APPENDIX

H-3 BATS

Bat Environmental Impact Assessment (EIA) Report

for

12-Month Pre-construction Bat Monitoring

For the proposed Mukondeleli Wind Energy Facility (WEF) Mpumalanga, South Africa

ANiMALiA

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For:	Bat Pre-Application (Scoping) Impact Assessment Report for 12-Month Pre-construction Bat Monitoring

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Applicable Legislation

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

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; Especially 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 attention, in addition to those listed as Threatened or Protected.

THE SOUTH AFRICAN BEST PRACTICE GUIDELINES for preconstruction studies recommends sensitivity map buffer rules and mitigation by avoidance. MacEwan, K., Sowler, S., Aronson, J., and Lötter, C. 2020. *South African Best Practice Guidelines for Pre-construction Monitoring of Bats at Wind Energy Facilities - ed 5*. South African Bat Assessment Association.

THE BAT MORTALITY THRESHOLD GUIDELINES imposes sustainable bat mortality thresholds for operating wind farms, indicating when wind farms need to apply active mitigation measures. MacEwan, K., Aronson, J., Richardson, E., Taylor, P., Coverdale, B., Jacobs, D., Leeuwner, L., Marais, W., Richards, L. 2018. *South African Bat Fatality Threshold Guidelines – ed 2*. South African Bat Assessment Association.

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Abbreviation	Explanation
ACR	African Chiroptera Report
BESS	Battery Energy Storage System
DEA	Department of Environmental Affairs
DMRE	Department of Mineral Resources and Energy
EIA	Environmental Impact Assessment
IRP	Integrated Resource Plan
MM	Meteorological ("Met") Mast
REC	Renewable Energy Complex
REF	Renewable Energy Facility
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SABAA	South African Bat Assessment Association
SEA	Strategic Environmental Assessment
ShM	Short Mast (passive bat detection system)
WEF	Wind Energy Facility
COD	Commercial Operation Date
Bp/h	Bat passes per hour

NEMA Requirements

The content of a specialist report is specified in the EIA Regulations GN R. 982, as amended (4 Dec 2014) Appendix 6. A specialist report prepared in terms of these Regulations must contain:

NEMA Requirement	Section/page in report
Details of the specialist who prepared the report, and the expertise of that specialist to compile a specialist report including a curriculum vitae.	Separate Curriculum Vitae
A declaration that the specialist is independent in a form as may be specified by the competent authority.	Page iii
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1
An indication of the quality and age of the base data used for the specialist report.	Sections 3; 4
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Sections 4; 5
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3
A description of the methodology adopted in preparing the report or carrying out the specialised process, inclusive of equipment and modelling used.	Section 3
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure.	Section 5
An identification of any areas to be avoided, including buffers.	Section 4.6
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 4.6
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 3.4

A description of the findings and potential implications of such findings on the impact of the proposed activity, or activities.	Sections 4 and 5
Any mitigation measures for inclusion in the EMPr.	Sections 6, 7 and 8
Any conditions for inclusion in the environmental authorisation.	Sections 5, 6, 7 and 8
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 5, 6 and 7
A reasoned opinion whether the proposed activity or portions thereof should be authorised, and regarding the acceptability of the proposed activity or activities. And if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr.	Sections 5, 6, 7 and 8
A description of any consultation process that was undertaken during the course of preparing the specialist report.	Sections 3

1 OBJECTIVES AND TERMS OF REFERENCE FOR THE STUDY

The objectives and terms of reference for the impact assessment are to provide the following:

- A description of the baseline characteristics and conditions of the receiving environment (e.g., site and/or surrounding land uses including urban and agricultural areas).
- An identification and evaluation of the predicted impacts of the project on the receiving environment.
- An assessment of the probability of each impact occurring, and the significance of each potential impact.
- Consider and evaluate the cumulative impacts in terms of the current and proposed WEF activities in the area.
- Recommendations to avoid negative impacts, as well as feasible and practical mitigation, management and/or monitoring options to reduce negative impacts that can be included in the EMPr
- A reasoned opinion as to whether the proposed activity, or portions of the activity should receive Environmental Authorisation (EA).

2 INTRODUCTION

This document is the bat EIA Report utilising the 12-month pre-construction bat assessment data for the proposed Mukondeleli Wind Energy Facility completed by Animalia Consultants (Pty) Ltd.

