWP (2020) state that wetlands with terrestrial vegetation occurring around the fringes and aquatic vegetation within the swamp itself are used extensively, with individuals recorded flying considerable distances from roost caves to reach these foraging areas.

In 1977, a dietary study examining stomach contents of 11 bent-winged bat (*Miniopterus schreibersii*) individuals collected from eastern and northern Australia found moths (Lepidoptera) were the main prey item (Vestjens and Hall, 1977). In a recent study using arthropod DNA metabarcoding of guano collected from caves, Kuhne et al. (2022) also found that moths comprised the main component of the SBWB diet. Of the 67 moth species identified, many are associated with agricultural landscapes, such as Pasture Webworm (*Hednota pedionoma*) and Armyworm (*Persectania dyscrita*) (Kuhne et al., 2022). These findings suggest SBWB may provide important ecosystem services by contributing to the control of populations of moth species considered to be agricultural pests (Kuhne et al., 2022).

Being an insectivorous bat, SBWBs have a high surface area to volume ratio and large, naked flight membranes, which in combination result in high rates of evaporative water loss (Webb et al., 1995). Consequently, they require access to surface water and drink on-the-wing from open waterbodies such as creeks and rivers, wetlands and farm dams (Threatened Species Scientific Committee, 2021). SBWBs are also known to access drinking water by licking droplets from drips in roost caves (Bourne and Hamilton-Smith, 2007; Codd et al., 1999).

SBWB-definite and SBWB-complex calls recorded during all bat surveys undertaken by EHP and Nature Advisory from 2010–2023 were pooled to investigate activity patterns relative to specific habitat types. Habitats at sites where bat detectors were deployed were classified into the following 9 categories:

- Planted eucalypts – mostly planted non-native Sugar Gums as wind rows or small patches.
- Forestry plantation – pine forestry plantation, located 4km east of the wind farm site.
- Pine tree row – planted pine trees as wind rows between paddocks.
- Remnant native woodland – small eucalypt patches close to Mustons Creek or wetlands and linear native eucalypt reserves along roadsides and occasionally between paddocks.
- Remnant tree – native remnant eucalypt trees within paddocks, that are not close enough to each other to form a patch (touching canopies).
- Cleared open land (non-treed) – grazed paddocks or cropped land without trees.
- Wetland – DEECA mapped wetlands and other wetlands and waterbodies mapped during site surveys.
- Permanent creek – Mustons Creek.
- Farm dam – artificially created wetlands for agricultural purposes.

Some habitat types were derived from aerial photograph analysis and have not been ground-truthed through field surveys. Hence, some categories were assumed to be remnant or planted trees based on their occurrence and location.

Table 18 summarises the call activity of confirmed SBWB (SBWB-definite) and SBWB-complex across all surveys in 2010, 2011, 2018, 2019, 2020 and 2023, and the different habitat types where detectors were placed (see also Figure 21).

Overall, SBWB activity (measured as calls per night) tended to be greater close to wetlands and wooded vegetation such as planted eucalypts and forestry plantations for confirmed SBWB calls. SBWB-complex calls, which include Little Forest Bat and Chocolate Wattled Bat calls were mostly recorded from wooded vegetation such as remnant native woodland (roadside) vegetation, planted eucalypts as well as pine tree rows.

The overall SBWB activity observed within the wind farm site is very low with 0.01 to 0.43 average calls per night at sites were calls of this this species were recorded. SBWB calls were recorded at 33 sites (25%) out of 128 sites.

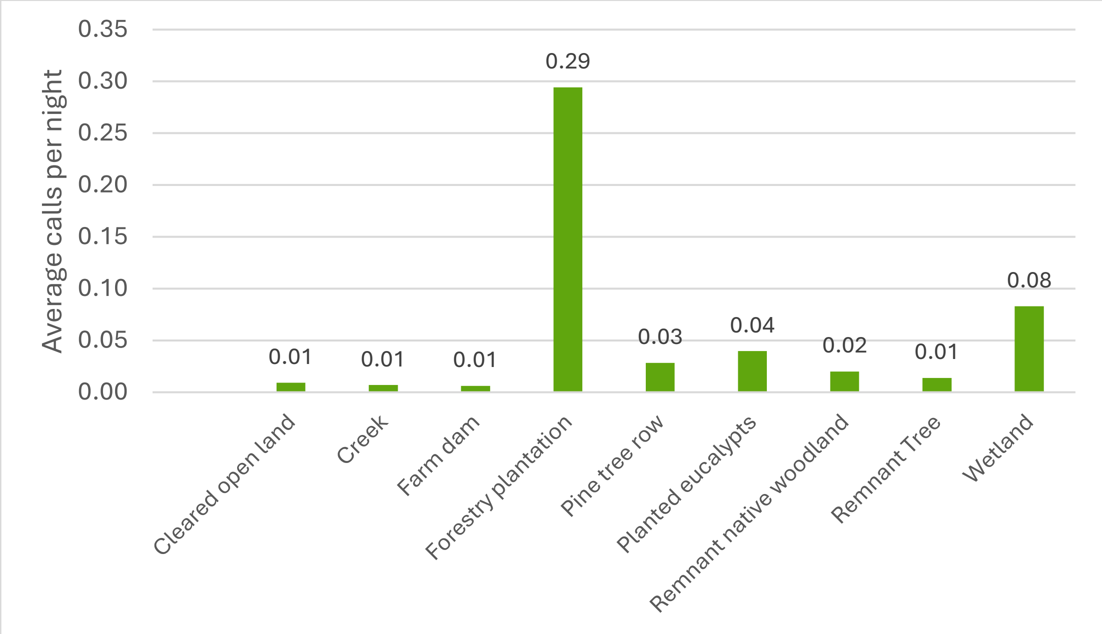
The pattern observed is partially skewed due to small sample sizes for some habitat features such as remnant trees and forestry plantations and does not indicate a reliable and robust pattern of habitat use when visualising abundance and occurrence (presence/absence) of calls.

The potential influence of nearby habitat features on SBWB bat activity limits the usage of statistical tools to draw reliable conclusions on SBWB utilisation patterns. Currently, a visual observation of the occurrence of calls (Figure 21) across habitat features, only shows considerable variability and that SBWB can utilise a range of habitats across the landscape.

Table 18: Southern Bent-wing Bat definite and species complex calls recorded across habitat types in 2010, 2011, 2018, 2019, 2020 and 2023 surveys

Habitat feature	Number of sites surveyed	Sites with SBWB calls	Total of SBWB calls	Average of SBWB calls per night	Sites with combined SBWB definite & complex calls	Total of combined SBWB definite & complex calls	Average of combined calls per night	Effort (survey nights)
Cleared open land	29	8	14	0.01	13	103	0.07	1520
Permanent creek	11	1	2	0.01	5	150	0.52	289
Farm dam	6	1	1	0.01	1	2	0.01	163
Forestry plantation	1	1	10	0.29	1	22	0.65	34
Pine tree row	13	2	9	0.03	6	134	0.42	317
Planted eucalypts	42	10	54	0.04	27	1020	0.75	1359
Remnant native woodland	16	4	7	0.02	7	491	1.40	350
Remnant tree*	3	3	95	1.30	3	413	5.66	73
Wetland	7	3	26	0.08	5	127	0.41	313
Total	**128**	**33**	**218**	**0.05**	**68**	**2462**	**0.56**	**4418**

* These high number of calls were observed by EHP in 2010 outside the current wind farm site at two sites close to remnant trees (HS1-2 and HS1-3) and between two large forestry plantations and have been excluded in the graph of Figure 18 to better show the distribution of calls at other habitat types.



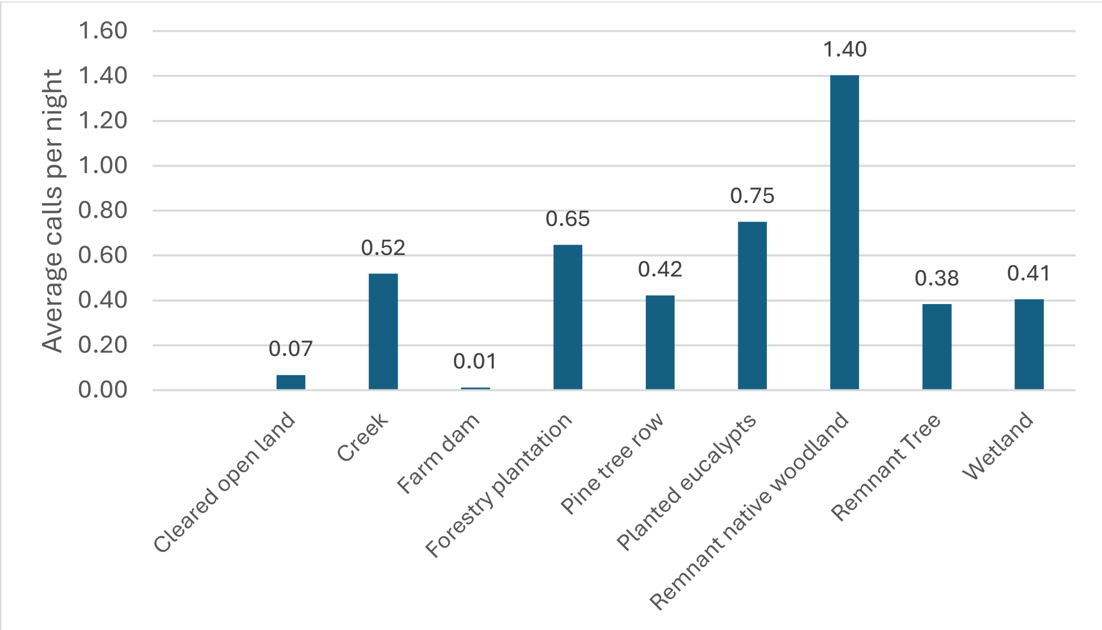


Figure 21: Southern Bent-wing Bat definite (above) and species complex average calls per detector-night (below) recorded across habitat types in 2010, 2011, 2018, 2019, 2020 and 2023 surveys excluding 69 SBWB calls and 318 complex calls recorded at two sites (HS1-2 and HS1-3) in 2010 (remnant tree) outside the wind farm boundary

For confirmed presence of SBWB in different habitat features, the highest proportion of sites surveyed with SBWB calls were forestry plantation, remnant tree and wetlands. However, it is noted for each of these categories there were small sample sizes with limited replication. For all remaining habitat features the confirmed presence of SBWB was less than 30% of sampling sites (Table 18) and included cleared open land (28% of sites), remnant native woodland (25% of sites), planted eucalyptus (21% of sites), farm dams (17%), creek (15%), and pine tree rows (8%). A similar pattern was recorded for the species complex although there was a higher proportion of sites with the call complex in planted eucalyptus, pine tree row and remnant trees.

9.1.3. Roost caves

SBWBs gather in late spring and early summer at maternity caves to give birth and raise their young, and then disperse in autumn to use non-breeding caves throughout the cooler parts of the year (Churchill, 2008). There are two major SBWB maternity caves with long histories of use: 'Bat Cave', located in the limestone cave system at Naracoorte in South Australia, and 'Starlight Cave', a sea cliff cave located near Warrnambool in Victoria (Threatened Species Scientific Committee, 2021). During the breeding season, the majority of the SBWB population is thought to roost in the two main maternity caves: around 28,000–35,200 bats in Bat Cave (Naracoorte, SA), and 17,233–18,000 bats in Starlight Cave, (Warrnambool, western Victoria) (Threatened Species Scientific Committee, 2021). A third, smaller maternity cave was discovered in 2015 near Portland, Victoria (Lumsden and Jemison, 2015). In 2020, The Department of Environment, Land, Water and Planning (DELWP) estimated there was a population of 1,000–1,500 individuals (including juveniles) using the Portland maternity cave (Threatened Species Scientific Committee, 2021).

Monitoring the abundance of SBWBs at the three maternity caves is ongoing, with data being used to develop long-term population models (Southern Bent-wing Bat National Recovery Team, 2022).

The SBWB maternity caves have specific structural characteristics that allow heat and humidity to build up, creating conditions suitable for rearing and development of dependent young (Dwyer, 1963). The caves used in winter are cooler, allowing the bats to lower their body temperature to facilitate the use of torpor, i.e. reduced metabolic rate (Baudinette et al., 1994; Hall, 1982). In Victoria, there are 18 caves used as roosting sites, spread throughout the south-west of the state, and in South Australia 52 caves are known to be used for roosting (Department of Environment, Land, Water and Planning, 2020).

Recent studies have collected data on patterns of movement between and use of caves that challenge previously held concepts of roost fidelity and temporal patterns of roost use. The Conservation Advice: *Miniopterus orianae bassanii* (Threatened Species Scientific Committee, 2021) summarises this as follows:

"*While caves that are consistently used by large numbers of Southern Bent-wing Bats may be considered critical sites, the availability of a large number of sites, even those used infrequently, may be equally important for the subspecies' survival*."

Table 19 lists publicly known and important SBWB roost cave locations throughout Victoria and Figure 22 shows their location in relation to HWF and other proposed and operational wind farms in south-west Victoria. Panmure and Grassmere non-maternity caves are the only SBWB caves identified within 30 kms of the HWF study area. The Warrnambool maternity cave is located 40 kms south of HWF.

During investigations for this report, further information on the occurrence of SBWB roosting caves in the Victorian Volcanic Plains region was sought from Nicholas White (Victorian Speleologist Association) on 8th May 2020, and from Amanda Bush (Arthur Rylah Institute) on 11th May 2020. Both experts confirmed that the important SBWB roost locations listed in Table 19 are the current extent of publicly available and confirmed SBWB roosting locations in the Victorian Volcanic Plains region and surrounds.

Smaller caves may occur throughout the region in areas of volcanic activity, particularly around volcanoes, recent lava flows and lava extrusion points, as outlined in the sections above, and provide potential SBWB habitat. However, many of these formations are small and very difficult to identify, requiring on ground surveys by geological and SBWB ecology experts.

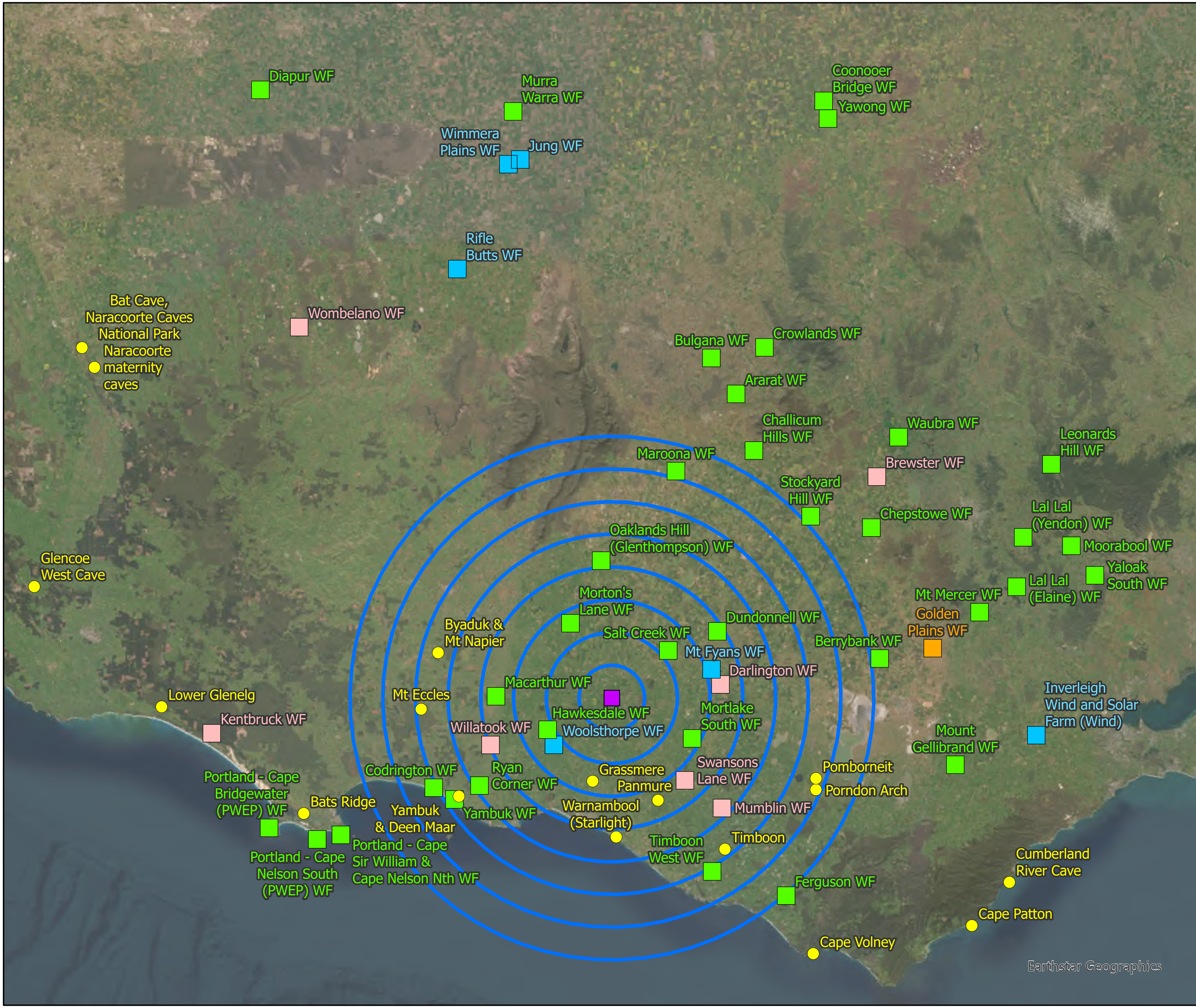
Table 19: Locations of maternity and non-maternity caves in Victoria

Location	Cave	Approx. distance from HWF	Description
Warrnambool	Starlight Cave, plus several other nearby caves	40 km S	Major maternity cave in Victoria
Byaduk	Church Cave	56 km WNW	A series of caves and a well-known roosting site (DELWP 2020a).
Mt Eccles National Park	Unnamed cave	60 km W	Situated within the Mt Eccles National Park and an important roost site (ACCIONA Energy 2009).
Panmure	Panmure cave	30 km SSE	Known roosting lava tube cave on private property (DELWP 2020a, Biosis 2018). Large numbers of bats use this as a roost (ACCIONA Energy 2009).
Pomborneit	Pomborneit cave	63 km ESE	Known roosting cave (DELWP 2020a, Rob Gration personal communication 2019). Can have up to 3000-4000 SBWB individuals which fluctuates over the winter period as bats move around (Reardon 2019). Was formerly disturbed through guano mining, but cave disturbance has been limited (Biosis 2018).
Grassmere	Grassmere (W5) cave	25 km SSW	Cave on private property (DELWP 2020a, Rob Gration personal communication 2019). Known to support large roosting SBWB numbers (ACCIONA Energy 2009).
Bats Ridge	Tom-the-cheap Cave	100 km WSW	A series of caves and a known roosting location near Portland (DELWP 2020a, Rob Gration personal communication 2019).
Yambuk	Yambuk Cave & Deen Maar cave	55 km SE	Known roosting caves (ACCIONA Energy 2009). SBWB detected near a cave here by Rob Gration in 2019 (personal communication 2019). A number of caves in an Indigenous Protection Area on the coast near Yambuk.
Portland	Cape Bridgewater Sea Cave	100 km WSW	Second known maternity cave in Victoria.
Lower Glenelg National Park	Unnamed cave	140 km W	Reasonable numbers of SBWB (ACCIONA Energy 2009).
Cape Volney	Unnamed cave	97 km SE	A series of sea cliff caves in the western end of the Otways used as an important roost (ACCIONA Energy 2009). Signs of bat activity but not confirmed as SBWB in 2019 (Rob Gration personal communication 2019).
Porndon	Porndon Arch	63 kms ESE	Used as an important roost (ACCIONA Energy 2009)

Location	Cave	Approx. distance from HWF	Description
Cape Patton	Unnamed cave	130 km SE	Used as an important roost (ACCIONA Energy 2009). Sea cliff caves exposed to the ocean between Lorne and Apollo Bay. No signs of SBWB in 2019 (Rob Gration personal communication 2019).
Lorne	Cumberland River Cave	130 km SE	Used as an important roost (ACCIONA Energy 2009)

Figure 22: Southern Bent-wing Bat roost caves and wind farms in Victoria

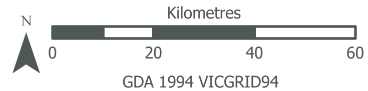
Project No: 18088.10
Project: Hexham Wind Farm
Date: 17/11/2025



Search area
SBWB roost cave
Hexham WF ,Planning application under development or consideration

Surrounding wind farm status

Operating
Under construction
Approved (Not operational)
Planning application under development or consideration



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9.1.4. Flight distances

Recent research has provided new insights on intercave movement patterns (ARI, 2025a; Bush et al., 2022; van Harten et al., 2022a, 2022b). The traditional view, based on the work of (Dwyer, 1963), had assumed there were two seasonal migrations, with all bats leaving overwintering caves in spring and taking several weeks to return to the maternity caves via stopovers at transition caves. In Autumn, bats were thought to disperse from the maternity sites to overwintering caves, where they would enter extensive periods of torpor. Individuals were assumed to remain at these overwintering caves for the duration of winter. However, the new research, which tracks PIT-tagged SBWBs in South Australia, has revealed far more complex movement patterns (van Harten et al., 2022a). Tracking data has shown that so-called 'overwintering caves' can be used at any time of year, leading to discontinuation of the term 'overwintering cave' in favour of 'non-maternity cave' (Bush et al., 2022).

The use of non-maternity caves is now understood to be highly dynamic. For example, bats leaving the Naracoorte maternity cave in early autumn may visit many non-maternity caves over the course of a few weeks before returning to the maternity cave (van Harten et al., 2022a). Large distances can be flown in short periods. There are numerous examples of individuals flying between the Naracoorte maternity cave and a non-maternity cave 70 km away (this cave also has a PIT-tag reader) over the period of just a few hours, and sometimes returning to the maternity cave on the same night – a total distance of 140 km in 24 hours (van Harten et al., 2022a). Periods of torpor also appear to be shorter than previously thought, with some rare activity during winter, including movement between caves (van Harten et al., 2022a)."

Given average nightly travel distances of 35 km from roost caves to foraging areas (Bush et al 2022), plus longer intercave movements of 70 to 85 km (Bush et al., 2022; van Harten et al., 2022a), SBWBs are likely to be present across and forage within southwestern Victoria, including the HWF site on an ongoing basis when accessing foraging areas or moving across the landscape between caves.

9.1.5. Flight heights

SBWB have a fast, direct flight pattern for foraging in open spaces (Dwyer, 1965). Observational records indicate that, in treed areas, SBWB typically forage just above the canopy or within gaps below the canopy (Department of Environment, Land, Water and Planning, 2020). New research has been released on GPS tracking studies undertaken in Victoria and South Australia in summer-autumn 2021–2024 and spring 2023 to directly investigate flight heights of SBWBs, which has been published as a preprint (i.e. not yet peer-reviewed) (Bush et al., 2025). This study found that most SBWB flights occurred within 0 – 30 m altitude, however flights up to 80 m were observed. The modelled data showed that SBWB are capable of flying to heights of more than 70 m and potentially up to 144 m (based on the upper bounds of the model estimates) above the ground at times, and can change height from near ground level to around 40 m within minutes. In addition, during summer SBWB were found to fly higher above treed areas than non-treed areas. The results suggest that, although the SBWB primarily flies at lower heights, it exceeds 30 m altitude at times, increasing the risk of mortalities due to wind turbine collision.

