Prepared for 4Sight Consultants on behalf of LET

Preliminary assessment of effects on long-tailed bats and their habitats at the proposed Waiuku Wind Farm

Bluewattle Ecology

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Prepared by: Gerry Kessels

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Front cover photo: Long-tailed bat in flight – Department of Conservation

EXECUTIVE SUMMARY

4Sight Consulting, on behalf of LET Capital Number 3 Limited Partnership (LET), commissioned Bluewattle Ecology to carry out a desktop assessment of the potential effects on long-tailed bats (Chalinolobus tuberculatus) of a proposed wind farm on the west coast of the North Island, north of Port Waikato. The assessment is to form part of an application for referral under the COVID fast-tracking process. The brief is to:

- review the acoustic bat monitoring (ABM) data supplied by 4 Sight;
- provide advice on potential effects on bats of the presence of the proposed Waiuku Wind Farm;
- provide advice on required further assessment required to refine the level of effect; and
- provide options to avoid, remedy, mitigate, offset or compensate the effect based on review of literature and similar projects already consented.

The following conclusions regarding a preliminary assessment of the potential effects of the proposed Waiuku Wind Farm on long-tailed bats are as follows:

- Long-tailed bats are present within and around the proposed Waiuku Wind Farm Site, and activity levels suggest commuting and foraging habitat within the Site. High activity levels were recorded along the north edge of the Waiuku pine forest, indicating a roost site, likely to be just outside of the Site;
- The direct effects of construction of the wind farm are likely to be low provided intrusions are minimised during the construction phase, and if best practice pre-felling tree protocols are adopted during construction;
- A review of national and international literature indicates that long-tailed bats may be at moderate to high risk of turbine strike associated with the operational wind farm. Application of the EcIA guidelines indicate a Very High 'un-mitigated' level of effects associated with strike risk. However, there are a number of avoidance, remediation and mitigation measures which can be employed to reduce strike risk; and
- Scientifically robust and site-specific monitoring and research is required to verify the efficacy of the proposed amelioration measures to minimise strike risk. If the combined benefits of the amelioration measures are proven to be effective then the level of effect would likely be Moderate; but residual effect management, including pre- and post- monitoring, combined with an adaptive management regime, may still be required.

1 INTRODUCTION

1.1 SCOPE

4Sight Consulting, on behalf of LET Number 3 Limited Partnership (LET) commissioned Bluewattle Ecology, to carry out a desktop assessment of the risk to long-tailed bats (*Chalinolobus tuberculatus*) of a proposed wind farm on the west coast of the North Island, north of the Waikato River. The assessment is to form part of an application under the COVID fast-tracking process consistent with the Environmental Protection Agency (EPA) Consent Application process. The scope of this assessment is to estimate the effects on long-tailed bats, which are confirmed to be present at the site by a recent bioacoustic survey by 4Sight ecologists.

The brief is to:

- review the acoustic bat monitoring (ABM) data supplied;
- provide advice on potential effects on bats of the presence of the proposed Waiuku Wind Farm;
- provide advice on required further assessment to refine the level of effect; and
- provide options to avoid, remedy, mitigate, offset or compensate the effect based on review of literature and similar projects already consented.

Importantly, this assessment relies solely upon information on the data from the 4Sight bioacoustic survey and that data gathered by a desktop study. No other field investigations were carried out to support this analysis. For this reason, it should be recognised that this assessment is preliminary and provisional.

1.2 BACKGROUND

LET is proposing to build the Waiuku Wind Farm in an area approximately seven kilometres north of Port Waikato, approximately nine kilometres south of Waiuku and adjacent to the Waiuku Forest. The project would cover approximately 500 hectares of land and would utilize the coastal environment and moving inland.

The majority of the Site's landscape is rural, characterized by large areas of open land with grass. There are a number of features that are typically associated with a working rural environment, such as fencing, shelterbelts, farm tracks, and rural buildings like woolsheds and dwellings. There are two dune lakes located on the property, as well as various farm drains. The Waiuku pine forest bounds the southern flank of the proposed wind farm site (hereafter known as 'the Site').

Because of a recorded decline in distribution of known bat populations and susceptibility to predation, long-tailed bats - one of New Zealand's only two extant terrestrial indigenous mammals - are afforded the highest threat status by the Department of Conservation (DOC) of Threatened – Nationally Critical.

1.3 HABITAT UTILISATION BY LONG-TAILED BATS IN PASTORAL LANDSCAPES

Once common throughout New Zealand, long-tailed bats numbers have declined markedly over the last 100 years (O'Donnell 2000). Although widespread throughout the North Island, there is little detailed information on current trends or population sizes. However, it is likely that North Island's populations of long-tailed bats are continuing to decline as a result of a combination of pressures such as competition and predation from invasive species (Pryde et al. 2005).

The survey data indicates that the Site provides commuting and foraging for long-tailed bats including shelter belts, plantation and native forest and shrub lands. A roost site appears to be present adjacent to the site and the site could provide roosting habitat. Long-tailed bats are edge adapted, with their wing morphology and echolocation calls adapted for foraging along edges and gaps (O'Donnell 2001). Although the Site is predominantly pasture, long-tailed bats are known to be active over open pasture, but are edge adapted so more likely to be utilising liner features along forest, woodlot and shelterbelt edges than open pastures. This habitat usage is consolidated by a network of exotic and indigenous remnant forest and wetlands, dune lakes, artificial pond, and mature shelterbelts scattered through the environment of Waiuku. These lines of shelterbelts and patchily distributed stands of mature trees enable bats to move around this landscape as they use these features as navigational features to guide them to and from key roosting and foraging habitats (Davidson-Watts 2019).

Long-tailed bats have been found to use a range of native and exotic tree species for roosting and have not been found to discriminate between tree species or forest types (O'Donnell and Sedgeley 1999, Sedgeley and O'Donnell 1999, Borkin and Parsons 2010). Individual bats normally have a number of trees in which they may roost on any given day and are not restricted to a single roost tree. They will also regularly change favoured roost trees. Throughout the year long-tailed bats enter daily torpor while in their day roosts, utilise 'communal' roosts for social interaction and breeding, and may also go into torpor over the cold winter months (June to August inclusive).

Long-tailed bats feed nocturnally on flying insects, particularly flies and moths. Bats feed over open areas, along waterways and bush edges. They tend to use linear landscape features such as gullies, bush edges or tracks to transit between feeding and roosting sites. They prefer to hunt in more open areas since their ability to manoeuvre in dense bush is limited. Thus, long-tailed bats foraging occurs:

(a) along forest edges (exotic and native);

(b) over pasture (predominantly along the edges of forests and shelterbelts) and low density regenerating shrub habitats;

(c) above wetlands; and

(d) over open water and along roads and clearings (Borkin and Parsons 2009, Griffiths 1996).

1.4 QUALIFICATIONS OF THE AUTHOR

The author of this report has been involved in the study and assessment of wind farm projects, as well as long-tailed bats over the last 25 years. He is an experienced and qualified ecologist and independent hearing commissioner. He has undertaken ecological assessments of wind farms since 1998, including Tararua Wind Farm, Te Uku, Hauāuru Mā Raki (HMR), Puketoi, Mt Cass, Poutoa, Kaimai and review of several others, such as the Castle Hill Wind Farm consent application. In 2011, Mr Kessels presented the findings of his research on assessing and predicting avian bird strike risk in New Zealand to the first Wildlife and Wind Farm Conference in Norway on behalf of the NZ Ecological Society. Mr Kessels is currently acting as an independent peer reviewer of the avian monitoring programme on the Waipipi (Waverly) Wind Farm and assisting Main Power with the development of avian monitoring plans for their consented Mt Cass Wind Farm.

The author is a certified with 'Bat Competency' by DOC as being suitably qualified to undertake and analyse data for bioacoustic surveys (using acoustic bat monitors (ABM)), identify long-tailed bat roosts and capture and handle long-tailed bats. He has project managed, peer reviewed, and been involved in numerous bat surveys throughout the North Island since 2004.

1.5 REPORT STRUCTURE

This report is structured as follows:

- **Methodology**: an overview of the methodology for the assessment;
- **Review of bioacoustics survey**: a summary of the 4Sight bioacoustic survey data and the conclusions drawn from it;
- **Literature review**: a summary of the results of a comprehensive international and national literature review regarding the effects of wind farms on bats;
- **Preliminary effects assessment**: an overview of the potential effects of the proposed wind farm on long-tailed bats, including construction effects and strike risk;
- **Recommendations**: recommendations for further assessment and investigation of methods to avoid, remedy and mitigate effects; and
- **Conclusions**.

