Bat Impact Assessment Report and Final Report of a 12-month Long-Term Preconstruction Bat Monitoring Study

- For the proposed Zonnequa Wind Farm, Northern Cape

Compiled by: Werner Marais

6 July 2018

PREPARED FOR:

Genesis Zonnequa Wind (Pty) Ltd

A JOINT VENTURE BETWEEN:

Atlantic Renewable Energy Partners (Pty) Ltd

101, Block A, West Quay Building
7 West Quay Road, Waterfront
Cape Town, 8000
www.atlanticep.com

and

Genesis Eco-Energy (Pty) Ltd

c/o Unit B10, Century Plaza,
Heron Crescent, Century City,
Cape Town

www.genesis-eco.com

By

2015/364493/07
Somerset West
Cape Town
7130

www.animalia-consult.co.za

Ref: R-1806-15

Appointment of Specialist

Specialist Company:	Animalia Consultants (Pty) Ltd
Fieldwork conducted by:	Werner Marais (1st, 2nd and 5th site visits) Aliénor Brassine (3rd and 4th site visits)
Report and data analysis done by:	Werner Marais
Appointed by:	Genesis Zonnequa Wind (Pty) Ltd
For:	12 Month pre-construction bat sensitivity monitoring and bat specialist EIA report

Independence:

Animalia Consultants (Pty) Ltd has no connection with the developer. Animalia Consultants (Pty) Ltd is not a subsidiary, legally or financially of the developer; remuneration for services by the developer in relation to this proposal is not linked to approval by decision-making authorities responsible for permitting this proposal and the consultancy has no interest in secondary or downstream developments as a result of the authorisation of this project.

Applicable Legislation:

Legislation dealing with biodiversity applies to bats and includes the following:

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; specifically sections 2, 56 & 97)

The act calls for the management and conservation of all biological diversity within South Africa. Bats constitute an important component of South African biodiversity and therefore all species receive additional attention to those listed as Threatened or Protected.

NORTHERN CAPE NATURE CONSERVATION ACT, No. 9 of 2009.

TABLE OF CONTENTS

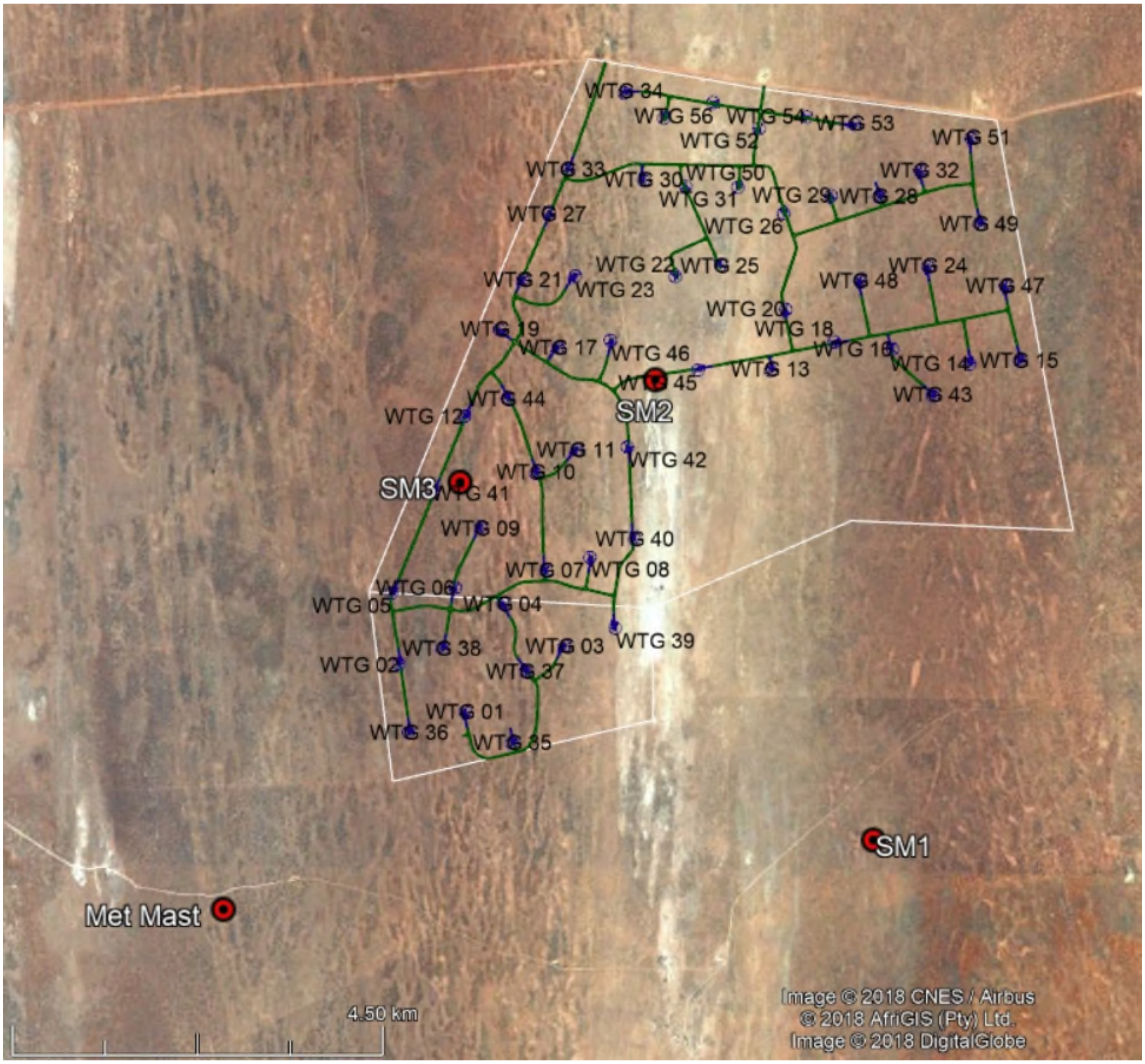


Figure 1: Map overview of the proposed Zonnequa Wind Farm (white farm portions) and proposed layout with access roads (green lines), with positions of the passive monitoring systems used to inform the study. SM1 refers to Short Mast 1, SM2 refers to Short Mast 2, etc.

1 OBJECTIVES AND TERMS OF REFERENCE FOR PRECONSTRUCTION STUDY

- Study bat species assemblage and abundance on the site.
- Study temporal distribution of bat activity across the night as well as the four seasons of the year in order to detect peaks and troughs in activity.
- Determine whether weather variables (wind, temperature, humidity and barometric pressure) influence bat activity.
- Determine the weather range in which bats are mostly active.
- Develop long-term baseline data for use during operational monitoring.
- Identify which turbines need to have special attention with regards to bat monitoring during the operation phase and identify if any turbines occur in sensitive areas and need to be shifted into less sensitive areas or removed from the layout.
- Assess the impacts of the proposed development on bats and determine the significance of the impacts.
- Detail the types of mitigation measures that are possible if bat mortality rates are found to be unacceptable, including the potential times/ circumstances which may result in high mortality rates.

2 INTRODUCTION

The Zonnequa Wind Farm is proposed to be developed approximately 19km south-east of Kleinsee in the Renewable Energy Zone (REDZ 8) in the Northern Cape Province. The two main affected properties, with a total extent of approximately 4434 ha, are Portion 1 of the Farm Zonnekwa 328, and the Remaining Extent of the Farm Zonnekwa 326.

The Zonnequa Wind Farm project site is proposed to accommodate the following infrastructure, which will enable the wind farm to supply a contracted capacity of up to 140MW:

- Up to 56 wind turbines with a maximum hub height of up to 130m. The tip height of the turbines will be up to 205m;
- Concrete turbine foundations and turbine hardstands;
- Temporary laydown areas which will accommodate the boom erection, storage and assembly area;
- Cabling between the turbines, to be laid underground where practical;
- An on-site substation of up to 150m x 150m in extent to facilitate the connection between the wind farm and the electricity grid;
- An overhead 132kV power line (assessed as a 300m , with a servitude of 32m, to connect the wind farm to the existing Gromis Substation;

- Access roads to the site (with a width of up to 10m) and between project components (with a width of approximately 8m);
- A temporary concrete batching plant; and
- Operation and Maintenance buildings including a gate house, security building, control centre, offices, warehouses, a workshop and visitors centre.

This impact assessment report covers the entire 12-month preconstruction bat monitoring study and the impact assessment for the proposed Zonnequa Wind Farm.

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. However, the dependence of a bat on each of these factors depends on the species, its behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above mentioned factors.

The site is evaluated by comparing the amount of surface rock (possible roosting space), topography (influencing surface rock in most cases), vegetation (possible roosting spaces and foraging sites), climate (can influence insect numbers and availability of fruit), and presence of surface water (influences insects and acts as a source of drinking water) to identify bat species that may be impacted by wind turbines. These comparisons are done mainly by briefly studying the geographic literature of each site, available satellite imagery and observations during site visits. Species probability of occurrence based on the above-mentioned factors are estimated for the site and the surrounding larger area (see Section 4.2).

General bat diversity, abundance and activity are determined by using a bat detector. A bat detector is a device capable of detecting and recording the ultrasonic echolocation calls of bats which may then be analysed with the use of computer software. A real-time expansion type bat detector records bat echolocation in its true ultrasonic state, which is then effectively slowed down during data analysis. Therefore, the bat calls become audible to the human ear, but still retain all of the harmonics and characteristics of the call from which bat species with characteristic echolocation calls can be identified. Although this type of bat detection equipment is advanced technology, it is not necessarily possible to identify all bat species by just their echolocation calls. Recordings may be affected by the weather conditions (i.e. humidity) and openness of the terrain (bats may adjust call frequencies). The range of detecting a bat is also dependent on the volume of the bat call. Nevertheless, it is a very accurate method of recording bat activity.

2.1 The Bats of South Africa

Bats form part of the Order Chiroptera and are the second largest group of mammals after rodents. They are the only mammals to have developed true powered flight and have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are compact and light, thereby reducing the total body weight. This unique wing profile allows for the manipulation of the wing camber and shape, exploiting functions such as agility and manoeuvrability. This adaption surpasses the static design of the bird wings in function and enables bats to utilise a wide variety of food sources, including, but not limited to, a large diversity of insects (Neuweiler 2000). Species based facial features may differ considerably as a result of differing life styles, particularly in relation to varying feeding and echolocation navigation strategies. Most South African bats are insectivorous and are capable of consuming vast quantities of insects on a nightly basis (Taylor 2000, Tuttle and Hensley 2001), however, they have also been found to feed on amphibians, fruit, nectar and other invertebrates. As a result, insectivorous bats are the predominant predators of nocturnal flying insects in South Africa and contribute greatly to the suppression of these numbers. Their prey also includes agricultural pests such as moths and vectors for diseases such as mosquitoes (Rautenbach 1982, Taylor 2000).

Urban development and agricultural practices have contributed to the deterioration of bat populations on a global scale. Public participation and funding of bat conservation are often hindered by negative public perceptions and unawareness of the ecological importance of bats. Some species choose to roost in domestic residences, causing disturbance and thereby decreasing any esteem that bats may have established. Other species may occur in large communities in buildings, posing as a potential health hazard to residents in addition to their nuisance value. Unfortunately, the negative association with bats obscure their importance as an essential component of ecological systems and their value as natural pest control agents, which actually serves as an advantage to humans.

Many bat species roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities, within the same population, concurrently (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum and according to O'Shea *et al*. (2003), bats may live for up to 30 years, thereby limiting the number of pups born due to this increased life expectancy. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity and the relatively low predation of bats when compared to other small mammals. Therefore, bat populations are not able to rapidly and adequately recover after mass mortalities and major roost disturbances.

2.2 Bats and Wind Turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesised that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, most bat mortalities have been found to be caused by barotrauma (Baerwald *et al*. 2008). This is a condition where low air pressure found around the moving blades of wind turbines, causes the lungs of a bat to collapse, resulting in fatal internal haemorrhaging (Kunz *et al*. 2007). Baerwald *et al*. (2008) found that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma. A study conducted by Arnett (2005) recorded a total of 398 and 262 bat fatalities in two surveys at the Mountaineer Wind Energy Centre in Tucker County, West Virginia and at the Meyersdale Wind Energy Centre in Somerset County, Pennsylvania, respectively. These surveys took place during a 6-week study period from 31 July 2004 to 13 September 2004. In some studies, such as that taken in Kewaunee County (Howe *et al.* 2002), bat fatalities were found to exceed bird fatalities by up to three-fold.

Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water, in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure as roosting spaces or that swarms of insects may get trapped in low pressure air pockets around the turbine, also encouraging the presence of bats. The presence of lights on wind turbines have also been identified as possible causes for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect densities that are attracted to the lights and subsequently encourage foraging activity of bats (Johnson *et al*. 2003). Clearings around wind turbines, in previously forested areas, may also improve conditions for insects, thereby attracting bats to the area and the swishing sound of the turbine blades has been proposed as possible sources for disorienting bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may also affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesised, from the author's personal observations, that the echolocation capabilities of bats are designed to locate smaller insect prey or avoid stationary objects, and may not be primarily focused on the detection of unnatural objects moving sideways across the flight path.

A pilot wind turbine in the Coega Industrial Development Zone, outside of Port Elizabeth in the Eastern Cape Province of South Africa, was surveyed for bird and bat carcasses. Over a period of one year, three surveys per week (total 154 inspections) were performed to search for bat and bird casualties. 17 bat fatalities and one live but injured bat was collected. Two bat species were involved, Cape serotine (*Neoromicia capensis*) and Egyptian free-tailed bat (*Tadarida aegyptiaca*). Of the 18 casualties, 15 were recorded mid-December to mid-March. One bird, a little swift (*Apus affinis*), was hit by a rotor blade. This is the first study to document bat and bird mortalities over the period of a year at a wind turbine in sub-Saharan Africa (Doty and Martin, 2013).

A pilot study was conducted at the Darling Wind Farm in the Western Cape to determine if bats are being killed by wind turbines at the facility. One bat carcass was found and identified as an adult female *Neoromicia capensis*. A necropsy showed that both lungs had pulmonary haemorrhaging and had collapsed. Histological examination revealed extensive haemorrhaging in the lungs consistent with barotrauma (Aronson et al. 2013).

Both of these South African studies point to South African bats being just as vulnerable to mortality from turbines as international studies have previously indicated. Therefore the two main species of concern are *Neoromicia capensis* and *Tadarida aegyptiaca*.

Whatever the reason for bat fatalities in relation to wind turbines, it is clear that this is a grave ecological problem, which requires attention. During a study by Arnett *et al*. (2009), 10 turbines monitored over a period of three months showed 124 bat fatalities in South-central Pennsylvania (America), which can cumulatively have a catastrophic long-term effect on bat populations if this rate of fatality continues. Most bat species only reproduce once a year, bearing one young per female, therefore their numbers are slow to recover from mass mortalities. It is very difficult to assess the true number of bat deaths in relation to wind turbines, due to carcasses being removed from sites through predation, the rate of which differs from site to site as a result of habitat type, species of predator and their numbers (Howe *et al*. 2002, Johnson *et al*. 2003). Mitigation measures are being researched and experimented with globally, but are still only effective on a small scale. An exception is the implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed. This relies on the principle that the prey of bats will not be found in areas of strong winds and more energy is required for the bats to fly under these conditions. It is thought that with the implementation of such a measure bats in the area are not likely to experience as great an impact as when the turbine blades move slowly in low wind speeds. However, this measure is currently not effective enough to translate the impact of wind turbines on bats to a category of low concern.

3 METHODOLOGY

Bat activity was monitored using active and passive bat monitoring techniques, and was in line with the South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1 (Sowler *et al.*, 2017). Active monitoring was carried out on site visits by the means of driven transects. A bat detector mounted on a vehicle was used and transect routes were chosen based on road accessibility. Sampling effort and prevalent weather conditions were considered for each transect.

Passive detection was completed by means of a passive bat monitoring system placed on the meteorological mast and short masts on site.

During each site visit, the passive data of the bat activity was downloaded from the monitoring systems. The data was analysed by classifying (as near to species level as possible) and counting positive bat passes detected by the systems. Classification was assisted by use of automated species identification by the Kaleidoscope software from Wildlife Acoustics.

A bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2ms (one echolocation call can consist of numerous pulses). A new bat pass is identified by a >500ms period between pulses. And as a standard it is accepted that more than one bat pass of the same species per minute, is considered to be the same individual bat, therefore bat passes/minute/species were capped at 1. Times of sunset and sunrise were automatically adjusted with the time of year. The **Table 1** below summarises the equipment setup that was used.

The impact on bats was identified and assessed as per Section 5.

3.1 Site Visit Information

Table 1: Equipment setup and site visit information.

<table>
<tr><td colspan="2" rowspan="5">Site visit dates</td><td>First Visit</td><td>29 May – 2 June 2017</td></tr>
<tr><td>Second Visit</td><td>5 – 8 September 2017</td></tr>
<tr><td>Third Visit</td><td>18 – 20 November 2017</td></tr>
<tr><td>Fourth Visit</td><td>21 – 24 March 2018</td></tr>
<tr><td>Fifth Visit</td><td>30 May – 1 June 2018</td></tr>
<tr><td rowspan="3">Met mast passive bat detection systems</td><td>Quantity on site</td><td colspan="2">1</td></tr>
<tr><td>Microphone heights</td><td colspan="2">10m; 97m</td></tr>
<tr><td>Coordinates</td><td colspan="2">Met Mast: 29.847250°S 17.194012°E</td></tr>
<tr><td rowspan="3">Short mast passive bat detection systems</td><td>Quantity on site</td><td colspan="2">3</td></tr>
<tr><td>Microphone height</td><td colspan="2">10m</td></tr>
<tr><td>Coordinates</td><td colspan="2">SM1: 29.839789°S 17.275207°E

SM2: 29.789965°S 17.247991°E

SM3: 29.801056°S 17.223718°E</td></tr>
<tr><td colspan="4">Replacements/ Repairs/ Comments</td></tr>
<tr><td colspan="2">First Visit</td><td colspan="2">The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Crows have been found to peck at microphones and subsequently destroying them. Hence, measures were taken for protection against birds, without noticeably compromising the effectiveness.