More generally, there is limited or no information on flight heights for most Australian bats, primarily due to technical limitations in recording bat activity across a vertical gradient (Adams et al., 2009). Only a handful of peer-reviewed studies worldwide have attempted to quantify different bat species' use of vertical space (i.e. vertical niche partitioning) (Voigt et al., 2020). To address this limitation, the EUROBATS *Guidelines for Consideration of Bats in Wind Farm Projects* recommends that, for pre-commissioning bat surveys designed to generate data for impact assessments at proposed wind farms, bat detectors should be used to survey bat activity above the canopy, preferably within proposed rotor swept heights (Rodrigues et al., 2015). The EUROBATS Guidelines suggest that at-height survey methods using detectors attached to kites or balloons have been shown to generate data that is limited in use, and instead recommend using stationary structures (Rodrigues et al., 2015). Therefore, attaching detectors to meteorological towers (met masts) is the most commonly employed method for investigating bat flights heights during pre-commissioning bat surveys at European wind farms (Roemer et al., 2017).

Following the EUROBATS Guidelines recommendation for monitoring bat activity at-height, several peer-reviewed studies, published in authoritative scientific journals, have used echolocation calls recorded by paired detectors placed at ground-level and at-height on met mats to quantify the activity of European insectivorous bats across a vertical gradient. The findings have been used to correlate relative activity at height to echolocation call structure and wing morphology, and also to model predicted risk of collisions with wind turbines. This research showed that for Schreiber's Bent-winged Bat *Miniopterus schreibersii*, 0.01% of all activity was recorded at-height (40-85 m AGL) (Roemer et al., 2019b, 2019a, 2017). This co-generic European bent-winged bat species has similar body size, wing morphology and high-frequency echolocation calls to SBWB (~53kHz). For more information, see:

- Roemer, C., Bas, Y., Disca, T., Coulon, A., 2019. Influence of landscape and time of year on bat-wind turbines collision risks. *Landscape Ecology* 34, 2869–2881.
- Roemer, C., Coulon, A., Disca, T., Bas, Y., 2019. Bat sonar and wing morphology predict species vertical niche. *The Journal of the Acoustical Society of America* 145, 3242–3251.
- Roemer, C., Disca, T., Coulon, A., Bas, Y., 2017. Bat flight height monitored from wind masts predicts mortality risk at wind farms. *Biological Conservation* 215, 116–122.

Further, a recent study conducted in Kenya, East Africa, also used bat detectors attached to met masts to quantify bat flight heights and relate the findings to the risk wind farms could pose to species that the authors characterised as either low, medium or high flying (Rainho et al., 2023). The study also concluded that those species that prefer to fly at lower altitudes were strongly associated with habitat variables, as opposed to those flying at higher altitudes who were more influenced by weather conditions.

Initial guidelines for monitoring bats at proposed wind farm developments published by the Victorian Government in 2007 recommended proponents undertake bat detector surveys with paired detectors at ground-level and at-height on a met mast or other portable tower structure (Lumsden, 2007). During Technical Reference Group consultations that Nature Advisory has been involved in, DEECA has routinely suggested this is a methodology that wind farm proponents should incorporate into pre-commissioning bat detector surveys. Consequently, over the last decade or so, met mast bat detector surveys have been conducted during pre-commissioning surveys at multiple proposed wind farms in south-west Victoria in an attempt to quantify use of vertical space by SBWB; for example, at Dundonell Wind Farm, Mortlake South Wind Farm, Bulgana Wind Farm, and Mt Fyans Wind Farm.

It is noted that there are a number of potential limitations with recording echolocation calls at height, such as increased noise from higher wind speeds. Plus, the high-frequency calls produced by SBWBs can be difficult to detect in these conditions due to increased atmospheric attenuation. However, as mentioned above, studies published in international peer-reviewed journals have shown that detectors attached at-height to met masts are capable of recording high-frequency (45-50 kHz) calling bat species (Rainho et al., 2023; Roemer et al., 2019b, 2017).

Results from publicly available examples of met mast bat detector studies on SBWB and Eastern Bent-winged Bat (EBWB) conducted in Victoria and NSW are presented below. These results are indicative only, as SBWB collision risk will be dependent on site-specific characteristics. It is noted that a comparison of predicted pre-construction survey risk compared with risk post-construction has not been undertaken at these sites, and that pre-construction activity has previously not been an adequate indicator of post-construction collision risk in bats (ARI, 2025b).

Surveys within geographic range of Eastern Bent-wing Bat

At Crowlands Wind Farm (CWF), located in central northern Victoria, met mast surveys were conducted in Autumn of 2005 (Brett Lane & Associates, 2006). This site was located outside the range of the SBWB but was potentially within the range of the EBWB. Bat detectors were placed 45 m AGL on two met masts and paired with ground-level detectors at the base of the masts. An additional 6 detectors were deployed at ground-level elsewhere across the site. The survey ran for 8 nights at met mast sites and 7-9 nights at other sites. In total, 2,343 calls were recorded. Of these, 1,187 were assigned to a species or complex. White-striped Free-tailed Bat and Gould's Wattled Bat/*Ozimops* spp. complex formed the majority of calls recorded, both at height and at ground level. No EBWB were recorded during the survey either at ground level or at 45 m (Brett Lane & Associates, 2006).

At Bald Hills Wind Farm (BHWF), located in south east Victoria, met mast surveys were conducted in Autumn 2003 at one site (one recorder at 45 m above ground and one at ground level), with the survey yielding 5 nights of useful data (CEE Consultants, 2003). This survey was within the range EBWB but not SBWB. In total, 107 calls were detected, with the large majority assigned to White-striped Free-tailed Bat, including all calls recorded at height. No EBWB calls were recorded during the survey at BHWF (CEE Consultants, 2003).

At Crookwell 2 Wind Farm (C2WF), in NSW, met mast surveys were conducted in Autumn, and late Spring – early Summer of 2017 (Brett Lane & Associates, 2018a). This survey was outside the range of the SBWB but within the range of the EBWB. One bat detector was mounted on a met mast at 50 m AGL and another at ground level at the same site. A further 8 detectors were deployed at ground level elsewhere across the site. The survey ran for 25 nights in Autumn and 8 nights in late Spring/early Summer. The 'EBWB/Forest Bat' species complex was recorded at height and at ground level. The YBSB was also recorded at ground level. The relative activity of the different microbat species was not reported.

At the proposed Alberton Wind Farm (AWF), in central east Victoria, met mast surveys were conducted in Summer-Autumn of 2015 (Brett Lane & Associates, 2016). This survey was outside the range of the SBWB, but potentially within the range of the EBWB. One recorder was mounted on a met mast at 50 m AGL, paired with a detector at ground level. A further four detectors were located at ground level at other sites. The survey ran for 13 nights for most detectors. In total, 1,205 bat calls were identified. No bat calls were detected at height. Calls at ground level were largely identified as Gould's Wattled Bat/*Ozimops* spp. complex (46.5%), Large Forest Bat (21.8%), and Little Forest Bat (11%). No EBWB calls were detected either at height or at ground-level during the met mast survey at AWF (Brett Lane & Associates, 2016).

Mills and Pennay (2017) surveyed bat activity at-height near the EBWB roost cave at Wee Jasper, NSW, using a bat detector attached to a tethered helium balloon. The at-height detector was paired with another detector placed at ground-level. One site was sampled near the entrance to Wee

Jasper for six nights, and six sites were sampled at Parsons Creek, about 20 km from Wee Jasper, over 19 nights. Close to the entrance to Wee Jasper, EBWB calls were recorded at ~100 m elevation on 3 of 6 nights (0.26 passes per hour). In comparison, EBWB calls were recorded on 6 of 6 nights at ground-level and were 9.3 times more likely to be recorded closer to ground level (2.46 passes per hour) than at-height. At Parsons Creek, the concentration of EBWB activity was much lower than Wee Jasper, no EBWB calls were recorded at 100 m elevation over 19 nights of sampling, while activity was recorded on the ground-level detector on 6 of 19 nights (0.23 passes per hour) (Mills and Pennay, 2017).

Surveys within geographic range of Southern Bent-wing Bat

At Dundonnell Wind Farm (DWF), in south-west Victoria, met mast surveys were conducted in Autumn of 2011 (Brett Lane & Associates, 2011). This survey was within the range of the SBWB. One recorder was mounted on a met mast at 50 m AGL for 14 nights, with two other detectors mounted at 25 m AGL (one with receiver pointing up and one with receiver pointing down) at the same site for 7 of those nights. In addition, four detectors were located at ground level for the remainder of the survey. The survey ran for 28 nights. In total, 3,578 bat calls were identified. At 50 m AGL, all calls were from White-striped Free-tailed Bat. At 25 m AGL, calls were split evenly (microphone facing up) or 4:1 (microphone facing down) between White-striped Free-tailed Bat and the *Ozimops* spp. complex. At ground level, calls were identified as Southern Free-tailed Bat (25.2%), Southern Forest Bat (18.8%), *Nyctophilus* spp. (18.3%), and Large Forest Bat (13.7%). The remainder of the ground-level calls were split between various species and complexes, including Bent-wing Bat spp. (0.4%) and the SBWB/Forest Bat species complex (1.5%) (Brett Lane & Associates, 2011).

At Mortlake South Wind Farm (MSWF), in south-west Victoria, met mast surveys were conducted in Spring of 2017 (Brett Lane & Associates, 2018b). This survey was within the range of SBWB and possibly EBWB. Bat detectors were mounted on two met masts at 50 m AGL, each paired with a detector installed at ground level. A further 5 detectors were placed at ground level elsewhere across the site. The survey ran for 24 nights. In total, 704 bat calls were identified. The majority of calls recorded at height were identified as White-striped Free-tailed Bat. The majority of calls at ground level were assigned to Forest Bat spp. YBSB was also recorded at ground level (0.4%). No SBWB or EBWB were recorded during the survey at MSWF (Brett Lane & Associates, 2018b).

At MacArthur Wind Farm (MWF), in south-west Victoria, met mast surveys were conducted in Autumn and Spring in 2014 (Wood, 2017). This survey was conducted within the range of the SBWB. One detector was mounted on a met mast at 45 m AGL, paired with another detector at ground level directly beneath. A further 8 detectors were mounted at ground level at a range of other sites. The survey effort comprised 388 bat detector nights in Autumn and 390 in Spring. A total of 19,086 bat calls were identified. Most calls at height were identified as White-striped Free-tailed Bat. In contrast, at ground level, just under half of all calls were from Chocolate Wattled Bat (37.6%) and Gould's Wattled Bat (10.3%). The remaining calls from ground-level were split evenly among a large number of species and complexes, including SBWB (9.0%). Confirmed SBWB calls were not detected at height, but calls assigned to a SBWB/Forest Bat species complex accounted for 1.3% of calls at height (Wood, 2017).

At the proposed Willatook Wind Farm (WWF), in south-west Victoria, met mast surveys were conducted from Summer-Autumn and Winter in 2019 (Nature Advisory, 2022), as well as in Spring in 2010 and 2018, plus in Autumn in 2011 (EHP, 2018). This survey was conducted within the range of the SBWB. Two detectors were mounted at 42 – 45 m at different sites, with two more recorders correspondingly located at ground level directly beneath. All other recorders (20 in 2019, 16 in 2011, 19 in 2010, and 33 in 2018) were located at ground level at different sites. The length of the survey varied depending on the location of the recorders (see Table 1), ranging from 20-156 nights in 2019, 7-59 nights in 2011, 7-26 nights in 2010, and 5-50 nights in 2018. In summary, YBSB, SBWB, and SBWB-Forest Bat spp. complex calls were recorded from several ground-level detectors. SBWB calls were not detected at-height. A total of 150 SBWB calls were identified from 4924 bat detector nights surveyed across all years.

At Mt Fyans Wind Farm (MFWF), in south-west Victoria, a met mast survey was conducted for seven nights in Summer-Autumn 2016. One detector was attached to the mast at 50 m, paired with another detector at ground-level. No SBWB were recorded at 50 m AGL or ground-level. However, due to an excessive amount of wind interference, the 50 m detector recorded few discernible bat calls. A very low call rate of overall bat activity was recorded from detectors at ground level from the same site (average of 0.03-0.04 calls per night) (Biosis, 2022).

Surveys outside Bent-wing Bat geographic range in Victoria

At Bulgana Wind Farm (BWF), in central west Victoria, met mast surveys were conducted in Spring of 2013 and Summer of 2014 (Brett Lane & Associates, 2015). This survey was outside the known range of both the SBWB and EBWB. One bat detector was mounted on a met mast 50 m AGL, paired with another at ground level. A further 8 detectors were located at ground-level at other sites. The survey ran for 29 nights in Spring, and 14 nights in Summer. In total, 3,472 bat calls were identified. Most calls detected at height were identified as White-striped Free-tailed Bat. Calls recorded at ground level were assigned to Large Forest Bat (38.4%), Southern Free-tailed Bat (29.2%) and Eastern Free-tailed Bat (14.4%). No confirmed SBWB or EBWB were detected at height or at ground-level during the met mast surveys at BWF, while 0.8% of calls identified at ground-level were assigned to a Forest Bat species complex (Brett Lane & Associates, 2015).

9.1.6. Potential impacts

Wind farms are one of nine potential threats listed in The National Recovery Plan, which describes potential impacts of the wind industry on the global population of SBWB as follows (Department of Environment, Land, Water and Planning, 2020, pp 12-13):

The impact of the recent proliferation of wind farms within the range of Southern Bent-wing Bats is currently unclear, however, it is possible that any wind farm built close to a Southern Bent-wing Bat significant roosting site could have a major impact on that population. International studies suggest there may be cumulative impacts of wind farms on migratory species in particular, with the impacts greater at particular times of the year and under certain weather conditions (Johnson et al. 2004; Kunz et al. 2007). The risk increases the closer the wind farm is to an important site, particularly a maternity site or migration path. Risks include cave destruction during construction, mortalities due to collisions, and altered access to foraging areas (Kerr and Bonifacio 2009).

The FFG Action Statement for SBWB also identifies wind farms as a threat (Department of Energy, Environment and Climate Action, 2023b, pp 2):

Onshore wind farm developments pose a number of risks to bats, including cave destruction during construction, mortalities due to collisions and barotrauma (a result of changing air pressure around moving blades), and limiting access to foraging areas. Evidence suggests peak mortality occurs over autumn.

The primary cause of bat mortality at wind farms is collision with operational turbine blades. Barotrauma has also been suggested as a direct impact pathway (Baerwald et al., 2008), but remains somewhat controversial due to difficulties in diagnosing the specific cause of death for bat carcasses discovered at wind farms (Rollins et al., 2012). To avoid confusion, it seems reasonable to assume that, for bat carcasses found beneath operating wind turbines, mortality was most likely the result of direct interaction with rotating turbine blades.

Direct impacts

As of March 2025, Nature Advisory is aware of a total of 32 SBWB mortalities detected during carcass searches at operational wind farms in Victoria that have been reported to DEECA (Table 20).

The investigation described in this report shows that SBWBs were recorded at multiple sites across the study area, particularly close to water bodies and native treed habitats. Consequently, there is a possibility that SBWB could occasionally collide with operational turbines at HWF.

Table 20: Total Southern Bent-wing Bat mortalities reported to DEECA up to March 2025

Source	Time period	Number of SBWB mortalities
Moloney et al. (2019) and Stark and Muir (2020)	Up to 2018	8
Bennett et al. (2022) - Cape Nelson North Wind Farm	2018 and 2019	3
"DEECA's submission presented to the Mt Fyans Wind Farm Panel on 3 April 2023 (section 6.24.1)"	Not disclosed	3
"DEECA has been notified of 8 SBWB mortalities being found during post-construction monitoring between March to May 2023." Note – one of the 8 carcasses referred to here was previously included in the 3 carcasses documented in DEECA's submission presented to the Mt Fyans Wind Farm Panel on 3 April 2023. Consequently, only 7 SBWB mortalities are listed here.	March to May 2023	7
Five carcasses detected during scent dog searches at two operational wind farms in south-west Victoria. The wind farm operators have provided information on these carcasses to DEECA, but the details have not yet been made public.	Autumn 2024	5
Email correspondence from DEECA to Wind Prospect in October 2025 states a total of 32 SBWB carcasses reported between 2015 and October 2025. Nature Advisory is currently not aware of details of five of these carcasses.	2022-2025	6
	Total	**32**

These mortalities represent actual carcasses found during searches and the estimated mortality would be higher, considering survey effort, scavenger rates and searcher efficiency. Detected mortalities are believed to represent a small fraction of overall bat mortality at operational wind farms (Moloney et al., 2019; Stark and Muir, 2020). Even in well-designed mortality monitoring programs, the likelihood of detecting carcasses of small insectivorous bats is relatively low (Moloney et al., 2019; Stark and Muir, 2020). Furthermore, there is potential for undetected impacts at operational wind farms when the BAM Plan monitoring period has ended. The impact rating for this species prior to implementing avoidance and mitigation measures is low (Table 16).

Cumulative impacts

It is difficult to determine the cumulative impacts on the SBWB without a central registry of operational monitoring data of wind farms in Victoria. Most mortality data from Victorian wind farms is not publicly available. The Arthur Rylah Institute are developing a Population Viability Analysis for the SBWB that may be able to predict the cumulative impacts of any proposed wind farm.

The Threatened Species Scientific Committee has undertaken a Population Viability Analysis on the combined South Australian and Victorian population of Southern Bent-wing Bat. Two models were used to calculate the number of mature adults predicted to be alive in 2056 and it revealed an overall population decline of 84% – 97% (TSSC 2021).

An analysis was undertaken by Symbolix (2020) to produce cumulative statistics and quantify the collision rates of different bird and bat species at wind farms in Victoria. Some of their findings are summarised below.

- Between 7 – 10.8 bat mortalities occur per turbine per year in Western Victoria
- The two most common bat species found to collide with turbines are the WSFB and Gould's Wattled Bat
- Mortalities are higher for WSFB than any other bird or bat.
- There were no specific mortality estimates for the SBWB.

However, in the last 12 months DEECA has provided additional information as listed above of mortality of at least 32 SBWB collisions known to have occurred to-date at a variety of wind farms in SW Victoria (Table 20).

While the scale of overall impact on the SBWB is low compared with other species, given that there have been recorded mortality of this species, it is possible that despite the mitigation measures above, mortality will occur.

9.2. Yellow-bellied Sheath-tailed Bat

EHP (2014) recorded unusually high numbers of YBSB calls at various sites across the study area in 2011 in both seasons, indicating very high activity levels at recording locations and no specific habitat preference within the study area (Table 21). This further suggests that there may be a resident population at the proposed wind farm that does not migrate north during spring, as the available literature suggests. However, over the past 10 years, bat call analysts have realised that calls which were previously attributed to YBSB in Victoria are more likely to be calls at the lower end of the Gould's Wattled bat call range, and therefore a number of the calls recorded as YBSB in 2010 and 2011 are possibly incorrectly identified (R. Gration, *pers. comm.*)

The 2018 and 2019 surveys indicated much lower levels of activity than previously recorded and at much fewer locations (Table 21), but as discussed in the limitations section of this chapter, this does not translate to population census and rather only confirms the species continued presence on site. The species was recorded close to windbreaks, wetlands, a farm dam and remnant native woodland (in linear roadside vegetation).

Locations of bat detector recorders between surveys also differed, but distances between those sites were not significant and all surveys targeted general potential habitat of microbat species such as windbreaks, remnant native woodland, waterways, dams and open paddocks. Therefore, the reason for differences in detected activity levels between years is unclear.

It is noted that there are discrepancies between what EHP reported in the text of the Flora and Fauna report and the call analysis results presented in Appendix 4.3 of the same report (EHP, 2018). Nature Advisory have assumed the call analysis results presented in Appendix 4.3 of the Flora and Fauna report are correct, and reported accordingly.

No YBSB calls were recorded during the Autumn 2023 survey.

Table 21: Numbers of Yellow-bellied Sheath-tailed Bat calls (2010-2019) by site

Survey location	Bat detector nights	Yellow-bellied Sheath-tailed Bat	Ave. calls per night
Spring 2010			
HS8	8	105	13.13
HS9	8	19	2.38
HS12	8	1	0.13
HS13	8	48	6.00
HS3-2	8	3	0.38
HS10-2	8	6	0.75
HS11-2	8	22	2.75
HS12-2	8	3	0.38
HS13-2	8	109	13.63
HS9-3	8	32	4.00
HS10-3	8	4	0.50
HS13-3	8	17	2.13
HS9-4	8	100	12.50
H10-4	8	27	3.38
HS8-4	6	10	1.67
HS12-4	6	3	0.50
HS13-4	6	52	8.67
Total	**382**	**561**	**1.47**
Autumn 2011			
HA8	9	26	2.89
HA10	9	4	0.44
HA21	21	5	0.24
Total	**413**	**35**	**0.08**
Spring 2018			
HX3	21	2	0.10
HX11	21	2	0.10
Total	**385**	**4**	**0.01**
Summer-Autumn 2019			
HG1	58	1	0.02
HS5	79	1	0.01
HS12	58	6	0.10
HS14	59	2	0.03
Total	**1560**	**10**	**0.01**

9.2.1. Habitat usage and behaviour

The YBSB is a wide-ranging species present through tropical and sub-tropical Australia. The species occurs in a wide range of habitats from wet and dry sclerophyll forests to open woodlands. It usually roosts in large tree hollows but sometimes uses buildings (Churchill, 2008; Menkhorst, 1995; NSW Office of Environment and Heritage, 2021).

There is no information on the number of YBSBs that are present in Victoria, but the species is considered to be a rare visitor to southern Australia, predominantly in late summer and autumn (NSW Office of Environment and Heritage, 2021). Many of the YBSBs recorded in Victoria have been found in exposed situations in an exhausted condition (e.g., hanging from the outside wall of buildings in broad daylight, or on fence posts in open paddocks), which might suggest that they have been unintentionally driven south by adverse wind conditions.

The YBSB is a large (mean body weight = 44 g), open-space adapted species that flies high and fast above the canopy, but has been observed flying lower over open spaces and at the forest edge (Churchill, 2008). The species has been recorded colliding with wind turbines further north in its range in NSW, where it is more abundant, indicating that it is vulnerable to turbine collision (Nature Advisory, unpublished data). Nature Advisory is not aware of any YBSB carcasses being recorded during mortality monitoring at operational wind farms in Victoria.

Nature Advisory (unpublished data) has recorded individual records of this species at proposed wind farm sites from Queensland through to south-western Victoria. Typically, in Victoria and NSW acoustic recordings indicate low levels of activity and are of few calls (1-5) recorded on one or two nights at different locations across a site.

The species' diet consists of invertebrates, predominately beetles. They are also known to forage on grasshoppers, leafhoppers, shield bugs, crickets, wasps and a few flying ants (Churchill, 2008; Hall and Richards, 2023).

9.2.2. Flight heights

The YBSB is an open-space adapted species that flies high and fast above the canopy of forests and woodlands (Hall and Richards, 2023). An extensive study of habitat utilization by the YBSB in the Cadia Valley (Orange district, NSW) was conducted in November 2004 by Richards (2008). In this study, ten woodland/open forest remnants ranging in size from 20-1700 ha were monitored for this species Regression analysis of the number of calls recorded was highly correlated (R^2 = 0.9459) with the approximate size of the remnants studied. There appeared to be a threshold of at least 500 ha before high levels of activity and relative abundance were observed (Richards, 2008).

At HWF, YBSB was recorded flying at a height of 42 m during the 2011 surveys, confirming that the species can fly at least at this height. Nature Advisory did not record the species flying at height in the study area during the 2018 – 2019 surveys.