2 METHODOLOGY

2.1 REVIEW OF 4SIGHT BAT SURVEY

4Sight ecologists undertook a bioacoustic survey using Department of Conservation designed and constructed type 'AR4' automated bat detectors (ABMs), at locations shown in Figure A-1 (Appendix I) between the 12th of December 2022 and the 11th January 2023 inclusive. Bluewattle Ecology has had no input into the survey design or its implementation.

The raw data from the 4sight bioacoustic survey was independently analysed by qualified bat ecologists on the Bluewattle Team. ABMs record any sound that may be a bat call or echolocation. When the ABM is triggered by a potential bat pass it records one file for each pass. The recordings are prepared in a form of a compressed image of a spectrogram, and are saved onto an SD card in the form of bitmap format images. The images were manually viewed using DOC developed "BatSearch 3.12" software. The frequency spectrum assessed ranges from 0 Hz to 88 kHz and images represent 1-6 seconds of recording. Where possible, differentiation between commuting, foraging or social calls were also determined.

2.2 SITE VISIT

The Site was visited by the author on 2 February 2023. The objective of the site visit was to obtain a better understanding of the present and potential habitats in the locality, as well as how the Site sits within the landscape relating to how bat may utilise or cross over it (see Sections 3 and 4).

2.3 LITERATURE AND DATABASE REVIEW

The presence of bats in the wider landscape surrounding the Site was determined by accessing the National Bat Database administered by the Department of Conservation (DOC) and the I-Naturalist NZ[1] database on 15 February 2023. In addition, internal databases and reports on long-tailed bats held by Bluewattle Ecology were reviewed.

There are no publicly available peer-reviewed scientific studies on the adverse effects of wind farm development on long-tailed bats. Accordingly, a number of international, bat research studies have been relied on to shape our understanding of bat populations and habitat use as it pertains to how long-tailed bats utilise potential habitat within the Site. Internationally, small insectivorous bat species (such as long-tailed bats), are considered one of the more challenging terrestrial mammal groups to study due to their small size, nocturnal behaviour, complex behavioural traits and high mobility (e.g. Jung and Threlfall 2016).

An extensive literature review from mainly overseas research on similar aerial insect feeding bat species has helped assess the potential effects on long-tailed bat populations from wind farms. This review can also help inform best practice guidelines to setup appropriate protocols for monitoring potential effects and to minimise the negative effects wind farms might have on bats during the detailed assessment and effects management phases.

2.4 REVIEW OF RELEVANT NZ WIND FARM CONSENTS

There is only one know operational wind farm that has consent conditions relating to long-tailed bats – Te Uku Wind Farm. However, conditions were developed for the consented, but not constructed, HMR wind farm proposal between Port Waikato and Raglan in 2010. The conditions pertaining to the HMR proposal were also reviewed to assist in the development of suitable performance strand and monitoring conditions.

2.5 ECOLOGICAL IMPACT ASSESSMENT GUIDELINES (ECIAG)

An assessment of ecological effects was undertaken in accordance with the Ecological Impact Assessment Guidelines (EcIA) (Roper-Lindsay et al. 2018). These best practice guidelines are widely used by New Zealand ecologists to provide a systematic, consistent, and transparent framework for undertaking assessment of ecological effects, while also providing for professional judgement and flexibility where appropriate. The guidelines have been used to determine:

Step 1: A preliminary 'Ecological value' of identified bat habitat in the Site;

Step 2: A preliminary 'Magnitude of Effect' of the construction and operation of the wind farm on bats and their habitats; and

Step 3: Determination of overall preliminary 'Level of Effect' after recommended efforts to avoid, remedy or mitigate for effects have been applied. An overall 'Level of Effect' (after efforts to avoid, remedy or mitigate for effects) is identified for effects on bats and their habitats using a matrix

[1] https://www.inaturalist.org/observations (accessed 19 February 2023).

approach. This approach combines the ecological values with the magnitude of effects resulting from the activity (see Appendix II).

Step 4: The matrix describes an overall 'Level of Effect' after efforts to avoid, remedy or mitigate effects on a scale from 'Very Low' to 'Very High'. This 'Level of Effect' is then used to guide the extent and nature of measures to demonstrably offset and/or compensate for any remaining residual effects.

3 REVIEW OF 4SIGHT BIOACOUSTIC SURVEY

3.1 REVIEW OF ABM DATA

Bioacoustic data provided by 4Sight has been analysed for its validity and accuracy to determine whether bats are present in the area and in what capacity. Monitoring with a total of ten ABMs for a duration of 31 nights resulted in 5239 recorded bat passes, where two ABMs failed completely (ABM17 and ABM25) and one partially (ABM10). The location of the ABMs in relation to the proposed wind farm Site and significant natural areas and potential wetland and lake habitats is shown in Figure 1. Weather data has not been reviewed to check if adverse weather conditions during the survey event (such as rain or wind) affected detection efficacy.

382 feeding buzzes were detected at six sites over the total survey period indicating a high level of feeding activity. (ABM16 and ABM9 had the highest levels of feeding activity during the survey period, with 242 and 104 feeding buzzes, respectively). The high level of feeding buzzes indicates suitable foraging habitat in close proximity to the monitors.

There were also social calls recorded at ABM16. These calls are commonly recorded in areas close to colonial roosts or swarming sites and suggest that bats were roosting in close proximity to this detector at the time of the survey. Table 1 and Figure 1 summarise the data into these behavioural call distinctions for each ABM survey site.

Table 1. Summary of recorded bat activity at the Waiuku Windfarm Site.

Monitor	Total	Feeding Buzzes	Social Calls
ABM2	5	0	0
ABM6	394	15	0
ABM9	724	104	0
ABM10	60	1	0
ABM11	179	7	0
ABM13	83	1	0
ABM14	335	12	0
ABM16	3459	242	5
ABM17	Malfunction		
ABM25	Malfunction		