The bat detectors were installed within their weatherproof containers and all peripherals attached.</td></tr>
<tr><td colspan="2">Second Visit</td><td colspan="2">The met mast 10m and 97m microphones were not functional since 12 July 2017. The 97m microphone was damaged and was replaced. Since the 10m microphone did not show any damage on testing, and since both microphones stopped recording on the same date, it is suspected that lightning or very strong static energy damaged the top microphone and caused an error on the bat detector. Upon detector reset the 10m mic was functional again.

The other Short Mast systems were functioning well.</td></tr>
</table>

Third Visit	Short Mast 2 stopped recording on 15 Oct 2017, which was noticed on the site visit in November 2017 and the system was reset. Static/lightning is also suspected to be causing the fault. All other systems functioned well.
Fourth Visit	All systems functioned and recorded well, no issues were encountered.
Fifth Visit	The systems were decommissioned, and the data downloaded from the SD cards.
Type of passive bat detector	SM2BAT+, Real Time Expansion (RTE) type
Recording schedule	Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were automatically adjusted in relation to latitude, longitude and season).
Trigger threshold	>16KHz, -18dB
Trigger window (time of recording after trigger ceased)	500ms
Microphone gain setting	12dB
Compression	WAC0
Single memory card size (each system uses 4 cards)	32GB
Battery size	18Ah; 12V
Solar panel output	20 Watts
Solar charge regulator	6 - 8 Amp with low voltage/deep discharge protection
Other methods	Terrain was investigated during the day for signs of roosting and foraging habitat.

3.2 Assumptions and Limitations

Distribution maps of South African bat species still require further refinement such that the bat species proposed to occur on the site (that were not detected) are assumed accurate. If a species has a distribution marginal to the site, it was assumed to occur in the area. The literature based table of species probability of occurrence may include a higher number of bat species than actually present.

The migratory paths of bats are largely unknown, therefore limiting the ability to determine if the wind farm will have a large-scale effect on migratory species. This limitation is partly overcome with this long-term sensitivity assessment.

The satellite imagery partly used to develop the sensitivity map may be slightly imprecise due to land changes occurring since the imagery was taken.

Species identification with the use of bat detection and echolocation is less accurate when compared to morphological identification, nevertheless it is a very certain and accurate indication of bat activity and their presence with no harmful effects on bats being surveyed.

Automated species identification by the Kaleidoscope software may produce a small portion of incorrect identifications or unknown identifications. In such a case the dominant frequency of the unknown call was simply used to group the bat into a family or genus group, using dominant frequency only as the determining factor. However, the automated software is very effective at distinguishing bat calls from ultrasonic noise, therefore the number of bat passes are not significantly overestimated.

It is not possible to determine actual individual bat numbers from acoustic bat activity data, whether gathered through transects or the passive monitoring systems. However, bat passes per night are internationally used and recognised as a comparative unit for indicating levels of bat activity in an area.

Spatial distribution of bats over the study area cannot be accurately determined by means of transects, although the passive systems can provide comparative data for different areas of the site. Transects may still possibly uncover high activity in areas where it is not necessarily expected and thereby increase insight into the site.

Exact foraging distances from bat roosts or exact commuting pathways cannot be determined by the current methodology. Radio telemetry tracking of tagged bats is required to provide such information if needed.

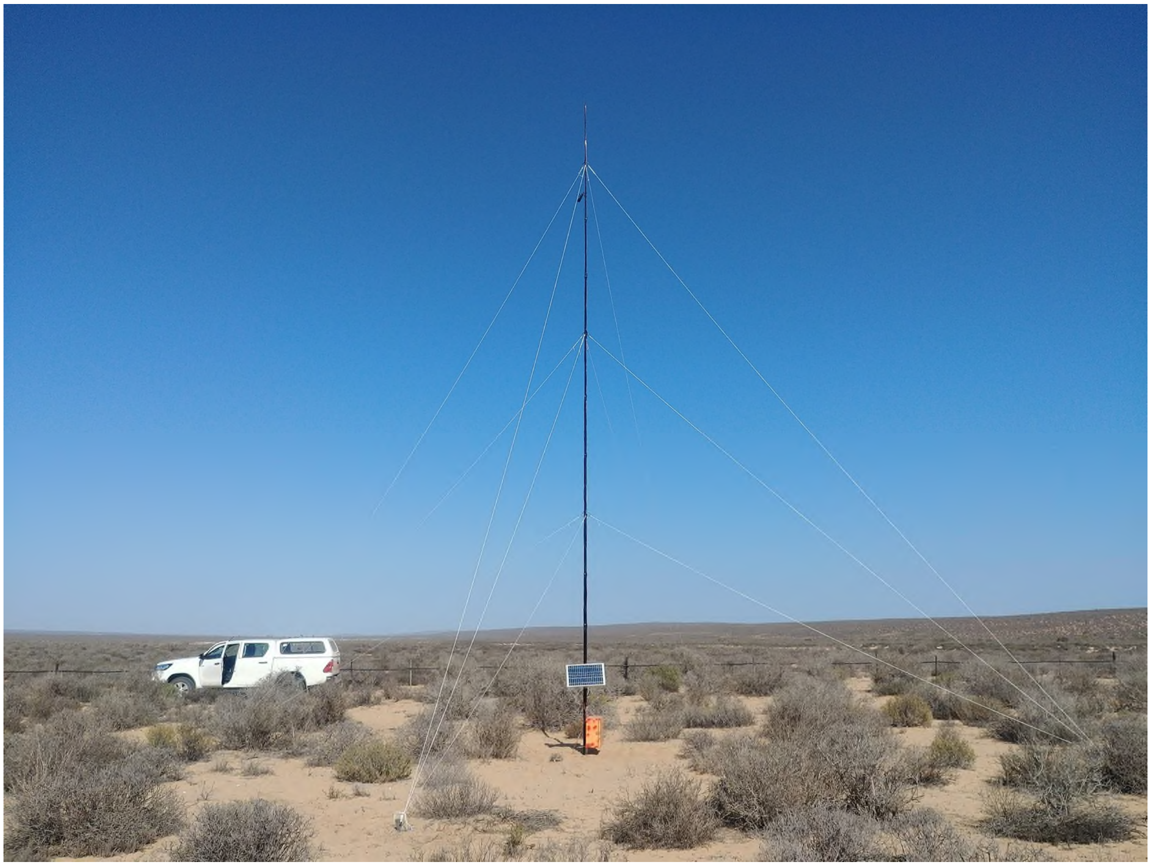


Figure 2: Short Mast 2 set up on site.

4 RESULTS AND DISCUSSION

4.1 Land Use, Vegetation, Climate and Topography

Currently the land use is mostly livestock farming with sheep, and land modification is very limited. The site is situated over two vegetation units namely the Namaqualand Salt Pans (Inland Azonal Vegetation) and Namaqualand Strandveld, with the Namaqualand Coastal Duneveld almost 2.5km to the west and a small portion of Namaqualand Klipkoppe Shrubland less than 6km to the south-east of the site (**Figure 3**). The last three mentioned vegetation units are all part of the Succulent Karoo Biome.

The Namaqualand Salt Pans vegetation unit is comprised of very flat terrain with depressions that are mostly without vegetation, apart from some occasional very salt tolerant succulents. The large depressions (pans) are seasonally moist and comprises of grey and white silt or clay soils, open surface water in these small pans is extremely rare, especially in the Kleinsee area (Mucina and Rutherford 2006). However, the seasonal moisture of the soil will still attract insects.

The slightly undulating Namaqualand Strandveld give rise to very low hills and small dunes on site. Vegetation comprises of low shrubs and small trees, and surface rock cover on site is very low. It is an arid winter rainfall area with a Mean Annual Precipitation (MAP) of 112mm, with almost all rainfall occurring from May to August and almost no rainfall in December and February (Mucina and Rutherford 2006).

The Namaqualand Coastal Duneveld generally have semi mobile sand dunes, but in the area closer to the site it is relatively stable with dwarf shrubland vegetation. Flora can present spectacular displays in wet years. MAP is only 114mm although fog can roll in from the coast

In general, the Namaqualand Klipkoppe Shrubland exhibits a large amount of exposed surface rock of granite and gneiss domes with boulder koppies, dominated by dwarf shrubs and a few scattered Quiver trees. MAP in general is about 160mm with episodic drought periods of one or two successive years where the MAP can remain below 100mm. This vegetation unit can offer suitable roosting and foraging space to bats and sometimes acts as an ecological oasis in the surrounding relatively featureless terrain (Mucina and Rutherford 2006). This vegetation unit is however not located within the site.

Vegetation units and geology are of great importance as these may serve as suitable sites for the roosting of bats and support of their foraging habits (Monadjem *et al.* 2010). Houses and buildings may also serve as suitable roosting spaces (Taylor 2000; Monadjem *et al.* 2010). The importance of the vegetation units and associated geomorphology serving as potential roosting and foraging sites have been described in **Table 2**.

Table 2: Potential of the vegetation to serve as suitable roosting and foraging spaces for bats.

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Namaqualand Strandveld	Low - Moderate	Low - Moderate	Larger plants, shrubs and small trees can offer limited roosting space, but in general the roosting potential is low on this site and within this vegetation unit. Farm buildings and artificial structures can provide ample roosting. Foraging potential is increased by the small pockets of wind shelter created by the slightly undulating terrain and small dunes.
Namaqualand Salt Pans	Low	Moderate	The sparsely vegetated terrain, low plants and lack of rocky outcrops does not allow for natural roosting space. Only farm buildings and artificial structures can provide ample roosting. Foraging potential is strongly contingent on seasonal changes when the salt depressions may be moist and succulents are flowering.
Namaqualand Coastal Duneveld	Low	Low - Moderate	The coastal environment with its associated insect activities may provide foraging potential in seasons with limited food supplies. The sparsely vegetated terrain, low height of plants and lack of rocky outcrops does not allow for much natural roosting space on site. Only farm buildings and artificial structures can provide ample roosting.
Namaqualand Klipkoppe Shrubland	Moderate - High	Moderate - High	Roosting space and wind shelter created by the more variable terrain may increase foraging and roosting potential. This vegetation unit is relatively far from the proposed turbine areas and not present within the site.

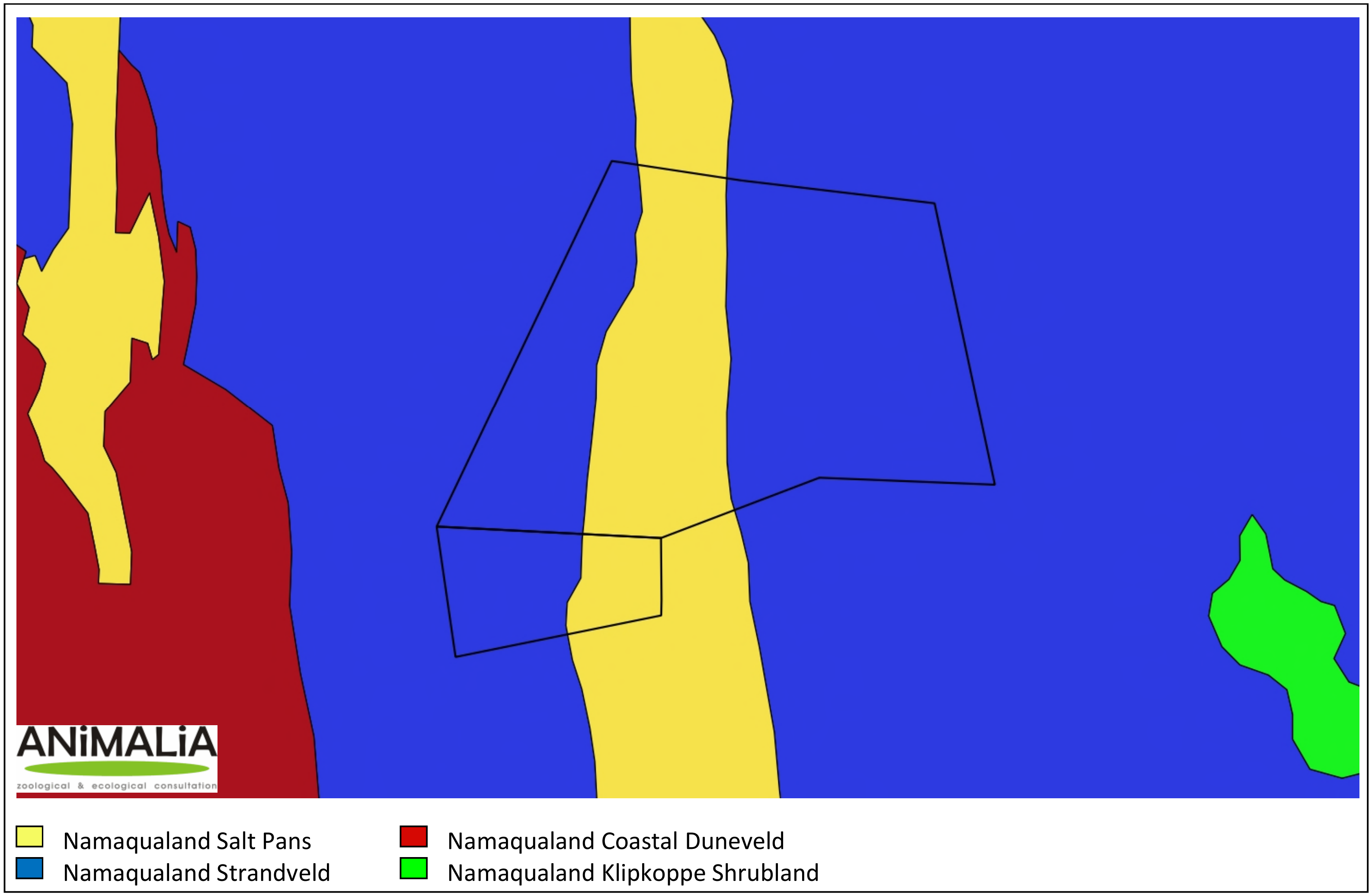


Figure 3: Vegetation units present on the Zonnequa Wind Farm site (Mucina and Rutherford 2006).

4.2 Currently Confirmed and Literature Based Species Probability of Occurrence

"Probability of Occurrence" is assigned based on the consideration of the presence of roosting sites and foraging habitats on the site, compared to literature described preferences. The probability of occurrence is indicative of the likelihood of encountering the bat species on site.

In **Table 3**, the column of "Likely risk of impact" describes the likelihood of risk of fatality from direct collision or barotrauma with wind turbine blades for each bat species. The risk was assigned by Sowler et al. (2017) based on species distributions, altitudes at which they fly and distances they traverse; and assumes a 100% probability of occurrence. The ecology of the most applicable bat species recorded in the vicinity of the site is discussed below.

Table 3: Table of species that may be roosting or foraging on the site, the possible site-specific roosts, and their probability of occurrence based on literature (Monadjem *et al.* 2010).

Species	**Common name**	**Probability of occurrence (%)**	**Conservation status (2016 Regional Listing)**	**Possible roosting habitat on site**	**Possible foraging habitat utilised on site**	**Likelihood of risk of fatality (Sowler, *et al.*, 2017)**
Tadarida aegyptiaca	Egyptian free-tailed bat	Confirmed	Least Concern	Roosts in rock crevices, hollows in trees, and behind the bark of dead trees. The species has also taken to roosting in roofs of buildings, which is more the case on site.	It forages over a wide range of habitats; its preferences of foraging habitat seem independent of vegetation. It seems to forage in all types of natural and urbanised habitats.	High
Miniopterus natalensis	Natal long-fingered bat	Confirmed	Near Threatened (2004 National Listing)	Cave and hollow dependent, no known caves close to the site. Will also roost in small groups or individually in culverts and other hollows.	Clutter-edge forager. May forage in more open terrain during suitable weather.	Medium - High
Neoromicia capensis	Cape serotine	Confirmed	Least Concern	Roosts in the roofs of houses and buildings.	It appears to tolerate a wide range of environmental conditions from arid semi-desert areas to montane grasslands, forests, and savannahs.	Medium - High
Eptesicus hottentotus	Long-tailed serotine	Confirmed	Least Concern	It is a crevice dweller roosting in rock crevices, as well as other crevices in buildings. No rock crevices on site, only building roofs.	It generally seems to prefer woodland habitats, and forages on the clutter edge.	Medium
Cistugo seabrae	Angolan wing-gland bat	20 - 30	Near Threatened	May roost in farm building structures, little is known about roosting habits. Restricted to arid regions of the country.	Clutter edge forager preferring terrain near open water, may possibly be found in man-made gardens, although not likely	Medium
Sauromys petrophilus	Roberts Flat-headed bat	Confirmed	Least Concern	Farm structures on site. Will utilise roosting space provided by the Namaqualand Klipkoppe Shrubland.	Open air forager that will fly over vast areas of flat terrain.	High

Rhinolophus capensis	Cape horseshoe bat	20 - 30	Near Threatened (2004 National Listing)	Roosts in caves and mine adits, no known caves in the immediate area. May utilise man made hollows.	Forages predominantly in the canopy of trees which may be found in man-made gardens.	Low
Rhinolophus clivosus	Geoffroy's horseshoe bat	20 - 30	Near Threatened (2004 National Listing)	Roosts in caves and mine adits, no known caves in the immediate area. May utilise man made hollows.	It is associated with a variety of habitats including thickets that may be found in man-made gardens.	Low
Nycteris thebaica	Egyptian slit-faced bat	30 - 40	Least Concern	Roosts in hollows, aardvark burrows, culverts under roads and the trunks of dead trees.	It appears to occur throughout the savannah and karoo biomes, but avoids open grasslands. May occur in the thickets of man made gardens	Low

4.3 Ecology of bat species that may be largely impacted by the Zonnequa Wind Farm

There are several bat species in the vicinity of the site that occur commonly in the area. These species are of importance based on their likelihood of being impacted by the proposed wind farm, due to high abundances and certain behavioural traits. The relevant species are discussed below.