Nature Advisory (unpublished data) have identified at least two individuals as mortalities under turbines at other wind farms within the species range at wind farms in NSW. This comes from current and past monitoring of 15 wind farms within the species range which would indicate that collisions, while evidently known to occur with turbines, is not a common occurrence for this species.

9.2.3. Threats

This species is reported to have the highest prevalence of Australian bat Lyssavirus in Australian echolocating bats, though the implications for the species are not known (Armstrong and Lumsden, 2017). Feral European honeybees commonly take over tree hollows in arid Australia and displace many fauna species, including YBSB. Habitat clearance and modification in eastern Australia are likely causes of a reduction in area of occupancy, as is the replacement of perennial species in riparian zones of arid areas (Armstrong and Lumsden, 2017).

The likely causes of population decline are attributed to:

- Disturbance to roosting and summer breeding sites.
- Foraging habitats are being cleared for residential and agricultural developments, including clearing by residents within rural subdivisions.
- Loss of hollow-bearing trees; clearing and fragmentation of forest and woodland habitat.
- Use of pesticides and herbicides which may reduce the availability of insects and can result in the accumulation of toxic residues in individual's fat stores.

The YBSB is listed as Threatened under the FFG Act. It is not listed under the EPBC Act and is listed as "least Concern" on IUCN's Red List of Endangered Species (Armstrong and Lumsden, 2017).

The IUCN Red list states; "this bat is listed as Least Concern given its wide distribution, use of a broad range of habitats, large population size, occurrence in protected areas, and the absence of significant key threats or evidence for a decline. Acoustic surveys in northern Australia often encounter this species, especially those employing full spectrum detectors that allow harmonic profiles to be observed, suggesting that it can be relatively common. It is recorded rarely in south-eastern Australia, and it is still unknown if these records represent occasional summer-autumn visitors (Hall and Richards, 2023), vagrants (Menkhorst, 1995) or small resident populations."

It is present in many protected" areas throughout Australia. Targeted surveys in Papua New Guinea are needed to more clearly define extent of occurrence and habitat association. Further ecological research is needed to investigate its status in the southern parts of its range as well as its basic ecology and roosting habits (Armstrong and Lumsden, 2017).

9.2.4. Potential impacts

The YBSB is a wide-ranging species through tropical and sub-tropical Australia. In Victoria, the species is considered to be a rare visitor in late summer and autumn (NSW Office of Environment & Heritage 2021). Many of the Victorian specimens have been found in exposed situations in an exhausted condition (e.g. hanging from the outside wall of buildings in broad daylight), which might suggest that they have been unintentionally driven south by adverse wind conditions. The species occurs in a wide range of habitats from wet and dry sclerophyll forests to open woodlands. It usually roosts in large tree hollows but sometimes uses buildings (Menkhorst 1995, Churchill 2008, NSW Office of Environment & Heritage 2021).

There is no information on the number of YBSB that visit Victoria as it is typically recorded rarely and irregularly. The number of individuals that occur in Victoria are not known but the low numbers recorded in the HWF bat survey area, compared with other, more common bat species, indicates that the Victorian population would be small and unlikely to represent a highly significant part of the overall, larger, national population.

The YBSB is a high-flying species that usually flies fast and straight above the canopy, but flies lower over open spaces and at the forest edge (Churchill 2008). It is thus potentially susceptible

10. Avoidance and mitigation measures

Mortalities due to collision with operational turbines at HWF are possible for SBWBs, GHFF and YBSBs. The proponent is developing proactive avoidance, minimisation and mitigation in consultation with DEECA and DCCEEW. The findings of the bat assessments formed the basis of the avoidance and mitigation process.

The proponent recognises that managing the risk of bat collisions with turbines requires a multi-faceted approach that is embedded in the avoidance and mitigation hierarchy but also accounts for the known ecology and behaviour of both species, site features relating to available habitat and foraging opportunities, and the influence of weather and season on bat activity. This approach aims to achieve a balanced outcome that enables wind farm operations whilst minimising, as far as practicable, the risk to SBWB, GHFF and YBSB.

Table 22 outlines the proposed avoidance and mitigation plan for HWF, which includes buffering high priority habitat and areas with high SBWB and YBSB activity, micro-siting turbines based on habitat quality habitat and SBWB and YBSB activity, and increasing low cut in speeds when HWF is operational.

Table 22: Summary of measures proposed for HWF to minimise impacts to SBWB, GHFF and YBSB

Principle	Area	Measure	Section ref.
Avoid	Turbine specifications	Minimum RSA 40 m AGL.	10.1.1
	Micro-siting: turbine habitat buffers	Avoid high quality habitat.	10.1.2
		Avoid areas with high SBWB-definite, SBWB complex and YBSB calls.	
		Microsite the proposed turbines based on overlap of 269m buffer around turbines, habitat and SBWB activity.	
		Minimise turbine buffer overlays with medium and low-quality SBWB habitat.	
Mitigate	Increasing low-windspeed cut-in	For moderate and higher-risk turbines, increasing nighttime low windspeed cut-in during periods when SBWB are most actively moving across the landscape (detailed in the BAM Plan).	10.2.1
	Turbine blade feathering	The proponent is committed to feathering turbine blades from the offset of operation to mitigate impacts to bats by preventing the blades from 'free-spinning' below the cut-in wind speed.	10.2.1
	Acoustic deterrents	Investigate the feasibility of trials.	10.2.2
Assess	Assessment of residual impacts	Potential for impacts to SBWB. If mortality is recorded further measures will be put in place. YBSB occurs in low number and may be recorded as mortality. Population estimates are unknown for this species but may be secure across its range.	10.3 10.5

Principle	Area	Measure	Section ref.
Offset	Offsetting residual impacts	Consider options to contribute to SBWB research and improved management.	10.4
Manage	BAM Plan implementation	Outlines monitoring protocols and responsibilities, trigger responses to a listed species being impacted by the wind farm, and reporting requirements.	10.5.1
Monitor	Mortality surveys	Regular surveys at 25% of randomly selected turbines.	
		Intensive surveys at higher-risk turbines during peak SBWB activity	
	Bat detectors	Acoustic monitoring to collect further data on temporal activity patterns of SBWB and YBSB in the study area	
	GHFF surveys	A combination of annual habitat surveys, species database monitoring and community engagement to assess the requirement for targeted GHFF surveys and implementation of a mitigation strategy.	

These measures are described below.

10.1. Avoidance

10.1.1. Turbine specifications

In the most recent annual update, the SBWBRT acknowledge that there could be a relationship between the physical characteristics of newer model turbines and collision risk to SBWB (Southern Bent-wing Bat National Recovery Team, 2022):

"Wind turbine characteristics continue to evolve. Newer proposed turbines are typically higher, with longer blades, and set higher off the ground. These features may alter mortality risk to SBWB however this has yet to be quantified."

Nature Advisory understands that the minimum RSA height for the proposed turbine model at HWF is 40 m AGL. Nature Advisory also understands that the minimum RSA height of turbines at the wind farms where SBWB carcasses have been detected are under 40 m AGL. Given that information on all SBWB mortalities detected to date at operational wind farms have not been made publicly available, it is unknown if the minimum RSA height of 40 m incorporates all turbines where mortalities have occurred. At HWF, several detectors were placed at height (42m/50m) and no threatened species or associated complexes were recorded at 42m/50 m above ground level during surveys in Summer-Autumn 2019 or Summer-Autumn 2020. The link between minimum RSA height and SBWB and YBSB mortalities remains uncertain, due to the limited available evidence.

Nature Advisory is currently undertaking analysis of existing monitoring data to investigate how turbine model specifications influence mortality rates for Australian bat species. Mortality data are being sourced from post-commissioning monitoring conducted at more than a dozen operational wind farms in Victoria, ACT and NSW. Preliminary results to date have revealed a trend whereby total bat mortality significantly decreases as minimum RSA height increases above 40 m AGL. Further, as turbine blades are raised higher above the ground, the number of microbat species impacted decreases, with open-space adapted taxa accounting for most mortalities (Nature

Advisory, 2024a). These findings are similar to those reported from the Northern Hemisphere, where risk of colliding with turbines has been shown to correlate with wing morphology and echolocation frequency (characteristics that are used to group bats into foraging guilds) and the proportion of time that bats from different foraging guilds spend flying high above the canopy at RSA heights (Arnett et al., 2016; Roemer et al., 2019b, 2017).

10.1.2. Turbine-habitat buffers

It is well-established that, for most insectivorous bats, activity increases closer to important habitat features, such as treed areas and water bodies, and decreases further away from these habitats into more open areas with less tree cover. Consequently, placing turbines close to these important bat habitats is likely to increase the chance of bat-turbine interactions (Arnett et al., 2016).

There are currently no Australian State or Federal guidelines that prescribe appropriate buffer distances between turbine blade edges and habitat features that are important for insectivorous bats (e.g., treed areas and water bodies) to reduce collision risks to an acceptable level. Two different turbine-habitat buffer distances have been proposed in the Northern Hemisphere:

- United Kingdom - minimum 50 m from nearest habitat feature (trees, hedges) to blade-tips (Natural England, 2014)
- Europe – minimum 200 m from nearest habitat feature (woodland, tree lines, hedgerow networks, wetlands, waterbodies and watercourses) to blade-tips (Rodrigues et al., 2015).

Justification presented for the 50 m buffer distance is based on evidence that the activity of bats found in the UK tends to decline rapidly with increasing distance from linear landscape features and woodlands (Natural England, 2014). In comparison, the EUROBATS guidelines were designed for a region with much greater species diversity, including several migratory bats that fly very long distances across the landscape, including over open areas with minimal tree cover (Rodrigues et al., 2015).

The effectiveness of buffer zones is less clear for bats like the SBWB that travel long distances for both daily and seasonal movement between foraging and roosting sites, and has not been specifically investigated in Australia (Umwelt, 2024).

HWF turbine-habitat buffers

Buffer distances for HWF are somewhat uncertain given that a final decision on the specific turbine model has not been made,. Presuming that the turbines will have a hub height of 150 m and blade length of 95 m (minimum RSA height of 40 m AGL), using the method to calculate the distance from the edge of the RSA to the edge of the nearest habitat feature (presuming that was a 30-m tall tree) described by Natural England (2014), the buffer distance would be 269 m from the base of the turbine to the nearest habitat edge for the EUROBATS (2015) 200-m buffer from RSA edge to habitat edge.

The formula used to calculate these turbine-habitat buffer distances is (Natural England, 2014, page 2):

$$b = \sqrt{(c + bl)^2 - (hh - fh)^2}$$

Where:

b = distance from the base of the turbine tower to the edge of the habitat feature.

c = prescribed buffer distance from the blade tip to the edge of the habitat feature.

bl = blade length

hh = hub height.

fh = feature height (in m) (see Figure 23).

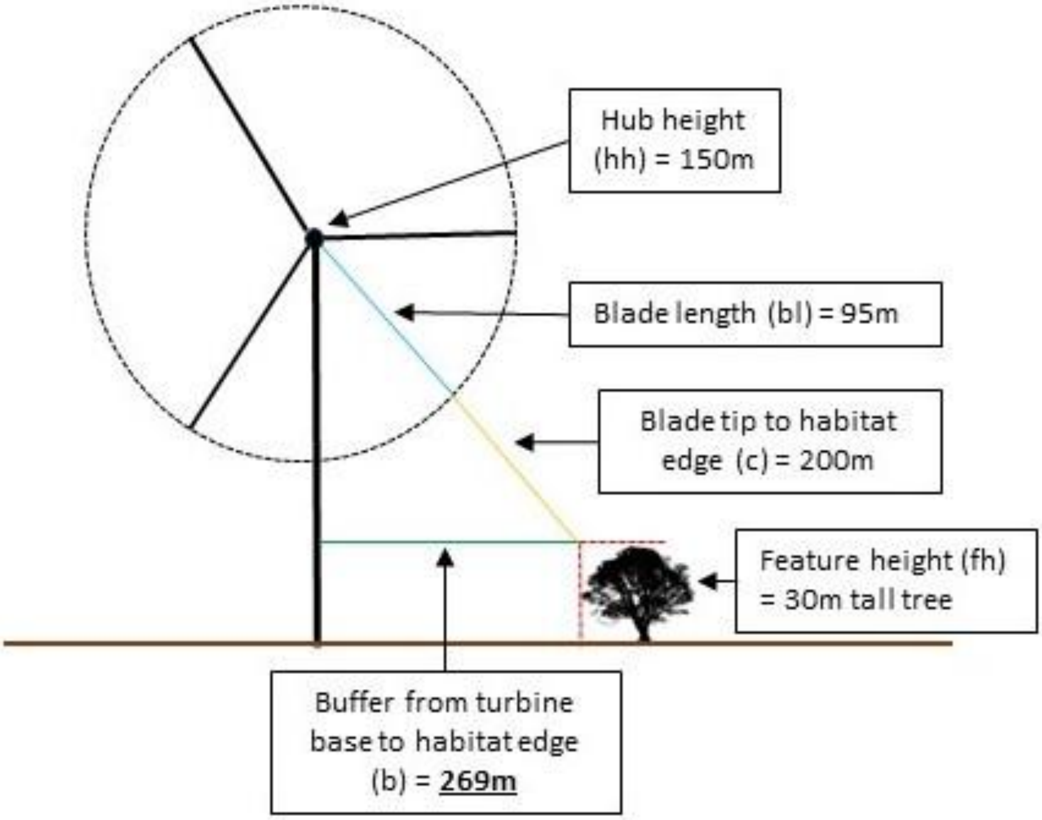

Figure 23: Schematic showing 269 m turbine-habitat buffer

Note – this diagram is not to scale.

The 269 m buffer required to achieve 200 m separation from blade tips to habitat edges includes a contingency because most trees present across the HWF study area are significantly less than 30 m tall, i.e. the distance from blade tips to the habitat features that are less than 30 m would be greater than 269 m.

It should be noted that the formula uses the maximum blade length and the hub height that may apply to the final turbine model selected. The buffer required would be calculated using this formula and the final turbine model specifications.

HWF design response

As acknowledged by DEECA during discussions with the proponent and Nature Advisory, it is not considered feasible to avoid all potential SBWB habitat throughout south-east Victoria using a 269 m buffer, In a workshop on 28 November 2024, DEECA have recommended the turbine habitat buffers at HWF follow a mitigation hierarchy using the 269 m buffer, including the following:

- Avoid high quality habitat.
- Avoid areas with high SBWB and SBWB-complex calls.

- Minimise turbine buffer overlays with medium and low quality SBWB habitat.

The findings of the bat assessments formed the basis of the avoidance areas. Hexham Wind Farm Pty Ltd and Nature Advisory have collaborated to microsite the proposed turbines based on overlap of 269m buffer around turbines, habitat and SBWB activity. The following categories were created:

- High priority avoidance - Creeks, wetlands, remnant native woodland, forestry plantations, and higher number of SBWB-definite or complex calls per night relative to other sites.
- Medium priority avoidance - Planted windrows and eucalypts, farm dams, and medium number of SBWB-definite or complex calls per night relative to other sites.
- Low priority avoidance - Scattered trees, isolated wind rows (100m away from other trees), and low/very low number of SBWB-definite or complex calls per night.

Micro-siting efforts commenced with a concept design that aimed to avoid most of the habitat. This includes the following buffers excluding project infrastructure:

- 100-metre buffer around DEECA-mapped wetlands and watercourses, including Mustons Creek, Drysdale Creek and smaller drainages. These waterways have cultural heritage sensitivity in addition to biodiversity sensitivity, therefore have been buffered as a precautionary approach to protect habitat. Watercourse crossings have been minimised through the siting of accessways;
- Brolga breeding site buffers as detailed in a separate Brolga Assessment Report (Nature Advisory, 2025).

These buffers are displayed in Figure 24. This formed a baseline design that was used to then microsite turbines relative to higher and medium priority areas based on habitat and known SBWB activity. The aim of this approach was to reduce the area of SBWB habitat within 269 m of turbines. Each turbine was given a rank of *higher*, *moderate* or *lower impact* prior to and following micro-siting. These categories were identified using the following strategy:

- Higher risk – turbine buffers which overlap with any high priority avoidance habitat and/or have medium, high or very high numbers of SBWB or SBWB complex calls per night (greater than 0.1 definite or 1 complex call per night; see Figure 18, Figure 19 & Figure 25);
- Moderate risk – more than 2.5% of the turbine buffer covers medium priority habitat;
- Lower risk – less than 2.5% of the turbine buffer overlaps with medium or low priority avoidance habitat. Buffers overlap with areas of very low or no SBWB activity.

The 2.5% habitat overlap limit was chosen as a project specific threshold to enable a small portion of overlap with habitat to occur, as it is practically very difficult to avoid medium and low priority habitat completely. The threshold aligns with the general principle of maximising avoidance, and maintaining a high proportion of habitat undisturbed. By capping the turbine buffer overlap with medium priority habitat at 2.5%, the framework ensures that turbines are only located in areas with very small amounts of habitat, and areas with higher proportions of habitat remain unaffected

Applying this principle in the context of the potential foraging habitat for SBWB provides a quantitative and transparent mechanism for defining what constitutes “negligible overlap” between turbine buffers and potential habitat. At present, there are no specific guidelines regarding this approach, but the framework ensures that at least 97.5% of the mapped habitat is outside the nominated turbine buffer, which is consistent with a precautionary (noting the species conservation status) yet pragmatic interpretation of the avoid minimise principle.

In total, 33 turbines were micro-sited to reduce the turbine buffer areas overlapping with SBWB habitat and areas of high activity (Figure 26). A further 14 turbines were moved from the original design due to other constraints.

Table 23 summarises the area reduction from micro-siting efforts relative to habitat features, and Appendix 2 further details the impact of the original turbine layout and the updated turbine layout for all turbines that were micro-sited.

Some of the key results from the micro-siting effort included:

- Relocating all seven turbines where the 269m buffer, in the baseline design, overlapped with **permanent creek** habitat;
- Relocating 82% of turbines where the 269m buffer in the baseline design overlapped with designated **wetland** habitat. This resulted in an area reduction of 93.6%.

Table 23: Summary of area reduction from micro-siting efforts relative to SBWB habitat features

Mapped SBWB habitat feature	WTG count	Original Layout Mapped habitat within 269m of WTG (m^2)	WTG count	Revised Layout Mapped habitat within 269m of WTG (m^2)	Area reduction from redesign
Farm dam	5	37,252.00	8	224,489.78	34.7%
Pine tree row	26	121,774.00	25	116,620.70	4.2%
Planted eucalypts	61	383,237.00	55	408,551.70	-6.6%
Remnant native woodland	15	61,169.00	8	28,927.33	52.7%
Wetland	11	220,715.00	2	14,143.66	93.6%
Permanent creek	7	45,593.00	0	-	100.0%

The following five turbines have been categorised as higher risk:

- Turbine 6
- Turbine 9
- Turbine 25
- Turbine 91
- Turbine 108

A further 41 turbines have been categorised as moderate risk. The risk category of each turbine at HWF is displayed in Figure 26 and outlined in Appendix 2.

10.2. Mitigation

10.2.1. Curtailment strategies

Increasing low-windspeed cut-in

For moderate and higher-risk turbines, the proponent is committed to increase the nighttime low windspeed cut-in to 4.5m/s during periods when SBWB are most actively moving across the landscape, as detailed in the BAM Plan.

Section 7.6 details the analysis to support increasing the low-windspeed cut-in. Principally, results showed that wind speed had a significant negative effect (estimate = −0.308, p = 2.70e-09), indicating that each unit increase in wind speed reduced the expected call count by about 26.44%.

The BAM Plan outlines the conditions for each turbine, and consider SBWB activity across wind speeds, temperature, time of night and habitat features. The following provides indicative parameters for moderate and higher-risk turbines (note - specific parameters for each turbine will require consultation with DEECA to confirm adequacy and acceptability of these measures):

Time of year: October to April (inclusive)

Time of night: 30 minutes before sunset to 30 minutes after sunrise

These recommendations have taken into consideration what is known on the species biology and the results from the HWF bat assessment surveys. SBWB are most active in the landscape between October – April (Threatened Species Scientific Committee, 2021). Furthermore, Section 7.7.2 outlines that most SBWB activity at HWF occurs between 1.5 to 6 hours after sunset. However, as there is activity outside of these times, it is advised that curtailment occurs across the entire night.

Most mitigation measures outlined for SBWB will have limited benefit to open-space foraging species, such as the YBSB. However, increasing the nighttime low windspeed cut-in for all turbines may provide benefit to these faster flying bat species who tend to fly higher and at higher windspeeds as shown by studies regarding benefits for bat species in general from increased low windspeed cut-in (Bennett et al 2022).

Turbine blade feathering

Turbine blades can still rotate below the cut-in speed when electricity is not being generated. ‘Feathering’ is the act of preventing the turbine blades from free-spinning below the cut-in speed, which is achieved by locking turbine blades or angling the blades to be parallel to the wind (Barré et al., 2023), In some cases, the blades may still move a minimal amount (e.g. 1–2 rotations/minute). This reduces the risk of bats colliding with spinning turbine blades (Whitby et al., 2024).

The proponent is committed to feathering turbine blades from the offset of operation to mitigate impacts to bats.