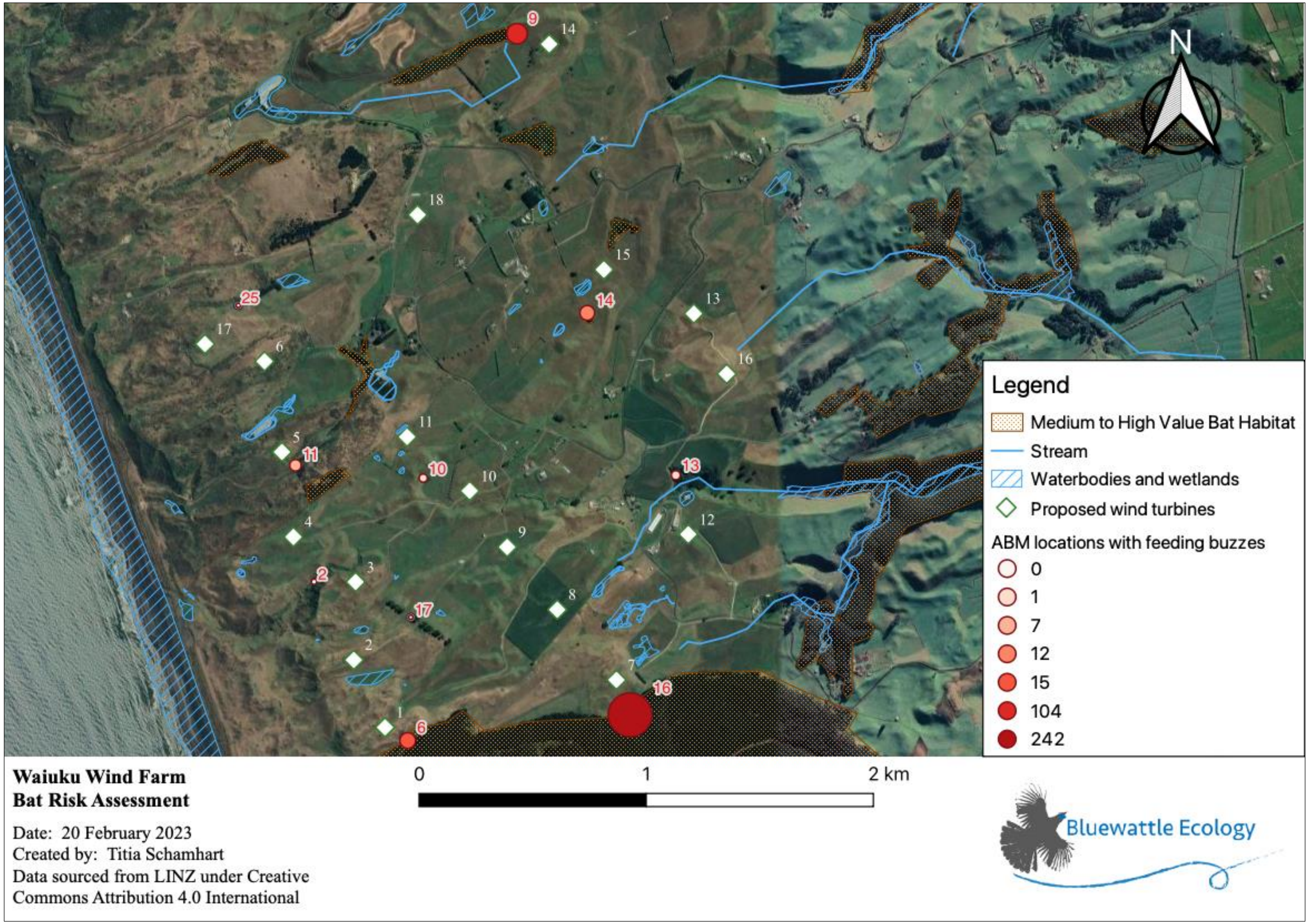

Figure 1. The proposed WWF site with turbine and ABM locations (supplied by 4Sight). The size of the ABM symbols reflects the total recorded bat passes varying between 5 passes at ABM2 and 3459 at ABM16. The deeper red the colour, the more feeding buzzes were recorded.

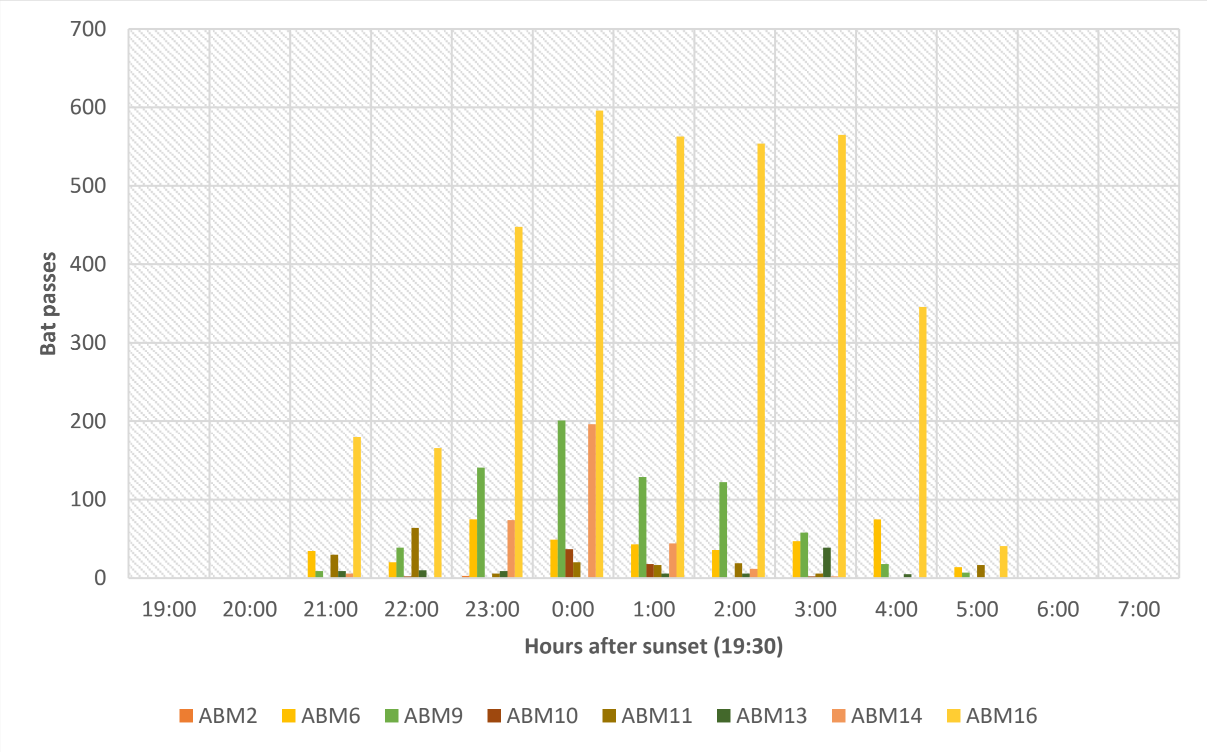

Figure 2. Total bat passes per hour after sunset, per monitor

4 LITERATURE AND DATABASE REVIEW

4.1 EXISTING DISTRIBUTION OF LONG-TAILED BATS IN THE LOCALITY

The Department of Conservation bat database was accessed (10/02/2023) for review of records of long-tailed and northern lesser short-tailed bats. Records from this part of the North Island are limited for short-tailed bats (*Mystacina tuberculata*), the closest documented population was 80 km away, and the vegetation on the Site would not support the needs of this species in any case. No further assessment was carried out on this species.

The nearest recorded known population of long-tailed bats is in the Hunua Ranges Regional Park, 40 km from the proposed wind farm. There are a number of other records of bats in the locality, with the closest passes recorded 4 km from both the south (Waiuku Forest), east and north (Manukau Lowlands) side of the Site. The Site is potentially part of the home range of these bats. The 4Sight bioacoustic survey has highest number of recorded bat passes within a 40 km range when compared to existing datasets (see section 3), suggesting this Site may be primary roosting and foraging habitat for a population of bats likely distinct to that found in the Hunua Ranges.

4.2 LITERATURE

No publicly accessible studies have investigated the impacts of wind farms on the spatial use of either of New Zealand's native bat species. Therefore, it is not clear what kind of behaviour either native species exhibit toward wind turbines. However, overseas research on similar insectivorous -bats can assist in determining possible effects on long-tailed bats from wind farms. International research show that wind farms can affect non-migratory, insectivorous bats in the following ways:

- Direct collision mortality or injury, barotrauma and other injuries;
- Loss and/or fragmentation of roosting, commuting and foraging habitat, (wind farms may form barriers to commuting or seasonal movements, and can result in severance of foraging habitat); and
- Displacement of individuals or populations (due to wind farm construction or because bats avoid the wind farm area) (Gaultier et al. 2023).

4.2.1 EFFECTS OF WINDFARMS ON MONOPHYLETIC INSECTIVOROUS BATS

Wind-turbine driven fatalities of monophyletic insectivorous bats (such as long-tailed bats) have been recorded in many regions of the world including Australia, Canada, USA, the UK and Europe (Baerwald *et al.,* 2009; de Lucas *et al.,* 2012; Rydell *et al.,* 2010). From 2000 onwards, 35% of all measured global multiple bat mortality events were due to collisions with wind turbines (O'Shea et al. 2016).

These fatalities are caused by the bats either being struck by turning blades or through barotrauma[2] as they fly through the rotor swept area (Baerwald et al. 2008, Rollins et al. 2012). Since bat species have low reproduction rates outside the tropics (Barclay et al. 2004), the potential losses caused by wind turbines must be considered as a mortality factor relevant to the population of a species at a landscape level.

Wind speed is consistently reported as a significant factor related to bat mortality at wind farms. Lower speeds (<6 m/s) are frequently associated with higher bat activity and subsequent fatalities (Arnett and Baerwald 2013, Cryan et al. 2014, Hein and Schirmacher 2016).

The counting of impact victims at wind turbines is still the only method to determine quantitative data on the mortality of bats at wind turbines. Searches for strike victims are methodologically complex if they are to provide meaningful data and, even in the best case of a daily search, only allow conclusions to be drawn about the collision risk during the entire previous night (Niermann et al. 2015).

International literature remains unclear on exactly how many individual bats may be injured around the wind turbine rotors and are still able to actively remove themselves from a potential search area for strike victim counts and possibly die later. This could cause an underestimation of the number of strike victims and the mortality rates that can be derived from them (see also the expert opinions evaluated by Voigt et al. 2020).