Tadarida aegyptiaca

The Egyptian Free-tailed Bat, *Tadarida aegyptiaca*, is a Least Concern species (IUCN Red List 2016) as it has a wide distribution and high abundance throughout South Africa, and is part of the Free-tailed bat family (Molossidae). It occurs from the Western Cape of South Africa, north through to Namibia and southern Angola; and through Zimbabwe to central and northern Mozambique (Monadjem *et al*. 2010). This species is protected by national legislation in South Africa (ACR 2010).

They roost communally in small (dozens) to medium-sized (hundreds) groups in caves, rock crevices, under exfoliating rocks, in hollow trees and behind the bark of dead trees. *Tadarida aegyptiaca* has also adapted to roosting in buildings, in particular roofs of houses (Monadjem *et al*. 2010). Therefore, man-made structures and large trees on the site would be important roosts for this species.

Tadarida aegyptiaca forages over a wide range of habitats, flying above the vegetation canopy. It appears that the vegetation has little influence on foraging behaviour as the species forages over desert, semi-arid scrub, savannah, grassland and agricultural lands. Its presence is strongly associated with permanent water bodies due to concentrated densities of insect prey (Monadjem *et al*. 2010).

The Egyptian Free-tailed bat is considered to have a High likelihood of risk of fatality due to wind turbines (Sowler *et al.* 2016). Due to the high abundance and widespread distribution of this species, high mortality rates due to wind turbines would be a cause of concern as these species have more significant ecological roles than the rarer bat species.

After a gestation of four months, a single young is born, usually in November or December, when females give birth once a year. In males, spermatogenesis occurs from February to July and mating occurs in August. Maternity colonies are apparently established by females in November.

Neoromicia capensis

Neoromicia capensis is commonly called the Cape serotine and has a conservation status of Least Concern (IUCN Red List 2016) as it is found in high numbers and is widespread over much of Sub-Saharan Africa.

High mortality rates of this species due to wind turbines would be a cause of concern as *N. capensis* is abundant and widespread and as such has a more significant role to play within the local ecosystem than the rarer bat species. They do not undertake migrations and therefore are considered residents of the site.

It roosts individually or in small groups of two to three bats in a variety of shelters, such as under the bark of trees, at the base of aloe leaves, and under the roofs of houses. They will use most man-made structures as day roosts which can be found throughout the site and surrounding areas (Monadjem *et al*. 2010).

They are tolerant of a wide range of environmental conditions as they survive and prosper within arid semi-desert areas to montane grasslands, forests, and savannas; indicating that they may occupy several habitat types across the site, and are amenable towards habitat changes. They are however clutter-edge foragers, meaning they prefer to hunt on the edge of vegetation clutter mostly, but can occasionally forage in open spaces. They are thought to have a Medium-High likelihood of risk of fatality due to wind turbines (Sowler *et al.* 2016).

Mating takes place from the end of March until the beginning of April. Spermatozoa are stored in the uterine horns of the female from April until August, when ovulation and fertilisation occurs. They give birth to twins during late October and November but single pups, triplets and quadruplets have also been recorded (van der Merwe 1994 and Lynch 1989).

Miniopterus natalensis

Miniopterus natalensis, also commonly referred to as the Natal long-fingered bat, occurs widely across the country but mostly within the southern and eastern regions and is listed as Near Threatened (Monadjem *et al*. 2010). This bat is a cave-dependent species and identification of suitable roosting sites may be more important in determining its presence in an area than the presence of surrounding vegetation. It occurs in large numbers when roosting in caves with approximately 260 000 bats observed making seasonal use of the De Hoop Guano Cave in the Western Cape, South Africa. Culverts and mines have also been observed as roosting sites for either single bats or small colonies. Separate roosting sites are used for winter hibernation activities and summer maternity behaviour, with the winter hibernacula generally occurring at higher altitudes in more temperate areas and the summer hibernacula occurring at lower altitudes in warmer areas of the country (Monadjem *et al*. 2010)

Mating and fertilisation usually occur during March and April and is followed by a period of delayed implantation until July/August. Birth of a single pup usually occurs between October and December as the females congregate at maternity roosts (Monadjem *et al.* 2010 & Van Der Merwe 1979).

The Natal long-fingered bat undertakes short migratory journeys between hibernaculum and maternity roosts. Due to this migratory behaviour, they are considered to be at high risk of fatality from wind turbines if a wind farm is placed within a migratory path (Sowler *et al.* 2016). The mass movement of bats during migratory periods could result in mass casualties if wind turbines are positioned over a mass migratory route and such turbines are not effectively mitigated. Very little is known about the migratory behaviour and paths of *M. natalensis* in South Africa with migration distances exceeding 150 kilometres.

A study by Vincent *et al.* (2011) on the activity and foraging habitats of Miniopteridae found that the individual home ranges of lactating females were significantly larger than that of pregnant females. It was also found that the bats predominately made use of urban areas (54%) followed by open areas (19.8%), woodlands (15.5%) orchards and parks (9.1%) and water bodies (1.5%) when selecting habitats. Foraging areas were also investigated with the majority again occurring in urban areas (46%), however a lot of foraging also occurred in woodland areas (22%), crop and vineyard areas (8%), pastures, meadows and scrubland (4%) and water bodies (4%).

Sowler *et al.* (2016) advise that *M. natalensis* faces a medium to high risk of fatality due to wind turbines. This evaluation was based on broad ecological features and excluded migratory information.

4.4 Transects

The purpose of transects are to further provide extra and additional insight into the habitat of the site and is not considered to be critical quantitive data. Transects are essentially only a small glimpse of data and not as meaningful as the passive data. The following transects were carried out on the following site visits:

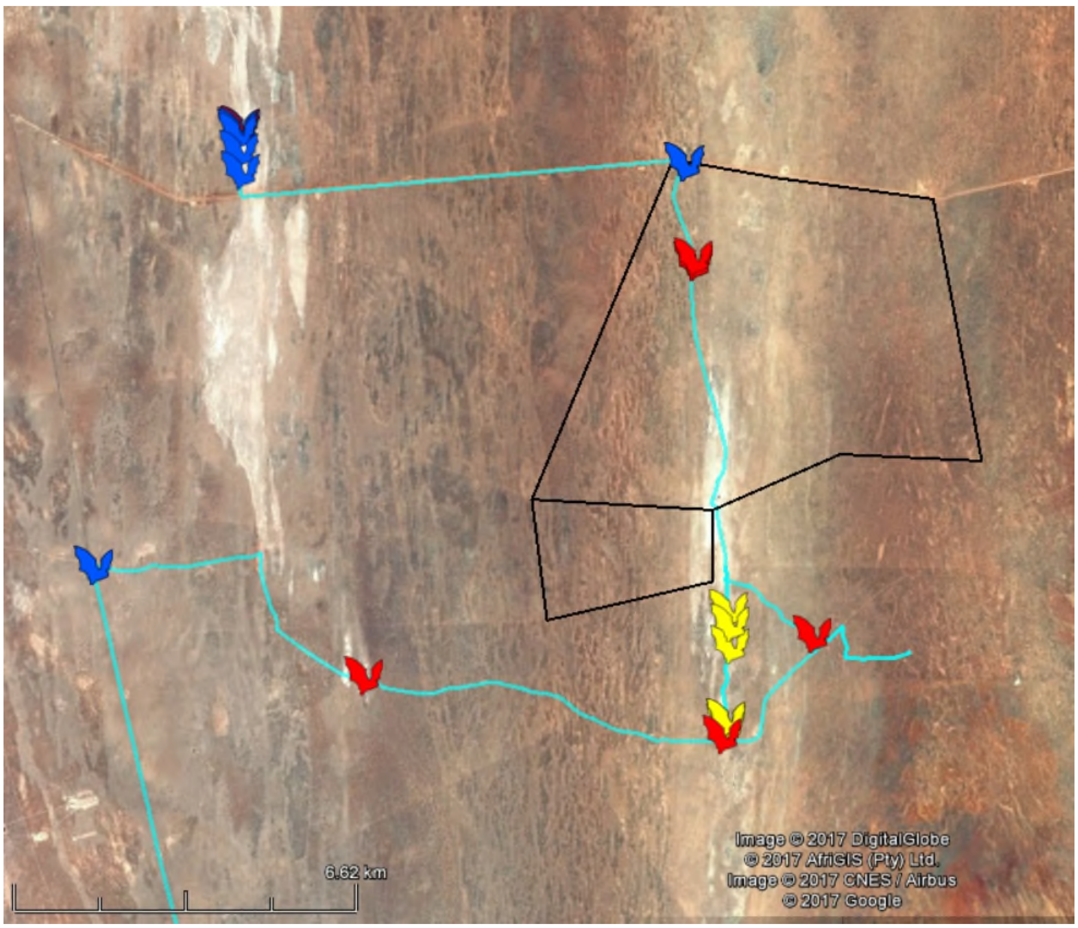
4.4.1 First Site Visit

Figure 4 below indicates the transect routes during the first site visit. Transect routes were not calculated and were carried out based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 4** displays the sampling effort and weather conditions prevalent during the transect survey.

Table 4: Transect distance, duration and average weather conditions experienced during the first site visit.

Date	Time started	Distance (km)	Duration (hours and minutes)	Temperature avg (˚C)	Rain (mm)	Wind speed avg (km/h)
31 May 2017	20:51	59.3km	2hr 20 min	17	0.0	11.2

Three bat species namely, *Tadarida aegyptiaca*, *Neoromicia capensis* and *Miniopterus natalensis* were recorded. To some degree the bat activity was higher close to farm structures and buildings.



Tadarida aegyptiaca *Neoromicia capensis* *Miniopterus natalensis*

Transect tracks

Figure 4: Transect routes and bat passes recorded across the site over the 1st site visit.

4.4.2 Second Site Visit

Figure 5 below indicates the transect routes during the second site visit. The SM2BAT+ Real time expansion type detector was used. **Table 5** displays the sampling effort and weather conditions prevalent during the transect survey.

Table 5: Transect distance, duration and average weather conditions experienced during the first site visit.

Date	Time started	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
6 September 2017	19:15	30km	2hr 11 min	12	0.0	8

Three bat species namely, *Tadarida aegyptiaca*, *Neoromicia capensis* and *Miniopterus natalensis* were recorded. To some degree the bat activity was higher close to farm structures and buildings.

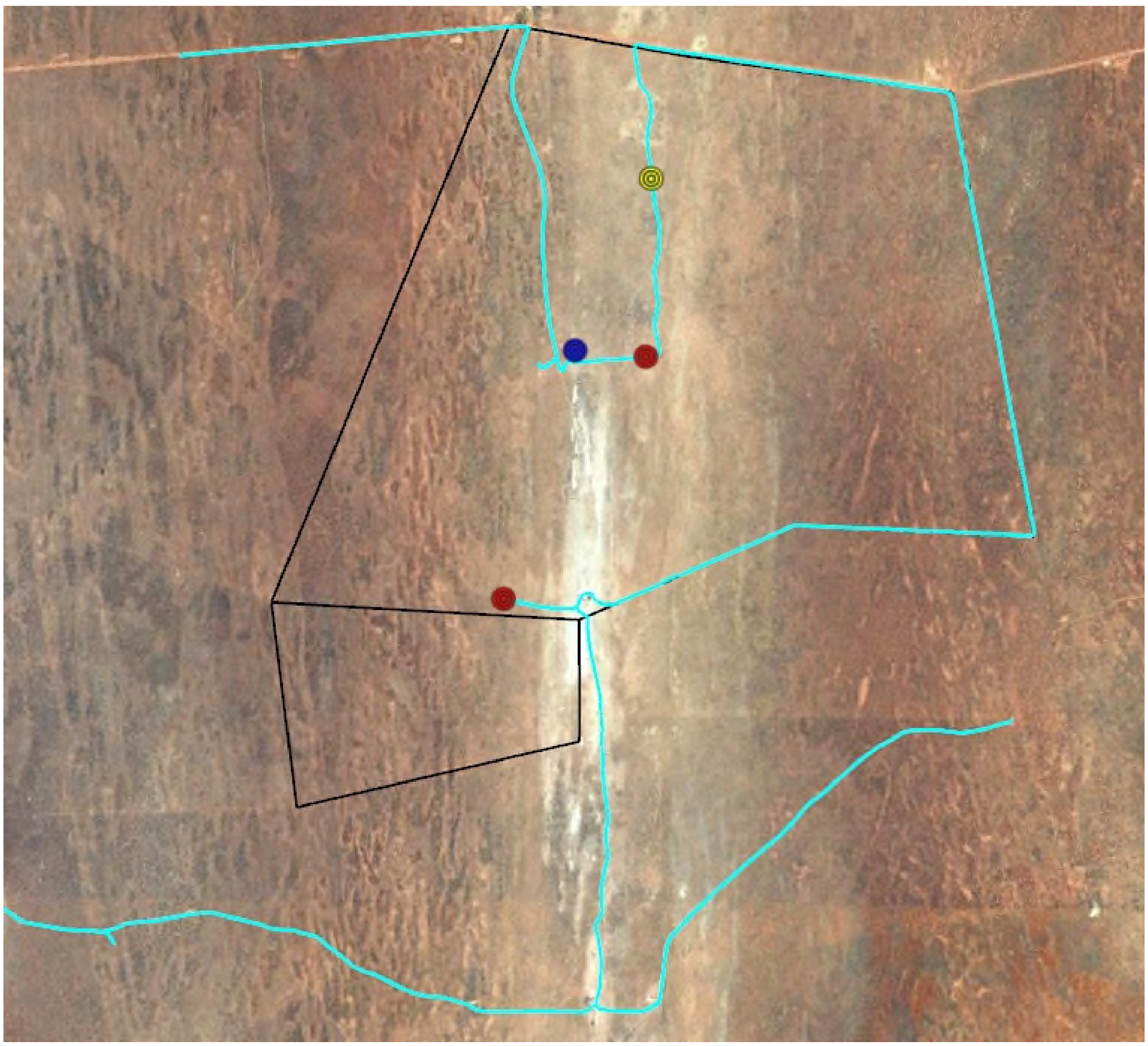


Figure 5: Transect routes and bat passes recorded near the site over the 2nd site visit.

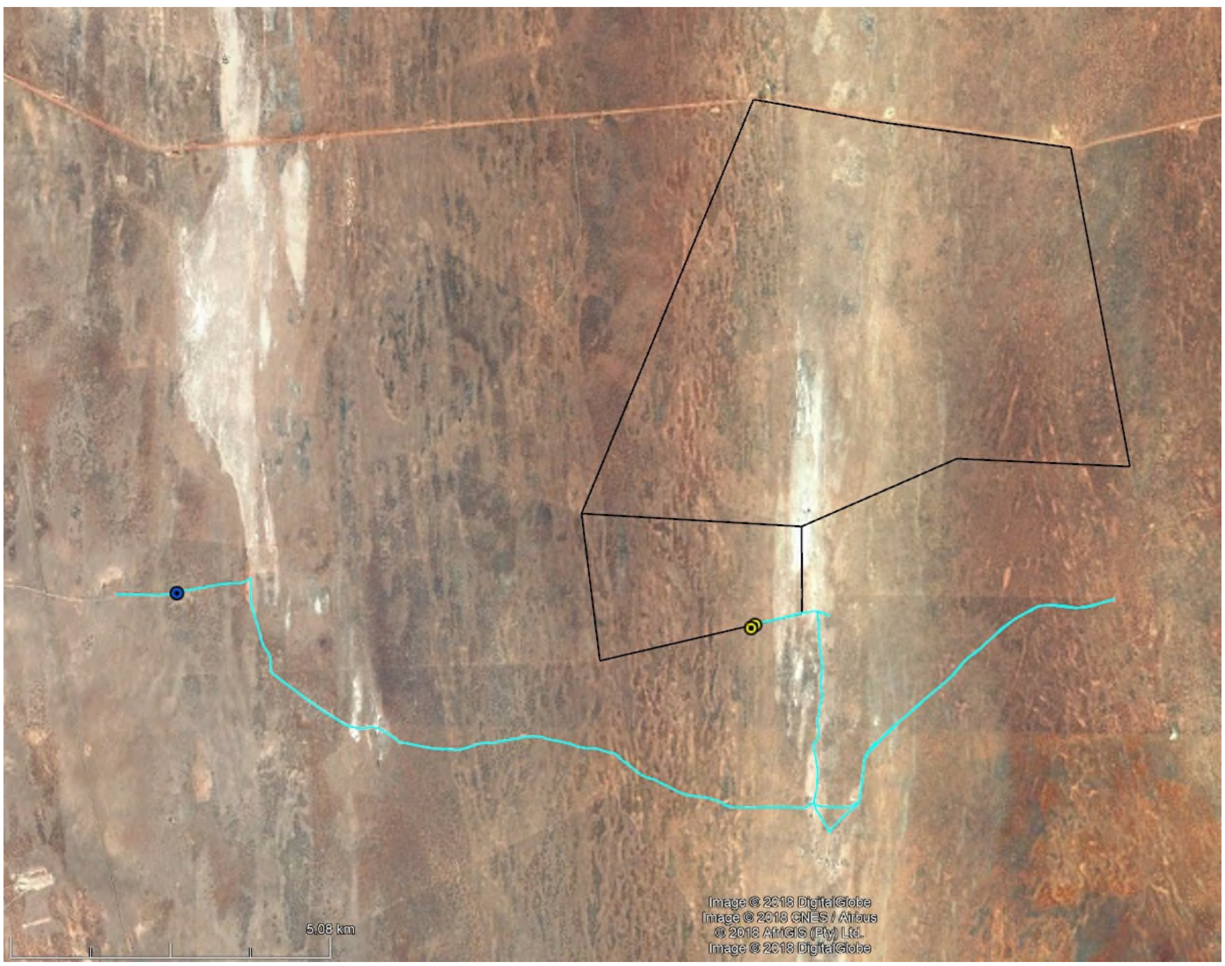
4.4.3 Third Site Visit

Figure 6 below indicates the transect routes during the third site visit. The SM2BAT+ Real time expansion type detector was used. **Table 6** displays the sampling effort and weather conditions prevalent during the transect survey.