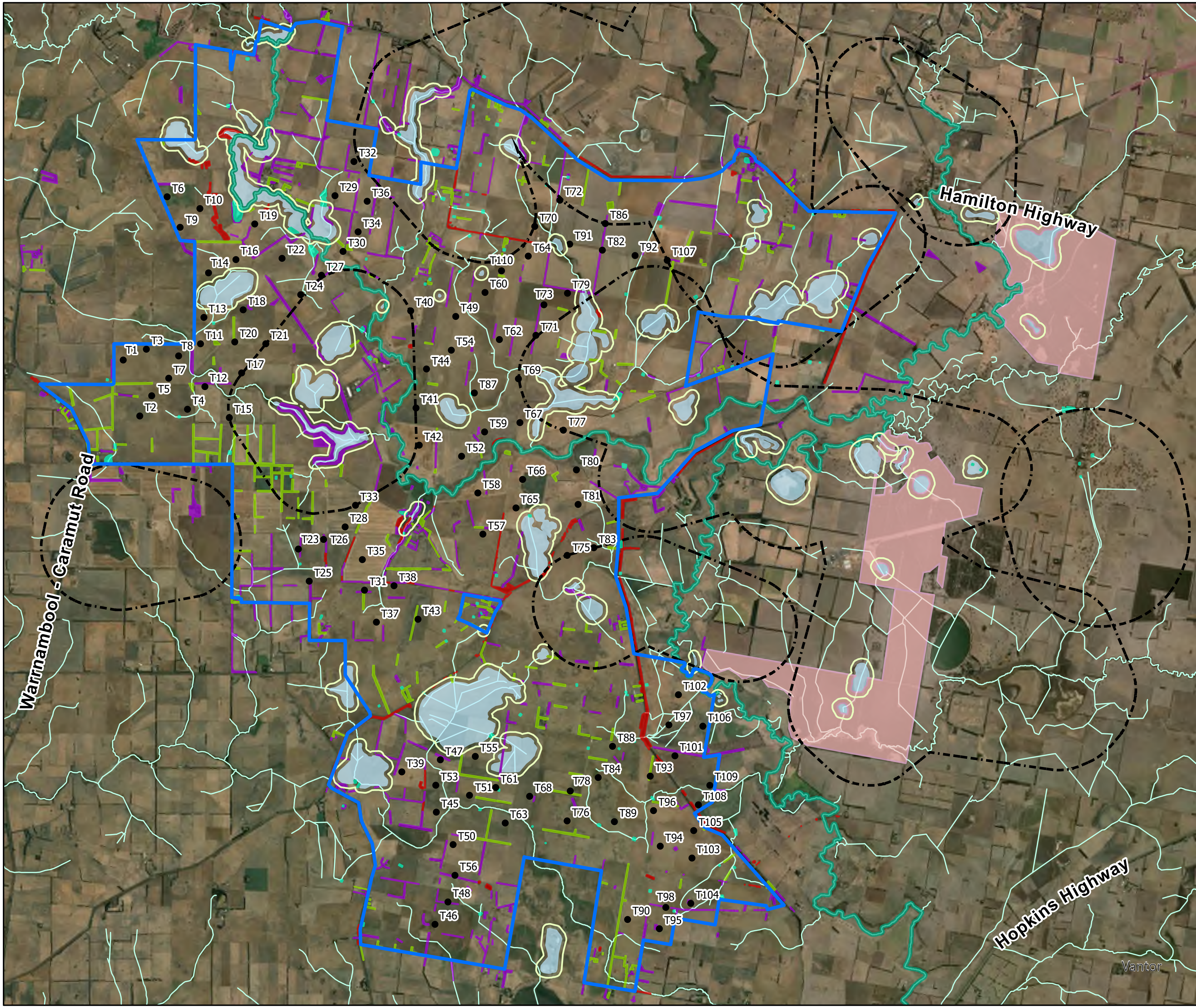

Figure 24: Turbine locations, bat habitat and buffered wetlands and watercourses

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

- Hexham wind farm boundary
- Turbine
- Watercourse
- Brolga turbine free buffer
- 100 watercourse and DEECA wetland buffer

Habitat features

- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland

Kilometres
0 1 2 3 4
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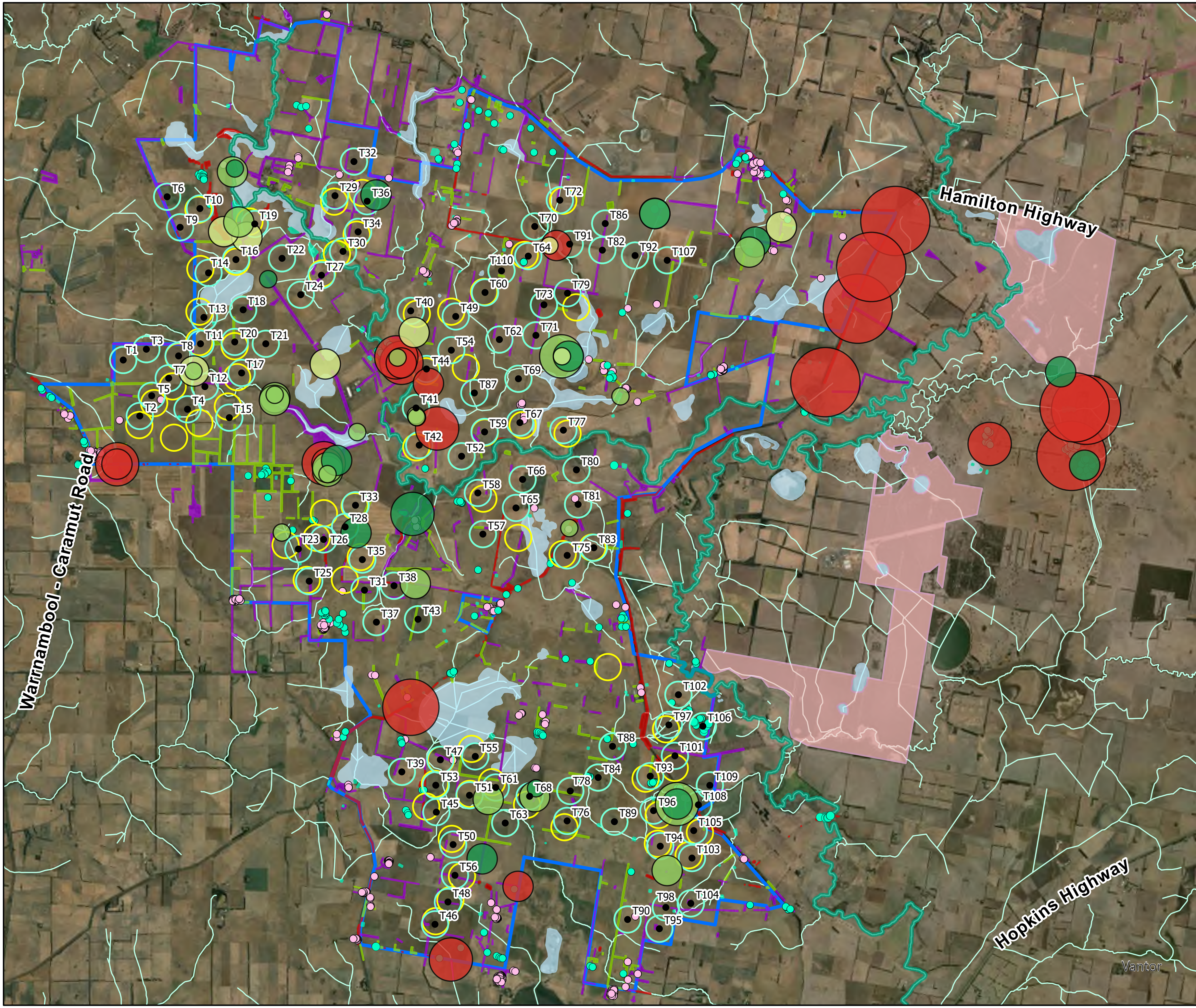

Figure 25: Turbine-Habitat buffer

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

Hexham wind farm boundary
Turbine
Turbine buffer (269m)_Original
Turbine buffer (269m)_Updated

Habitat features

Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Sites with calls by year

2010
2011
2018
2019
2020
2023

Rate of combine calls per night

Very Low (<0.05)
Low (0.05 to 1)
Medium (1-5)
High (5-10)
Very high (>10)

N
Kilometres
0 1 2 3 4
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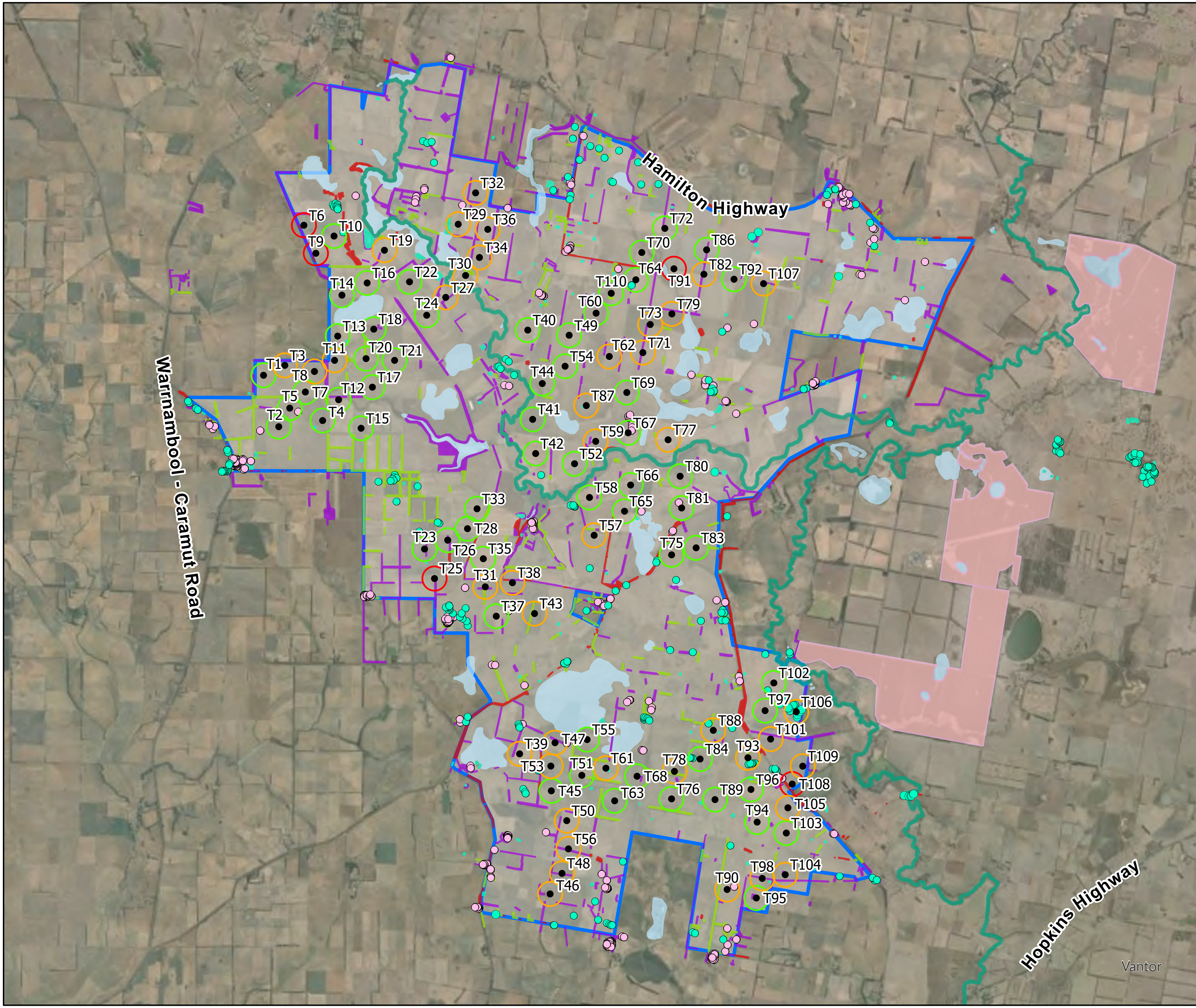


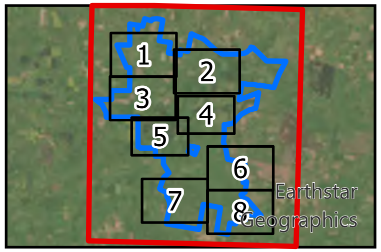
Figure 25A: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

- Wind farm boundary
- Turbine

Habitat features
- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland
- Planted tree
- Remnant tree

Risk category
- Higher
- Lower
- Moderate



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Kilometres

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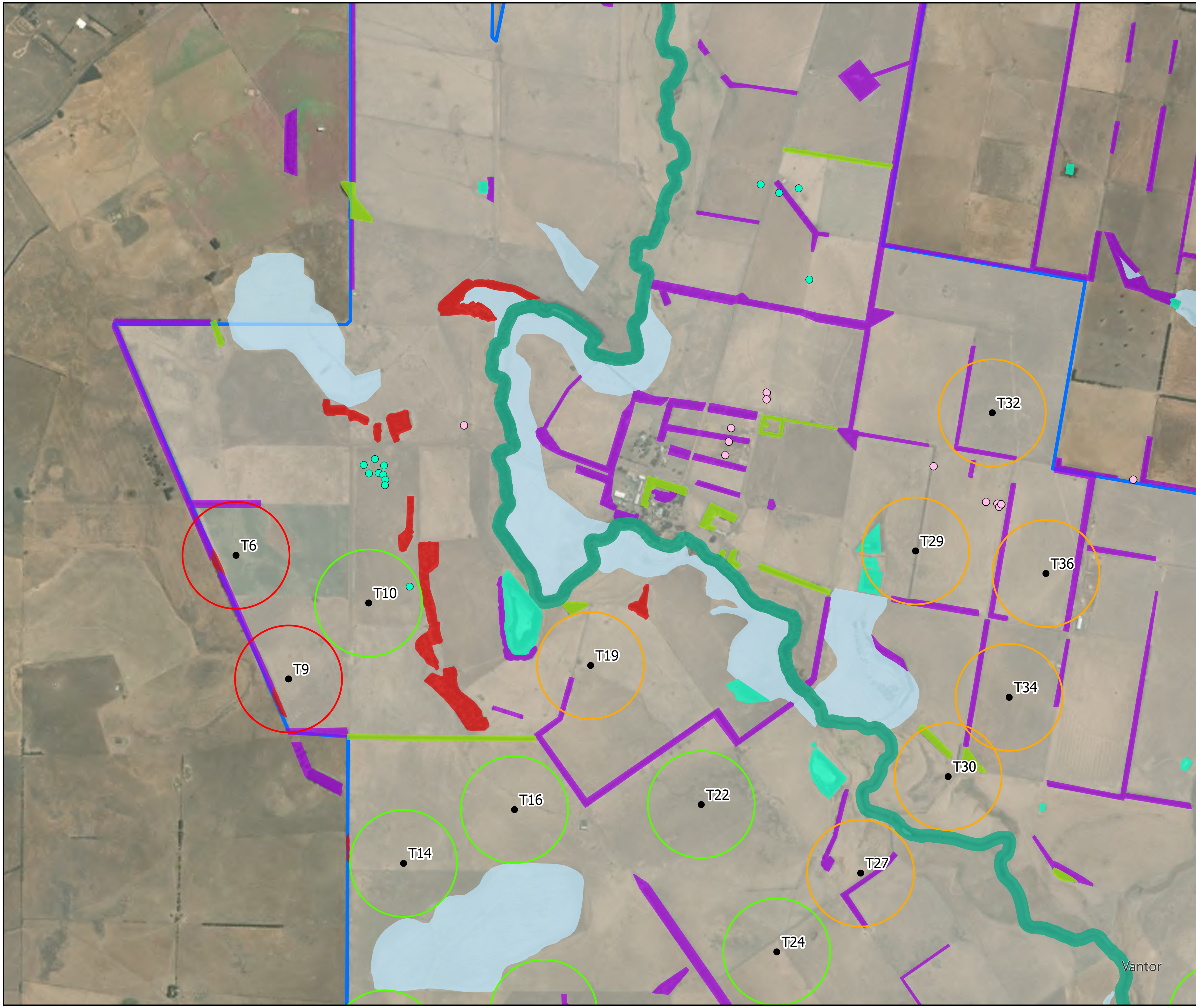


Figure 25A1: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

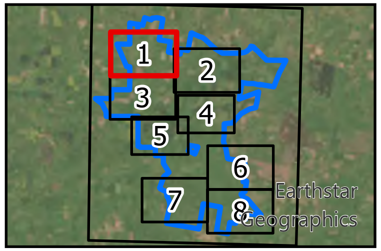
Wind farm boundary
Turbine

Habitat features

Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Higher
Lower
Moderate



N
Kilometres
0 0.2 0.4 0.6 0.8 1
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Figure 25A2: Risk category of turbines

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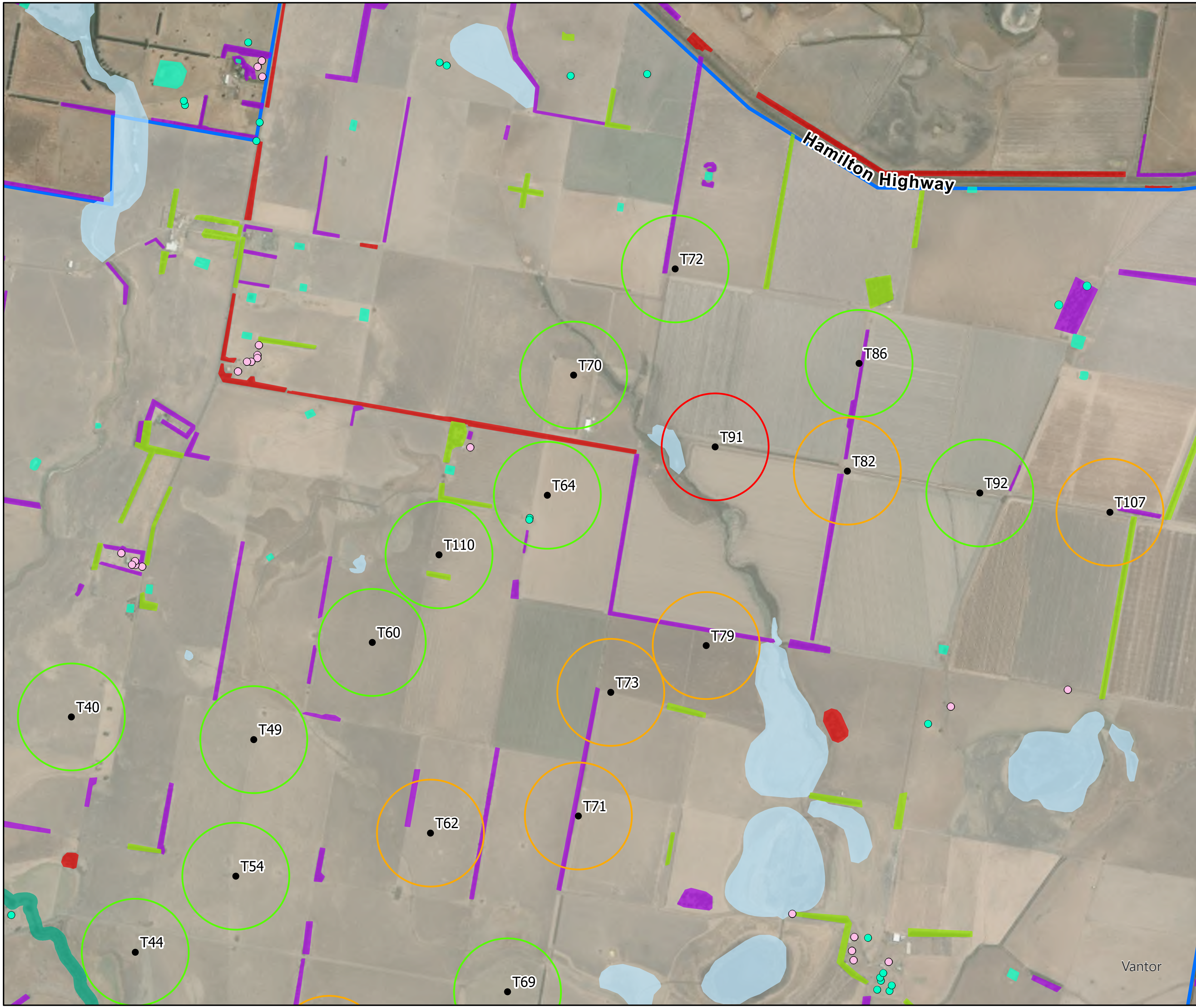
Project: Hexham Wind Farm
Date: 18/11/2025



Wind farm boundary
Turbine

Habitat features
Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category
Higher
Lower
Moderate

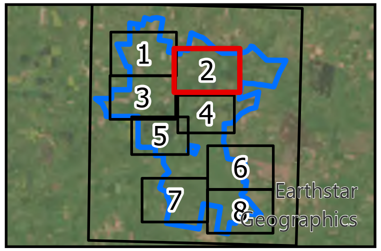


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Figure 25A3: Risk category of turbines

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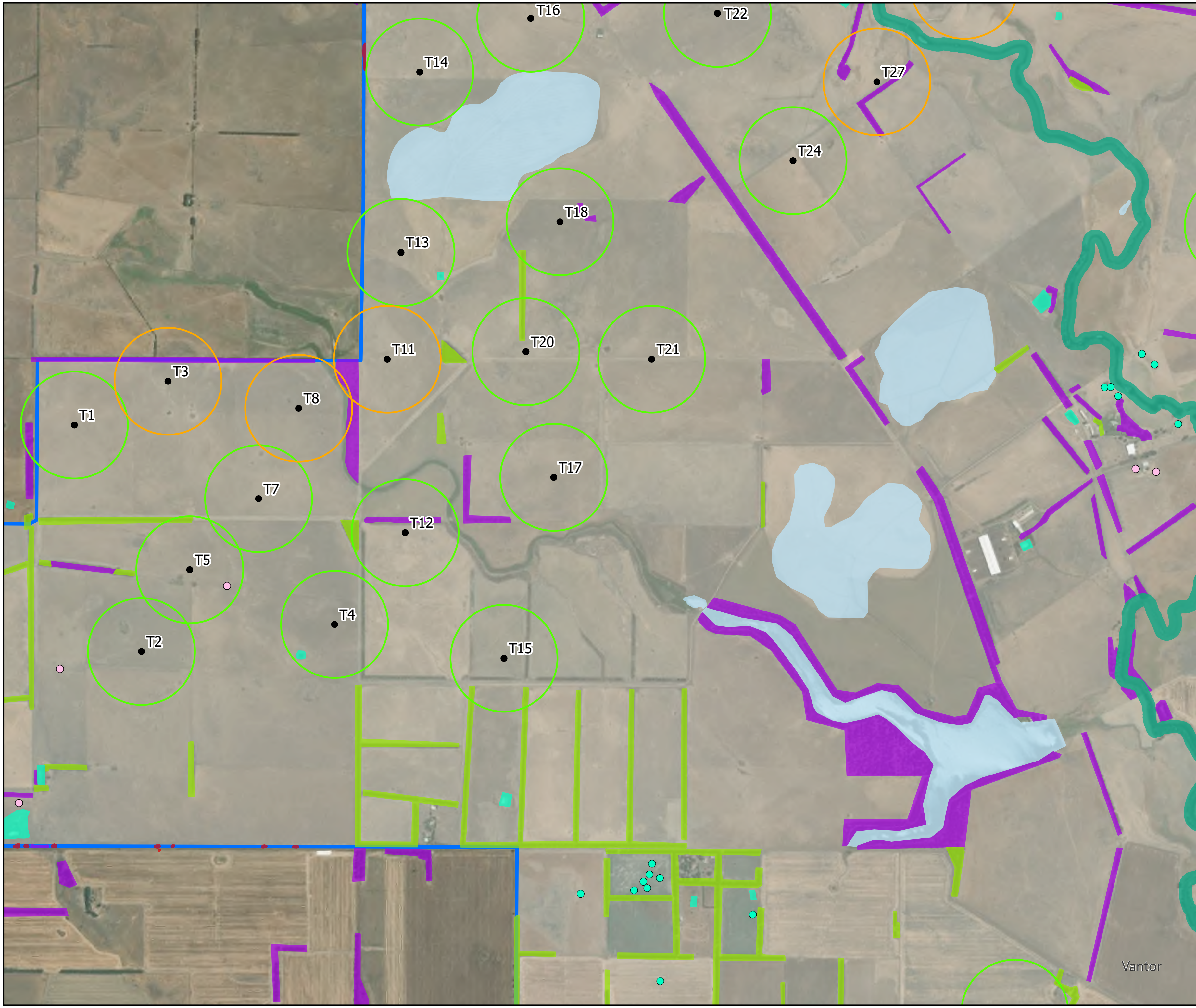
Project: Hexham Wind Farm
Date: 18/11/2025