2.1 Project description

Mukondeleli Wind RF (Pty) Ltd is proposing to develop the Mukondeleli Wind Energy Facility (WEF), with a maximum export capacity of up to 300 MW, located in the Govan Mbeki Municipality in the Mpumalanga Province of South Africa. The proposed WEF and associated infrastructure are subject to a full Scoping and EIA process in terms of the 2014 NEMA EIA Regulations, as amended.

The proposed Mukondeleli WEF and associated infrastructure include the following components:

- Up to 54 wind turbine generators (WTGs) with a maximum capacity of up to 300 MW.
- Turbines with a hub height of up to 200 m and a rotor diameter of up to 200m.
- Hardstand areas of approximately 1 500m^2 per turbine.
- Temporary construction laydown and storage area of approximately 4 500m^2 per turbine.
- Medium voltage cabling connecting the turbines will be laid underground.
- It is proposed that Lithium Battery Technologies, such as Lithium-Ion Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology; however, the specific technology will only be determined following Engineering, Procurement and Construction (EPC) procurement.A solid state Lithium-ion Battery Energy Storage System (BESS) comprising of several utility scale battery modules within shipping containers or an applicable housing structure on a concrete foundation.
- Internal roads with a width of up to 10 m providing access to each turbine, the BESS, on-site substation (SS), step-down SS and laydown area. The roads will accommodate cable trenches and stormwater channels (as required) and will include turning circle/bypass areas of up to 20 m at some sections during the construction phase. As such, the roads and cables will be positioned within a 20 m wide corridor. Existing roads will be upgraded wherever possible, although new roads will be constructed where necessary.
- A temporary construction laydown/staging area of approximately 4.5 hectares (ha) which will also accommodate the operation and maintenance (O&M) buildings.
- A 33/132kV on-site SS to feed electricity generated by the proposed Mukondeleli WEF into the step-down SS with protection and metering.

In addition to the wind turbines to be installed on the project site, the proposed development also comprises a 132 kV overhead power line and a step-down SS to feed the electricity generated by the project into the proposed Green Hydrogen Electrolyser facility located at Sasol Secunda which is between 5 and 10 km from the on-site SS. The 132 kV power line and step-down SS at Sasol is subject to a separate Basic Assessment Application to be undertaken by the applicant.

Table 2-1. Key technical details for the Mukondeleli WEF

Component	Description / Dimensions
Site coordinates (centre point)	Lat 26°37'34.04"S; Long 29°10'24.53"E
Affected farm portion/s	Bosjesspruit 291 (Portions 0, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 14 and 56) Van Tondershoek 317 (Portions 1, 2, 7, 8, 11 and 12) Brandspruit 318 (Portions 1 and 9) Tweefontein 321 (Portions 5 and 6)
Application site area	Approximately 3 6~~1~~00 ha
Total project footprint area (including the internal roads, but excluding access roads leading to the site)	TBC
Total WEF capacity	Up to 300 MW
BESS capacity	Up to 3~~1~~00 MW/~~4~~1200 MWh
Proposed technology	Wind turbines and associated infrastructure, including a ~~Lithium-ion~~ BESS
Number of turbines	Up to 54 turbines
Turbine hub height from ground	Up to 200m
Turbine rotor diameter	Up to 200m
Turbine blade length	Up to 100m
Height of BESS	Approximately 5-10m
Height of the on-site Substation	Approximately 7 – 10m Up to 22 m (including lighting)
On-site SS and BESS complex area	Approximately 4 ha
Construction laydown area	Approximately 43 ha
Permanent laydown area	To be determined based on the final layout
O&M building area	Part of the construction laydown area
Turbine hardstand area	Approximately 1 500m² per turbine
Width of internal access roads	Up to 10m, including turning circle/bypass areas of up to 20m. The roads and cables will be positioned within a 20m wide corridor.
Length of internal access roads	To be determined based on the final layout
Site access	R546
Grid connection and proximity	Connection to step-down substation (to be built at Sasol facility) Approximately 17km
Height of substation fencing	Up to 3m high
Type of fencing	Galvanised steel

Port of entry for the wind turbines

The wind turbines are to be shipped to the Durban or Richards Bay port, both ports are approximately 500km away from the site.

Construction timeframe

The anticipated timeframe is a minimum of 36 months.