Table 6: Transect distance, duration and average weather conditions experienced during the third site visit.

Date	Time started	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
20 November 2017	21:17	31km	1h 31 min	17.5	0.0	19.5

The Egyptian Free-tailed bat (*T. aegyptiaca*) and some members of the Vespertilionidae family (same family to which *N. capensis* belong), were recorded near the site. In general the bat activity was very low on the night of the transect.



Tadarida aegyptiaca Vespertilionidae

Transect tracks

Figure 6: Transect routes and bat passes recorded near the site during the 3rd site visit.

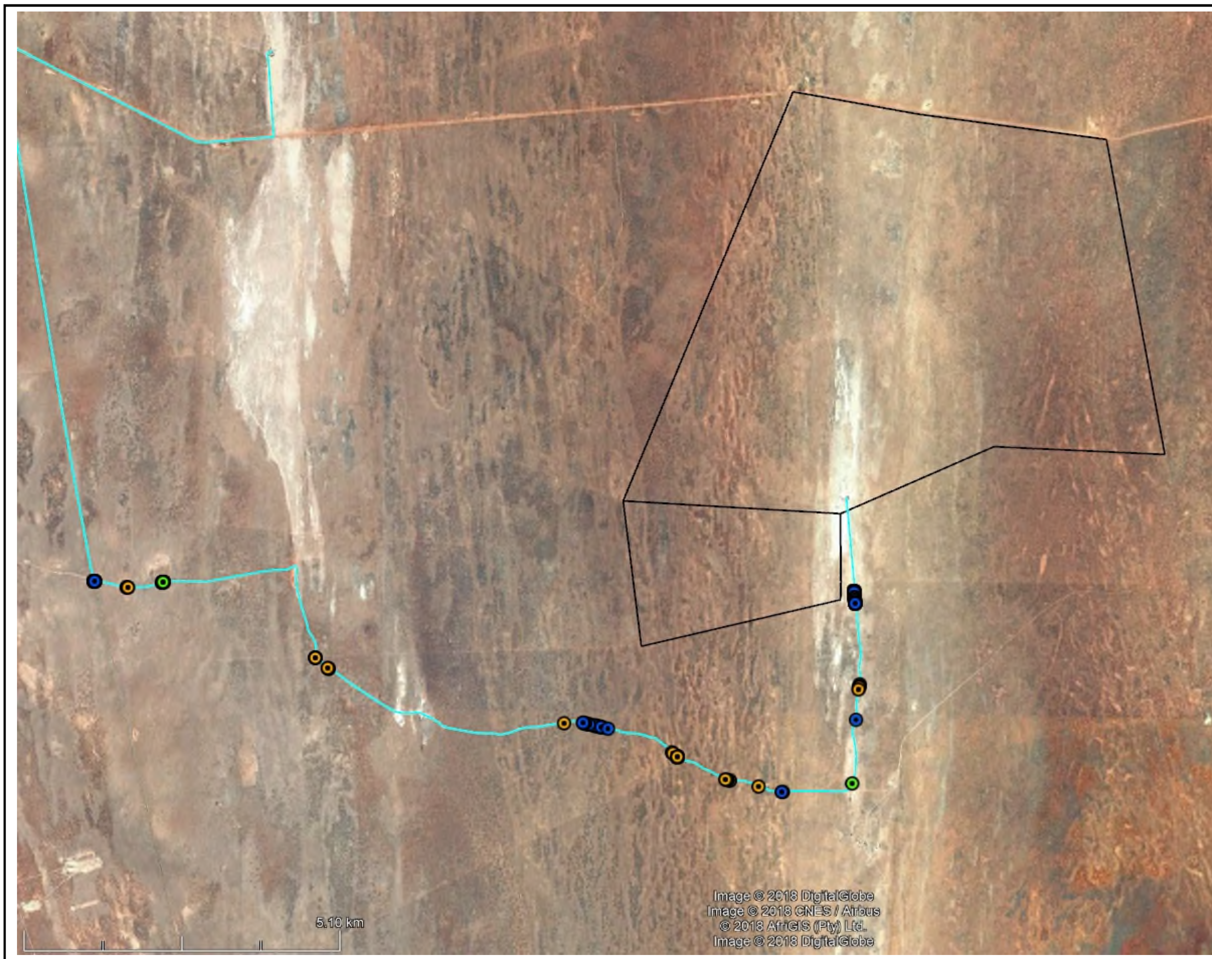
4.4.4 Fourth Site Visit

Figure 7 below indicates the transect routes during the fourth site visit. The SM2BAT+ Real time expansion type detector was used. **Table 7** displays the sampling effort and weather conditions prevalent during the transect survey.

Table 7: Transect distance, duration and average weather conditions experienced during the fourth site visit.

Date	Time started	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
23 March 2018	21:34	31.7km	1h 24 min	19	0.0	13

The Egyptian Free-tailed bat (*T. aegyptiaca*), Robert's Flat headed bat (*S. petrophilus*) and some members of the Vespertilionidae family (same family to which *N. capensis* belong), were recorded near the site. Bat activity was slightly higher on this evening than during most other transects.



Tadarida aegyptiaca Vespertilionidae *Sauromys petrophilus*

Transect tracks

Figure 7: Transect routes and bat passes recorded near the site during the 4th site visit.

4.5 Sensitivity Map

Figure 8 depicts the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are most probable to occur on site. Therefore, the sensitivity map is based on the species ecology and habitat preferences. This map can be used as a pre-construction mitigation in terms of improving turbine placement with regards to bat preferred habitats and sensitive areas on site.

Table 8: Description of parameters used in the compilation of a sensitivity map.

<table>
<tr><td>Last iteration</td><td>June 2018</td></tr>
<tr><td>High sensitivity buffer</td><td>200m radial buffer</td></tr>
<tr><td>Moderate sensitivity buffer</td><td>100m radial buffer</td></tr>
<tr><td rowspan="8">Descriptions of features used to develop the high and moderate sensitivities (corresponding to numbers in Figure 8)</td><td>1: Dug out dam getting water from a wind pump, therefore more reliable water source. Although the dam does not hold water for long periods as it quickly evaporates. A kraal is nearby. Combination of moisture and animals will attract insects and therefore bats. High sensitivity.</td></tr>
<tr><td>2: Confirmed livestock congregation area with water tanks and drinking trough. Livestock kraals and other common congregation areas regularly attract multiple insects and therefore insectivorous bats. High sensitivity.</td></tr>
<tr><td>3: Confirmed livestock congregation area with water tanks and drinking trough. High sensitivity.</td></tr>
<tr><td>4: Confirmed kraal with water tanks and drinking trough. High sensitivity.</td></tr>
<tr><td>5: Very seasonal water depression Moderate sensitivity.</td></tr>
<tr><td>6: Livestock congregation area combined with a farm dam. High sensitivity.</td></tr>
<tr><td>7: Housing residence. Artificial shelter from roofs and moisture from gardens can support multiple bats. High sensitivity.</td></tr>
<tr><td>8: Kraal with a cement farm dam. Combination of moisture and animals will attract insects and therefore bats. High sensitivity.</td></tr>
<tr><td rowspan="2">Features used to develop the remaining moderate sensitivities</td><td>The different vegetation types and landform. Dunes and slopes can offer airspace sheltered from wind for insect prey and subsequently attract insectivorous bats. Larger woody shrubs can offer similar sheltered airspace.</td></tr>
<tr><td>Very seasonal water sources that may have some accessible water only for a few days a year.</td></tr>
</table>

Table 9: Description of sensitivity categories utilised in the sensitivity map.

Sensitivity	Description
Moderate Sensitivity and its buffers	Areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within these areas and their buffers may acquire priority (not excluding all other turbines) during post-construction studies, and in some instances there is a higher likelihood that mitigation measures may need to be applied to them.
High Sensitivity and its buffers	Areas that are deemed critical for resident bat populations, capable of elevated levels of bat activity and support greater bat diversity/activity than the rest of the site. These areas are 'no-go' zones and turbines (including turbine blades) must not be placed in these areas and their associated buffers.

Table 10: Turbines located within bat sensitive areas and buffers (including turbine blades).

Bat sensitive area	Proposed turbine layout
High bat sensitivity area	None
High bat sensitivity buffer	None
Moderate bat sensitivity area	WTG03, WTG07, WTG08, WTG11, WTG17, WTG39, WTG14, WTG15, WTG23, WTG40, WTG42, WTG43, WTG46
Moderate bat sensitivity buffer	WTG10, WTG33

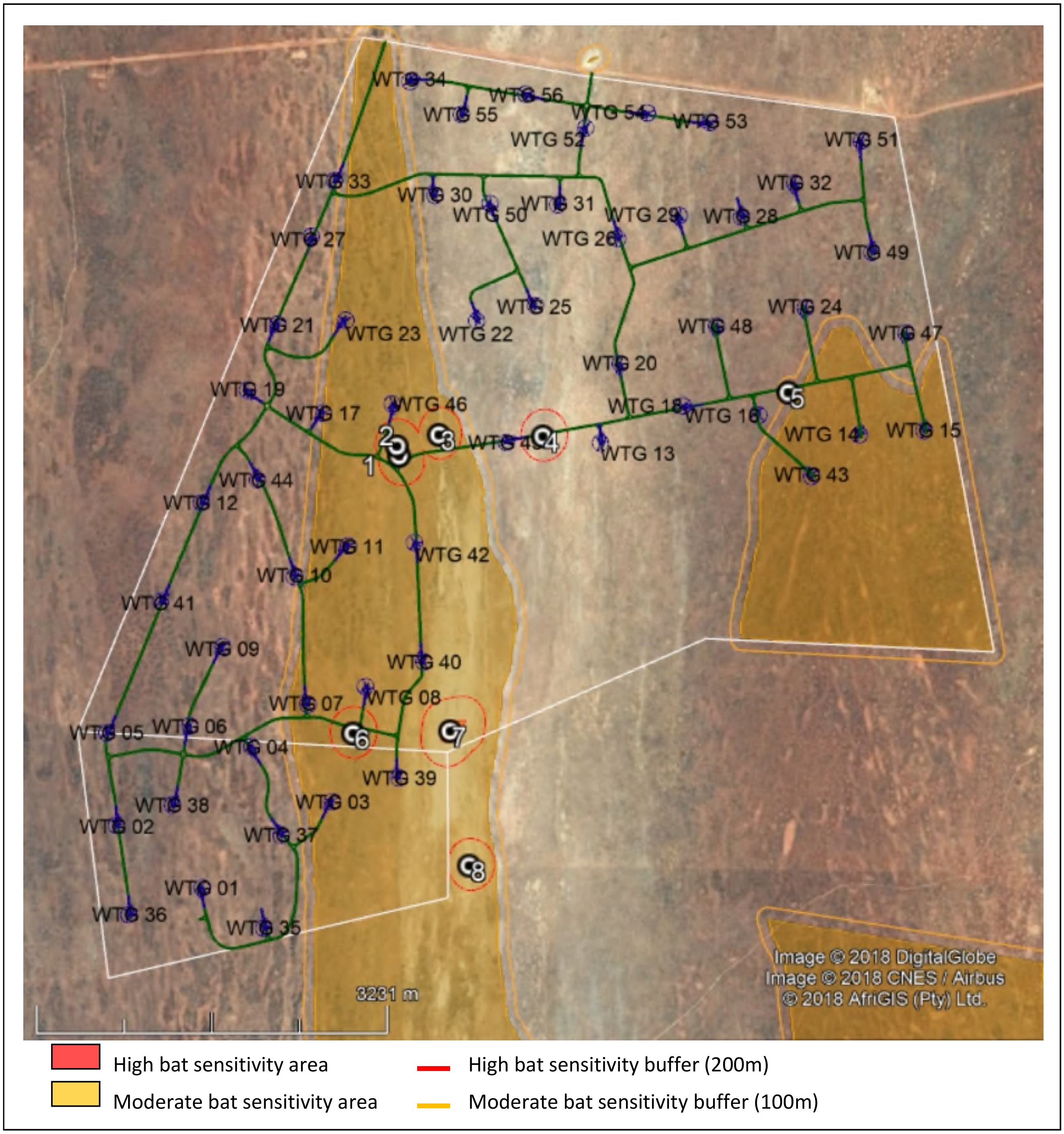


Figure 8: Bat sensitivity map of the proposed Zonnequa Wind Farm in relation to the proposed turbine layout, showing moderate and high sensitivity zones and their associated buffers. It also indicates descriptions of sensitivities explained in **Table 8.**

4.6 Passive Data

4.6.1 Abundances and Composition of Bat Assemblages

Average hourly bat passes detected per night and the total number of bat passes detected over the monitoring period by the systems are displayed in **Figures 9 - 16**. Five bat species were detected namely *Eptesicus hottentotus*, *Tadarida aegyptiaca, Sauromys petrophilus, Neoromicia capensis and Miniopterus natalensis*. Some less identifiable calls were grouped in their families, on this site it only includes the family Vespertilionidae which consists many species of which *N. capensis* is a part of.

Tadarida aegyptiaca were most commonly detected by the monitoring systems on site, at 10m and 97m. Such abundant species are of a large value to the local ecosystems as they provide a greater contribution to most ecological services than the rarer species, due to their higher numbers. Short Mast 2 had the highest bat activity levels, possibly due to it being located near a high sensitivity areas. Short Mast 1 had the lowest activity, and the highest bat activity was in March for all systems except Short Mast 1.

The monitoring systems detected the migratory species, *Miniopterus natalensis.* The species displayed seasonal peaks that coincided with the peaks in activity of other bat species on site, except at SM2 the seasonal peak was slightly later in autumn. This is not clearly evident of a migration event, however the possibility still exists that the species move into the area in late autumn, but may not necessarily be at risk of impact since its activity at 97m was only 1 bat pass for the entire 12 months.

The annual average mean number of bat passes per hour for the met mast system is indicating a Low Risk level for bat impacts at 97m with 0.04 average passes per hour, and a High Risk at 10m with 0.34 average passes per hour. The highest annual average mean number of bat passes per hour was at SM2 at 10m with 0.86 average passes. Above 0.13 is considered to be a High potential risk, and below 0.07 is considered a Low potential risk. This is according to the "Estimated turbine related bat fatality risk levels based on bat activity levels for different terrestrial ecoregions" as depicted in the "South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1" (Sowler *et al.*, 2017).