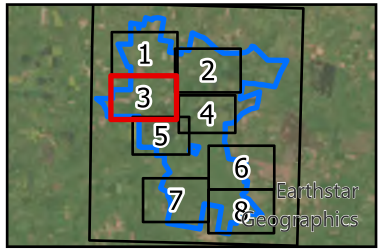
Wind farm boundary
Turbine

Habitat features

Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Lower
Moderate



N

Kilometres

0 0.2 0.4 0.6 0.8 1

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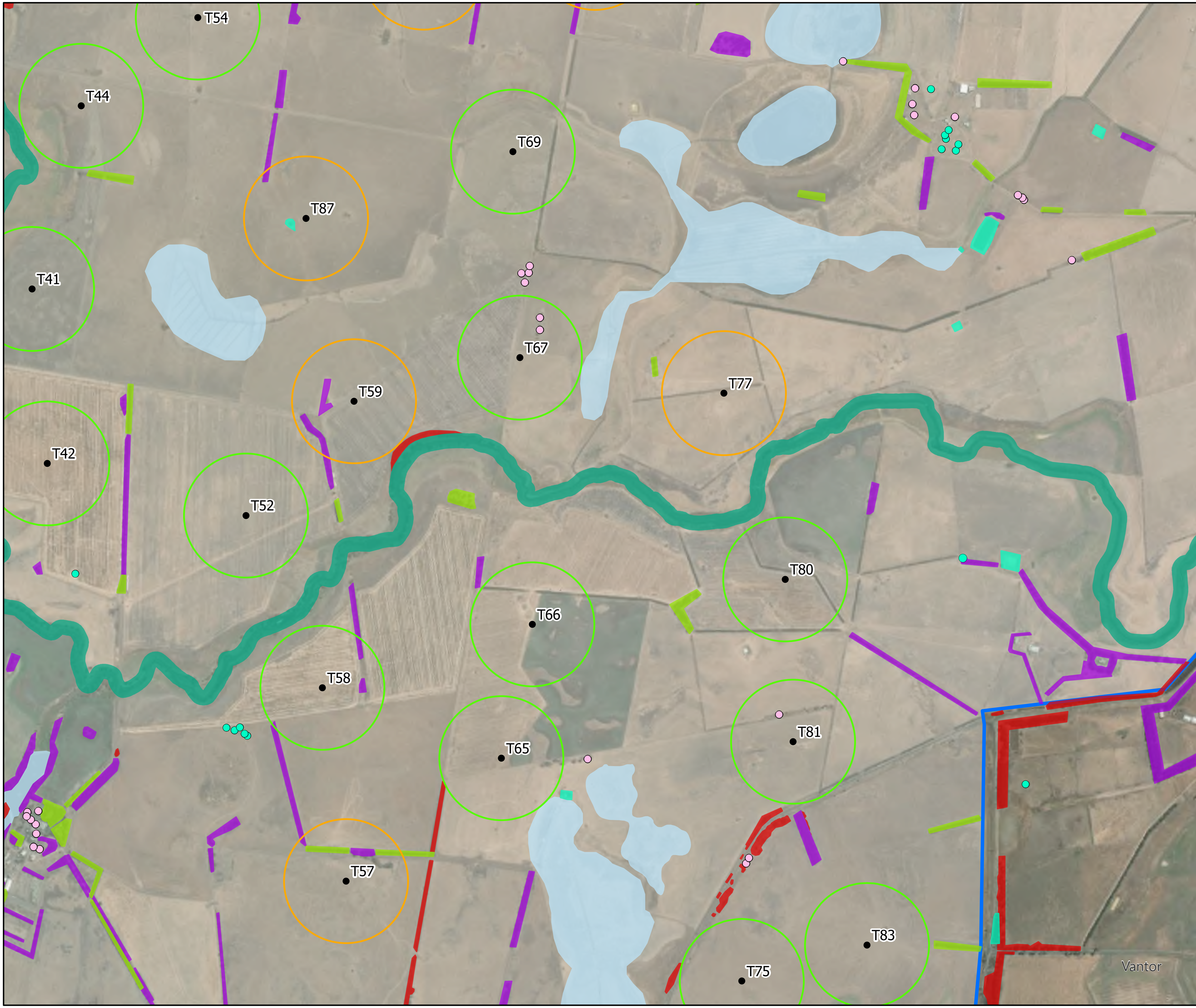


Figure 25A4: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

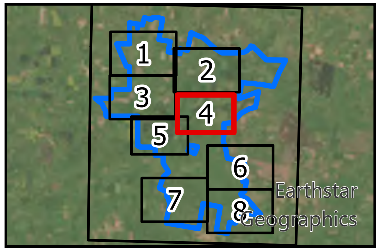
Wind farm boundary
Turbine

Habitat features

Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Lower
Moderate



Kilometres
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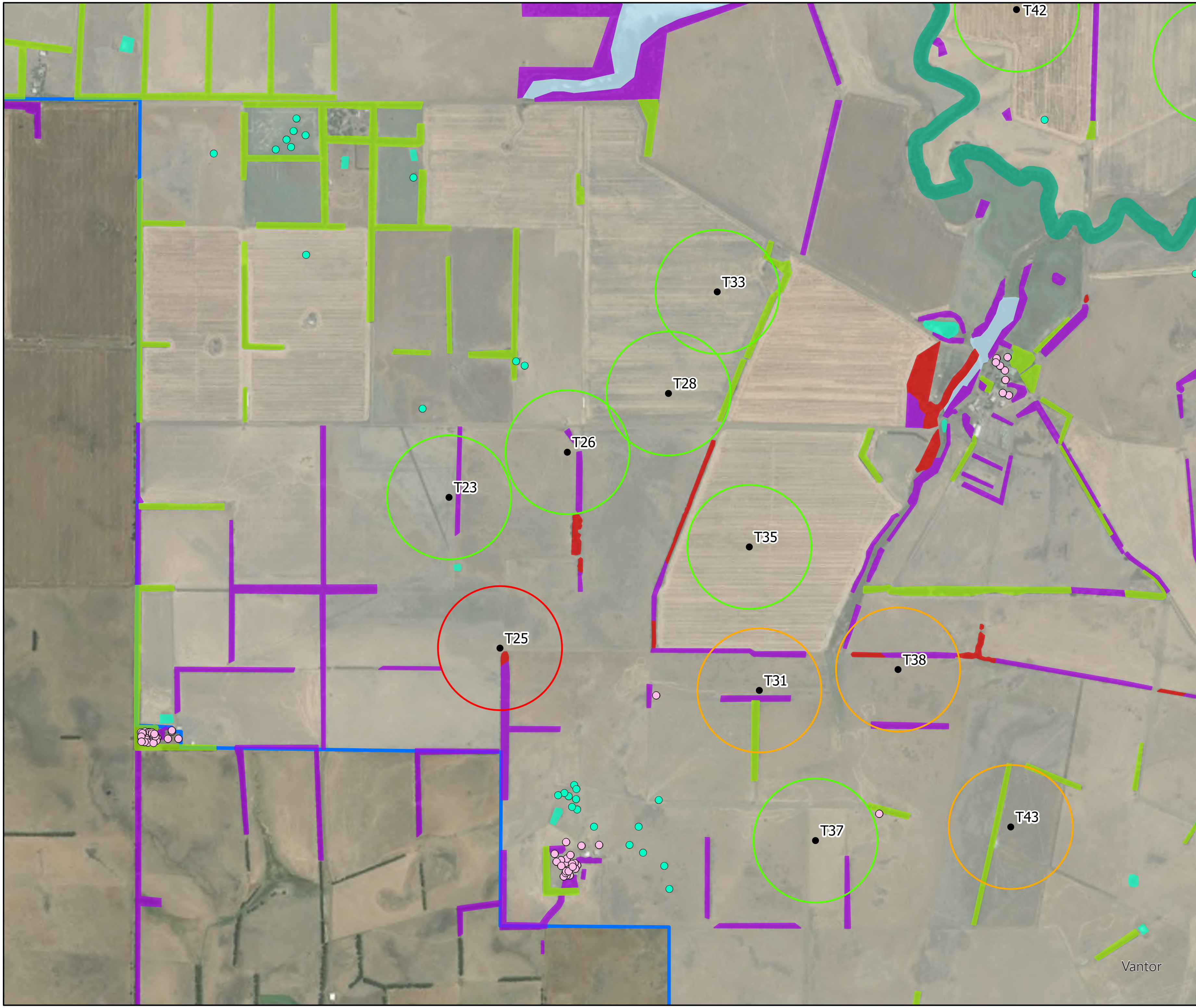


Figure 25A5: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

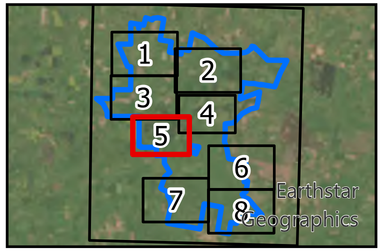
Wind farm boundary
Turbine

Habitat features

Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Higher
Lower
Moderate



Kilometres
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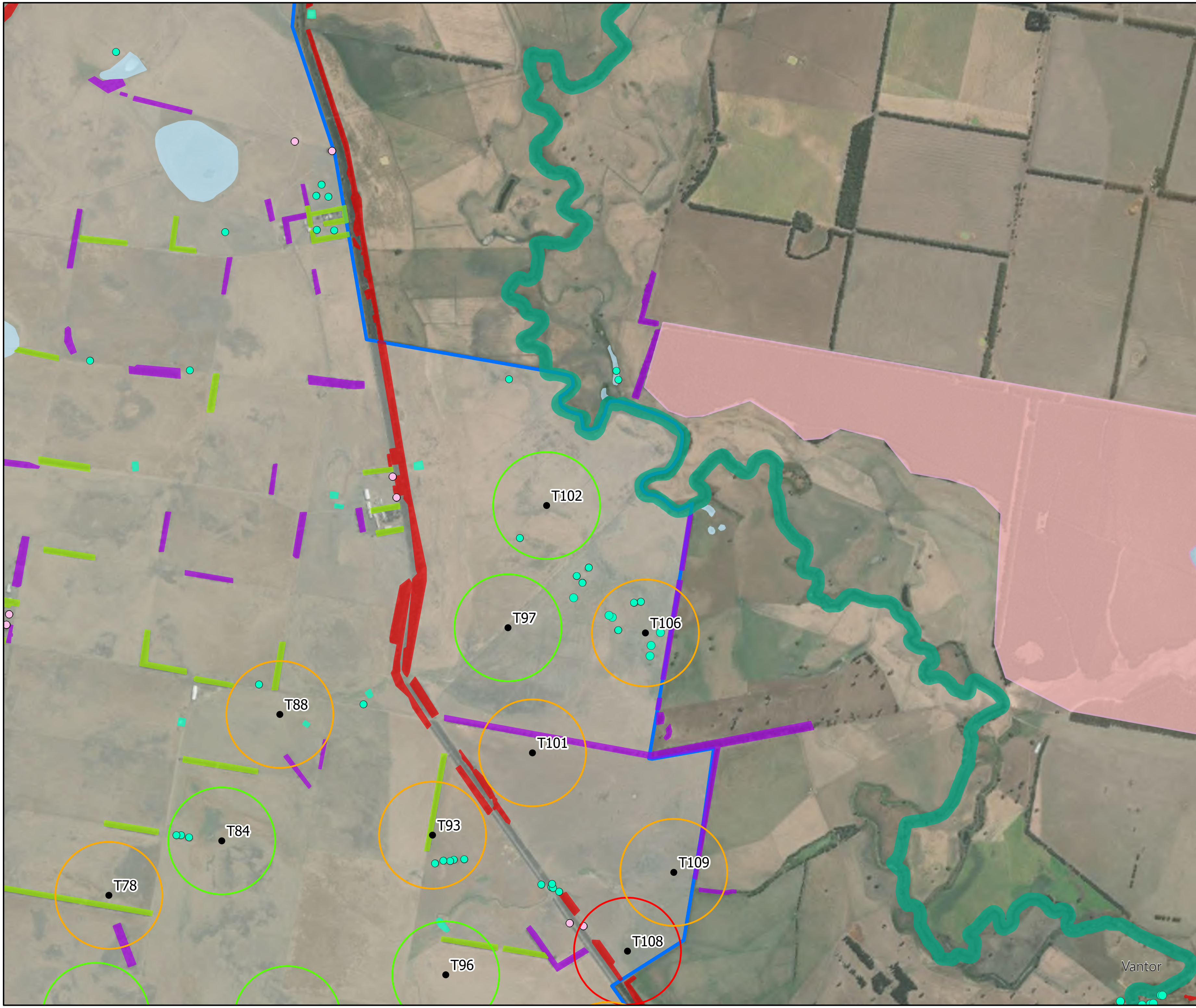


Figure 25A6: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

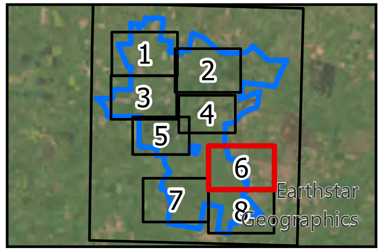
- Wind farm boundary
- Turbine

Habitat features

- Farm dam
- Forestry plantation
- Permanent creeks
- Pine tree row
- Planted Eucalypts
- Remnant native woodland
- Wetland
- Planted tree
- Remnant tree

Risk category

- Higher
- Lower
- Moderate



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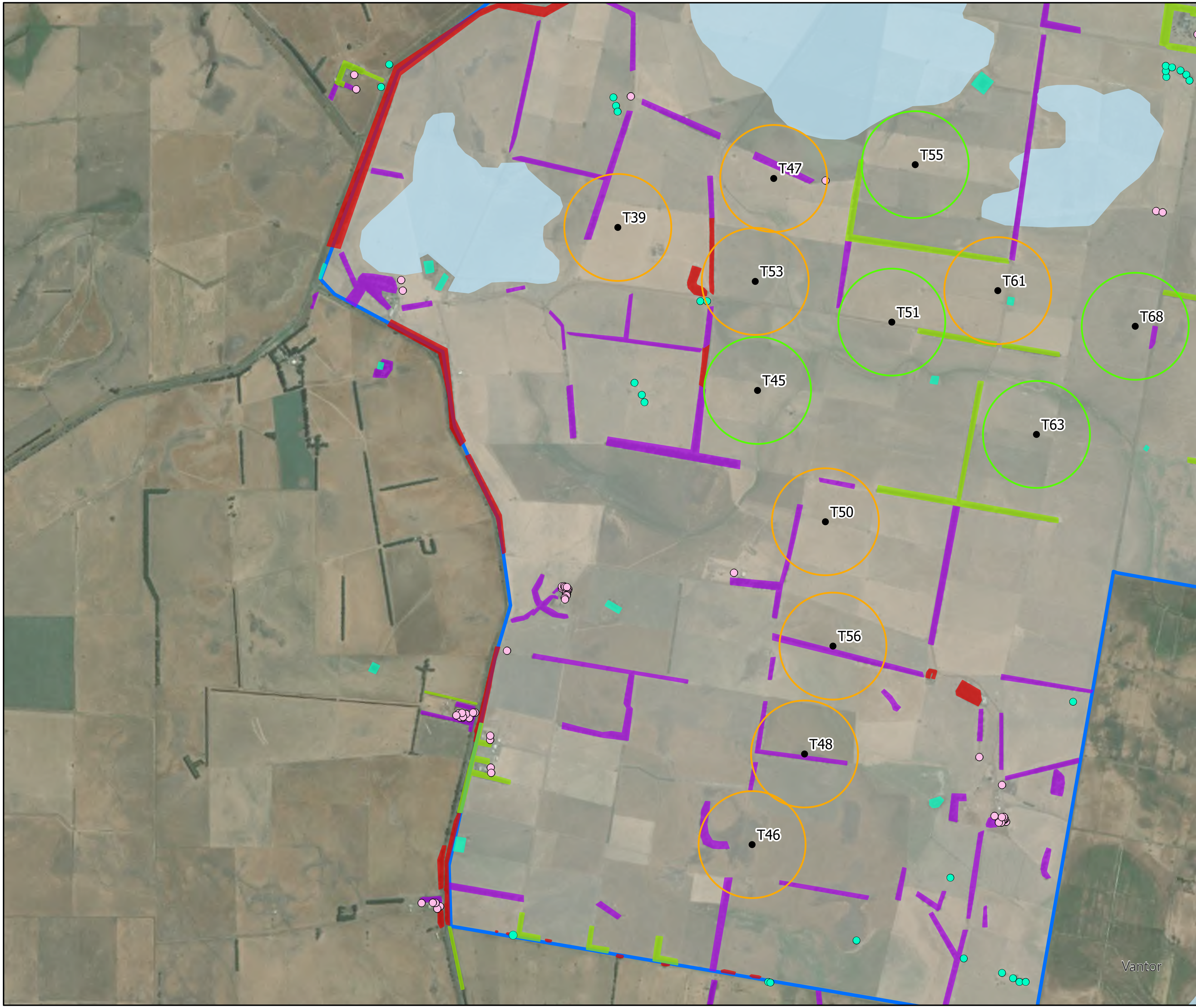


Figure 25A7: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

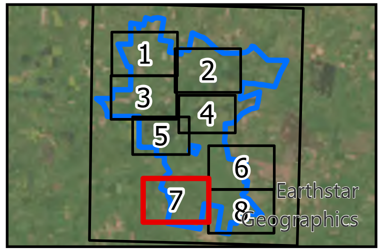
Wind farm boundary
Turbine

Habitat features

Farm dam
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Lower
Moderate



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Kilometres

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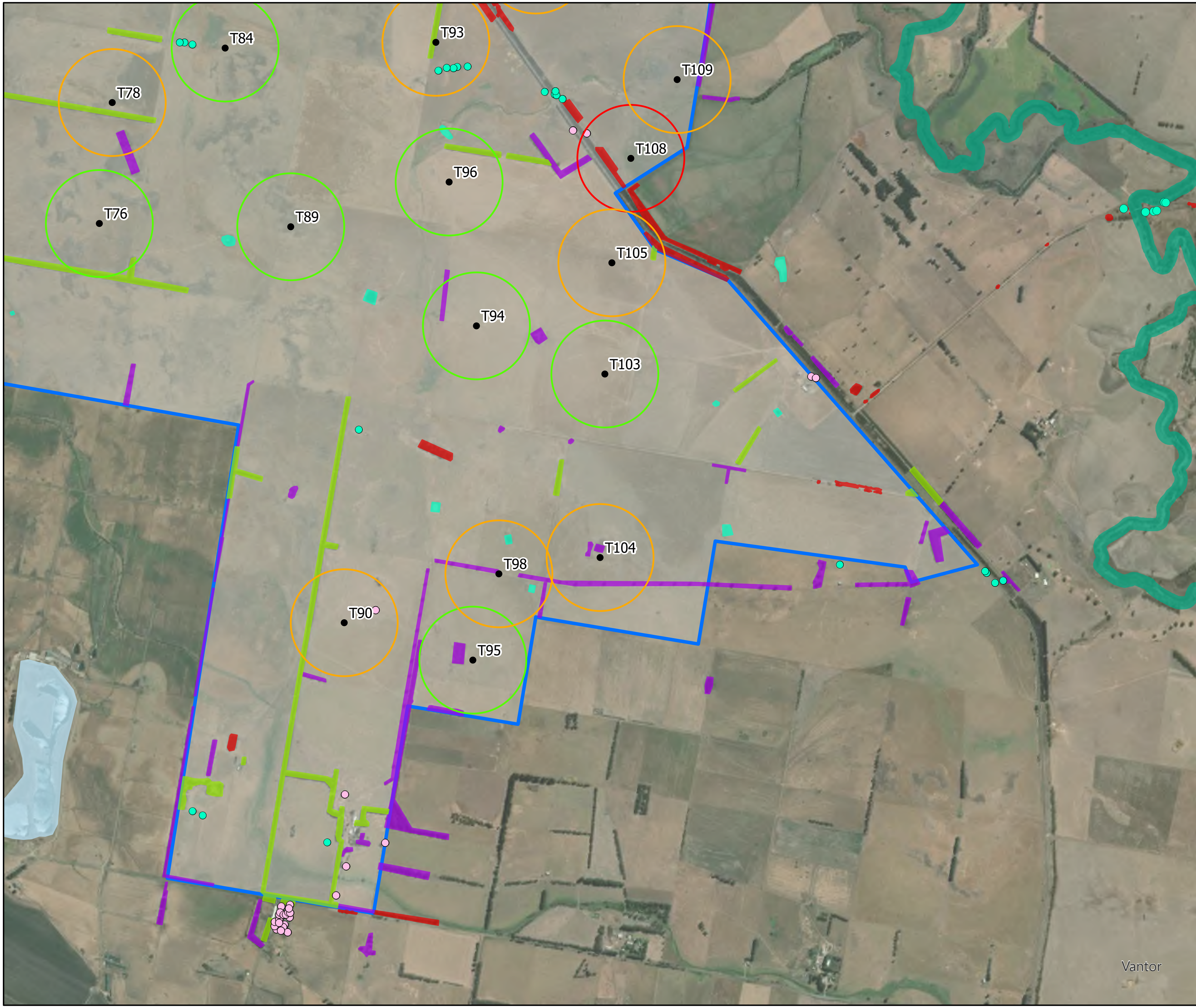


Figure 25A8: Risk category of turbines

Project No: 18088.10
Project: Hexham Wind Farm
Date: 18/11/2025

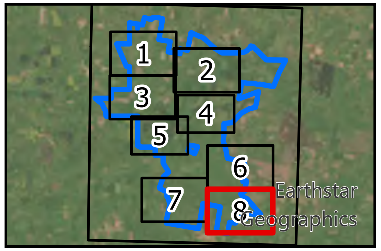
Wind farm boundary
Turbine

Habitat features

Farm dam
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
Planted tree
Remnant tree

Risk category

Higher
Lower
Moderate



Kilometres
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10.2.2. Acoustic deterrents

Ultrasonic acoustic deterrent systems have been proposed as a method to reduce activity of echolocating bats to mediate bat-human conflicts (Zeale et al., 2016), including close to wind turbines. These systems generate ultrasonic sound within the frequency range used by bats that is designed to mask returning echoes from the bat's echolocation signal, forcing them to leave the airspace (Arnett et al., 2013). Findings presented by Weaver et al. (2020) and Good et al. (2022) provide promising evidence that ultrasonic acoustics deterrents can reduce bat collisions, but the effectiveness appears to be species-specific. Good et al. (2022) had similar findings, however were tested on turbines alongside a curtailment of 5 m/s and not as a stand-alone measure.

While this technology has the potential to play a role in impact reduction for at least some bats species, there are limitations and its efficacy for reducing impacts to Australian bats needs to be systemically tested. Acoustic deterrents mounted on a turbine tower or nacelle cannot generate a high frequency (40-50kHz) acoustic envelope that covers the entire rotor swept area at a sound pressure level loud enough to generate deterrence behaviour from echolocating bats (Arnett et al., 2013; Good et al., 2022; Schirmacher, 2020; Weaver et al., 2020). As higher frequencies attenuate faster as they travel through air than lower frequencies, ultrasonic acoustic deterrents will potentially have the lowest level of effectiveness for high frequency calling species (e.g. SBWB).

In response to the impact triggers detailed in the BAM Plan, Hexham Wind Farm Pty Ltd is committed to investigating the feasibility of acoustic deterrent trials alongside consultation with DEECA. It is acknowledged that as an emerging technology, the application and effectiveness of these devices is largely inconclusive, particularly for specific species such as SBWB. However, it is also recognised that efficacy trials of available technologies may yield acceptable results for future implementation.

10.2.3. Other technologies in development or testing

Potential methods for deterring bats from airspace within turbine RSAs include light, radar and sound (Werber et al., 2023). Most technologies in the active deterrent space appear to be in early testing phases, with limited evidence of efficacy when implemented at-scale at operational wind facilities. Consequently, while there are some promising developments, most of these technologies are not yet commercially available as off-the-shelf products ready for use at operational wind farms. These include:

- Electromagnetic radiation produced by marine radar as a deterrent (Gilmour et al., 2020).
- Using drones to disturb wildlife (Kuhlmann et al., 2022; Werber et al., 2023).
- Creating ultrasonic noise by ejecting compressed air from nozzles as a supersonic jet (Romano et al., 2019).
- Attaching passive ultrasonic whistle directly onto turbine blades (Zeng and Sharma, 2023).
- Attaching miniaturised speakers directly onto turbine blades (Cooper et al., 2020).
- Visual deterrents, such as dim ultraviolet light (Gorresen et al., 2015).
- Automated monitoring systems incorporating thermal video, radar and/or echolocation to trigger short-term curtailment when target species are detected approaching a turbine (McClure et al., 2021; Rabie et al., 2022).