In a review of European research on the effects of wind farms on bats, Gaultier et al (2020), found that bats also face the loss, displacement or fragmentation of habitat that can occur during the construction of a wind farm. This did not only include the construction of the turbines, but also the access roads, pads, power lines, and temporary or permanent buildings. Forest clearing or hedgerow/shelterbelt destruction can affect the roosting, commuting, and foraging of several species; it can decrease the attractiveness of certain habitats, preventing individuals from reaching previously connected areas or lengthening the distances needed to reach these areas. The bat species extensively using woodland for commuting and foraging, such as *Myotis spp*., are the most impacted by habitat fragmentation and

[2] Barotrauma: internal haemorrhaging of the lungs resulting from rapid decompression in the vortices behind the moving blade tips

destruction, in opposition to open-space foragers species, such as *Pipistrellus nathusii*, which are less dependent on landscape features for their daily movement and feeding (Gaultier et al 2020).

4.2.2 FLIGHT HEIGHTS & STRIKE RISK

No published research that primarily investigate flight altitude in New Zealand bats in relation to wind farms have been conducted to date, but there is considerable overseas research on effects associated with wind farms on similar insectivorous bat species.

However, a New Zealand study that investigated spatial and temporal variation in long-tailed bat echolocation activity showed bats flying at heights between 4 m and 30 m (Le Roux et al. 2014). According to this study, it appears that the majority of long-tailed bats living in rural habitats do not fly at the altitude which would make them at risk to collision with most wind turbine rotors (depending on the turbine specification, but in the proposed Waiuku Wind Farm case it is understood the blade tips will be no lower than 30 m from the ground). In a 2017 thermal imaging study (Borkin 2017) found that 88% of 'confirmed bats' and 77% of 'probable bats' were typically commuting and foraging at the top of, or above, the tree canopy cover along the Waikato River bank in southern Hamilton. However, variations in behaviour have been observed in different habitats and different locations; for example long-tailed bats behaviour in urbanised areas of Hamilton City (Dumbleton and Montemezzani 2020, Aughton 2021, Caskey and Tempero 2022, G Kessels *pers obs*), indicates that long-tailed bats may adjust their flight heights according to the environment they are present in and adjust variations in flight height to tree canopy height.

A study on the potential impact of wind development sites on multiple bat species in the north-eastern USA, demonstrated that the majority of observed bats flew at approximately tree canopy height (Reynolds 2006). In this study, microphones were placed at ground-level, in the upper- canopy zone and at turbine level height. It was shown that 49% of bat passes occurred at ground level, 34% in the canopy zone and 17% of bat passes were recorded at turbine level height.

However, previous studies in Germany on impacts of wind facilities on bats, such as the non-migratory, insectivorous common pipistrelle (*Pipistrellus pipistrellus*, Brinkmann et al. 2006), indicate frequent flying altitudes near wind turbine blades, perhaps being attracted to insect aggregation. In this context, bats were shown to fly at altitudes of above 40 m and at wind speeds of up to 10.9 m/s. Similarly, a study on the effectiveness of acoustic bat deterrents at wind farms in the US (Horn et al. 2007) investigated bat activity near the wind turbine rotor swept zone, which extended from 38 m to 120 m above ground. It was demonstrated that most bats (60%) flew below 38 m, however, 34.5% of all observed bats flew between 38 m and 120 m, and 5.5 % flew above 120 m height. The medium-sized insectivorous Brazilian free-tailed bats (*Tadarida brasiliensis*) in Zimbabwe has been shown to perform foraging flights accompanied by feeding echolocation calls at altitudes that ranged from 0 m to 500 m altitude (Fenton and Griffin 1997). These previous studies indicate a markedly variability in flight altitude of bat species. Correspondingly, it has been proposed that bats may be altering the altitudes of their nightly flights in dependence of weather conditions and cloud cover (Dürr and Bach 2004).

4.2.3 CURTAILMENT

A practice sometimes used at operational wind farms overseas is to curtail turbine operation at low wind speeds, typically below 6 m/s, during periods of high bat activity. This generally occurs from summer to autumn (Arnett et al. 2008, 2011, 2016, Arnett and Baerwald 2013, Hein and Schirmacher

2016, Behr et al. 2017, Martin et al. 2017, Thompson et al. 2017, Hayes et al. 2019, Rodhouse et al. 2019, Adams et al. 2021, Whitby et al. 2021).

A study conducted at a wind farm in southern Australia found that increasing the turbine cut-in speed from 3.0 to 4.5 m/s significantly reduced bat fatalities by 54%. Curtailment was given as the primary reason for the reduction in mortality, as there was no significant difference in bat call activity between study years, but rather a non-significant increase during curtailment. The four-month curtailment trial resulted in an annual loss of 0.16% of generation in megawatt-hours and a reduction of 0.09% in revenue at Cape Nelson North, which is similar to values reported in other studies reporting on the costs of the implementation of curtailment (Baerwald et al. 2009a, Arnett et al. 2011, Martin et al. 2017, Hayes et al. 2019).

The effectiveness of curtailment technology to reduce strike risk by bats has not yet been tested in New Zealand, but its efficacy could be trialled using operational wind farms where long tailed bats are present.

4.2.4 DETERRENCE

The effectiveness of ultrasonic deterrence technology to reduce strike risk by bats has not yet been tested in New Zealand. For several years, deterrence has been discussed and more recently trialled, as a method to reduce bat strikes at wind turbines overseas.

Its efficacy could be trialled in NZ using current technology developed by NRG Systems[3]. The deterrent system emits an ultrasonic acoustic field at frequencies that are similar to those used by bats for communication. This disrupts their ability to receive and interpret their own echolocation calls, making it difficult to navigate their surroundings. By jamming their echolocation systems, bats are discouraged from entering the treated areas. According to a 2020 study by Weaver et al. installing deterrents significantly reduced bat fatalities for *Lasiurus cinereus* and *Tadarida brasiliensis* by 78% and 54% respectively. However, the researchers found that there was no significant reduction in fatalities for other species in the genus *Lasiurius,* showing that deterrents may help reduce the impact of some bat species, but further research is needed to determine how effective they are for specific target species at any particular wind farm site.

Other literature suggests that previous deterrence attempts using ultrasonic interference signals were either only successful in some species, or they showed intra- and interspecific success rates that fluctuated greatly over time (Romano et al. 2019). All studies published up to now have also been carried out on American bats. In addition, the only low reduction rates so far (often only in the range of 30% per species and year; Romano et al. 2019) are not sufficient to reliably avoid killing bats at wind turbines. According to the current state of knowledge, this method is therefore currently not a proven means of reducing bat strikes at wind turbines (see also Schirmacher 2020).

Theoretically, bats could also be deterred by radar radiation. So far, however, this idea has not been implemented in wind turbines, either with stationary or mobile systems (Arnett and Baerwald 2013). In addition, it is suspected that the deterring effect of the radar beams is based on the fact that they

[3] https://illumination.duke-energy.com/articles/new-technology-helps-protect-bats-from-wind-turbines

cause stress and hyperthermia in the animals (Nicholls and Racey 2007). However, this method of deterrence would have to be viewed as critical in terms of species protection *a priori*.

4.3 NEW ZEALAND WIND FARM CONSENTS RELATING TO BATS

There is only one known operational wind farm in New Zealand that that has consent conditions relating to long-tailed bats – Te Uku Wind Farm.

There have been studies on the effects of bats on other wind farms, such as Hauāuru Mā Raki, Kaimai and Kaiwaikawe. The ecological reports, expert evidence, and proposed or consented conditions of these proposed wind farms have also been reviewed as part of this assessment where available.

4.3.1 TE UKU WINDFARM

An ecological assessment of the Te Uku site during the pre-consenting and pre-construction phase found the presence of long-tailed bats on or near the wind farm site (Kessels & Associates, 2007). The Te Uku wind farm is the first in New Zealand to have post-construction monitoring targeting both avifauna and bats.

The Waikato District Council resource consent (252/06) sets out the conditions for the construction and operation of the Te Uku wind farm. The avifauna and bat monitoring that takes place after construction responds to condition 6.1(b), which required "*Strike monitoring programmes for long-tailed bats, New Zealand falcon, and other indigenous birds*."