The site displays a very strong gradient of bat activity levels with height above ground, where the met mast detected 7.7 times less bats at 97m than at 10m (**Figure 9**). These activity gradients are in general exponential meaning the activity becomes progressively less with height. The minimum proposed turbine dimensions at a hub height of 130m and a rotor diameter of 150m, sets the lowest possible rotor swept height above ground at 55.5m

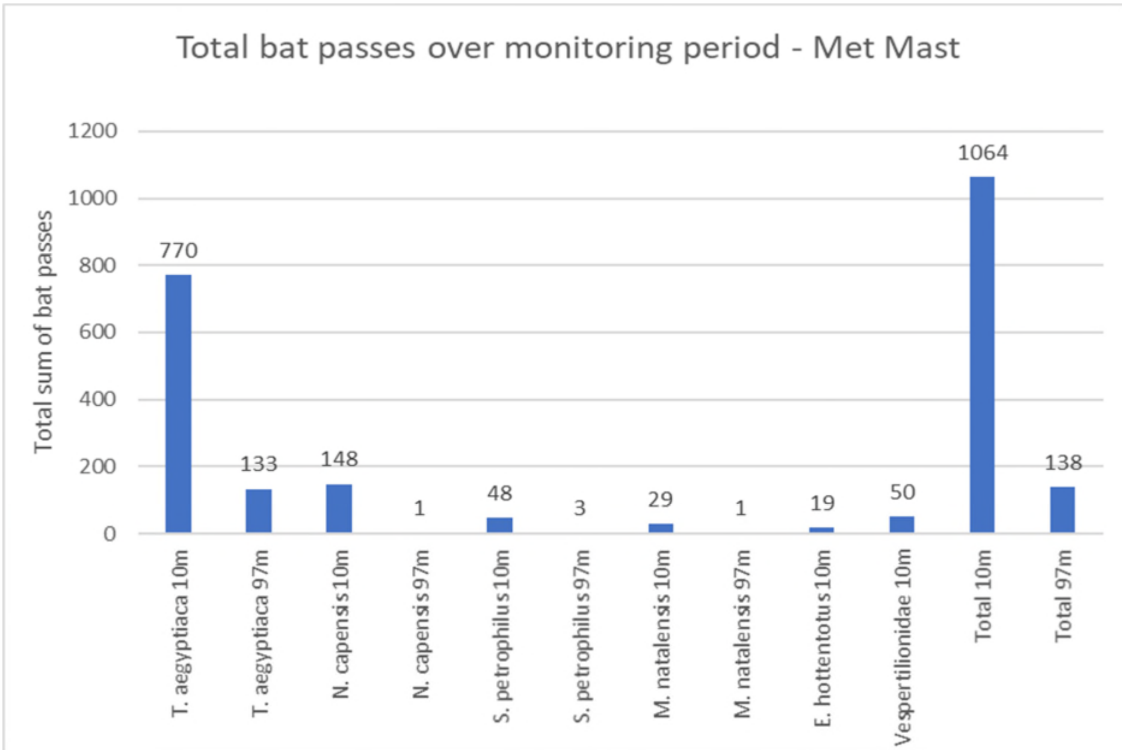


Figure 9: Total bat passes recorded over the monitoring period by the detector mounted on the Met Mast.

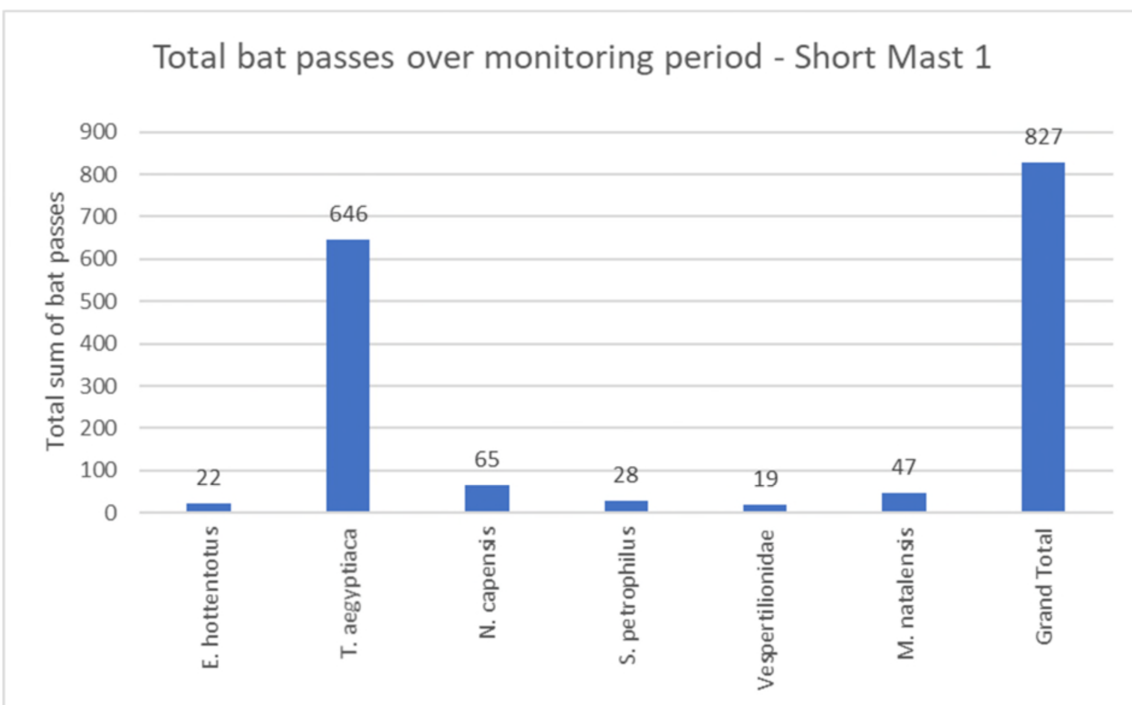


Figure 10: Total bat passes recorded over the monitoring period by the detector mounted on SM1.

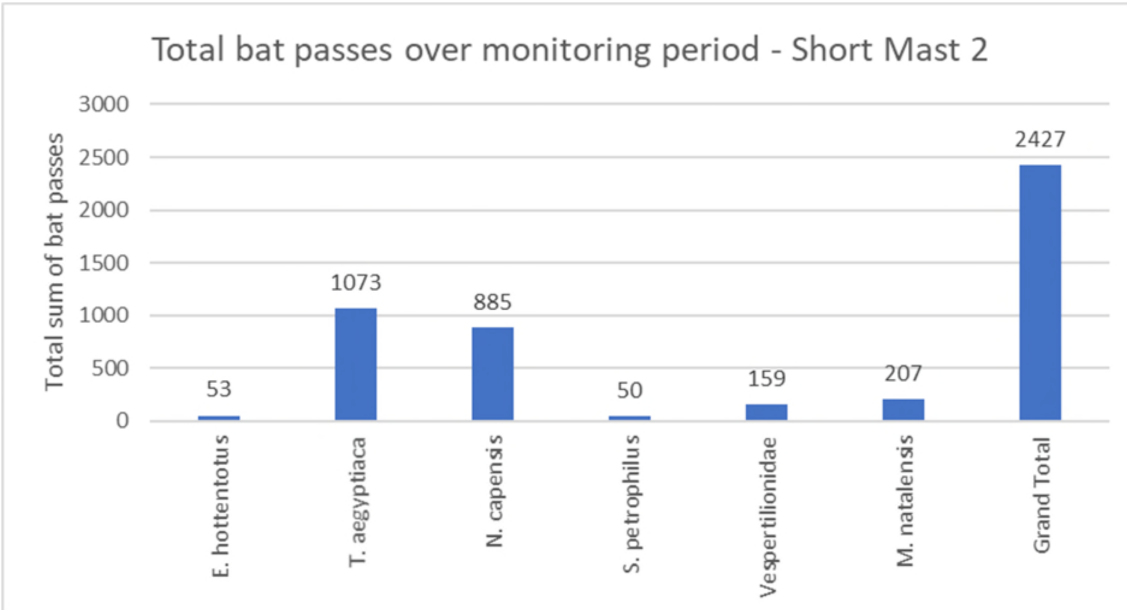


Figure 11: Total bat passes recorded over the monitoring period by the detector mounted on the SM2.

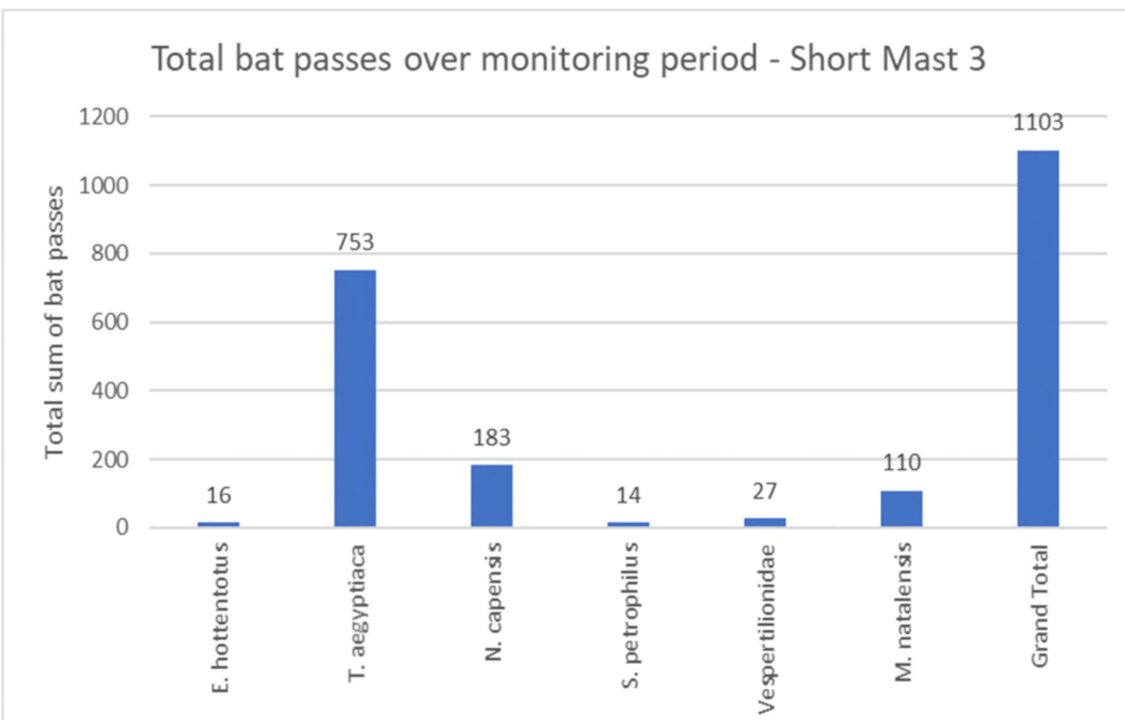


Figure 12: Total bat passes recorded over the monitoring period by the detector mounted on the SM3.

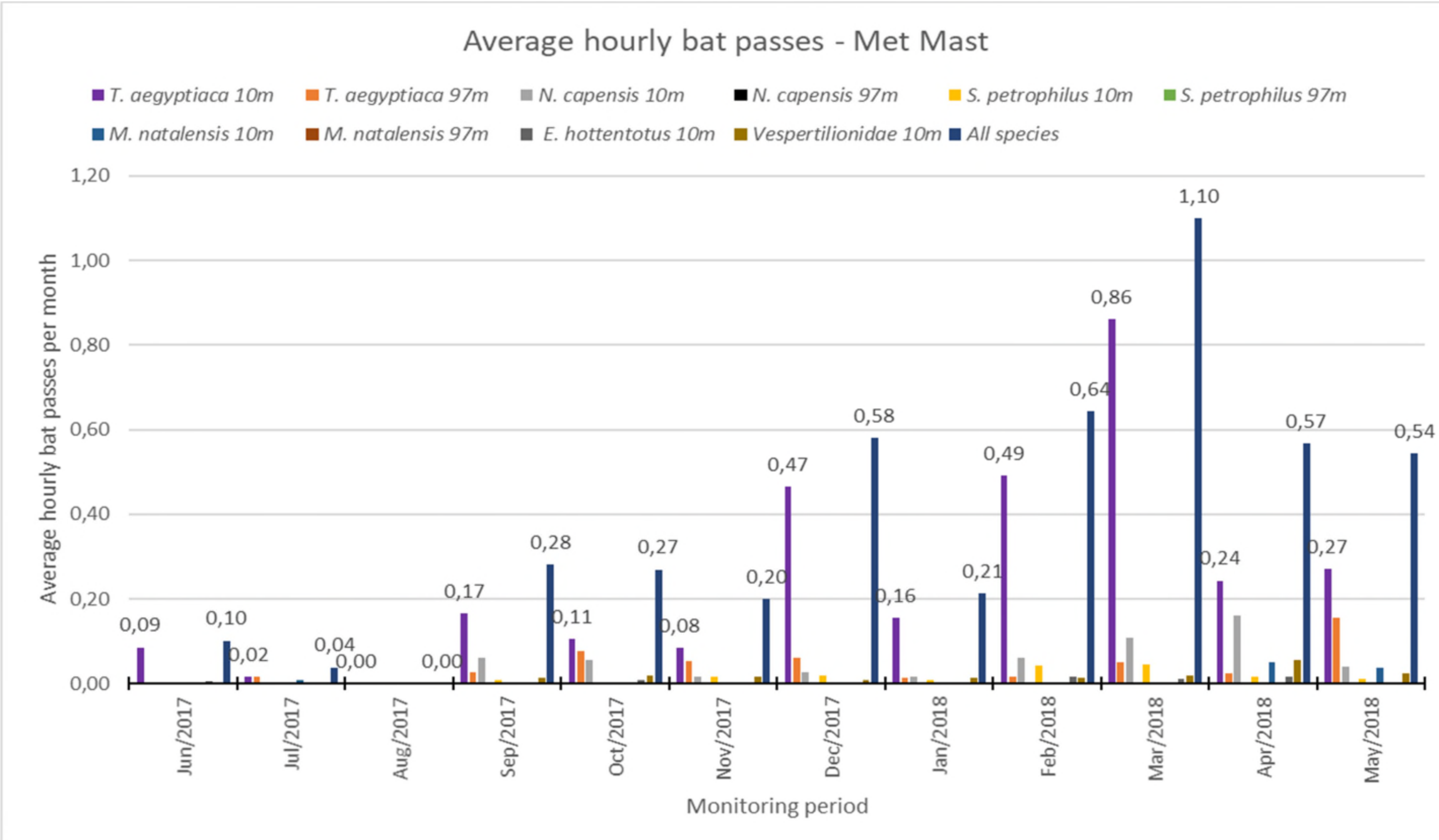


Figure 13: Average hourly bat passes recorded per month by the detector mounted on the Met Mast.

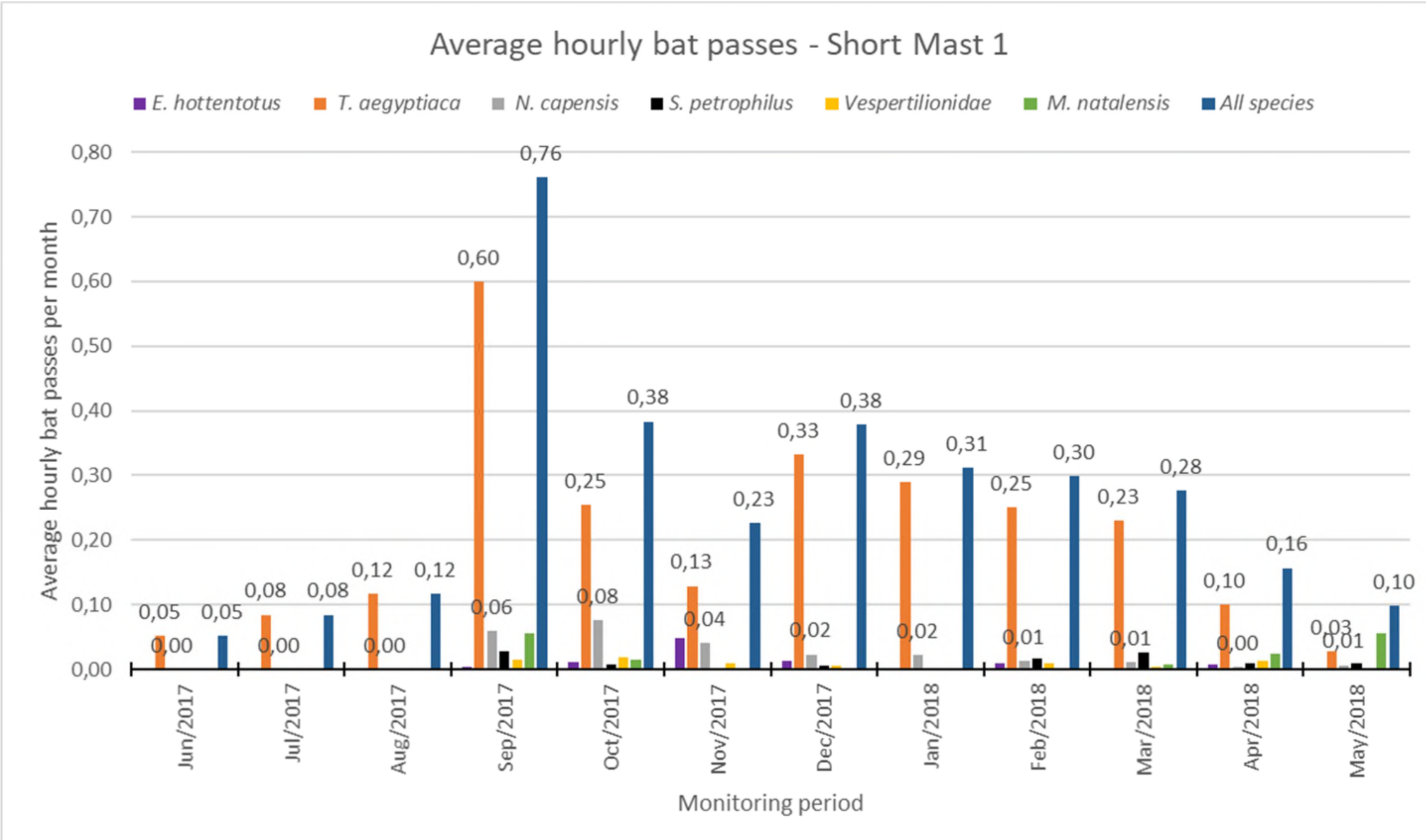


Figure 14: Average hourly bat passes recorded per month by the detector mounted on SM1.