The evolution of these emerging technologies may help manage collision risk and residual impacts on bats, but will require assessment. An adaptive monitoring and management approach, in line with intervening developments in scientific research, government policy and mitigation technologies, is proposed for this project.

10.3. Assessment of residual impacts

During construction, human presence and construction noise from project activities may result in temporary disturbance of local bat populations. Construction may also result in foraging habitat being removed. The project will require vegetation to be cleared to construct project infrastructure, however the amount of habitat removed is insignificant in the context of the regional foraging landscape. During project construction noise will be generated from heavy vehicle movements and human activity on the site, as well as blasting from the on-site quarry.

The main impact pathway for bats relevant to the project is the direct collisions with operating wind turbine blades, leading to bat mortality. These are discussed further below.

10.3.1. Overall bat assemblage

Potential indirect impacts

During construction, project activities have the potential to result in temporary disturbance of local bat populations, through removal of foraging habitat, as well as behaviour disturbance due to human activity, and construction noise and lighting.

Construction will result in the loss of up to 8.168 ha of native vegetation patches and six scattered trees. Of this vegetation, 1.31 ha includes EVCs containing woodland in their general descriptions and 6.12 ha containing wetlands, therefore 7.43 ha has been assumed bat habitat as a precautionary measure, despite some of these areas not containing trees and wetlands. The loss of native vegetation is unlikely to have a material effect on the availability of foraging habitat for bat populations. Through an iterative and careful design process, a substantial proportion of impacts on native vegetation was avoided.

Most construction stage activity will occur during daylight hours and will be temporary and intermittent (estimated to last for short periods at any work site within the longer project construction period). Nighttime security lighting will only be used at the terminal station, and at temporary construction compounds. Any impacts of lighting or noise during construction will be temporary, and intermittent, and largely occurring during the day when bats are not active. Therefore, any impacts from lighting and noise during construction are not expected to be significant

Once construction is complete, there will be a lower level of vehicle traffic and human activity associated with operating the completed wind farm During operation, turbines generally only require aviation warning lighting when within close proximity to airfields. This consists of red flashing lights which are not known to attract bats, and there is no known international literature to suggest that this kind of lighting is of any concern at onshore wind farms.

Lighting and noise during construction and operation is not likely to significantly impact on bats foraging and commuting through HWF.

Potential direct impacts

Direct collisions with operating wind turbine blades or towers is the most likely impact on bats as a result of the project.

Post-construction monitoring of bat deaths from turbine collisions at 15 Victorian wind farms between 2003 to 2018 recorded 13 species (DEECA 2025). Three bat species accounted for 83% of all recorded deaths with most bat deaths being the White-striped Free-tailed Bat (WSFB; 67%), which typically flies higher above the ground than most other species of Victorian bats. DEECA notes that the WSFB (DEECA 2025) was the most commonly impacted species across wind farms in Victoria. Symbolix (2020) used post-construction monitoring results to model collision mortality. Overall, they predicted, between 7 and 10.8 bat mortalities occur per turbine per year in Western Victoria. Median annual per turbine mortality for individual species was 4.7 – 5.0 for WSBF, 1.6 – 1.8 for Gould's Wattled Bat, and 0.5 - 0.8 for Eastern False Pipistrelle.

Thus, if the project is approved and constructed there will be some bat mortality from collisions with wind turbines, as occurs with other operating wind farms in the region. As bat activity in the project site is comparatively lower than for other wind farm sites in the region, the cumulative impact to the bat community generally from the project is assessed as low.

As noted in Section 7.4, results of paired bat recording (at ground level and 42 – 50 m) showed that most calls were from the ground-based detector indicating bats in these areas typically fly around ground level. Species recorded at a height of 42 m were Gould's Wattled Bat, the WSFB and the Forest bat complex (see Table 10 above). Presence of the YBSB was noted at 42 m.

A comprehensive element of project design has been to selectively place wind turbines in areas that will minimise potential impacts with bats (detailed in Table 23). This highly selective placement of turbines to avoid habitats most used by bats will minimise the likelihood of collisions with turbines as supported by other studies. For example, Lumsden and Bennett (2005) surveyed bat assemblages at 30 sites in south-eastern Australia, in five habitat categories representing a range of tree densities from remnant woodland blocks (>35 trees/ha) to sparsely scattered trees (<1 tree/ha), and open paddocks devoid of trees. They found that overall activity in open paddocks was significantly lower compared to the forested categories. While all species were recorded in open paddocks, for eight of the ten species this represented <7% of their total activity recorded across all habitat categories.

Based on both on-site recording and considering the results of post construction monitoring of bat deaths (Symbolix 2020), it is likely that WSFB, Gould's Wattled Bat, Chocolate Wattled Bat, Large Forest Bat and Little Forest Bat will collide with operating wind turbines. Each of these species are common and widely distributed and considered to be secure (i.e., not threatened). 'Widely distributed' refers to species whose distribution is not restricted to a small portion Australia, and that are recorded commonly throughout their distribution. Based on Symbolix (2020), WSFB and Gould's Wattled Bat will be the most impacted. This is likely related to the species' foraging habits, which take them high above the tree canopy and open ground while feeding on flying insects, bringing them into turbine RSA heights frequently, and the fact that they are among the most common and widespread species of micro-bat in Australia. The higher RSA height of 40 m proposed for HWF is expected to lessen these impacts compared with some Victorian wind farms described in Symbolix (2020) that have lower minimum RSA heights.

Considering that a) placement of wind turbines has avoided much of the treed and forested areas and b) that the minimum blade tip is higher than most operating wind farms in Victoria, the overall impact of the proposed HWF on bats is considered to be lower than impacts at other operating wind farms in western Victoria. A BAM Plan with specific triggers for non-threatened species will be put in place to respond to impacts on these species if impacts are higher than anticipated.

10.3.2. Southern Bent-wing Bat

As the SBWB has been recorded on the HWF site there is a risk that it may collide with operating turbines. The risk of SBWB colliding with turbines has been assessed and it has been deduced that the impact rating on this species after implementation of avoidance and mitigation measures is likely to be low, as explained below.

The Recovery Plan for the SBWB states that the impacts from wind farms on the population are unclear at this stage (DELWP 2020), though it is possible that if a wind farm is built close to a roosting site, it may have a major impact on that population. The risk increases the closer the wind farm is to a maternity cave or dispersal route and potential impacts include cave destruction during construction, mortalities due to collision with turbines and altered access to foraging areas (DELWP 2020). Individuals from the Warrnambool maternity cave population are the most likely to occur at the proposed wind farm site. The current estimate if there are around 17,233–18,000 bats in Starlight Cave (Warrnambool, western Victoria) during a breeding season (Threatened Species Scientific Committee, 2021).

As the wind farm is located greater than 25 km from any known non-breeding cave and 40 km from a maternity cave, impacts due to construction activities and destruction of caves is considered highly unlikely.

Despite an extensive surveying effort of 4,418 detector nights, activity levels of the SBWB were low across the study area with an overall average number of calls in the study area of 0.05 calls per detector night. SBWB was only recorded from 33 out of 128 sites in the study area.

Targeted efforts were undertaken to ensure areas with repeated SBWB activity were removed from locations where turbines were to be placed and a range of other measures employed, as indicated in Table 22. While this has removed some of the risk, further turbines with a higher risk have been identified. Proactive curtailment will be applied during seasonal SBWB activity, which will see all turbines assessed as moderate to higher risk have low-wind cut-in speeds defaulted to 4.5m/s. In addition, reactive curtailment based on impact triggers detailed in the BAM Plan will further increase low-wing cut-in speeds This measure is derived from the analysis of SBWB for the wind farm detailed in Section 7.6 and will be detailed in the BAM Plan.

Movement between the regions surrounding the site of highest activity and areas of suitable habitat is a possibility and this may take individuals directly over turbine locations. Given the evidence provided in the preceding sections regarding flight heights in open areas, where turbines are proposed to be situated, the infrequency with which SBWB calls were recorded and the proposed RSA minimum blade tip height of 40 m, it is considered there is a low risk of turbine collision if the species were to traverse the site.

The closest known non-breeding caves are Grasmere Cave 25 km SSW and Panmure 30 km SSE of the site. These sites are within the known nightly flight ranges of the species. Additionally, HWF is located within range of other non-breeding caves between which SBWB may undertake occasional, longer-distance movements of up to 70 km. It is possible that bats may travel to the proposed wind farm site from these caves though the majority of movements will be closer to non-breeding caves. Given this, it is unlikely that high numbers of individuals would be on site regularly or for extended periods and likely that they won't be flying as high as the lower RSA height of turbines (i.e. 40+ m) often. The times of SBWB calls were typically well after sunset (average approximately four hours) indicating roosting sites are unlikely to be close by.

The nearest major maternity cave is the Warrnambool maternity cave. However, a considerable focus of project design has been to avoid habitats where this species has been recorded in the past. The lack of records where the turbines are now proposed at HWF is based on repeated surveys at a high survey effort during the species' dispersal period. This is not evidence to indicate that it does not regularly use the HWF site during these times in autumn, winter and early spring.

Activity levels were generally thought to be lower for most of the non-breeding season (April through to September), when the SBWB is at non-breeding caves. New information has shown that SBWBs are significantly more active in winter than previously thought, which can include frequent (e.g., over successive nights) inter-cave movements of as far as 70 km (van Harten 2020, TSSC 2021). Some bats roost in clusters, whilst others roost individually at this time. However, acoustic surveys during winter at other wind farms in south-east Victoria have indicated a reduction in activity over the winter months (June – August; Biosis 2024).

Monitoring of impacts on the SBWB has been outlined for in the proposed BAM Plan, which is detailed in Section 10.5. The BAM Plan presents a series of escalating measures to address and further minimise any potential ongoing issues to the SBWB.

Potential cumulative impacts on the Southern Bent-wing Bat population

Given the low activity levels of SBWB and the lack of suitable foraging habitat where turbines are proposed (see above), the proposed HWF is considered to represent a low impact on the species. While the scale of overall impact on the SBWB is low compared with other species, given that there have been recorded mortality of this species, it is possible that despite the mitigation measures above, mortality will occur.

The implementation of the BAM Plan with escalating mitigation measures to be implemented, if required, in response to mortalities, will further minimise the ongoing risk to the species. Thus, it is considered unlikely that the HWF will lead to a long-term decrease in the size of the population. The extent of impact is unlikely to compromise its future survival, and the impact rating is considered to be low. Significant impacts on the Warrnambool maternity cave population estimated at 17,000 to 18,000 individuals are considered highly unlikely from the construction and operation of the HWF.

10.3.3. Yellow-bellied Sheath-tail Bat

The YBSB is a wide-ranging species through tropical and sub-tropical Australia. In Victoria, the species is considered to be a rare visitor in late summer and autumn (NSW Office of Environment & Heritage 2021).

Many of the Victorian specimens have been found in exposed situations in an exhausted condition (e.g. hanging from the outside wall of buildings in broad daylight), which might suggest that they have been unintentionally driven south by adverse wind conditions. The species occurs in a wide range of habitats from wet and dry sclerophyll forests to open woodlands. It usually roosts in large tree hollows but sometimes uses buildings (Menkhorst 1995, Churchill 2008, NSW Office of Environment & Heritage 2021).

There is no information on the number of YBSB that visit Victoria as it is typically recorded rarely and

Prior to implementation of the mitigation hierarchy, it was considered unlikely that the proposed HWF would result in levels of mortality sufficient to cause a significant impact on the species and, therefore, a very low impact rating on the YBSB was predicted (see Section 9.2.4). This impact rating was due to the very small number of calls recorded in recent years despite considerable survey effort, and therefore the potential level of activity of the species is expected to be low. The impact rating for this species after implementing avoidance and mitigation measures is still very low (Table 16).

However, the BAM Plan considers YBSB, along with SBWB, and has established impact triggers and associated mitigation. Therefore, no residual impacts are expected for this species.

10.3.4. Grey-headed Flying-fox

As outlined in Section 8.3, it is considered unlikely that the GHFF would visit the proposed HWF regularly to feed, due to lack of foraging resources within the HWF boundary. However, there may be occasional flights across the site if the temporary GHFF camp is re-established in the pine plantation to the east of the wind farm.

Consequently, it is considered unlikely that the proposed wind farm will result in levels of mortality sufficient to cause a significant impact on the species. The impact rating for this species after implementing avoidance and mitigation measures is still very low (Table 16). However, specific measures have been included in the BAM Plan to address impacts to this species, and therefore, no residual impacts are expected for this species.

Potential cumulative impacts on the GHFF population

Salt Creek WF (operational), Woolsthorpe WF (approved), and Swansons Lane WF (proposed) may occasionally cause collisions to the species. It is unlikely that HWF will contribute significantly to cumulative impacts to GHFF with the surrounding proposed projects. However, specific measures will be included in the BAM Plan to address impacts to these species.

10.3.5. Collision Risk Model

A Collision Risk Model (CRM) can be a valid tool for measuring the likelihood of collision, and when reapplied at the same site over time can also help to monitor the effectiveness of a wind farm's approach to management. However, there are limitations within the context of applying a CRM to microbats that inhibits it’s use. The key limitation relates to acoustic data recording not capturing abundance, as recording devices can only record presence or absence in any given location. Because of this, CRM is an inaccurate measure of potential impacts on microbats. If, at some point, technological advances are made to capture abundance, the volume of SBWB data collected is unlikely to satisfy the minimum data requirements to apply a CRM.

10.4. Offsetting

The final element of the avoidance and mitigation hierarchy looks to offset any residual impacts. HWF has committed to financial compensation measures in response to the relevant impact triggers detailed in Section 5 of the BAMP. These compensation measures are detailed in Section 4.3 of the BAM Plan.

Whilst it’s premature to detail the type of offsets, some examples of possible offsetting could include contributing funds to:

- The Southern Bent-wing Bat Recovery Team (SBWBRT) to help fund research and management objectives;
- Habitat restoration projects. Including those designated for private land via organisations such as Trust for Nature;
- Research programs designed to improve the knowledge base about SBWB (e.g. diet, reproduction, flight dynamics, etc.);
- Funding measures to maintain or improve known SBWB roosts.
- Technologies to better monitor populations and their activity.

The potential for financial contributions from the wind industry toward an offset fund are described as follows (Department of Environment, Land, Water and Planning, 2020):

"Offset requirements from wind farm developments may have positive benefits to local communities or landholders if funding was provided to implement on-ground management actions, such as cleaning rubbish out of caves."

Further, Section 6.2 of the Recovery Plan states that (Department of Environment, Land, Water and Planning, 2020):

"Develop a site-specific register of projects related to on-ground habitat management on both public and private land, and research/monitoring requirements for the Southern Bent-wing Bat. Prioritise the projects to direct funding to the most urgent tasks. The register could also be used to respond to requests for potential offsets resulting from wind farm developments."

The Conservation Advice also outlines several priority conservations and management actions that could potentially be funded by contributions from wind farm proponents under an offset agreement (Threatened Species Scientific Committee, 2021):

- *Implement management actions to increase the condition and extent of foraging habitat, especially within foraging range of key roosting sites.*
- *Establish conservation covenants or management agreements on private land containing important roost or foraging sites.*
- *Investigate and trial options for restoring caves previously used by the Southern Bent-wing Bat but rendered unsuitable due to guano mining or other anthropogenic activities.*

There are also a number of conservation actions detailed in the SBWB Action Statement (Department of Energy, Environment and Climate Action, 2023b, pp 4-6) that may benefit from industry support and offsetting measures, including programs relating to:

- Community engagement and awareness
- Controlling feral cats and foxes
- Identifying and protecting key habitat
- Investigating voluntary agreements and/or covenants
- Managing built infrastructure
- Managing public access
- Research into pathogens and disease
- Restoration and/or revegetation
- Surveys and monitoring

In any instance offsetting is being considered, DEECA and the SBWBRT will be consulted.

10.5. Monitoring and management

10.5.1. Bat and Avifauna Management Plan (BAM Plan)

The BAM Plan has been prepared for HWF in accordance with the *Onshore Wind Farm Guidance – interim guidance on bird and bat management* (DAWE 2022) and the *Onshore Wind Farm Guidance: Best practice approaches when seeking approval under Australia's national environment law* (DCCEEW 2024). The BAM Plan outlines monitoring protocols and responsibilities, trigger responses to a listed species being impacted by the wind farm, and reporting requirements. Adaptive management measures to reduce impacts are considered as part of the BAM Plan.

Mortality monitoring

A suitably qualified ecologist, as per the DCCEEW guidelines, has prepared the BAM Plan.

Mortality monitoring is a critical component of the BAM Plan to empirically assess the effectiveness of increasing low-wind speed cut-in at HWF. The specific details of the mortality monitoring regime are described in the BAM Plan including the following components:

- Mortality surveys conducted monthly with conservation scent dogs at 25% of randomly selected turbines.
- Intensive scent dog surveys (e.g., two surveys per week over 2-4 weeks) at all higher-risk turbines during periods of peak SBWB activity.

The frequency, timing and duration of intensive targeted scent dog surveys will be determined in consultation with DEECA, with advice sought from the SBWBRT.

Acoustic bat surveys

Bat detector surveys during the two-year post-commissioning period will be required to collect further data on temporal activity patterns of SBWB and YBSB in the study area. Paired bat detectors should be placed at ground-level and on turbine nacelles. Consultation with DEECA and the SBWBRT will be required to determine the frequency, timing and duration of the bat detector surveys.

A critical component of the post-commissioning bat detector surveys is to use weather data recorded at ground-level and nacelle to test how variation in a range of environmental factors, such as wind speed, air temperature and rainfall, influence bat activity. A two-year survey period combining site-specific information on weather conditions, bat echolocation call activity and bat mortalities could generate sufficient data to inform the development of a smart curtailment algorithm for HWF. Research in the Northern Hemisphere has shown smart curtailment algorithms that make predictions about the level of risk to bats at wind energy facilities under various environmental conditions, and then use this information to guide curtailment decisions, have great potential in reducing bat fatalities while also reducing energy loss when compared to employing blanket turbine curtailment (Barré et al., 2023; Behr et al., 2017; Hayes et al., 2023, 2019).

GHFF targeted surveys

Because the GHFF is expected to appear sporadically and unpredictably at the HWF site, monitoring is anticipated to be challenging and indirect. The presence of this species is influenced by fruiting and flowering events, especially the flowering of Sugar Gum in SW Victoria, which is known to attract these bats to the region. Given these factors and the distance of HWF from permanent camps, establishing an effective regular monitoring program is not feasible. Instead, the monitoring program will be based on an alternative strategy as follows, and during the first two operational years of the wind farm.

- **Habitat surveys**: Undertake annual habitat suitability assessments in and around the wind farm site (e.g., presence of flowering gums, or other fruiting trees, presence of water).
- **Species database monitoring**: Annual reviews of relevant databases, including the National Flying-fox monitoring viewer1 to get up-to-date information on camp locations and numbers.
- **Community engagement**: Regular discussions with wind farm personnel, landholders, and DEECA/DCCEEW regarding the species presence, and assess its potential increase in prevalence within the site and its surroundings.

This information will guide the qualified ecologist in scheduling field visits to confirm GHFF presence, estimate numbers, and potentially map flight paths within the wind farm layout to identify areas of potential collisions.

Impact triggers

Another critical component of the BAM Plan would be defining trigger events (e.g., SBWB or YBSB mortalities) and prescribing mitigation actions (e.g., stepped increases in nighttime cut-in speed) and monitoring protocols to be implemented if impacts are detected. As above, triggers, mitigation measures and intensive monitoring designed to assess the effectiveness of these management actions under an adaptive management framework would be described in detail in the BAM Plan, following consultation with DEECA.

When an impact trigger is reached, the following actions are taken:

- **Label the turbine** as a "high-risk turbine".
- **Intensify monitoring:** More frequent or additional carcass searches (within a 70 m radius) at the high-risk turbine and all turbines within 1 km to assess the extent of the impact, minimise the chances of scavenging, and maximise carcass detections. Intensified monitoring is recommended to be temporarily implemented.
- **Adaptive mitigation:** Mitigation measures and process of assignment and re-assignment of risk. Mitigations should be increased as a higher-level impact trigger is reached and only be lowered back (e.g., reversing turbine labelling and curtailment cut-in speeds) if the mortality event is concluded to be a one-off occurrence, unlikely to lead to a significant impact, or the implementation of other mitigation measures alone or in combination are proven to be effective (see below). It is recommended to apply curtailment and other active mitigation measures when the species is likely to be regularly active on site (i.e., October to April). Mitigation measures can include, but are not limited to:
    - *Nighttime low wind speed curtailment*. Low wind speed curtailment is a well-known and broadly applied effectively proven mitigation measure to reduce bat collisions worldwide (Adams et al., 2021; Bennett et al., 2022). Cut-in speeds for curtailment will increase as a higher-level impact trigger is reached.
    - *Ultrasound acoustic deterrents*. This mitigation measure can be used in combination with curtailment or alone if proven to be effective (Good et al., 2022; Weaver et al., 2020). The combination of this mitigation with curtailment can also be used to revert curtailment cut-in speeds.
    - *GHFF detection technology*. There is limited information due to lack of existing studies (therefore high uncertainty) on effectiveness of mitigation measures for flying foxes. The proponent is committed to trialling mitigation measures as evidence emerges on their effectiveness, including on-demand shutdown (using radar or thermal/infrared cameras) or targeted shutdown (using weather radar) in the event of a GHFF trigger.
    - Other technologies as they become available and effective, including acoustic detectors, radar, thermal or a combination could be used to implement smart curtailment or deterrents (Gilmour et al., 2020; Matzner et al., 2020; Rabie et al., 2022). A comprehensive literature review of available methods indicates that curtailment and acoustic deterrents are the most tested and proven mitigation options, either alone or in combination (see Appendix 3).
- **Mitigation monitoring:** All mitigation actions that are implemented will be monitored, and the outcomes will be provided to the Responsible Authority. The assessment of the outcomes is intended to determine whether the action(s) were effective in minimising/avoiding the impacts or whether escalation or alternative measures are required.

- **Incident investigation and reporting** to the Responsible Authority, including but not limited to the following key information:
  - Date and time of mortality,
  - Identify, if possible, wind direction and speed when the bat was struck,
  - Weather conditions,
  - Description of the season,
  - Location of mortality relative to habitat, vegetation and water sources,
  - Proximity to nearest known SBWB roost caves,
  - Analysis of any other mortality on the site,
  - Conclusions of investigation regarding risk to SBWBs and likelihood of further mortalities on site,
  - Recommendations for future actions to mitigate impacts on SBWBs, and
  - Options for other mitigation including deterrents.

All aforementioned monitoring and mitigation are detailed in the *Hexham Wind Farm Bat and Avifauna Management Plan*.

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Appendices

Appendix 1: Limitations of bat detector surveys

General considerations

Remotely deployed electronic recording devices, such as bat detectors, occasionally experience technical difficulties, such as errors in writing data onto memory cards, failure of internal electronic components, loose internal connectors, and batteries discharging to a level where the unit shuts down (Hayes, 2000). As a result, the number of nights and total hours of recording can vary between the different detectors deployed during a survey (Griffiths et al., 2020).

Bat detectors are only capable of detecting echolocation calls that arrive at the microphone above a critical sound pressure level (SPL) and at a sufficiently high signal-to-noise ratio (SNR) (Russo et al., 2018). This means that, for an echolocation call to be recorded by a bat detector, it must be louder than background or ambient noise (Agranat, 2014). Sources of background noise that can interfere with a bat detector's ability to detect and record bat echolocation calls include sound generated by civil infrastructure (e.g. windmills, power inverters), traffic, wind, rain, dripping/running water and insects (Fraser et al., 2020). As the level of background noise can change from night-to-night, or within a single survey night, the timing and duration of bat detector surveys should be designed to ensure that an adequate number of nights are sampled when background acoustic conditions are conducive to recording bat calls (Department of the Environment, Water, Heritage and the Arts, 2010).