Services to be accommodated on site

Below are the list of services, facilities and manpower required during construction:

- Changing rooms;
- Sanitary facilities (hand washing basins, toilets, showers);
- Potable water facilities;
- Canteen or similar space with adequate ventilation and cooling for personnel to have breaks lunch;
- Sewage and wastewater facility;
- Emergency room equipped for first aid;
- Site manager's office equipped with printer, scanner, Wi-Fi connection, HVAC system;
- Security office with surveillance monitors, suitable data and phone connection and HVAC system;
- Septic tank;
- Wheel washing facilities at the entrance of the site for trucks and cars;
- Storage container for minor parts;
- Car parks;
- Loading / unloading and storage area; and
- Security facilities.

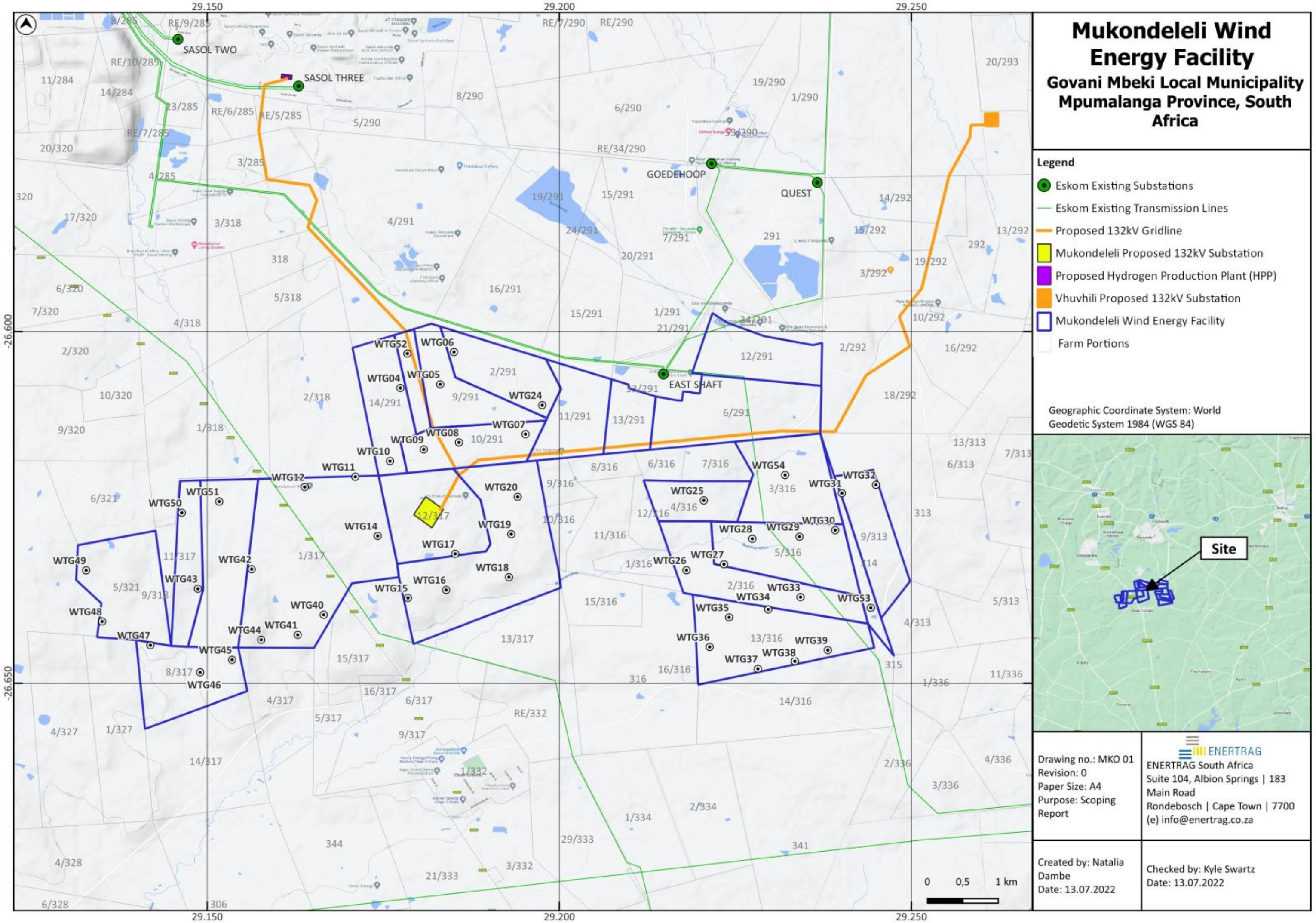

Figure 2-1. Proposed turbine layout of the Mukondeleli WEF.