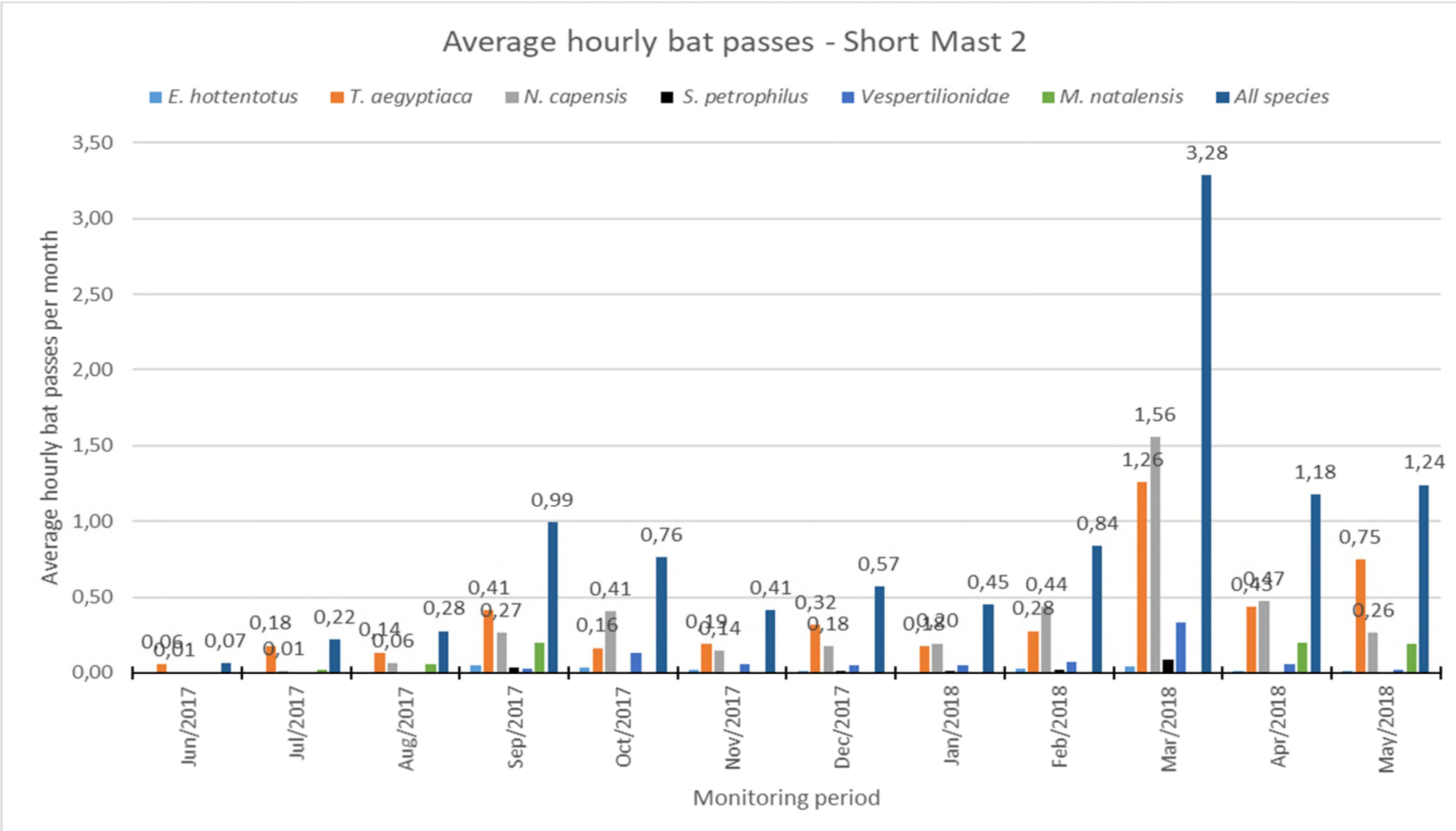


Figure 15: Average hourly bat passes recorded per month by the detector mounted on SM2.

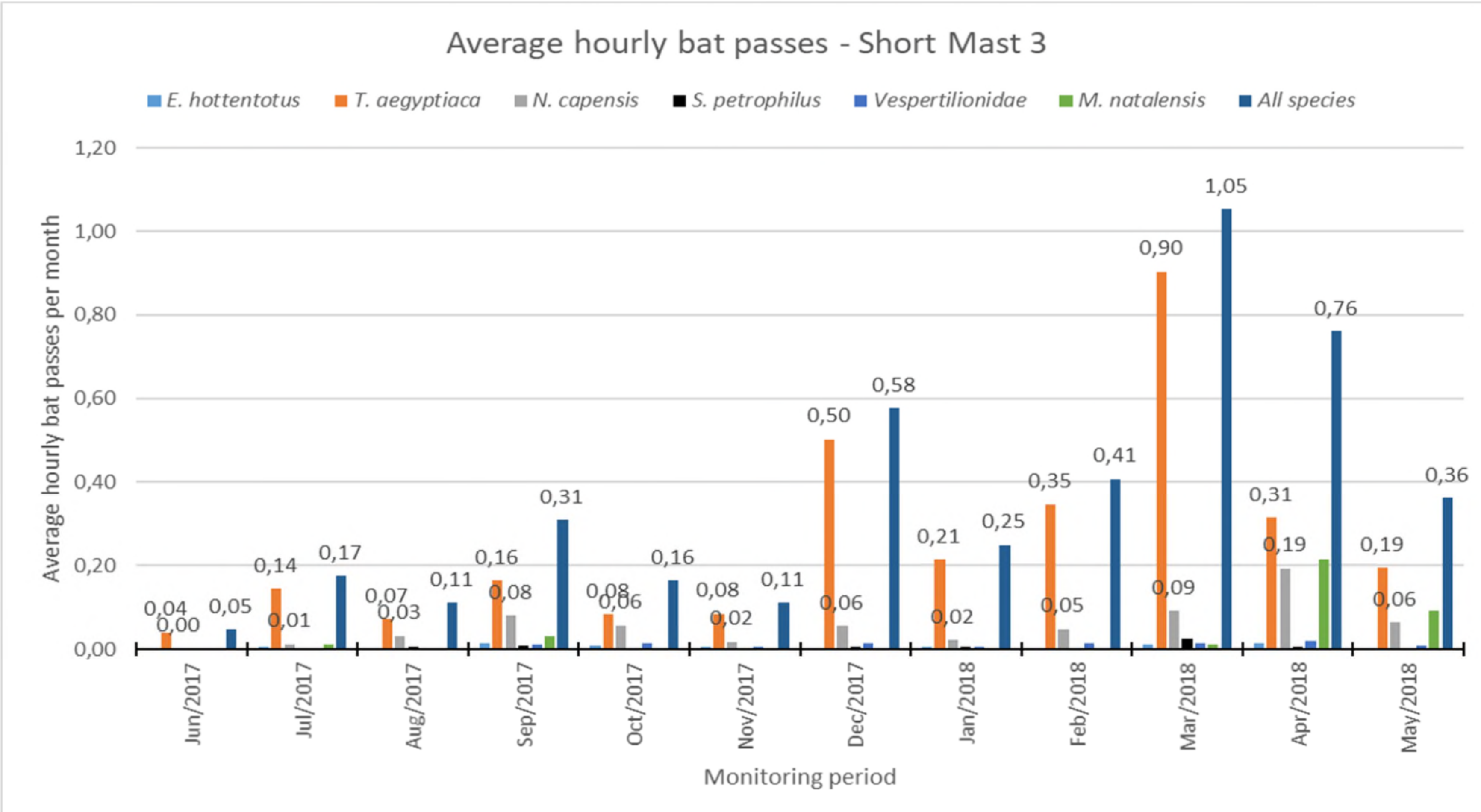


Figure 16: Average hourly bat passes recorded per month by the detector mounted on SM3.

4.6.2 Temporal Distribution

The sum of all bat passes recorded by the monitoring systems of the particular species are displayed per night over the monitoring period (**Figures 17 - 20**). This information is useful to graphically compare seasonal differences and indicate peak activity periods that occurred. It can also be used to inform a schedule for mitigation measures, when required. As expected bat activity started to increase in spring, with higher and also more regular bat activity in start to mid-autumn. The month of March had the highest bat activity.

Each system showed one or two peculiar high peaks of activity for one night, for the respective systems and these nights were: Met Mast on 21 September 2017 and 14 March 2018, SM1 on 3 September 2017, SM2 on 3 September 2017 and 16 May 2018, SM3 on 30 July 2017. The reasons for these peaks in activity are unknown and the fact that it's not occurring on the same night for each system indicates that it's not a phenomenon happening on the entire site at the same time. Insectivorous bats follow insect swarms and activity, which can have very complex dynamics that's not always practical and feasible to measure during the time constraints of a preconstruction bat assessment.

However, this matter may still be important for operational mitigations where needed, since understanding the underlying cause can assist in predicted the next night of such an event.

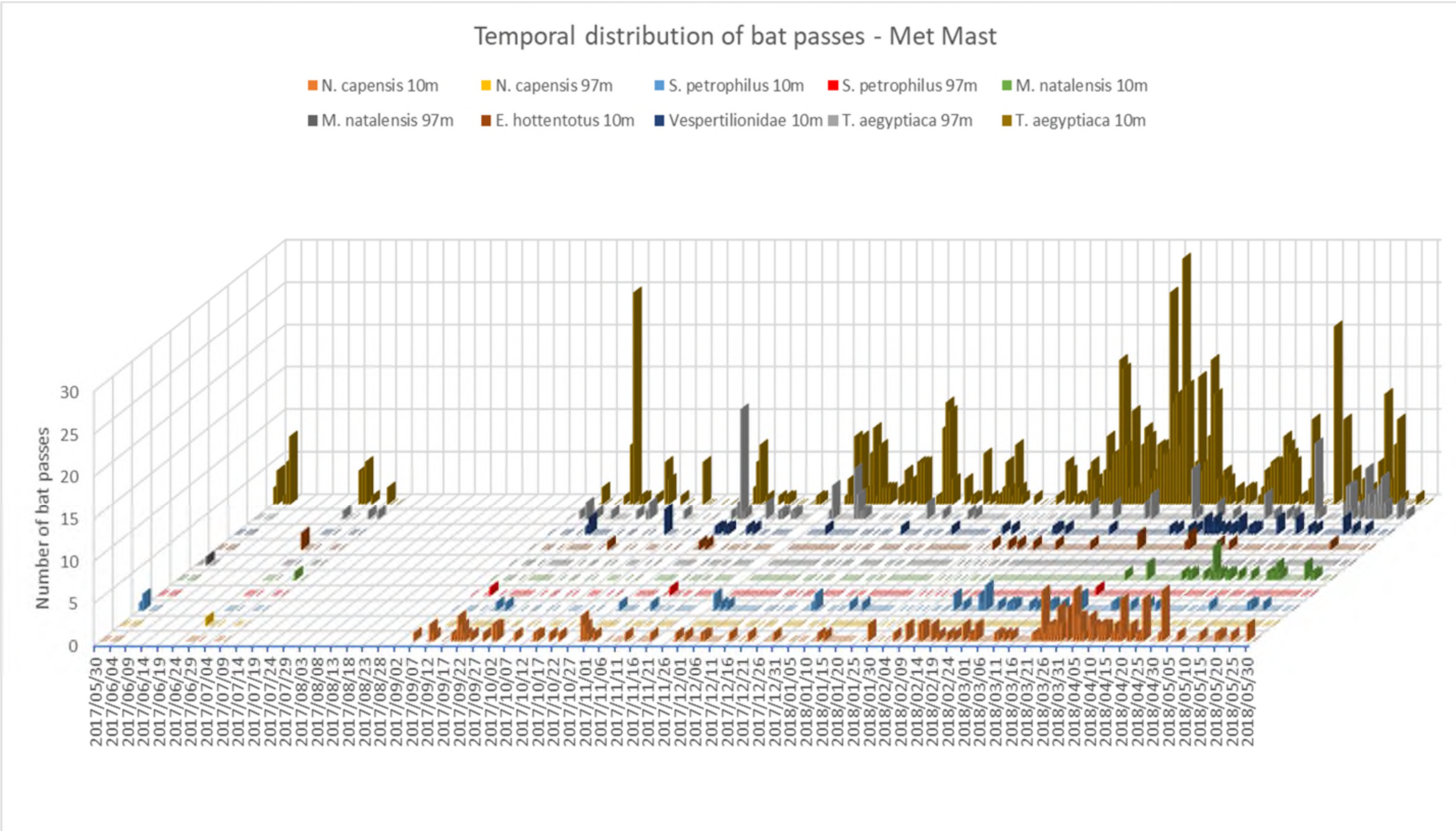


Figure 17: Temporal distribution of bat passes detected at the Met Mast.

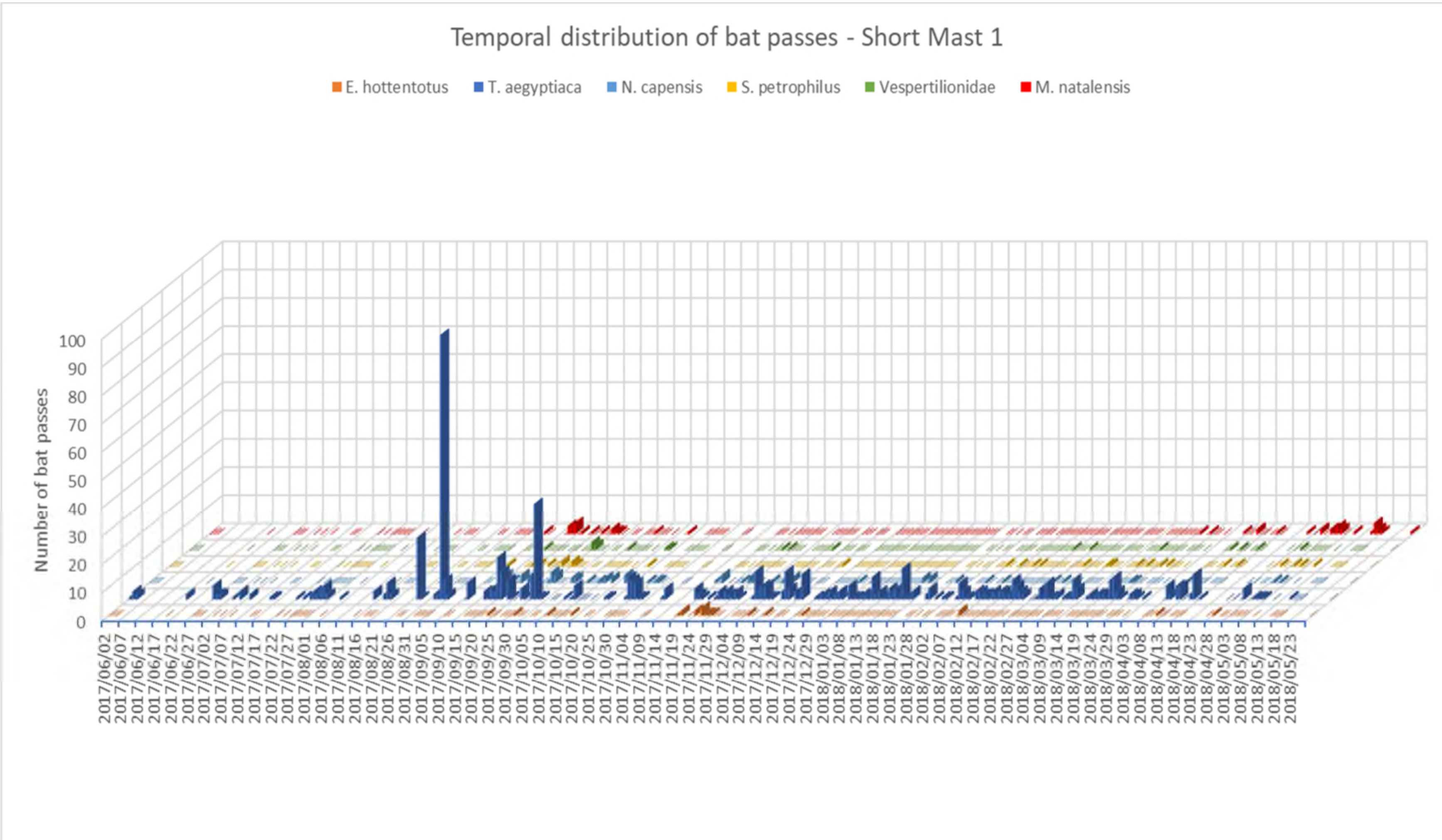


Figure 18: Temporal distribution of bat passes detected at SM1.