Bat activity levels within and between nights may vary in response to weather variables such as air temperature, relative humidity, barometric pressure, wind speed, direction and gusts, and rain (Erickson and West, 2002; Milne et al., 2005). Typically, bats are found to be less active during the following circumstances:

- When minimum nighttime temperature drops below a critical threshold (actual value depends on survey location);
- At higher wind speeds, e.g. over 10 m per second; and
- During moderate to heavy rainfall.

To account for variation that can occur in bat activity from night-to-night, the bat detector surveys conducted for this investigation encompassed a much greater temporal replication (total bat detector nights across all four survey periods = 2,414) than is typically undertaken for biodiversity surveys designed to asses potential impacts of development projects to listed bat species in Australia (see Department of the Environment, Water, Heritage and the Arts, 2010).

Overlap in species-specific call characteristics

Insectivorous bats generate ultrasonic sounds using their vocal chords and 'listen' to the corresponding echoes which provide the bat with a three-dimensional acoustic image of their immediate surroundings (Fenton, 2013). As opposed to bird song, where calls are used to communicate messages and information to conspecifics, bats use echolocation calls to orientate, detect obstacles, and acquire spatial information on the presence and location of food and other key resources (Moss and Surlykke, 2001). To optimise the sensory information provided by echolocation calls, bats change call structure when flying through different habitat structures (e.g. open versus cluttered areas) or performing different tasks, such as commuting or foraging (Runkel et al., 2021). Consequently, calls produced by one bat species may at times closely resemble those of other species (Barclay, 1999). The considerable variability in calls produced by free-flying echolocating bats often makes it difficult, or sometimes impossible, to assign species-level identifications to passively recorded calls (Barclay, 1999; Russo et al., 2018).

Further, some Australian co-generic species produce echolocation calls which cannot be distinguished; for example, all species within the *Nyctophilus* genus (long-eared bats). Consequently, calls produced by these species are grouped into a species complex (Milne, 2002; Pennay et al., 2004).

Relative activity versus abundance

Passively collected echolocation call data cannot be used to quantify numbers of bats present in a given area (Hayes, 2000). As an example, if 10 calls of a particular species are recorded, it is not known if this represents 10 individuals of that species flying past the detector, or one individual flying past 10 times. Therefore, it is not possible to determine population numbers (abundance), but rather only a measure of relative activity (e.g., calls per night per site). Activity indices generated from passively collected echolocation data are the industry standard method used worldwide in ecological research and environmental management to investigate factors driving landscape-scale patterns and processes in bat communities (Fraser et al., 2020). Trapping is required in situations where additional information is required, such as estimating local abundance, morphometric measurements, or determining the sex, age or reproductive status of individual bats.

Zone of detection

Echolocation calls produced by bats attenuate (reduce in amplitude) as they travel through air, with higher frequency calls attenuating faster than lower frequency calls (Schnitzler and Kalko, 2001). The rate at which a call reduces in amplitude is influenced by geometric and atmospheric attenuation. Geometric attenuation causes a halving of call amplitude with each doubling of the distance to the bat emitting the call (Russo et al., 2018). Atmospheric attenuation is influenced by several factors, including air temperature, humidity and call frequency, and causes a linear decline in SPL with increasing distance between a calling bat and the ultrasonic microphone (Goerlitz, 2018).

Because lower-frequency calls travel further through air than higher-frequency calls, low-frequency calling bat species are more likely to be recorded by a bat detector when they are further away from the microphone than high-frequency calling species (Adams et al., 2012). In Australia, low frequency calling species, such as White-striped Free-tailed Bat (*Austronomus australis*, characteristic frequency 10-15 kHz), are likely to be detected at greater distances from a bat detector than higher-frequency calling species, such as Chocolate Wattled Bat (*Chalinolobus morio*, 47-51 kHz). Detection ranges of free-flying bats have been calculated for some species in the Northern Hemisphere. Of particular relevance to this investigation is the detection distance of 30 m reported for Schreiber's Bent-winged Bat (Barataud et al., 2015). As mentioned above, this co-generic Miniopterid species has similar wing morphology, flight patterns and high-frequency calls as SBWB.

In comparison, specific detection ranges for free-flying Australian echolocating bats are largely unknown, as this is difficult to measure in the field and is likely to vary significantly from survey-to-survey depending environmental conditions, the surrounding habitat, the type of detector used, and what the bat is doing (Adams et al., 2012).

While there is likely to be variation in detection distances for different species, and in different habitat types or environmental conditions, the bat detectors used during this investigation are typically able to record most echolocating bat species that are present within a volume of airspace (the detection zone) approximately 20 – 30 m from the microphone (Sherwood Snyder, Wildlife Acoustics, pers. comm.).

The co-generic EBWB, which has similar flight patterns, foraging strategy and high-frequency calls as SBWB, are typically recorded by a ground-level bat detector as they fly above the canopy at a distance of 25-30 m from the microphone (Michael Pennay, pers. comm.).

Zero crossing versus full-spectrum call data

Broadband bat detectors (that can record signals across the ultrasonic frequency range) are required in surveys where multiple species with different call characteristics are present. Depending on the make and model of detector, broadband detectors record two different types of data, described below.

Zero crossing (ZC) – this recording method was developed by Chris Corben to extract the basic time-frequency content of an ultrasonic signal. Put simply, a detector using ZC mode takes measurements of an incoming audio signal's most prominent (loudest) ultrasonic frequency at a given time. ZC recordings do not contain amplitude information, and they do not multiple frequencies that are present within a signal at any point in time. This means that components of bat echolocation calls such as harmonics, overlapping calls, and faint signals in the presence of background noise are not captured in ZC mode (Adams et al., 2012). However, the resulting recordings take up very little data space, which was an important considering when the ZC method was invented, because at that time floppy disks were the industry standard data storage technology.

Despite the limitations mentioned above, ZC globally (Fraser et al., 2020), particularly in situations where data storage capacity is an important consideration. Notably, published bat call identification guides for Australian echolocating bats use ZC data (e.g., Milne, 2002; Pennay et al., 2004), and there are currently no publicly available guides based on full-spectrum call data. Similarly, most automated call identification software systems use metrics calculated from ZC data to distinguish calls produced by different species; for example, see Adams et al. (2010) and Lo Cascio et al. (2022).

Full-spectrum – in this mode, a detector will record acoustic data as audio (WAV) files that capture the entire frequency range present within a signal (not just the loudest frequency at any particular point in time), plus amplitude, harmonic frequencies, and also background noise. This extra detail can help to distinguish bat calls from background noise and in some cases help to differentiate calls produced by different species. For example, calls produced by several Emballonurid (sheath-tailed bat) species present in northern Australia cannot be consistently and reliably separated from ZC files (Milne, 2002). Recent research using full-spectrum data has shown that the amount of energy (amplitude) that sheath-tailed bats put into different harmonics can be used to differentiate some species in some situations (Armstrong et al., 2020).

One important consideration when recording full-spectrum data is the much larger file sizes compared to ZC data files. Recoding in full-spectrum mode can result in memory cards filing up very quickly during field deployments and requires a large amount of hard disk storage capacity to house data from completed surveys. This is particularly relevant for the intensive (6-8 week-long) seasonal bat detector surveys that are currently required for proposed wind farms within the SBWB range of south-west Victoria. Current limitations in storage capacity and computing power makes dealing with full-spectrum call datasets of this size problematic.

As mentioned above, even if full-spectrum data were recorded, the methods used to identify bat calls to species or complex-level rely on metrics extracted from a ZC version of the full-spectrum file. So, the first step in analysis is to convert all the full-spectrum data into ZC files, then use the metrics from ZC files to conduct various types of semi-automated ID processes, followed by manually inspecting spectrograms of subsets of the calls based on target species of interest (e.g., Adams et al., 2010; Lo Cascio et al., 2022).

Appendix 2: Turbine-habitat buffer micro-siting

The following table documents Wind Prospect's turbine micro-siting efforts to avoid SBWB habitat and areas of high SBWB-definite and complex call activity.

The following legend applies to this section:

Brolga home range buffer including 300m distubance
Brolga home range turbine blade buffer
Revised SBWB layout
Revised SBWB layout - 269m buffer
EES turbine layout
EES layout - 269m buffer
Unconstrained area suitable for turbine placement
SBWB NA Habitat features
Farm dam
Forestry plantation
Permanent creeks
Pine tree row
Planted Eucalypts
Remnant native woodland
Wetland
SBWB habitat within the EES layout - 269m buffer
SBWB habitat within the revised layout - 269m buffer

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T1		Open	22.21	97.68	NC	NC	0.15	Lower	Lower
		Planted Eucalypts	0.53	2.32	NC	NC	0.15		
T2		Open	22.73	100	NC	NC	0.16	Lower	Lower
T3		Open	21.59	94.98	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.14	5.02	NC	NC	0.33		
T4		Open	22.73	100	22.60	0.13	0.45	Lower	Lower
		Farm dam	0	0	0.13	0.56	0.16		
T5		Open	22.73	100	22.51	99.01	0.15	Lower	Lower
		Pine tree row	0	0	0.23	0.99	0.14		
T6		Open	20.85	91.72	NC	NC	0.14	Higher	Higher
		Planted Eucalypts	1.55	6.83	NC	NC	0.46		
		Remnant native woodland	0.34	1.48	NC	NC	0.43		
T7		Open	22.73	100	NC	NC	0.16	Lower	Lower
T8		Open	22.08	97.12	21.94	96.51	0.15	Lower	Moderate
		Planted Eucalypts	0.65	2.88	0.79	3.49	0.23		
T9		Open	21.67	95.32	NC	NC	0.15	Higher	Higher
		Planted Eucalypts	0.77	3.37	NC	NC	0.22		
		Remnant native woodland	0.3	1.33	NC	NC	0.39		
T10		Open	22.73	100	NC	NC	0.16	Lower	Lower
T11		Open	21.07	92.7	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.66	7.3	NC	NC	0.49		
T12		Open	22.17	97.52	21.49	94.55	0.15	Moderate - Interfered with pine tree row.	Lower - Shifted to have reduced impact on pine tree row.
		Pine tree row	0.56	2.48	0.40	1.77	0.26		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Planted eucalypts	0	0	0.83	3.67	0.24		
T13		Wetland	1.38	6.07	0	0	0	Higher - Interfered with a wetland	Lower - Moved to avoid mapped wetland area. Intersection with farm dam is an unavoidable outcome.
		Farm dam	0	0	0.09	0.38	0.31		
		Open	21.35	93.92	22.65	99.62	0.16		
T14		Remnant native woodland	0.13	0.55	0	0	0	Higher - Impacted on remnant native woodland	Lower - Location amended to avoid both remnant native woodland and wetland.
		Open	22.61	99	22.73	100	0.16		
T15		Open	22.73	100	22.73	100	0.16	Lower	Lower
		Pine tree row	0	0	0.36	1.60	0.23		
T16		Wetland	0.65	3	0	0	0	Higher – Intersected with DEECA mapped wetland.	Lower – Location amended to avoid wetland.
		Open	22.08	97	22.73	100	0.16		
T17		Open	22.43	98.65	22.73	100	0.16	Lower - Buffer impacted on planted Eucalyptus	Lower - Moved to have no impact on planted Eucalyptus
		Planted Eucalypts	0.31	1.35	0	0	0		
T18		Open	22.3	98.09	NC	NC	0.15	Lower	Lower
		Pine tree row	0.14	0.6	NC	NC	0.08		
		Planted Eucalypts	0.3	1.31	NC	NC	0.09		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T19	SBWB-complex: low	Open	19.9	87.54	22.36	98.35	0.15	Higher - Impacted on a farm dam, pine tree row, permanent creek and planted eucalyptus	Moderate - Moved to avoid permanent creek, areas of planted eucalypts and pine tree row. Remaining areas of planted eucalypts are unavoidable.
		Farm dam	1.58	6.94	0	0	0		
		Permanent creeks	0.1	0.46	0	0	0		
		Pine tree row	0.44	1.94	0	0	0		
		Planted Eucalypts	0.71	3.13	0.38	1.65	0.11		
T20		Open	22.45	98.77	22.24	97.83	0.15	Lower	Lower
		Pine tree row	0.28	1.23	0.49	2.17	0.32		
T21		Open	22.73	100	NC	NC	0.16	Lower	Lower
T22		Open	22.73	100	NC	NC	0.16	Lower	Lower
T23	SBWB-complex: low	Open	22.73	100	22.05	96.99	0.15	Lower	Lower
		Planted Eucalypts	0	0	0.68	3.01	0.20		
T24		Open	22.73	100	NC	NC	0.16	Lower	Lower
T25		Open	21.98	96.71	21.92	96.43	0.15	Higher	Higher
		Planted Eucalypts	0.6	2.66	0.67	2.93	0.20		
		Remnant native woodland	0.15	0.65	0.15	0.65	0.19		
T26		Open	22.28	98.02	22.04	96.94	0.15	Lower	Lower
		Planted Eucalypts	0.45	1.98	0.70	3.06	0.20		
T27		Open	20.47	90.05	21	92.39	0.14	Higher - Impacted on a permanent creek and eucalyptus plantations.	Moderate - Now avoids the permanent creek footprint, however avoidance of the
		Permanent creeks	0.56	2.47	0	0	0		
		Planted Eucalypts	1.7	7.48	1.73	7.61	0.51		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
									planted eucalyptus is unavoidable.
T28	SBWB-complex: low	Open	22.22	97.74	NC	NC	0.15	Lower	Lower
		Pine tree row	0.51	2.26	NC	NC	0.29		
T29		Farm dam	1.85	8.13	1.64	7.19	5.79	Higher - Buffer intersected with farm dams, wetland area and planted eucalyptus.	Moderate - Location was amended to avoid mapped wetland area. The remaining area of planted eucalypts and mapped farm dam area is unavoidable.
		Wetland	0.74	3.25	0	0	0		
		Open	19.29	84.84	20.74	91.23	0.14		
		Planted Eucalypts	0.86	3.79	0.36	1.57	0.1		
T30		Open	18.36	80.75	21.23	93.4	0.15	Higher - Buffer originally interacted with a permanent creek and planted pine row.	Moderate - Relocated to avoid permanent creek. Intersection with pine tree row and planted eucalypts is an unavoidable outcome.
		Permanent creeks	3.56	15.65	0	0	0		
		Pine tree row	0.82	3.6	1.29	5.66	0.72		
		Planted Eucalypts	0	0	0.21	0.94	0.06		
T31		Open	21.63	95.16	20.65	90.83	0.14	Higher - Buffer footprint impacted on remnant native	Moderate - Moved to avoid remanent native woodland.

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Pine tree row	0	0	0.63	2.76	0.40	woodland and planted eucalyptus.	Remaining planted eucalypts and pine tree rows are unavoidable.
		Planted Eucalypts	0.94	4.13	1.46	6.41	0.43		
		Remnant native woodland	0.16	0.71	0	0	0		
T32		Open	21.49	94.52	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.25	5.48	NC	NC	0.37		
T33		Open	22.21	97.69	22.14	97.40	0.15	Lower	Lower
		Pine tree row	0.53	2.31	0.59	2.60	0.38		
T34		Open	21.57	94.9	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.16	5.1	NC	NC	0.34		
T35		Remnant native woodland	0.16	0.71	0	0	0	Higher - Overlapped with a section of remnant native woodland.	Lower - Was relocated to avoid remanent native woodland.
		Open	22.57	99.29	22.73	100	0.16		
T36	SBWB-definite: Very low. SBWB-complex: low	Open	20.95	92.16	NC	NC	0.14	Moderate	Moderate
		Planted Eucalypts	1.78	7.84	NC	NC	0.52		
T37		Open	22.46	98.78	NC	NC	0.15	Lower	Lower
		Pine tree row	0.001	0.005	NC	NC	0		
		Planted Eucalypts	0.28	1.21	NC	NC	0.08		
T38		Open	21.21	93.28	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.28	5.64	NC	NC	0.38		
		Remnant native woodland	0.24	1.07	NC	NC	0.32		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T39		Open	21.71	95.48	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.03	4.52	NC	NC	0.3		
T40		Open	22.66	99.7	22.73	100	0.16	Lower - Buffer zone had slight interaction with planted eucalypts.	Lower - Moved to avoid planted eucalypts,
		Planted Eucalypts	0.07	0.3	0	0	0		
T41	SBWB-definite: Very low. SBWB-complex: very low	Open	22.73	100	NC	NC	0.16	Lower	Lower
T42		Open	22.42	98.63	22.73	100	0.16	Higher - Had slight interaction with permanent creek in buffer footprint.	Lower - Location was amended to avoid permanent creek completely.
		Permanent creeks	0.31	1.37	0	0	0		
T43		Open	21.74	95.63	NC	NC	0.15	Moderate	Moderate
		Pine tree row	0.99	4.36	NC	NC	0.56		
T44	SBWB-complex: low	Open	22.4	98.54	22.73	100	0.16	Higher - Had marginal intersection with a permanent creek and pine tree row.	Lower - Relocated to avoid permanent creek and pine tree row.
		Permanent creeks	0.2	0.9	0	0	0		
T45		Open	21.16	93.1	22.72	99.93	0.16	Higher - Intersected with remnant native vegetation & planted eucalypts	Lower - Moved to avoid remnant native vegetation & planted eucalypts
		Planted eucalypts	1.11	4.88	0.01	0.07	0		
		Remnant native woodland	0.46	2.02	0	0	0		
T46		Open	21.74	95.62	21.67	95.33	0.15	Moderate	Moderate
		Planted Eucalypts	1	4.38	1.06	4.67	0.31		
T47		Open	21.77	95.78	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.96	4.22	NC	NC	0.28		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T48		Open	22.01	96.84	21.62	95.10	0.15	Moderate	Moderate
		Planted Eucalypts	0.72	3.16	1.11	4.90	0.33		
T49		Open	22.47	98.83	22.73	100	0.16	Lower - Impacted on planted eucalypts.	Lower - Position was changed to avoid planted eucalypts entirely.
		Planted Eucalypts	0.27	1.17	0	0	0		
T50		Open	21.82	95.98	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.91	4.02	NC	NC	0.27		
T51		Open	22.47	98.84	NC	NC	0.15	Lower	Lower
		Pine tree row	0.26	1.16	NC	NC	0.15		
T52		Open	22.73	100	NC	NC	0.16	Lower	Lower
T53		Open	22.07	97.09	22.25	97.89	0.15	Higher - Impacted on a segment of remnant native woodland and planted eucalypts.	Moderate - Been shifted to reduce impact to native remanent woodland. Planted eucalypts are still slightly impacted.
		Planted Eucalypts	0.04	0.17	0.04	0.17	0.01		
		Remnant native woodland	0.62	2.73	0.44	1.94	0.57		
T54		Open	21.92	96.44	22.73	100	0.16	Moderate - Footprint intersected with planted eucalypts.	Lower - Location has moved to avoid planted eucalypts entirely.
		Planted Eucalypts	0.81	4	0	0	0		
T55		Open	16.43	72.29	22.72	99.93	0.16	Higher - Footprint intersected with a mapped wetland and pine tree row.	Lower - Moved to avoid mapped wetland area and have reduced proximity to pine tree row.
		Pine tree row	0.08	0.37	0.02	0.07	0.01		
		Wetland	6.22	27.34	0	0	0		
T56		Open	21.34	93.85	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.4	6.15	NC	NC	0.41		
T57		Open	21.88	96.25	NC	NC	0.15	Moderate	Moderate
		Pine tree row	0.54	2.36	NC	NC	0.3		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Planted Eucalypts	0.32	1.39	NC	NC	0.09		
T58		Open	22.42	98.61	NC	NC	0.15	Lower	Lower
		Planted Eucalypts	0.32	1.39	NC	NC	0.09		
T59		Open	21.79	95.85	21.84	96.09	0.15	Higher - Minor impact on a section of remnant native woodland. Planted eucalypts were also impacted.	Moderate - Moved slightly to avoid remanent native woodland. The interference with planted eucalypts is unavoidable.
		Planted Eucalypts	0.92	4.04	0.89	3.91	0.26		
		Remnant native woodland	0.02	0.1	0	0	0		
T60		Open	22.73	100	NC	NC	0.16	Lower	Lower
T61		Farm dam	0.09	0.39	0.09	0.39	0.32	Higher – Interaction with mapped wetland, pine tree rows and planted eucalypts.	Moderate - Position amended to avoid the impact on the wetland, however interaction with pine tree rows and planted eucalypts is unavoidable.
		Open	21.28	93.63	21.83	96.04	0.15		
		Pine tree row	0.77	3.37	0.58	2.55	0.37		
		Planted Eucalypts	0.37	1.65	0.23	1.02	0.07		
		Wetland	0.22	0.96	0	0	0		
T62		Open	21.96	96.62	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.77	3.38	NC	NC	0.23		
T63		Open	22.73	100	NC	NC	0.16	Lower	Lower
T64		Open	22.61	99.44	22.68	99.76	0.16	Moderate - Minor interaction with a mapped remnant woodland area, as well as pine tree	Lower - Relocated to avoid native remanent native woodland and pine tree row.