The consent conditions required that records be kept and documented of turbine strikes, and that an assessment be made of the effects of the construction and operation of the wind farm on long-tailed bat populations. The strike monitoring program lasted for three years from the date the wind farm became operational. The consent also required ongoing population monitoring of long-tailed bats for the first three years after the wind farm became operational. Population monitoring was to be conducted by way of presence and absence monitoring. Despite conducting mark-recapture monitoring during the pre-consenting monitoring of the wind farm, the practice was discontinued due to the low number of bats caught.

The consent condition 6.7 required that the post-construction monitoring be reported on a quarterly basis, in order to summarise the results of the previous months' monitoring, any specific outcomes of the monitoring, and the proposed monitoring for the following three-month period. Data and reporting form this wind farm is not publicly available. However, the 2014 Post-construction Avifauna & Bat Monitoring report is available and has been reviewed as part of this preliminary assessment (see section 5.3).

5 PRELIMINARY EFFECTS ASSESSMENT

5.1 SUMMARY OF POTENTIAL EFFECTS

The potential direct and indirect effects of the Waiuku Wind Farm on bats and their habitats can be divided into two categories:

- Effects during construction (section 5.2); and
- Effects during operation (section 5.3).

Section 5.2 provides a preliminary effects assessment associated with the construction of the wind farm, such as removal of, or damage to, roosting, foraging and commuting habitats, which can be addressed by good design and best practice during construction in order to avoid, remedy or mitigate significant adverse effects.

The operational wind farm's primary potential adverse effects are associated with collision risk with the turbines and displacement of bats from potential habitat. Thess effects are less well understood and more difficult to address, as scientific research on how long-tailed bats interact with operational wind farms is sparse.

Potential adverse effects in accordance with the effects matrix approach detailed in the EcIAG (refer to Appendix II for a summary of the methodology), and feasible avoidance, remediation, mitigation, offset/compensation solutions for long-tailed bats, are summarised in Table 2. Table 2 provides three columns that assess the scale of potential effects:

- The column titled "Magnitude of potential effects on baseline conditions" provides an assessment of the magnitude of the potential effect of the activity, without considering the significance of the biodiversity values being assessed – in other words, it assesses the "raw" effect.
- The column titled "Level of Effect (before avoidance, remediation, mitigation, or offset/compensation measures applied)" provides an assessment of the magnitude of potential effects, taking into account the significance of the biodiversity values being considered. For very high ecological values, the level of effect will be higher; whereas for low ecological values, the level of effect will be lower. The assessment in Table 2 has conservatively applied Very High ecological values to the long-tailed bat and its habitat.
- The column titled "Level of Effect (after avoidance, remediation, mitigation, or offset/compensation measures applied)" provides an assessment of the potential effects, taking into account the impact of the identified measures to avoid, remedy, mitigate, or offset/compensate effects.

The following sections provide more detail on the scale of these potential effects, while section 6 presents a summary of avoidance, remediation mitigation and offsetting/compensation measures which could be applied to ameliorate these adverse effects.

5.2 DIRECT EFFECTS ASSOCIATED WITH CONSTRUCTION OF THE WIND FARM

International research (see section 4.2.1 above) and New Zealand studies in southern Hamilton associated with assessing the effects of urbanisation (Mueller et al, 2021) indicate that habitat removal during construction of the wind farm infrastructure may cause significant adverse effects, not just by loss of habitat but also fragmentation and displacement effects, if not addressed by a range of suitable avoidance, remediation and mitigation measures.

Further bioacoustic surveys will be required to accurately determine the location and extent of habitat usage within the Site to gauge the exact extent of these effects. However, the footprint and locations of the turbine platforms, access roads and other associated infrastructure are likely to be a relatively small size and lower quality when assessed at a the wider landscape context. Similar pastoral/treeland/forest habitats are abundant in this locality, suggesting that these potential effects will likely be a Low overall adverse effect, assuming suitable design and construction methodologies are adopted.

However, removal of any temporary or communal roost could result in significant adverse effects on bats in the locality by removing possibly limited roosting trees and/or causing mortality/injury of bats as the trees are chopped down. Long-tailed bats are cavity roosting bats. Roost trees are both in large trees within indigenous vegetation and in non-native trees such as pine, macrocarpa, elm, wattle, popular, and eucalypt (Daniel 1981, O'Donnell and Sedgeley 1999, Pryde et al. 2005, Griffiths 2007). Any standing dead or mature tree with a diameter of >15 cm diameter at breast height may contain suitable roost cavities for long-tailed bats. Felling occupied roost trees can result in mortality of long tail bats. Fatalities are most likely during the winter torpor period (May-September) when roosting bats are likely to be unresponsive.

The simplest way to determine roost usage is to survey for potential or occupied roosting trees within the Site and design infrastructure to avoid requiring removal of these trees. Mitigation, in the form of recreating suitable roost trees is an alternative approach. There are DOC developed best practice guidelines to survey for and undertake pre-felling surveys of potential roost trees to minimise the risk of mortality or injury and these guidelines are widely used through New Zealand.

In addition, as discussed below, the proximity of a turbine to a known roost tree, or within the commuting or foraging habits of bats can create turbine collision risk, so the design of the wind farm needs to consider collision risk, in addition to removal of habitat during the detailed design of the wind farm layout based on an understanding of bat habitat usage within and adjacent to the Site.

5.3 TURBINE BLADE STRIKE RISK EFFECTS

There are no peer-reviewed, published research on the effects of collision risk on long-tailed bats. However, the one study of the effects of an operational wind farm on bats in New Zealand suggest the effect of collision risk is low. The Te Uku Wind Farm has been built near a known population of bats, and was found to be utilised as foraging and commuting habitat (Kessels, 2007). This 28-turbine wind farm was commissioned in March 2011. Post-construction monitoring of avifauna and bats was carried out for three years (Bull & Cummings, 2014). This wind farm, while being positioned on open farmland, is in immediate proximity to Pirongia Forest, a large area of mature indigenous forest with a known bat population.

At the completion of the three years of post-construction monitoring, statistical analysis was applied to the pre- and post-construction data. The analysis focused on bat activity not population size, so care is needed interpreting the results so not to confuse detection rates with actual population size.

The report concludes that: "*Statistical comparisons between pre and post construction indicate the construction and operation of the turbines is not having a significant impact on the movements of long-tailed bats in the area*." While encouraging, caution should be applied when using this data to this Site, as bat pass detection rates were notably lower at Te Uku than that found by 4Sight at Waiuku, with mean passes per night at Te Uku ranging from 0 to 2.5 per night, while in the case of Waiuku some of the ABMs ranged over 10 passes per night up to, in one case, over 100 passes per night (see Table 1).

Based on the review of international studies it is considered possible that long-tailed bats may suffer mortality as a result of interactions with the turbines (see section 4.2 above). Non-migratory bat species most at risk are fast-flying, open-air foragers that are generally less manoeuvrable (Arnett et al. 2008). Risk generally reduces as bats become smaller, fly slower, forage in increasing clutter, and are more manoeuvrable. Long-tailed bats are non-migratory, edge/gap-foraging, aerial hawking bats with moderate manoeuvrability (O'Donnell 2001, Parsons 2001). These behavioural characteristics suggest that (as a general proposition) they have a moderate risk of direct impact with turbine blades, or via barotrauma (Baerwald et al. 2008).

However, several behaviours exhibited by long-tailed bats may increase the risk level of turbine mortality:

- Tree roosting: This is a common feature of bat species suffering from turbine strike. It is theorised that bats are investigating turbines as potential roost trees (Kunz et al. 2007).
- Aerial hawking: some species of Insectivorous -bats have been found to forage higher than 35 m above the ground, potentially within the rotor sweep zone (Kunz et al. 2007).
- Wide ranging: Long-tailed bats cover distances exceeding 10 km while foraging. Therefore, even if the roost tree is far from the turbines they are at risk while foraging.
- Preferential foraging along forest edges and linear corridors: Anthropogenically formed vegetation edges are preferred foraging areas for long-tailed bats. The habitat associated with the proposed wind farm contains a number of these areas.

Given this research, it is considered possible that bats are at risk of wind turbine strike at the proposed Waiuku Wind Farm.