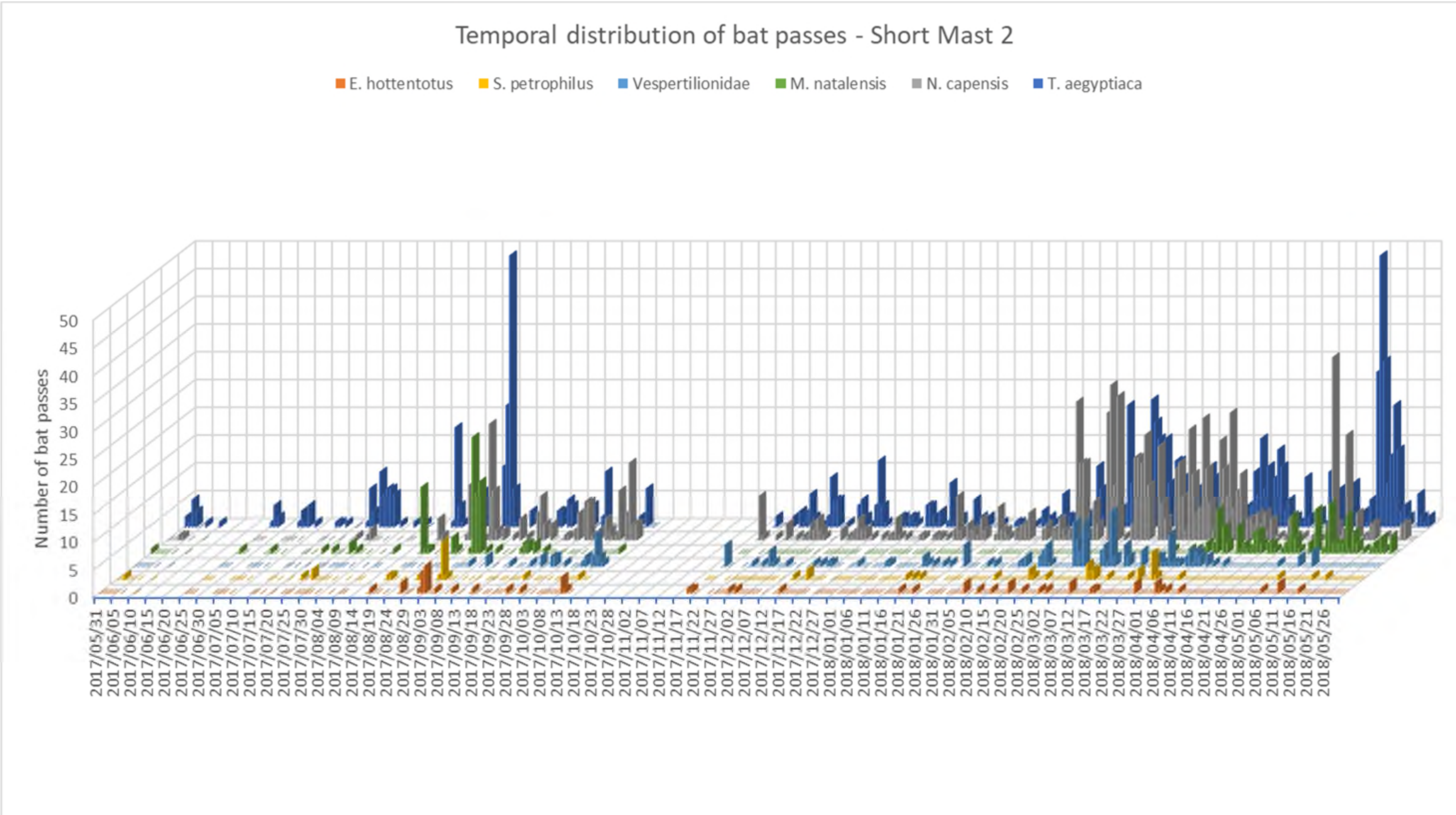


Figure 19: Temporal distribution of bat passes detected at SM2.

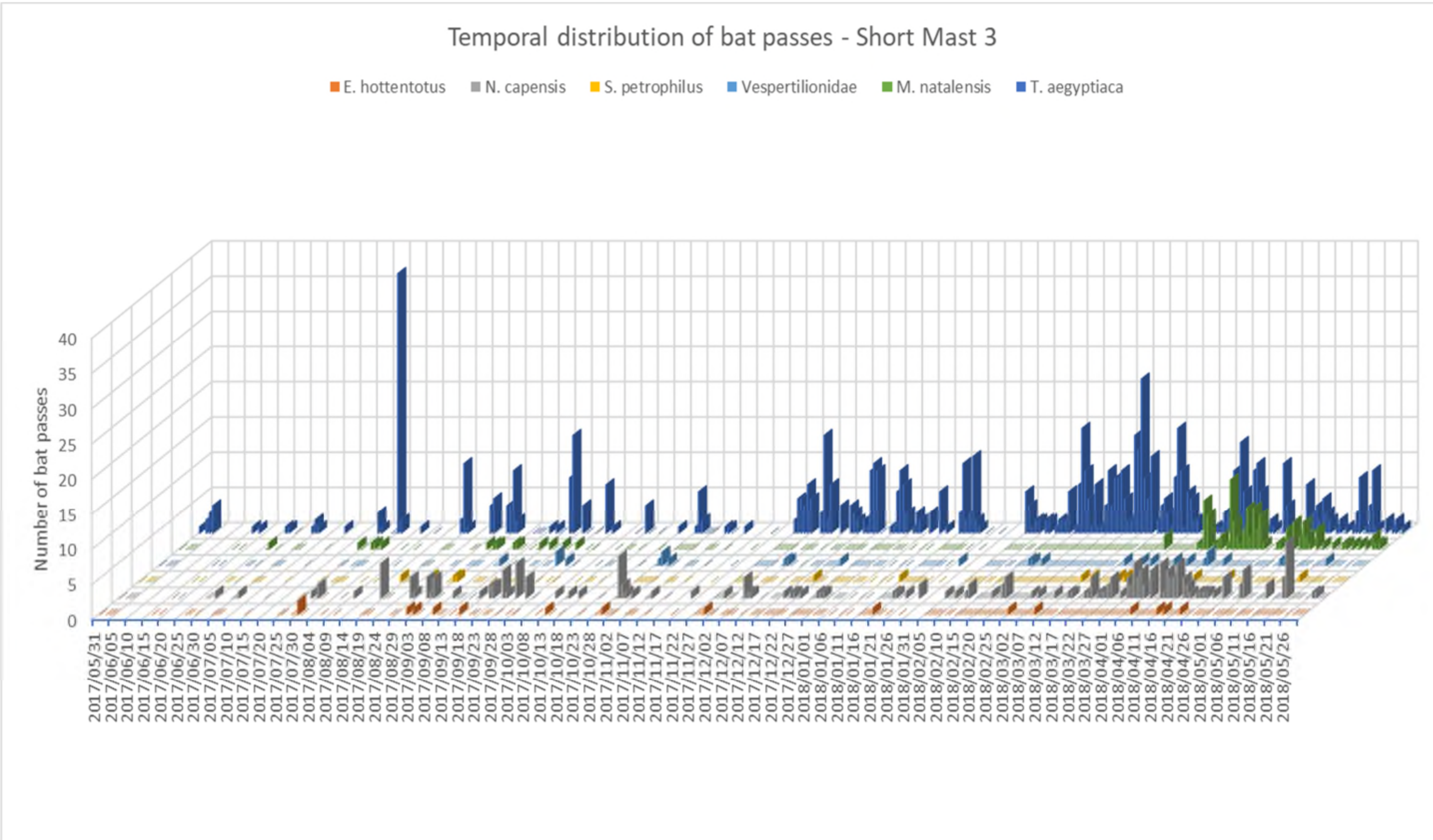


Figure 20: Temporal distribution of bat passes detected at SM3.

4.6.3 Relation between Bat Activity and Weather Conditions

Several sources of literature describe how numerous bat species are influenced by weather conditions (O'Farrell *et al.* 1967, Rachwald 1992, Arnett *et al*. 2010). Weather may influence bats in terms of lowering activity, changing time of emergence and flight time. It is also important to note that the environmental factors are never isolated and therefore a combination of the environmental factors can have synergistic or otherwise contradictory influences on bat activity. For example, a combination of high temperatures and low wind speeds will be more favourable to bat activity than low temperatures and low wind speed, whereas low temperature and high wind speed will be the least favourable for bats. Below are short descriptions of how wind speed, temperature and barometric pressure influences bat activity.

Wind speed

Some bat species show reduced activity in windy conditions. Strong winds have been found to suppress flight activity in bats by making flight difficult (O'Farrell *et al.* 1967). Several studies at proposed wind facilities in South Africa have documented discernibly lower bat activity during higher wind speeds.

Wind speed and direction also affects availability of insect prey as insects on the wing often accumulate on the lee side of wind breaks such as tree lines (Peng *et al.* 1992). At edges exposed to wind, flight activity of insects, and therefore bats may be suppressed and at edges to the lee side of wind bat activity may be greater.

Temperature

Flight activity of bats generally increases with temperature. Flights are of shorter duration on cooler nights and extended on warmer nights. Rachwald (1992) noted that distinct peaks of activity disappeared in warm weather such that activity was mostly continuous through the night. During nights of low temperatures bats intensified foraging shortly after sunset (Corbet and Harris 1991).

Peng (1991) found that many families of aerial dipteran (flies) insects preferred warm conditions for flight. A preference among insects for warm conditions has been reported by many authors suggesting that temperature is an important regulator of bat activity, through its effects on insect prey availability.

The aim of such an analysis will be to determine the wind speed and temperature range within which 80% of bat passes were detected. These values of wind speed and temperature may be used, if found to be necessary during the operation phase, to inform mitigation measures for turbines based on conserving 80% of detected bat passes. This keeping in mind the synergistic or otherwise contradictory effects that the combination of wind speeds and temperatures can have on bat activity. This analysis is not included in this report since bat activity at 97m were too low to provide reliable relationship curves, and therefore the risk of impact in the rotor swept zone is also considered to be low. However, if found during the operational bat mortality monitoring study that bats are being killed in unsustainable numbers, the analysis can be performed with data from the most applicable turbines.

5 IMPACT ASSESSMENT EVALUATION

Tables 11 – 13 below indicate the evaluated impacts associated with the proposed Zonneqwa Wind Farm during the construction and operation phases. No significant impacts are identified for the decommissioning phase.

5.1.1 Construction phase

Table 11: Evaluation of the impact of foraging habitat loss during the construction phase.

Impact	**Destruction of foraging habitat by clearing of vegetation**	
Description of impact	During construction some very limited foraging habitat will inevitably be destroyed to clear ground for the Wind Farm. Apart from the hardstands this includes roads, substations, laydown areas, etc. (especially focusing on vegetation cleared temporarily for construction purposes). However, this impact is not considered to have a significant effect on bat populations. The *Tadarida. aegyptiaca* species found to have a high occurrence on site, have a very wide habitat tolerance and will be able utilise the open spaces on site for foraging.	
	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Short (2)	Short (2)
Magnitude	Minor (2)	Minor (2)
Probability	Definite (5)	Definite (5)
Significance	**Low (25)**	**Low (25)**
Status (Positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation: Rehabilitate cleared vegetation where possible at areas such as laydown yards.		
Residual risks: Disturbed vegetation is minimal and can be rehabilitated, therefore the residual risk is low.		

5.1.2 Operation phase

Table 12: Evaluation of the impact of bat mortalities due to the moving turbine blades during the operation phase.

Impact	**Bat mortalities due to moving turbine blades**

Description of impact	Foraging and/or migrating bats can be killed by moving turbine blades, this happens either by direct impact or due to barotrauma (see Section 2.2).	
	Without mitigation	**With mitigation**
Extent	Medium (3)	Medium (3)
Duration	Long term (4)	Long term (4)
Magnitude	High (8)	Moderate (6)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (45)**	**Low (26)**
Status (Positive or negative)	Negative	Negative
Reversibility	Medium	High
Irreplaceable loss of resources?	Medium	Low
Can impacts be mitigated?	Yes	
Mitigation: Turbine layout adjustments to avoid high sensitivities and their buffers (already implemented), and where needed reducing blade movement at selected turbines and high-risk bat activity times/weather conditions, if the operational bat mortality study find bat mortalities to be above sustainable levels. If reducing blade movements is not technically feasible, alternative and equally effective mitigations should be recommended during the operational bat mortality monitoring study. Acoustic deterrents are developed well enough to be trialled, if needed. Also refer to Section 6 of this report for initial mitigation measures that must be implemented from the start of operation.		
Residual risks: Prolonged mortalities to bats in an area can alter bat population genetics permanently, and also shift species compositions of populations in an area. If impacts are high and unmitigated, the residual effect over time can be high.		

Table 13: Evaluation of the impact of increased likelihood of bat mortalities due to bat attractions by security and/or operational light sources.

Impact	**Increased bat mortalities due to light attraction**	
Description of impact	Security and/or operational lights used close to or on turbines will attract higher insect numbers and thereby attract additional insectivorous bat activity. This will highly increase the likelihood of impacts by turbine blades. This is not applicable to red aviation lights. If not mitigated, all species found to be dominant on site will be significantly impacted since they will all be attracted to the increased insect numbers at outside lights, as opposed to cave dwelling bat species which may be repelled by light sources. Cave dwelling bat species did not occur in high numbers on site. This impact can have detrimental effects if not mitigated, but fortunately it is extremely simple and cost effective to mitigate.	
	Without mitigation	**With mitigation**
Extent	Medium (3)	Medium (3)
Duration	Long term (4)	Long term (4)

Magnitude	High (8)	Minor (2)
Probability	Probable (3)	Very improbable (1)
Significance	**Medium (45)**	**Low (9)**
Status (Positive or negative)	Negative	Negative
Reversibility	Medium	High
Irreplaceable loss of resources?	Medium	No
Can impacts be mitigated?	Yes	
Mitigation: Only use lights with low sensitivity motion sensors that switch off automatically when no persons are nearby, to prevent the creation of regular insect gathering pools.		
Residual risks: Prolonged mortalities to bats in an area can alter bat population genetics permanently, and also shift species compositions of populations in an area. If impacts are high and unmitigated, the residual effect over time can be high.		

6 PROPOSED MITIGATION MEASURES AND DETAILS

The correct placement of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area and have already been applied as the preferred and initial layer for mitigation, since the applicant designed the turbine layout to accommodate the bat sensitivity map through the avoidance of high sensitivity areas. Turbines within moderate sensitivity and moderate sensitivity buffers have a higher likelihood of possibly requiring mitigation, if found to be required by the operational monitoring study.

Additional to mitigation by location of turbines to avoid known highly sensitive areas, other options that may be utilised when necessary include curtailment, blade feathering, blade lock, acoustic deterrents or light lures. The following terminology applies:

Curtailment:

Curtailment is defined as the act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by locking or feathering the turbine blades, with the aim to raise the cut-in speed without free-wheeling.

Cut-in speed:

The cut-in speed is the wind speed at which the generator is connected to the grid and producing electricity. For some turbines, their blades will spin at full or partial Revolutions per Minute (RPMs) below cut-in speed when no electricity is being produced.

Feathering or Feathered:

Feathering refers to adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation. Normally operating turbine blades are angled almost perpendicular to the wind at all times.

Free-wheeling:

Free-wheeling occurs when the blades are allowed to rotate below the cut-in speed or even when fully feathered and parallel to the wind. In contrast, blades can be “locked” and cannot rotate, which is a mandatory situation when turbines are being accessed by operations personnel.

Acoustic deterrents:

This is a developing technology and may be trailed with during wind farm operation, if needed. It works on the principle of emitting ultrasonic noise that creates airspace where bats can’t utilise echolocation effectively. Bats tend to avoid such airspaces.

Increasing cut-in speed:

The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed, and turbines are programmed to be feathered at 90° until the increased wind speed is reached over some average number of minutes (usually 5 – 10 min), therefore triggering the turbine blades to pitch back "into the wind" and begin to spin normally and produce power.

Feathering or blade locking that renders blades motionless below the manufacturers cut-in speed, and don't allow free rotation without the gearbox engaged, is more desirable for the conservation of bats than allowing free rotation below the manufacturer's cut-in speed. This is because bats can still collide with rotating blades even when no electricity is being produced.

Currently the most effective method of mitigation, after correct turbine placement, is alteration of blade speeds under environmental conditions favourable to bats.

A basic "6 levels of mitigation" (by blade manipulation or curtailment), from light to aggressive mitigation is structured as follows:

1. No curtailment (free-wheeling is unhindered below manufacturer's cut-in speed so all momentum is retained, thus normal operation).
2. Partial feathering (45-degree angle) of blades below manufacturer's cut-in speed in order to allow the free-wheeling blades half the speed it would have had without feathering (some momentum is retained below the cut-in speed).
3. Ninety-degree feathering of blades below manufacturer's cut-in speed so it is exactly parallel to the wind direction as to minimise free-wheeling blade rotation as much as possible without locking the blades.
4. Ninety-degree feathering of blades below manufacturer's cut-in speed, with partial feathering (45-degree angle) between the manufacturer's cut-in speed and mitigation cut-in conditions.
5. Ninety-degree feathering of blades below mitigation cut-in conditions.
6. Ninety-degree feathering throughout the entire night.

It is recommended that Level 3 mitigation be applied to all turbines on site from the start of operation, from sunset until sunrise every night for the months of March, April, May, August and September. This implies 90-degree feathering below the manufacturer's cut in speed to minimise free-wheeling, which does not result in high production loss but can lessen the likelihood of bat impacts significantly. If this mitigation is not technically feasible, based on the model of turbine to be used, the bat specialist conducting the operational bat mortality study must recommend a technically feasible alternative. The specialist conducting the operational bat mortality monitoring may also after the first year of operational monitoring recommend Level 3, or other required mitigations, to be applied to selected turbines only, based on the bat mortality results. This is an adaptive management approach and the effectiveness of the adaptive management will have to be determined during the second year of the operational monitoring study.

In the event that the Zonneqwa Wind Farm is approved, a minimum of 2 years of operational bat mortality monitoring must be conducted, initiating from the start of the facility's operation.

7 CUMULATIVE IMPACTS FROM NEARBY WIND FARMS

Other operationg wind farms or proposed wind farms with valid environmental authorisations within a radius of 30km from the site are depicted in **Figure 21** below. All facilities shown have received environmental authorisation or is in the process of obtaining an environmental authorisation, to the best current knowledge of the specialist. All of the facilities indicated in **Figure 21** fall mostly within the Succulent Karoo ecoregion, with a small patch of Montane Fynbos and Renosterveld in the proposed Kap Vley facility. All surrounding facilities have bat sensitivity maps compiled and this can allow for continous natural bat foraging habitat and movement corridors through the facilities by avoidance of high sensitivities.