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Pine tree row	0.07	0.32	0	0	0	row and planted eucalypts.	Impact on planted eucalypts was unavoidable. Move also improved general WTG spacing.
		Planted Eucalypts	0.05	0.23	0.05	0.24	0.02		
		Remnant native woodland	0	0.01	0	0	0		
T65		Open	17.96	79	22.73	100	0.16	Higher - Footprint impacted on a mapped wetland and planted eucalypts.	Lower - Moved and the resulting location lessens the impact on wetland but impacts a small area of remnant native woodland.
		Planted Eucalypts	0.78	3	0	0	0		
		Wetland	3.99	18	0	0	0		
T66		Open	22.63	99.57	22.73	100	0.16	Moderate - Small area of impact on a mapped wetland.	Lower - Relocated to avoid any impact on the mapped wetland.
		Wetland	0.1	0.44	0	0	0		
T67		Open	21.85	96.11	22.73	100	0.16	Higher - Footprint interfered with a mapped wetland.	Lower - Moved to avoid the wetland.
		Wetland	0.88	3.89	0	0	0		
T68	SBWB-definite: Very low. SBWB-complex: low	Open	22.36	98.37	NC	NC	0.15	Lower	Lower
		Pine tree row	0.14	0.63	NC	NC	0.08		
		Planted Eucalypts	0.23	1	NC	NC	0.07		
T69		Open	22.73	100	NC	NC	0.16	Lower	Lower
T70		Open	22.73	100	NC	NC	0.16	Lower	Lower
T71		Open	21.75	95.66	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.99	4.34	NC	NC	0.29		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T72		Open	22.22	97.75	22.19	97.59	0.15	Lower	Lower
		Planted Eucalypts	0.51	2.25	0.55	2.41	0.16		
T73		Open	22.26	97.91	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.47	2.09	NC	NC	0.2		
T75		Open	22.48	98.87	22.73	100	0.16	Moderate - Small interference with footprint of remnant native woodland.	Lower - Moved to avoid remanent native woodland.
		Remnant native woodland	0.26	1.13	0	0	0		
T76		Open	21.28	93.61	22.19	97.63	0.15	Moderate - Impacted on pine tree rows.	Lower - Location altered to reduce impact to pine tree rows.
		Pine tree row	1.45	6.39	0.54	2.37	0.3		
T77		Open	21.51	94.61	22.73	100	0.16	Lower - Footprint intersected with a mapped permanent creek.	Moderate - Moved to avoid the permanent creek entirely.
		Permanent creeks	1.22	5.39	0	0	0		
T78		Open	21.29	93.63	NC	NC	0.15	Moderate	Moderate
		Pine tree row	1	4.42	NC	NC	0.56		
		Planted Eucalypts	0.44	1.95	NC	NC	0.13		
T79		Open	15.87	69.82	21.86	96.16	0.15	Higher - Footprint impacted on a mapped wetland and pine tree row.	Moderate - Location was amended to avoid wetland area. The resulting impact to planted eucalypts row is unavoidable.
		Pine tree row	0.17	0.76	0	0	0		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Planted Eucalypts	0	0	0.87	3.84	0.26		
		Wetland	6.69	29.42	0	0	0		
T80		Open	22.73	100	NC	NC	0.16	Lower	Lower
T81		Open	22.73	100	NC	NC	0.16	Lower	Lower
T82		Open	21.73	95.57	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.01	4.43	NC	NC	0.3		
T83		Open	22.73	100	NC	NC	0.16	Lower	Lower
T84		Open	22.73	100	NC	NC	0.16	Lower	Lower
T86		Open	22.07	97.1	NC	NC	0.15	Lower	Lower
		Planted Eucalypts	0.66	2.9	NC	NC	0.19		
T87		Farm dam	0.12	0.51	NC	NC	0.41	Moderate	Moderate
		Open	22.52	99.05	NC	NC	0.16		
		Planted Eucalypts	0.1	0.44	NC	NC	0.03		
T88		Farm dam	0.05	0.22	NC	NC	0.18	Moderate	Moderate
		Open	22.16	97.49	NC	NC	0.15		
		Pine tree row	0.36	1.59	NC	NC	0.2		
		Planted Eucalypts	0.16	0.71	NC	NC	0.05		
T89		Open	22.73	100	NC	NC	0.16	Lower	Lower
T90		Open	21.93	96.49	NC	NC	0.15	Moderate	Moderate
		Pine tree row	0.8	3.51	NC	NC	0.45		
T91	SBWB-complex: low	Open	21.32	93.79	NC	NC	0.15	Higher - Interacted with a mapped wetland within its footprint.	Higher - unable to be moved due to landowner constraints, and

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Wetland	1.41	6.21	NC	NC	0.17		therefore the impact has not been avoided.
T92		Open	22.63	99.56	NC	NC	0.16	Lower	Lower
		Planted Eucalypts	0.1	0.44	NC	NC	0.03		
T93		Open	22.19	97.62	22.03	96.93	0.15	Lower	Moderate
		Pine tree row	0.54	2.38	0.70	3.07	0.45		
T94		Open	22.26	97.9	22.37	98.42	0.15	Lower - Interacted with planted eucalypts.	Lower - Moved slightly to overlap less with planted eucalypts
		Planted Eucalypts	0.48	2.1	0.36	1.58	0.11		
T95		Open	22.15	97.42	NC	NC	0.15	Lower	Lower
		Planted Eucalypts	0.59	2.57	NC	NC	0.17		
T96		Farm dam	0	0	0.15	0.67	0.54	Lower	Lower
		Open	22.2	97.67	22.07	97.07	0.15		
		Pine tree row	0.53	2.33	0.51	2.25	0.33		
T97		Open	22.73	100	NC	NC	0.16	Lower	Lower
T98		Farm dam	0.19	0.84	NC	NC	0.68	Moderate	Moderate
		Open	21.68	95.38	NC	NC	0.15		
		Planted Eucalypts	0.86	3.78	NC	NC	0.25		
T101		Open	21.83	96.01	21.38	94.06	0.15	Higher - Originally impacted upon remnant native woodland.	Moderate - Location was shifted to avoid native remnant woodland. The resulting impact to planted
		Planted Eucalypts	0	0	1.35	5.93	0.4		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
		Remnant native woodland	0.91	3.99	0	0	0		eucalypts is unavoidable.
T102		Open	22.73	100	NC	NC	0.16	Lower	Lower
T103		Open	22.71	99.88	22.73	100	0.16	Lower - Impacted on a portion of planted eucalypts.	Lower - There was a minor change to the location of T103 to avoid planted eucalypts. However, the primary reason for change allowed T105 to avoid interference with native remanent woodland.
		Planted Eucalypts	0.03	0	0	0	0		
T104		Open	21.53	94.72	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.2	5.28	NC	NC	0.35		
T105		Open	21.25	93.48	22.24	97.85	0.15	Higher - Impacts on mapped remnant native woodland.	Moderate - Relocated to reduce impact on remnant native woodland. Some impact on the woodland is unavoidable.
		Pine tree row	0.12	0.52	0.12	0.52	0.07		
		Remnant native woodland	1.36	6	0.37	1.63	0.48		
T106		Open	21.71	95.51	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	1.02	4.49	NC	NC	0.3		
T107		Open	21.87	96.22	NC	NC	0.15	Moderate	Moderate
		Pine tree row	0.5	2.21	NC	NC	0.28		
		Planted Eucalypts	0.36	1.57	NC	NC	0.1		

Turbine	SBWB call activity	Habitat type	Original		Updated		% of total habitat feature in Project Area	Impact	
			Old area within buffer (ha)	Percentage of turbine buffer	New Area (ha)	Percentage of turbine buffer		Original	Updated
T108	SBWB-definite: Very low. SBWB-complex: low	Open	21.49	94.52	NC	NC	0.15	Higher	Higher
		Planted Eucalypts	0.2	0.86	NC	NC	0.06		
		Remnant native woodland	1.05	4.62	NC	NC	1.36		
T109		Open	22.01	96.84	NC	NC	0.15	Moderate	Moderate
		Planted Eucalypts	0.72	3.16	NC	NC	0.21		
T110		Open	22.5	98.99	NC	NC	0.15	Lower	Lower
		Pine tree row	0.23	1.01	NC	NC	0.13		

Appendix 3: Summary of literature on mitigation measures for bat impacts of wind farms

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Acoustic deterrent	Weaver et al. (2020) Global Ecology and Conservation, 24, e01099	Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines	Trial at operational wind farm	Ultrasound	Deterrents mounted on the nacelles significantly reduced bat fatalities at a wind farm in US (Texas) for *Lasiurus cinereus* and *Tadarida brasiliensis* by 78% and 54%, respectively. We observed no significant reduction in fatalities for other species in the genus *Lasiurius*.
Acoustic deterrent	Sievert et al. (2021) Report by University of Massachusetts. Report for US Department of Energy. Report No. DE-EE0007032.	A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines	Trial outside wind farms	Ultrasound	Passively activated (blown by the wind) ultrasonic deterrent that is intended to be implemented on turbine blades. The developed deterrent produce ultrasound in the 25-35 kHz, 35-45 kHz, and 45-55 kHz ranges. Researchers played recordings of these sounds to bats in a laboratory setting, and showed that flight paths of Mexican free-tailed bats *Tadarida brasiliensis* were affected, but tricolored bats *Perimyotis subflavus* were not.
Acoustic deterrent	Good, R. E., Iskali, G., Lombardi, J., McDonald, T., Dubridge, K., Azeka, M., & Tredennick, A. (2022) The Journal of Wildlife Management, 86(6), e22244.	Curtailment and acoustic deterrents reduce bat mortality at wind farms	Trial at operational wind farm	Smart curtailment	Tested with curtailment combined with acoustic deterrent. Curtailment alone reduced bat mortality by 42.5%. Curtailment plus deterrent reduced mortality by 66.9% (species dependent, ranging from 58.1% in some species to 94.4% in others.
Acoustic deterrent	Arnett, E. B., Hein, C. D., Schirmacher, M. R., Huso, M. M., & Szewczak, J. M. (2013). PloS One, 8(6), e65794.	Evaluating the Effectiveness of an Ultrasonic Acoustic Deterrent for Reducing Bat Fatalities at Wind Turbines	Trial at operational wind farm	Ultrasound emission	Used waterproof box (~45x45 cm, 0.9 kg) that housed 16 transducers that emitted continuous broadband ultrasound from 20–100 kHz (manufactured by Deaton Engineering, Georgetown, Texas). 21–51% fewer bats were killed per treatment turbine than per control turbine.
Acoustic deterrent	Cooper, D., Green, T., Miller, M., & Rickards, E. (2020). Frontier Wind LLC, Rocklin, CA (United States).	Bat Impact Minimization Technology: An Improved Bat Deterrent for the Full Swept Rotor Area of Any Wind Turbine (No. DE-EE0007034; CEC-500-2020-008)	Trial at operational wind farm	Ultrasound emission	The Strike Free system developed for this project extended the ultrasonic coverage to the entire area swept by the turbine blades, not just the centre of the turbine. Did this by attaching transmitters onto the blades of the turbines. Saw approx. 73.5% less fatalities at turbines with treatment in contrast to control turbines.
Acoustic deterrent	Gilmour, L. R., Holderied, M. W., Pickering, S. P., & Jones, G. (2021). Journal of Experimental Biology, 224(20), jeb242715.	Acoustic deterrents influence foraging activity, flight and echolocation behaviour of free-flying bats	Trial not on wind farm	Ultrasound emission, thermal video	Used stereo thermal videogrammetry and acoustic methods. Filmed bats using two synchronised thermal imaging cameras (Optris PI640 thermal imaging camera). Deaton ultrasonic speakers, emitted ultrasound at a frequency range of 20–100 kHz. Overall bat activity was reduced by 30%.
Acoustic deterrent	Kinzie, K., Hale, A., Bennett, V., Romano, B., Skalski, J., Coppinger, K., & Miller, M. F. (2018). General Electric Co., Schenectady, NY (United States).	Ultrasonic Bat Deterrent Technology (No. DOE-GE-07035)	Trial at operational wind farm	Ultrasound emission, thermal video	Tried different setup but found no statistically significant benefit compared to previously existing systems. Up to 60% bat activity reduction.

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Acoustic deterrent	NRG Systems (2021)	Exploring How Attenuation Affects NRG Systems' Bat Deterrent System	Trial at operational wind farm	Ultrasound emission	Investigates attenuation of ultrasound, study showed a 6db loss of sound volume for every doubling of radius. Also showed ultrasound devices performed better with lower humidity and temperature.
Acoustic deterrent	Romano, W. B., Skalski, J. R., Townsend, R. L., Kinzie, K. W., Coppinger, K. D., & Miller, M. F. (2019). Wildlife Society Bulletin, 43(4), 608-618.	Evaluation of an Acoustic Deterrent to Reduce Bat Mortalities at an Illinois Wind Farm	Trial at operational wind farm	Ultrasound emission	29.2% - 32.5% reduction in bat mortality, air jet ultrasonic emitters mounted on turbine nacelles. The deterrent system jets (nozzles) produced a broad-band sound designed to overlap the entire range of frequencies (~30–100 kHz) generated by and audible to most bat species
Acoustic deterrent	Zeng, Z., & Sharma, A. (2023). arXiv preprint arXiv:2302.08037.	Novel ultrasonic bat deterrents based on aerodynamic whistles	Lab	Ultrasound emission	Explores single to six whistle acoustic design outputting 20 Hz - 50 kHz frequency range.
Radar and acoustic deterrent	Gilmour et al. (2020) Plos One, 15(2), e0228668.	Comparing acoustic and radar deterrence methods as mitigation measures to reduce human-bat impacts and conservation conflicts	Trial outside wind farms	Radar and ultrasound	Ultrasonic speakers were effective as bat deterrents at foraging sites, but radar was not. In riparian sites (border of England and Wales), ultrasonic deterrents decreased overall bat activity (filmed on infrared cameras) by ~80% when deployed alone and in combination with radar. Species responded differently to the ultrasound treatments.
Visual and acoustic deterrent	Werber et al. (2023) Remote Sensing in Ecology and Conservation, 9(3), 404-419.	Drone-mounted audio-visual deterrence of bats: implications for reducing aerial wildlife mortality by wind turbines	Trial outside wind farms	Drone	A drone with auditory and visual signals decreases bat activity. Activity decreases significantly (~40%) below and significantly above (~50%) the drone flight altitude at Northern Israel. LIDAR was used to assess the drone impact below its flight altitude and RADAR to assess impact above its flight altitude.
Visual and acoustic deterrent	Kuhlmann, K., Fontaine, A., Brisson-Curadeau, É., Bird, D. M., & Elliott, K. H. (2022). Methods in Ecology and Evolution, 13(4), 842-851.	Miniaturization eliminates detectable impacts of drones on bat activity	Trial at operational wind farm	Drone	Found that smaller UAV models had negligible impact on bat activity, suggest that when employing drones as a deterrent, the size of the drone should be taken into consideration.
Visual deterrent	Cryan et al. (2022) Animals, 12(1), 9.	Influencing activity of bats by dimly lighting wind turbine surfaces with ultraviolet light	Trial at operational wind farm	Ultraviolet light	No significant change in nighttime bat, insect, or bird activity at wind turbines when lit with UV light compared with that of unlit nights (US, Colorado).
Visual deterrent	Gorresen, P. M., Cryan, P. M., Dalton, D. C., Wolf, S., Johnson, J. A., Todd, C. M., & Bonaccorso, F. J. (2015). Endangered Species Research, 28(3), 249-257.	Dim ultraviolet light as a means of deterring activity by the Hawaiian hoary bat *Lasiurus cinereus semotus*	Trial not on wind farm	Ultraviolet light	44% reduction in bat detections in treatments with dim, flickering UV light compared to control, despite increased insect biomass with UV treatment. Duty cycle of flickering was 0.1-5sec, peak wavelength 365nm, spectral spread 10nm, power density of 1 microwatt cm^-2 over circular area of 20m. Hawaii.

Mitigation method	Citation	Title	Study type	Method investigated	Brief summary
Curtailment	Bennett et al. (2022) Austral Ecology, 47(6), 1329-1339.	Curtailment as a successful method for reducing bat mortality at a southern Australian wind farm	Trial at operational wind farm	Low wind-speed curtailment	Increasing turbine cut-in speed from 3.0 to 4.5 ms-1 from dawn to dusk at a southern Australian wind farm significantly reduced bat fatalities by 54%.
Curtailment	Anderson et al. (2022) Facets, 7, 1281-1297.	Effects of turbine height and cut-in speed on bat and swallow fatalities at wind energy facilities	Correlational at operational wind farms	Low wind-speed curtailment	Raising cut-in speeds result in fewer bat fatalities in Canada (Ontario). Turbines under nocturnal mitigation killed 33% fewer bats than turbines without cut-in adjustments in late summer.
Curtailment	Adams et al. (2021) PloS ONE, 16(11), e0256382.	A review of the effectiveness of operational curtailment for reducing bat fatalities at terrestrial wind farms in North America	Trials at operational wind farms	Low wind-speed curtailment	Meta-analysis of experimental studies (n = 36 control-treatment studies from 17 wind farms in US) 63% decrease in fatalities. A non-linear model shows that fatality rates decreased when the difference in curtailment cut-in speeds was 2m/s or larger.
Curtailment	Martin et al. (2017) Journal of Mammalogy, 98(2), 378-385.	Reducing bat fatalities at wind facilities while improving the economic efficiency of operational mitigation	Trial at operational wind farm	Low wind-speed and high T curtailment	Raising cut-in speed of turbines (from 4 to 6 m/s) reduced bat fatalities by 62% (CI 34–78%) at a US wind farm (Vermont). Cut-in speed at 6.0 m/s was always done at T > 9.5°C, unlike cut-in at 4 m/s (wind speed only).
Curtailment	Baerwald et al. (2009) Journal of Wildlife Management, 73(7), 1077-1081.	A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities	Trial at operational wind farm	Low wind-speed curtailment and turbine modifications	Increasing turbine cut-in speed from 4.0 to 5.5 m/s resulted in a significant 60% reduction in bat fatalities. Comparing turbines with cut-in speed at 4.0 m/s against turbines with modified angles to reduce rotor speed (blades near motionless in low-wind speeds), resulted in a significant reduction in bat fatalities by 57.5%. Study conducted at a wind farm in Canada (Alberta).
Curtailment	Rnjak et al. (2023) Mammalia, 87(3), 259-270.	Reducing bat mortality at wind farms using site-specific mitigation measures: a case study in the Mediterranean region, Croatia	Trial at operational wind farm	Low wind-speed curtailment	Wind turbine curtailment was implemented in the high collision risk period at a wind farm in Croatia. Estimated total number of bat fatalities decreased by 78% when implementing curtailment from sunset to sunrise at variable turbine cut-in speeds (5.0 - 6.5 m/s).

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Curtailment	Whitby, M. D., Schirmacher, M. R., & Frick, W. F. (2021). Bat Conservation International, Austin, Texas.	The State of the Science on Operational Minimization to Reduce Bat Fatality at Wind Energy Facilities. A report submitted to the National Renewable Energy Laboratory.	Trial across multiple wind farms.	Low wind-speed curtailment	33-79% fatality reduction estimate based on 5m/s increase in cut in speed (extrapolated). 0.06-3.2% annual energy production loss.
Curtailment	Rabie, P. A., Welch-Acosta, B., Nasman, K., Schumacher, S., Schueller, S., & Gruver, J. (2022). PloS ONE, 17(4), e0266500.	Efficacy and cost of acoustic-informed and wind speed-only turbine curtailment to reduce bat fatalities at a wind energy facility in Wisconsin	Trial at operational wind farm	Low wind-speed curtailment	Used Turbine Integrated Mortality Reduction (TMIR) system reduced bat fatalities by 75-84%, compared to wind-speed only curtailment (WOC) (47%). Using software and acoustic detection of bats in real time.
Curtailment	Arnett, E. B., Schirmacher, M., Huso, M. M., & Hayes, J. P. (2009). Bat Conservation International. Austin, Texas, USA.	Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities. An annual report submitted to the Bats and Wind Energy Cooperative	Trial at operational wind farm	Low wind-speed curtailment	Tested curtailment at low wind speeds. Found now difference between cut-in speeds of 5m/s vs 6.5m/s. Fully operation turbines had ~5.2 times as many fatalities as curtailed ones. Pennsylvania, USA.
Curtailment	Arnett, E. B., Huso, M. M., Schirmacher, M. R., & Hayes, J. P. (2011). Frontiers in Ecology and the Environment, 9(4), 209-214.	Altering turbine speed reduces bat mortality at wind-energy facilities	Trial at operational wind farm	Low wind-speed curtailment	Bat mortality 5.4 and 3.6 times that of 2008 & 2009 compared to turbines employing low wind speed curtailment in this study, with less than a 1% loss of power generation annually. Pennsylvania, USA.
Curtailment	Maclaurin, G., Hein, C., Williams, T., Roberts, O., Lantz, E., Buster, G., & Lopez, A. (2022). Wind Energy, 25(9), 1514-1529.	National-scale impacts on wind energy production under curtailment scenarios to reduce bat fatalities	Trial at operational wind farm	Low wind-speed curtailment	Focusses more on implications for annual energy production rather than mitigating bat fatalities. Compares smart curtailment against blanket curtailment, under low, medium and high levels of curtailment. USA.
Curtailment	Măntoiu, D. Ş., Kravchenko, K., Lehnert, L. S., Vlaschenko, A., Moldovan, O. T., Mirea, I. C., & Voigt, C. C. (2020). European Journal of Wildlife Research, 66(3), 1-13.	Wildlife and infrastructure: impact of wind turbines on bats in the Black Sea coast region	Trial at operational wind farm	Low wind-speed curtailment	Found that WT in Romania in migration corridor killed approx. 30 bats/WT/year, curtailment reduced fatality rates by 78%. Used hydrogen stable isotope rations to est. Origin of some bats, came from as far away as Ukraine, Belarus & Russia. Test involved raising cut-in speeds from 4m/s to 6.5m/s, applied during high-risk migration periods.

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Curtailment	Smallwood, K. S., & Bell, D. A. (2020). The Journal of Wildlife Management, 84(4), 685-696.	Effects of Wind Turbine Curtailment on Bird and Bat Fatalities	Trial at operational wind farm	Shut down curtailment	Found that curtailment helped reduce bat fatalities significantly but had substantially less effect on reducing bird fatalities. Found that bats were twice as likely to pass through the rotors of operating turbines compared to inoperable ones, suggesting again that some species may be attracted to operating rotors. Findings also suggest that designing turbines without accessible interior spaces could reduce fatalities of cavity-nesting and cavity-roosting birds.
Curtailment	Squires, K. A., Thurber, B. G., Zimmerling, J. R., & Francis, C. M. (2021). Animals, 11(12), 3503.	Timing and Weather Offer Alternative Mitigation Strategies for Lowering Bat Mortality at Wind Energy Facilities in Ontario	Data from operational wind farms	Multiple weather variables for curtailment	Rain and low temperatures saw reduced bat activity and fatalities. Wind conditions, moon illumination, and rain to primarily influence migration flights, while temperature, humidity, air pressure, and rain to influence foraging. Mortality and activity were lower when it rained, highest with above-average temperatures, and declined with wind speed.
Curtailment	Hayes, M. A., Hooton, L. A., Gilland, K. L., Grandgent, C., Smith, R. L., Lindsay, S. R., & Goodrich-Mahoney, J. (2019). Ecological Applications, 29(4), e01881.	A smart curtailment approach for reducing bat fatalities and curtailment time at wind energy facilities	Trial at operational wind farm	Smart curtailment	A new system of tools for analysing bat activity and wind speed data to make near real-time curtailment decisions when bats are detected treatment turbines (N=10) vs. control turbines (N=10) at a US wind farm (Wisconsin). Overall reductions in bat fatalities (~74% to 91% per species). ~3.2% loss in power output, 48% reduction in downtime compared to other USA windfarms using standard curtailment.
Curtailment (Smart)	Matzner, S., Warfel, T., & Hull, R. (2020). Ecological Informatics, 57, 101069.	ThermalTracker-3D: A thermal stereo vision system for quantifying bird and bat activity at offshore wind energy sites	Trial with drone	Smart curtailment	Thermal tracking to predict flight paths of flying animals. Software was able to estimate drone within +-20m of actual position against GPS for 90% of data points.
Curtailment (Smart)	Barré, K., Froidevaux, J. S., Sotillo, A., Roemer, C., & Kerbiriou, C. (2023). Science of the Total Environment, 866, 161404.	Drivers of bat activity at wind turbines advocate for mitigating bat exposure using multicriteria algorithm-based curtailment	Trial at operational wind farm	Smart curtailment	Investigated algorithm controlled curtailment compared to traditional blanket curtailment. Reduces fatal collisions by 7-31% compared to blanket curtailment.
Curtailment (Smart)	Hayes, M. A., Lindsay, S. R., Solick, D. I., & Newman, C. M. (2023). Wildlife Society Bulletin, 47(1), e1399.	Simulating the influences of bat curtailment on power production at wind energy facilities	Trial at operational wind farm	Low wind-speed curtailment and smart curtailment	Focusses more on implications for annual energy production, comparing blanket curtailment to smart curtailment, rather than any impacts on mortality. Energy losses ranged between 0.2 and 1.7% for blanket curtailment, vs 0.0 to 0.9% for smart curtailment. Canada.
Thermal video detection	Georgiev, M., & Zehtindjiev, P. (2022) Wind Europe.	Real-Time Bird Detection and Collision Risk Control in Wind Farms	Trial at operational wind farm	Thermal imaging	Used thermal imaging to detect birds. Testing detection rates of birds, 83.1 to 91.8% correct detection rates. Detection ranges: 60cm wingspan at 350m, 100cm at 600m, 150cm at 1050m.Detection rates of bats looks <10%.