The level of risk and quantification of strike injury or mortality is not able to be determined at this point in time. However as shown in Table 2, it is considered that on the balance of review of New Zealand and overseas research, and given the high detection rates at some of the sites at Waiuku, without mitigation strike risk could result in a Very High Level of effects (by application of EcIA guidelines). A number of measures will likely be required to minimise this potential adverse effect as outlined in section 6. If these measures were shown to be successful and an adaptive management regime, supported by ongoing monitoring, adopted to account for uncertainties in the initial research, the overall level of effect following suitable avoidance, remedy and mitigation measures may be Moderate.

Table 2. Preliminary Effects Matrix and suggested mitigation for long-tailed bats (using EcIAG effects matrix guidelines – see Appendix II).

Potential Adverse Effect (assuming the site has a preliminary 'Very High' Biodiversity Value as bat habitat – refer to Tables 1 & 2 in Appendix II)	**Magnitude of potential effects on baseline conditions[4] - See Tables 4 & 5 Appendix II**	**Level of Effect (before avoidance, remediation, mitigation, or offset/compensation measures applied)**	**Possible avoidance, remediation, mitigation, or offset/compensation measures**	**Level of Effect (after avoidance, remediation, mitigation, or offset/compensation measures applied -**
Direct habitat removal: Within a landscape context level, only a relatively small amount of potential foraging and commuting habitat would be removed. This excludes predominantly pasture habitats, further than 25m from Very High value habitats, which itself is considered to be of Low habitat value. While the loss of potential roost trees is an issue, protocols can be followed to avoid the removal of actual occupied roost trees.	Negligible	Low.	a) Avoid removing or dissecting high quality bat habitats, such as potential roost sites, foraging areas or commuting routes. b) Restoration of suitable vegetation to create alternative roosting, foraging or commuting habitats. c) Implement best-practice tree felling protocols, for any removal of potential roost trees.	**Likely Negligible**
Habitat displacement and fragmentation through bats avoiding the site because of disturbance form the wind farm operation.	Low	Moderate	Enhance habitat for local population through habitat restoration and targeted animal pest control	**Likely Low**
Potential injury or mortality of bats from turbine strike, including direct effects and 'ecological sink' effects). Overseas data shows a high risk on similar species. However, limited monitoring of long-tailed bats at Te Uku and species-specific flight height data suggests effects may be low. However, as the effects may be ongoing and given the threat status of long tailed bats, a precautionary approach should be undertaken until further species-specific evidence is available.	High	Very High	a) Turbines relocated to a yet to be specified distance from known roost sites. b) Instigate curtailment regimes at peak nightly activity periods and/or peak breeding periods. c) Install deterrent technology on turbines to deter bats from entering rotor sweep areas. d) Over time, recreate and protect high quality roosting, foraging and commuting habitat in the home range of this population of bats to attract individuals to higher quality habitats away from the wind farm site.	**Unknown at this point in time**. Appropriate and site-specific monitoring and research is required to verify the efficacy of the proposed amelioration measures. If the proposed combined benefits of the amelioration measurers are proven to be effective then the level of effect would likely be **Moderate requiring residual effect management, including pre and post monitoring /adaptive management regime and additional offsets or compensation as required.**

[4] Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (EIANZ, 2018).

6 RECOMMENDATIONS

6.1 APPROACH

To ensure that bats are protected by minimising the risk of collision, an assessment of impact at a site requires a detailed appraisal of:

- The level of bat activity recorded at the site assessed both spatially and temporally.
- The risk of turbine-related mortality for long-tailed bats recorded at the site during bat activity surveys (this includes determination of flight paths, nearby roost sites, and flight heights).
- The effect on long-tailed bats population status if predicted impacts are not mitigated.

The above information should be interpreted in the wide landscape context of habitat availability to determine the likely impacts on local populations. Relevant factors that should be considered include whether populations are at the edge of their range, cumulative effects, presence of protected areas designated for their bat interest and proximity to maternity roosts, key foraging areas or key flight routes, including possible migration routes.

It is recommended that at the detailed assessment phase, LET develop and implement a Bat Management Response Plan (BMRP) that allows the rigorous assessment of risk to bats in the wind farm area, responds appropriately to any negative interactions associated with the construction and operation of the wind farm, and enhances the habitat within which bats forage and reproduce outside of the wind farm Site, but within the home range of this population of bats

The BMRP should be informed by further assessment of the risks to bats in the wind farm area and should provide for:

1) Further evaluation of levels of bat activity prior to construction, including activity at proposed turbine sites, particularly for any turbines near the Waiuku Forest edge;
2) Assessment of levels of bat activity, flight heights and collision risk at turbines (including pre-construction studies and monitoring of mortality at turbines post-commissioning);
3) Determination of the size of the bat population in the vicinity of the Site;
4) Implementation of measures to avoid, remedy or mitigate adverse effects on bats, including carefully considering turbine location, assessing the effectiveness of, and implementing appropriate measures, such as adopting effective curtailment or deterrence technologies, and providing alternative commuting, foraging and roosting habitat away from the Site; and
5) Assesses if enhancement of bat habitat through revegetation and predator control of known habitats outside of the Site, is required for any residual adverse effects.

6.2 MONITORING

The detailed assessment of the Waiuku Wind Farm project should include further bioacoustic monitoring (along with weather and windspeed information), methods to estimate population size (for example, mark and recapture studies) and potentially thermal imaging and visual surveys.

Should the wind farm be built, and become operational, further monitoring would likely be required, such as post-construction bioacoustic monitoring, carcass searches (ideally using dogs), and survey techniques, such as thermal imaging monitoring, to study how bats interact with the turbines.

7 CONCLUSION

The following conclusions regarding a preliminary assessment of the potential effects of the proposed Waiuku Wind Farm on long-tailed bats are as follows:

- Long-tailed bats are present within and around the proposed Waiuku Wind Farm Site, and activity levels suggest commuting and foraging habitat within the Site. High activity levels were recorded along the north edge of the Waiuku pine forest, indicating a roost site, likely to be just outside of the Site;

- The direct effects of construction of the wind farm are likely to be low provided intrusions are minimised during the construction phase, and if best practice pre-felling tree protocols are adopted during construction;

- A review of national and international literature indicates that long-tailed bats may be at moderate to high risk of turbine strike associated with the operational wind farm. Application of the EcIA guidelines indicate the potential for Very High 'un-mitigated' level of effects associated with strike risk; and

- Scientifically robust and site-specific monitoring and research is required to verify the efficacy of the proposed amelioration measures to minimise strike risk. If the combined benefits of the amelioration measures are proven to be effective then the level of effect would likely be Moderate; but residual effect management, including pre- and post- monitoring, combined with an adaptive management regime, may still be required.

8 REFERENCES & BIBLIOGRAPHY

Adams, E. M., J. Gulka, and K. A. Williams. 2021. A review of the effectiveness of operational curtailment for reducing bat fatalities at terrestrial wind farms in North America. PLoS One 16:e0256382.

Appel, G., P. Bobrowiec, and A. Lopez-Baucells. 2019. Temperature, rainfall, and moonlight intensity effects on activity of tropical insectivorous bats .pdf:1–12.

Arnett, E. B., and E. F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. Bat evolution, ecology, and conservation:435–456.

Arnett, E. B., E. F. Baerwald, F. Mathews, L. Rodrigues, A. Rodríguez-Durán, J. Rydell, R. Villegas-Patraca, and C. C. Voigt. 2016. Impacts of wind energy development on bats: a global perspective. Bats in the Anthropocene: conservation of bats in a changing world:295–323.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, and R. R. Koford. 2008. Patterns of bat fatalities at wind energy facilities in North America. The Journal of Wildlife Management 72:61–78.

Arnett, E. B., M. M. Huso, M. R. Schirmacher, and J. P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9:209–214.

Aughton, H. 2021. Hamilton City Wide Bat Survey. Page 15. Project Echo, Hamilton, New Zealand.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current biology 18:R695–R696.

Baerwald, E. F., J. Edworthy, M. Holder, and R. M. Barclay. 2009a. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. The Journal of Wildlife Management 73:1077–1081.

Baerwald, E. F., J. Edworthy, M. Holder, and R. M. R. Barclay. 2009b. A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. Journal of Wildlife Management 73:1077–1081.

Barclay, R. M., J. Ulmer, C. J. MacKenzie, M. S. Thompson, L. Olson, J. McCool, E. Cropley, and G. Poll. 2004. Variation in the reproductive rate of bats. Canadian Journal of Zoology 82:688–693.