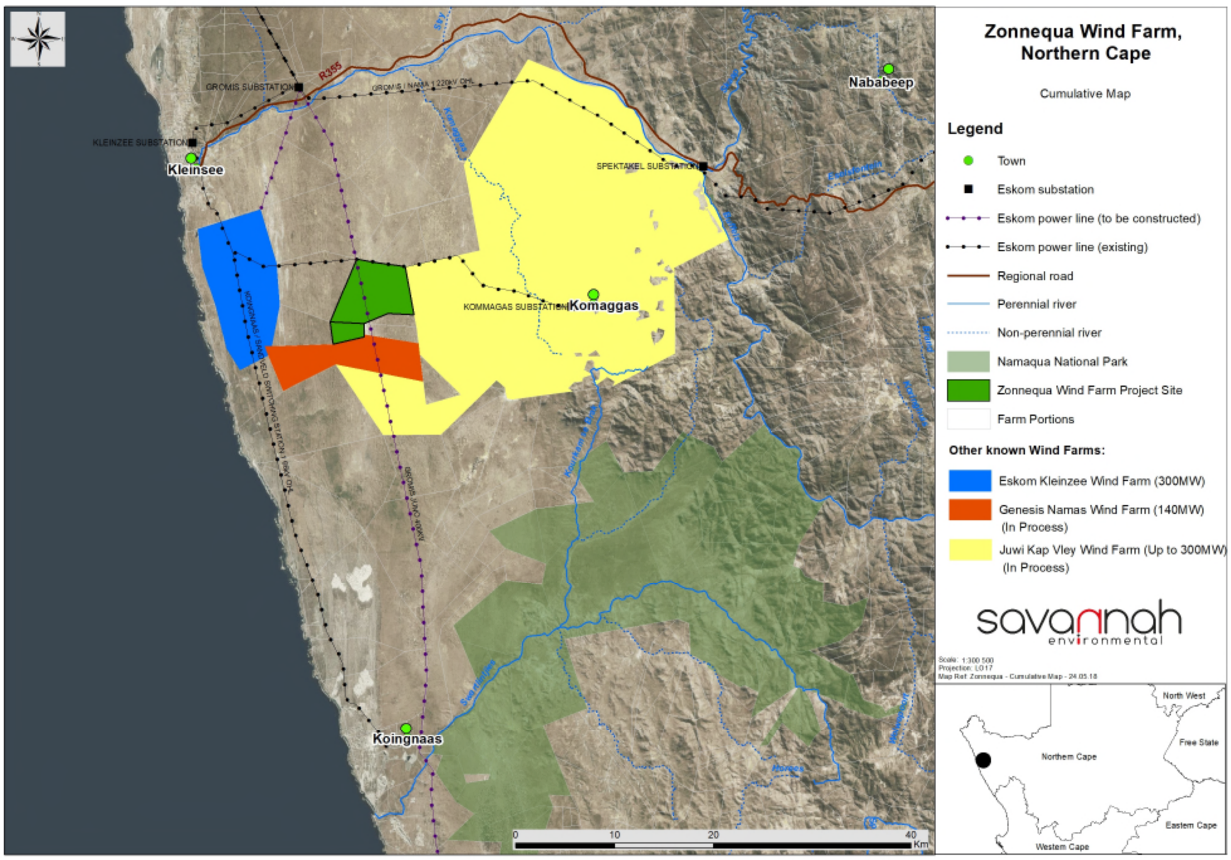


Figure 21: Neighbouring and nearby proposed and approved wind farms in relation to the proposed Zonnequa Wind Farm site.

Table 15 below indicates the current bat impact risk for each site, which is related to the ecoregion it belongs to. The table also indicates the overal averages without and with the proposed Zonnequa Wind Farm. This is according to the "Estimated turbine related bat fatality risk levels based on bat activity levels for different terrestrial ecoregions" (**Table 14**) as depicted in the "South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1" (Sowler *et al*., 2017). The data of bat activity was retrieved from the relevant specialist reports where available.

Table 14: Estimated turbine related bat fatality risk levels based on bat activity levels for different terrestrial ecoregions (Sowler *et al*., 2017)

Risk Level*	Annual average ranges of mean number of bat passes per hour per Terrestrial Ecoregion (Olson et al. 2001) at 60m						
	Montane Fynbos & Renosterveld	Lowland Fynbos & Renosterveld	Succulent Karoo	Nama Karoo	Drakensberg Montane Grasslands, Woodlands and Forest	KwaZulu-Cape Coastal Forest Mosaic	Maputuland Coastal Forest Mosaic**
Low	0.0 – 0.17	0.0 – 0.55	0.0 – 0.07	0.0 – 0.71	0.0 – 0.22	0.0 – 14.60	0.12 – 28.59
Medium	0.18 – 0.31	0.56 – 0.86	0.08 – 0.13	0.72 – 1.15	0.23 – 0.35	14.61 – 19.84	28.60 – 34.53
High	> 0.31	> 0.86	> 0.13	> 1.15	> 0.35	> 19.84	> 34.53

Table 15: Bat impact risks for the Zonnequa Wind Farm and surrounding facilities.

Wind Farm	Highest average bat passes/ hour/ year (>40m above ground)	Risk Level (Sowler *et al.*, 2017)
Eskom Kleinsee	0.60	High
Juwi Kap Vley	0.03	Low
Genesis Namas	0.04	Low
Average of facilites without Namas	**0.22**	**High**
Zonnequa	0.04	Low
Average of facilites with Namas	**0.18**	**High**

It's important to note that several limitations and inconsistencies exist between sites on the overall total bat passes of each site. This includes specialist methodology and type of bat detectors used, recording conditions and locations of bat detectors. Actual mortality monitoring data from the area will be capbale of informing the impacts more accurately.

Table 16 below considers the impact significance for the most applicable cumulative impact of bat mortaltities due to blade colisions or barotrauma, during the operation phase.

Table 16: Significance statement for the impact of bat mortalities due to direct blade impact or barotrauma on a cumulative scale.

Impact	**Bat mortalities due to moving turbine blades - Cumulative**	
Description of impact	Foraging and/or migrating bats can be killed by moving turbine blades, this happens either by direct impact or due to barotrauma (see Section 2.2). Local extinctions of populations can occur in an area if the impacts are very severe. Mortalities of bats due to wind turbines during foraging and migration can have significant ecological consequences as the bat species at risk are insectivorous and thereby contribute significantly to the control of flying insects at night. On a project specific level insect numbers in a certain habitat can increase if significant numbers of bats are killed off. But if such an impact is present on multiple projects in close vicinity of each other, insect numbers can increase regionally and possibly cause outbreaks of colonies of certain insect species.	
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Regional (4)	Regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	Moderate (6)	High (8)
Probability	Improbable (2)	Probable (3)
Significance	**Low (28)**	**Medium (48)**
Status (Positive or negative)	Negative	Negative
Reversibility	High	Medium
Irreplaceable loss of resources?	Low	Medium
Can impacts be mitigated?	Yes	Yes
Mitigation: All facilities in the area must avoid high sensitivities and their associated buffers during turbine layouts (already implemented for the Zonnequa Wind Farm), and where needed reducing blade movement at selected turbines and high-risk bat activity times/weather conditions, if the operational bat mortality study find bat mortalities to be above sustainable levels. If reducing blade movements is not technically feasible, alternative and equally effective mitigations should be recommended during the operational bat mortality monitoring study. Acoustic deterrents are developed well enough to be trialled, if needed. Also refer to Section 6 of this report for initial mitigation measures that must be implemented from the start of operation. Each facility needs to adhere to its specific recommended mitigation measures.		
Residual risks: Prolonged mortalities to bats in an area can alter bat population genetics permanently, and also shift species compositions of populations in an area. If impacts are spread over a larger area, high and unmitigated, the residual effect over time can be detrimental.		

It is logical to deduce that an increased number of facilities in an area will increase the risk levels of impacts on bats. But in **Table 15** it should be noted that the area in between facilities within the 30km has not been considered (this can only be done meaningfully with actual mortality numbers), and these areas contribute towards the support of a much larger bat population. Therefore, the risk level decreased slightly with the addition of the Zonnequa facility.

Ultimately it remains the responsibility of each wind farm to apply appropriate mitigations where needed and to lower their risk levels and estimated impacts to acceptable sustainability thresholds. This will lower the overall cumulative impact of all wind farms in the area. If all recommendations are adhered to the development of the Zonnequa Wind Farm is acceptable from a cumulative perspective.

8 CONCLUSION

Five bat species were detected namely *Miniopterus natalensis, Neoromicia capensis, Eptesicus hottentotus, Sauromys petrophilus* and *Tadarida aegyptiaca* by the passive systems and during the driven transects. The *T. aegyptiaca* (Egyptian Free-tailed bat) were the most dominant at all passive recording systems. Although this species has a conservation status of least concern, such abundant species are of a large value to the local ecosystems as they provide a greater contribution to most ecological services than the rarer species, due to their higher numbers.

The monitoring systems detected the migratory species, *Miniopterus natalensis.* The species displayed seasonal peaks that coincided with the peaks in activity of other bat species on site, except at SM2 the seasonal peak was slightly later in autumn. This is not clearly evident of a migration event, however the possibility still exists that the species move into the area in late autumn, but may not necessarily be at risk of impact since its activity at 97m was only 1 bat pass for the entire 12 months of monitoring.

The annual average mean number of bat passes per hour for the met mast system is indicating a Low Risk level for bat impacts at 97m with 0.04 average passes per hour, and a High Risk at 10m with 0.34 average passes per hour. The highest annual average mean number of bat passes per hour was at SM2 at 10m with 0.86 average passes. Above 0.13 is considered to be High potential risk, and below 0.07 is considered Low potential risk. This is according to the "Estimated turbine related bat fatality risk levels based on bat activity levels for different terrestrial ecoregions" as depicted in the "South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1" (Sowler *et al.*, 2017).

The site displays a very strong gradient of bat activity levels with height above ground, where the met mast detected 7.7 times less bats at 97m than at 10m (**Figure 11**). These activity gradients are in general exponential meaning the activity becomes progressively less with height. This indicates that higher and larger turbine models, with a higher lowest rotor swept height, can significantly reduce the risk of impacts on bats. The minimum proposed turbine dimensions with a hub height of 130m and a rotor diameter of 150m, effectively sets the lowest possible rotor swept height above ground at 55.5m. But it is very likely that the applicant may use larger and more effective turbines.

A sensitivity map was compiled indicating potential roosting and foraging areas. **Table 6** indicates the different type of features used to inform the map. Upon investigation of some of these features on site, their level of sensitivity was adjusted. Short Mast 2 detected the highest bat activity, likely since it is located near a high sensitivity. The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity.

High Bat Sensitivity areas and their buffers are 'no – go' areas due to expected elevated rates of bat fatalities due to wind turbines. Turbines within Moderate Bat Sensitivity areas and their buffers have a higher likelihood to cause fatality in some instances that mitigation measures may need to be applied to them. The applicant designed the turbine layout to avoid High Bat Sensitivities and their buffers.

It is logical to deduce that an increased number of facilities in an area will increase the risk levels of cumulative impacts on bats. The addition of the Zonnequa Wind Farm will also possibly increase cumulative effects, although undisturbed areas exist between the wind farms where bat populations can be supported and overall a much larger bat population is considered in cumulative assessments. The Zonnequa Wind Farm displays a low risk of impacts to bats, and ultimately it remains the responsibility of each wind farm to apply mitigations where needed and to lower their risk levels and estimated impacts below acceptable sustainability thresholds. This will lower the overall cumulative impact of all wind farms in the area.

It is recommended that Level 3 mitigation (See Section 6) be applied to all turbines on site from the start of operation, from sunset until sunrise every night for the months of March, April, May, August and September. This implies 90-degree feathering below the manufacturer's cut in speed to minimise free-wheeling, which does not result in high production loss but can lessen likelihood of bat impacts significantly. If this mitigation is not technically feasible, based on the model of turbine to be used, the bat specialist conducting the operational bat mortality study must recommend a technically feasible alternative. The specialist conducting the operational bat mortality monitoring may also, after the first year of operational monitoring, recommend Level 3, or other required mitigations, to be applied to selected turbines only, based on the bat mortality results. This is an adaptive management approach and the effectiveness of the adaptive management will have to be determined during the second year of the operational monitoring study.

In the event that the Zonneqwa Wind Farm is approved, a minimum of 2 years of operational bat mortality monitoring must be conducted, initiating from the start of the facility's operation.

Considering the findings of the pre-construction monitoring study and the impact assessment, it is the reasoned opinion of the specialist that the development of the Zonnequa Wind Farm is acceptable within the proposed site, from a bat impact perspective. This is subject to the implementation of the recommended mitigation measures.

9 REFERENCES

African Chiroptera Report, 2016. *African Bats, Pretoria.*

Baerwald, E. F., D'Amours, G. H., Klug, B.J. and Barclay, R. M. R. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. *Current Biology* 18: 695-695.

Barclay, R. M. R., Baerwald, E. F., and Gruver, J. C. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85: 381-387.

Hester, S. G. and Grenier, M.B. 2005. *A conservation plan for bats in Wyoming*. Lander, WY: Wyoming Game and Fish Department, Nongame Program.

Horn, J. W., Arnett, E. B. and Kunz, T.H. 2008. Behavioural responses of bats to operating wind turbines. *Journal of Wildlife Management* 72: 123-132.

Howe, R. H., Evans, W. and Wolf, A. T. 2002. Effects of wind turbines on Birds and Bats on Northeastern Wisconsin. Report submitted to *Wisconsin Public Service Corporation and Madison Gas and Electric Company*.

Johnson, G. D., Erickson, W. P., Stickland, M. D., Shepherd, M. F., Shepherd, D. A. and Sarappo, S. A. 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. *The American Midland Naturalist Journal* 150: 332-342.

Kunz, T. H., Arnett, E. B., Erickson, W. P., Hoar, A. R., Johnson, G. D., Larkin, R. P., Strickland, M. D., Thresher, R. W., Tuttle, M. D. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypothesis. *Frontiers in Ecology and the Environment* 5: 315-324.

Lynch, C. D. 1989. The mammals of the north-eastern Cape Province. *Mem. Nas. Mus. Bloemfontein* 25: 1-116.

MacEwan, K., Aronson, J., Richardson, E., Taylor, P., Coverdale, B., Jacobs, D., Leeuwner, L., Marais, W., Richards, L. September 2017. South African Bat Fatality Threshold Guidelines for Operational Wind Energy Facilities – ed 1. *South African Bat Assessment Association*.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. & Schoeman, M.C. 2010. Bats of southern and central Africa – A biogeographic and taxonomic synthesis, Ultra Litho (Pty) Ltd, Johannesburg.

Mucina, L. and Rutherford, M. C. 2006. The Vegetation of South Africa, Lesotho and Swaziland-*Strelitzia 19,* South African National Biodiversity Institute, Pretoria.

Neuweiler, G. 2000. *The Biology of Bats*. Oxford University Press.

O'Shea, T. J., Bogan, M. A. and Ellison, L. E. 2003. Monitoring trends in bat populations of the United States and territories: Status of the science and recommendations for the future. *Wildlife Society Bulletin*, 31: 16-29.

Rautenbach, I.L. 1982. *Mammals of the Transvaal*. Pretoria: Ecoplan.

Sowler, S., Stoffberg, S., MacEwan, K., Aronson, J., Ramalho, R., Forssman, K., Lötter, C. 2017. South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1. *South African Bat Assessment Association*.

Taylor, P. J. 2000. Bats of southern Africa, University of Natal Press, Pietermaritzburg.

Tuttle, M. D. and Hensley, D. L. 2001. *The Bat House Builder's Handbook*. (BCI) Bat Conservation International.

van der Merwe, M. 1979. Growth of ovarian follicles in the Natal clinging bat. *South African Journal of Zoology* 14: 111-117.

van der Merwe, M. 1994. Reproductive biology of the Cape serotine bat, *Eptesicus capensis,* in the Transvaal, South Africa. *South African Journal of Zoology* 29: 36-39.

Vincent, S., Nemoz, M. and Aulagnier, S. 2011. Activity and foraging habitats of *Miniopterus schreibersii* (Chiroptera: Miniopteridae) in southern France: implications for its conservation. *The Italian Journal of Mammalogy* 22: 57-72.

Werner Marais

Zoologist and Ecologist

MSc Biodiversity & Conservation

Pr.Sci.Nat. – SACNASP registration no. 400169/10

(Zoological Science)

DISCLAIMER

The services carried out and reported in this document have been done as accurately and scientifically as allowed by the resources and knowledge available to Animalia Consultants (Pty) Ltd at the time on which the requested services were provided to the client. Animalia Consultants (Pty) Ltd reserves the right to modify aspects of the document including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

Although great care and pride have been taken to carry out the requested services accurately and professionally, and to represent the relevant data in a clear and concise manner; no responsibility or liability will be accepted by Animalia Consultants (Pty) Ltd. And the client, by receiving this document, indemnifies Animalia Consultants (Pty) Ltd and its staff against all claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by Animalia Consultants (Pty) Ltd; and by the use of the information contained in this document. The primary goal of Animalia's services is to provide professionalism that is to the benefit of the environment as well as the community.