Behr, O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, I. Niermann, M. Reich, R. Simon, N. Weber, and M. Nagy. 2017. Mitigating bat mortality with turbine-specific curtailment algorithms: A model based approach. Pages 135–160 Wind Energy and Wildlife Interactions: Presentations from the CWW2015 Conference. Springer.

Borkin, K. 2010. Ecology of New Zealand's Long-tailed bat (Chalinolobus tuberculatus) in exotic plantation forest. Unpublished PhD thesis, University of Auckland.

Borkin, K. 2017. Thermal image of long-tailed bats at Riverlea, Hamilton: Wildland Consultants Ltd. Page 12. A report prepared for Aecom NZ Ltd.

Borkin, K., and S. Parsons. 2009. Long-tailed bats' use of a Pinus radiata stand in Kinleith Forest: Recommendations for monitoring. New Zealand Journal of Forestry 53:38–43.

Borkin, K., and S. Parsons. 2010. The importance of exotic plantation forest for the New Zealand long-tailed bat (Chalinolobus tuberculatus). New Zealand Journal of Zoology 37:35–51.

Brinkmann, R., Schauer-Weisshahn, H., & Bontadina, F. (2006). Survey of possible operational impacts on bats by wind facilities in Southern Germany. Prepared for the Administrative District of Freiburg – Department 56: Conservation
and Landscape Management. Ecological Consultancy Dr. Robert Brinkmann, Gundelfingen, Germany

Bull, L. & Cummings, G. .2014. Project Te Uku Post-construction Avifauna & Bat Monitoring. Year 3 Annual report. Boffa Miskell Ltd , prepared for Meridian Energy Ltd

Caskey, L., and G. Tempero. 2022. Hamilton City Long-tailed Bat Survey: Annual monitoring report, 2022. Page 19. ERI Report, Repoert prepared for Go Echo. Environmental research Institute. Division of Health, Engineering, Computing and Science, University of Waikato, Hamilton, New Zealand.

Cryan, P. M., P. M. Gorresen, C. D. Hein, M. R. Schirmacher, R. H. Diehl, M. M. Huso, D. T. S. Hayman, P. D. Fricker, F. J. Bonaccorso, and D. H. Johnson. 2014. Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences 111:15126–15131.

Daniel, M. J. 1981. First record of a colony of long-tailed bats [Chalinolobus tuberculatus] in a Pinus radiata forest. New Zealand Journal of Forestry.

Daniel, M. J., and G. R. Williams. 1984. A survey of the distribution, seasonal activity and roost sites of New Zealand bats. New Zealand journal of ecology:9–25.

Davidson-Watts, I. 2019. Long-tailed bat trapping and radio tracking. baseline report 2018 and 2019 Southern Links, Report prepared for AECOM by Davidson-Watts Ecology (Pacific) Ltd., Hamilton.

Dumbleton, H., and W. Montemezzani. 2020. Hamilton city long-tailed bat survey. Page 35. Prepared for Project Echo by 4sight consulting.

Dürr, T., and L. Bach. 2004. Bat deaths and wind turbines–a review of current knowledge, and of the information available in the database for Germany. Bremer Beiträge für Naturkunde und Naturschutz 7:253–264.

Fenton, M., & Griffin, D. (1997). High-altitude pursuit of insects by echolocating bats. Journal of Mammalogy, 78(1), 247- 250

Gaultier, S. P.; Blomberg, S.; IjÃs, A; Vasko, V; Vesterinen, E.J.; Brommer, J.E. and Lilley, T.M. 2020. Bats and Wind Farms: The Role and Importance of the Baltic Sea Countries in the European Context of Power Transition and Biodiversity Conservation. Environmental Science & Technology Vol. 54. 10385-10498

Gaultier, S. P., T. M. Lilley, E. J. Vesterinen, and J. E. Brommer. 2023. The presence of wind turbines repels bats in boreal forests. Landscape and Urban Planning 231:104636.

Griffiths, R. W. 2007. Activity patterns of long tailed bats Chalinolobus tuberculatus in a rural landscape South Canterbury New Zealand. New Zealand Journal of Zoology 34:247–258.

Hayes, M. A., L. A. Hooton, K. L. Gilland, C. Grandgent, R. L. Smith, S. R. Lindsay, J. D. Collins, S. M. Schumacher, P. A. Rabie, and J. C. Gruver. 2019. A smart curtailment approach for reducing bat fatalities and curtailment time at wind energy facilities. Ecological Applications 29:e01881.

Hein, C. D., and M. R. Schirmacher. 2016. Impact of wind energy on bats: a summary of our current knowledge. Human–Wildlife Interactions 10:4.

Homan, H. J., G. Linz, and B. D. Peer. 2001. Dogs increase recovery of passerine carcasses in dense vegetation. Wildlife Society Bulletin:292–296.

Horn, J., Arnett, E., Jensen, M., & Kunz, T. 2007 . Testing the effectiveness of an experimental acoustic bat deterrent at the Maple Ridge wind farm. Prepared for the Bats and Wind Energy Cooperative and Bat Conservation International, Austin, USA. Center for Ecology and Conservation Biology, Boston University, Boston, USA.

Horn, J. W., Arnett, E. B., Jensen, M., and T. H. Kunz. 2008a. Testing the effectiveness of an experimental acoustic bat deterrent at the Maple Ridge wind farm. Report Prepared for: The Bats and Wind Energy Cooperative and Bat Conservation International, Austin, TX.

Jung, K., and C. G. Threlfall. 2016. Urbanisation and its effects on bats—a global meta-analysis. Bats in the Anthropocene: conservation of bats in a changing world:13–33.

Kessels, G. 2007. WEL Wind park Te hauhiko O Wharauroa: Ecological Assessment, Wharauroa Plateau, Te Uku. Kessels & Associates, Hamilton.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. The Journal of Wildlife Management 71:2449–2486.

Le Roux, D. S., N. N. Le Roux, and J. R. Waas. 2014. Spatial and temporal variation in long-tailed bat echolocation activity in a New Zealand city. New Zealand journal of zoology 41:21–31.

de Lucas, M., M. Ferrer, M. J. Bechard, and A. R. Muñoz. 2012. Griffon vulture mortality at wind farms in southern Spain: Distribution of fatalities and active mitigation measures. Biological Conservation 147:184–189.

Martin, C. M., E. B. Arnett, R. D. Stevens, and M. C. Wallace. 2017. Reducing bat fatalities at wind facilities while improving the economic efficiency of operational mitigation. Journal of Mammalogy 98:378–385.

Mathews, F., M. Swindells, R. Goodhead, T. A. August, P. Hardman, D. M. Linton, and D. J. Hosken. 2013. Effectiveness of search dogs compared with human observers in locating bat carcasses at wind-turbine sites: a blinded randomized trial. Wildlife Society Bulletin 37:34–40.

Maseyk, F., G. Ussher. G Kessels, M. Christensen, M Brown (nee Doole). 2018. Local government guidance for Biodiversity Offsetting under the Resource Management Act. Prepared for the Biodiversity Working Group on behalf of the BioManagers Group

Mueller, H., I. Davidson-Watts, and G. Kessels. 2021. Peacocke Structure Plan Area Change – Long-tailed bat report. 4Sightingh consulting for Hamilton City Council, New Zealand

Nicholls, B., and P. A. Racey. 2007. Bats avoid radar installations: could electromagnetic fields deter bats from colliding with wind turbines? Plos One 2:e297.

Niermann, I., F. Korner-Nievergelt, R. Brinkmann, and O. Behr. 2015. Searching for collision victims as a basis for checking the effectiveness of switch-off algorithms. In Reducing the risk of bat collisions at onshore wind turbines (RENEBAT II). Pages 165–204. Hanover.

O'Donnell, C. 2000. Conservation status and causes of decline of the threatened New Zealand Long-tailed Bat Chalinolobus tuberculatus (Chiroptera: Vespertilionidae). Mammal Review 30:89–106.

O'Donnell, C. 2001. Home range and use of space by Chalinolobus tuberculatus, a temperate rainforest bat from New Zealand. Journal of Zoology 253:253–264.

O'Donnell, C., M. Pryde, P. van Dam-Bates, and G. P. Elliot. 2017. . Controlling invasive predators enhances the long-term survival of endangered New Zealand long-tailed bats (Chalinolobus tuberculatus): implications for conservation of bats on oceanic islands. Biological Conservation 214:156–167.

O'Donnell, C., and J. Sedgeley. 2012. DOC best practice manual of conservation techniques for bats v1.0:172.

O'Donnell, C., and J. A. Sedgeley. 1999. Use of Roosts by the Long-Tailed Bat, Chalinolobus tuberculatus, in Temperate Rainforest in New Zealand. Journal of Mammalogy 80:913–923.

O'Shea, T. J., P. M. Cryan, D. T. Hayman, R. K. Plowright, and D. G. Streicker. 2016. Multiple mortality events in bats: a global review. Mammal Review 46:175–190.

Parsons, S. 2001. Identification of New Zealand bats (Chalinolobus tuberculatus and </i>Mystacina tuberculata<i>) in flight from analysis of echolocation calls by artificial neural networks. Journal of Zoology 253:447–456.

Paula, J., M. C. Leal, M. J. Silva, R. Mascarenhas, H. Costa, and M. Mascarenhas. 2011. Dogs as a tool to improve bird-strike mortality estimates at wind farms. Journal for Nature Conservation 19:202–208.

Pryde, M. A., C. F. J. O'Donnell, and R. J. Barker. 2005. Factors influencing survival and long-term population viability of New Zealand long-tailed bats (Chalinolobus tuberculatus): Implications for conservation. Biological Conservation 126:175–185.

Reynolds, D. (2006). Monitoring the potential impact of a wind development site on bats in the Northeast. The Journal of Wildlife Management, 70(5), 1219-1227.

Rodhouse, T. J., R. M. Rodriguez, K. M. Banner, P. C. Ormsbee, J. Barnett, and K. M. Irvine. 2019. Evidence of region-wide bat population decline from long-term monitoring and Bayesian occupancy models with empirically informed priors. Ecology and evolution 9:11078–11088.

Rollins, K. E., D. K. Meyerholz, G. D. Johnson, A. P. Capparella, and S. S. Loew. 2012. A forensic investigation into the etiology of bat mortality at a wind farm: barotrauma or traumatic injury? Veterinary pathology 49:362–371.

Romano, W. B., J. R. Skalski, R. L. Townsend, K. W. Kinzie, K. D. Coppinger, and M. F. Miller. 2019. Evaluation of an acoustic deterrent to reduce bat mortalities at an Illinois wind farm. Wildlife Society Bulletin 43:608–618.

Roper-Lindsay, J., S. A. Fuller, S. Hooson, M. D. Sanders, and G. T. Ussher. 2018. Ecological impact assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. Second edition.

Rydell, J., L. Bach, M.-J. Dubourg-Savage, M. Green, L. Rodrigues, and A. Hedenström. 2010. Bat Mortality at Wind Turbines in Northwestern Europe. Acta Chiropterologica 12:261–274.

Schirmacher, M. R. 2020. Evaluating the effectiveness of an ultrasonic acoustic deterrent in reducing bat fatalities at wind energy facilities. Bat Conservation International, Austin, TX (United States).

Sedgeley, J. A., and C. F. J. O'Donnell. 1999. Roost selection by the long-tailed bat, Chalinolobus tuberculatus, in temperate New Zealand rainforest and its implications for the conservation of bats in managed forests. Biological Conservation 88:261–276.

Smith, D., K. Borkin, C. Jones, S. Lindberg, F. Davies, and G. Eccles. 2017. Effects of land transport activities on New Zealand's endemic bat populations: reviews of ecological and regulatory literature October 2017:249.

Thompson, M., J. A. Beston, M. Etterson, J. E. Diffendorfer, and S. R. Loss. 2017. Factors associated with bat mortality at wind energy facilities in the United States. Biological Conservation 215:241–245.

van der Zwan, W.; Kessels, G.H.A. 2018: Significant natural areas of the Waikato District: terrestrial and wetland ecosystems. Waikato Regional Council Technical Report 2017/36. Kessels Ecology Contract Report to Waikato Regional Council, Hamilton, 134 p

Voigt, C. C., M. Roeleke, O. Heim, L. S. Lehnert, M. Fritze, and O. Lindecke. 2020. Expert assessment of bat monitoring methods for wind power projects. Pages 57–76 Evidence-based bat protection in wind power projects. Springer, Berlin.

Weaver, S. P., C. D. Hein, T. R. Simpson, J. W. Evans, and I. Castro-Arellano. 2020. Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines. Global Ecology and Conservation 24:e01099.

Whitby, M. D., M. R. Schirmacher, and W. F. Frick. 2021. The state of the science on operational minimization to reduce bat fatality at wind energy facilities. A Rep Submitt to Natl Renew Energy Lab. Austin, Texas.

APPENDIX I 4SIGHT BIOACOUSTIC SURVEY

Figure A- 1. Location of ABMs and wind turbines at proposed Waiuku Wind Farm during the 4sight survey

APPENDIX II ECOLOGICAL EFFECTS ASSESSMENT GUIDELINES TABLES

Table A2-1: Ecological values assigned to habitats (adapted from EIANZ, 2018).

Attributes to be considered when assigning ecological value or importance to a site or area of vegetation/habitat/community.	
Matters	**Attributes to be considered**
Representativeness	Attributes for representative vegetation and aquatic habitats: ■ Typical structure and composition ■ Indigenous species dominate ■ Expected species and tiers are present Attributes for representative species and species assemblages: • Species assemblages that are typical of the habitat • Indigenous species that occur in most of the guilds expected for the habitat type
Rarity/ distinctiveness	Attributes for rare/distinctive vegetation and habitats: ■ Naturally uncommon, or induced scarcity ■ Amount of habitat or vegetation remaining ■ Distinctive ecological features ■ National priority for protection Attributes for rare/distinctive species or species assemblages: ■ Habitat supporting nationally Threatened or At Risk species, or locally uncommon species ■ Regional or national distribution limits of species or community ■ Unusual species or assemblages ■ Endemism
Diversity and Pattern	■ Level of natural diversity, abundance and distribution ■ Biodiversity reflecting underlying diversity ■ Biogeographical considerations – pattern, complexity ■ Temporal considerations, considerations of lifecycles, daily or seasonal cycles of habitat availability and utilisation
Ecological context	■ Site history, and local environmental conditions which have influenced the development of habitats and communities ■ The essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience (from "intrinsic value" as defined in RMA) ■ Size, shape and buffering ■ Condition and sensitivity to change ■ Contribution of the site to ecological networks, linkages, pathways and the protection and exchange of genetic material ■ Species role in ecosystem functioning – high level, key species identification, habitat as proxy

Table A2-2: Ecological values assigned to species (adapted from EIANZ, 2018).

Value	Species values
Very high	Nationally Threatened - Endangered, Critical or Vulnerable.
High	Nationally At Risk – Declining.
Moderate	Nationally At Risk - Recovering, Relict or locally uncommon or rare
Low	Not Threatened Nationally, common locally
Negligible	Exotic species, including pests

Table A2-3: Scoring for sites or areas combining values for four matters in Table 1

Value	Description
Very High	Area rates High for 3 or all of the four assessment matters listed in Table 4. Likely to be nationally important and recognised as such.
High	Area rates High for 2 of the assessment matters, Moderate and Low for the remainder, or Area rates High for 1 of the assessment maters, Moderate for the remainder. Likely to be regionally important and recognised as such.
Moderate	Area rates High for one matter, Moderate and Low for the remainder, or Area rates Moderate for 2 or more assessment matters Low or Very Low for the remainder Likely to be important at the level of the Ecological District.
Low	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
Negligible	Area rates Very Low for 3 matters and Low or Very Low for remainder.

Table A2-4: Criteria for describing magnitude of effect (EIANZ, 2018).

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline[1] conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

[1]Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (EIANZ, 2018).

Table A2-5: Timescale for duration of effects (EIANZ, 2018).

Timescale	Description
Permanent	Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long-term	Where there is likely to be substantial improvement after a 25 year period (e.g. the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary[1]	Long term (15-25 years or longer – see above) Medium term (5-15 years) Short term (up to 5 years) Construction phase (days or months)

[1]Note that in the context of some planning documents, 'temporary' can have a defined timeframe.

Table A2-6: Criteria for describing overall levels of adverse ecological effects (EIANZ, 2018).

Ecological V lue (Table 1) / Magnitude (Table 2	Very high	High	Moderate	Low	Negligible
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low