2.2 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 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 lifestyles, particularly in relation to various 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 obscures 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 species of bats 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 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. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity of up to 30 years (O'Shea *et al.* 2003) and the relatively low predation of bats when compared to other small mammals. However, bat populations are not able to adequately recover after mass mortalities and major roost disturbances.

2.3 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 hypothesized 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.

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 dependency of a bat on each of these factors is subject to 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. 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 turbines, also encouraging the presence of bats. The presence of lights on wind turbines has also been identified as a possible cause for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect activity and subsequent increased 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. The swishing sound of turbine blades has also been proposed as a possible source for disorientation in bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may additionally affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesized, from 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.

South African operational monitoring studies currently point to South African bats being just as vulnerable to mortality from turbines as international studies have previously indicated. The main species of concern are *Laephotis capensis*, *Tadarida aegyptiaca* and *Miniopterus natalensis,* on this site and in general. They will be discussed in depth in this report (Section 4.3).

Whatever the reason for bat fatalities in relation to wind turbines, it is clearly a significant ecological problem which requires attention. Most bat species only reproduce once per year, bearing one young per female, thus 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). Various mitigation measures are being researched and experimented with globally. The implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed, has been proven to be the most effective mitigation measure currently. 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 anyways. The impact on bats foraging in the area will be higher when uncurtailed turbine blades are left to turn slowly in low wind speeds; it is a misperception that faster turning blades present a higher mortality risk.

A cautionary tale regarding the cumulative impacts that wind energy is able to exert on bat populations is provided through the case study of the hoary bat (*Lasiurus cinereus*). This bat is a common, migratory species across much of the Americas and is currently listed as Least Concern (Gonzalez *et al*. 2016). However, it is also the most frequently encountered victim of fatality around turbine stands in North America. Using population modelling, it has been calculated that hoary bats could decline by as much as 90% over the next 50 years, assuming static population growth rates, and allowing for the current expansion of the wind energy industry in the United States and Canada (Frick *et al*. 2017). There has been an urgent call to curb hoary bat deaths on account of wind farms before the risk of extinction escalates.

It is important from both a conservation and an ecological standpoint to maintain the abundance of even our common species, especially given the scale of wind energy prospecting occurring in South Africa at present.

2.4 Bats and Power lines

There exists no evidence of powerlines in South Africa impacting bats during their operational phase. Theories suggest that electromagnetic energy around high voltage power lines can influence bat navigation, but this has not been proven. However, during construction of the powerline pylons, earthworks and blasting may damage or destroy underground bat caves should such pylons be positioned on top of bat caves.

3 METHODOLOGY

3.1 Literature-based and On-site Inspections

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 principally by briefly studying the geographic literature of each site, available satellite imagery and by ground-truthing with site visits. The probability of occurrence based on the above-mentioned factors are estimated for the species both expected and confirmed on site as well as the larger surrounding area.

3.2 Passive Monitoring

Several site visits were made to the Mukondeleli WEF between November 2020 and February 2022. Passive data are available from this period. Passive data can ground truth bat sensitivity features and habitats delineated in the bat sensitivity constraints map and collect bat activity data for different seasons.

Passive bat detection systems (**Figure 3-1**) were set up on a meteorological mast (Met Mast) with microphones at 10m, 55m and 110m. The equipment setup is detailed in **Table 3-1** below. Additionally, a short mast bat detection system was also set up, with a microphone at 7m (ShM). These systems were set to gather bat activity data every night for 12 months to form part of the long-term pre-construction monitoring and inform the EIA study. The data from the four passive systems is fully analysed and discussed in **Section 4.5.**

The data were analysed by classifying (as near to species level as possible) and counting positive bat passes detected by the systems. 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 >1 000ms period between pulses. These bat passes are summed into hourly intervals which are used to calculate nocturnal distribution patterns over time. Times of sunset and sunrise are automatically adjusted with the time of year. Nightly bat totals over time are useful for displaying abrupt peaks in activity on specific nights or short time periods, and to visually represent the spread of bat activity over the monitoring period. This may assist in developing mitigation schedules, if required during operation.

Table 3-1. Equipment setup and site visit information.

Site visit dates	Setup	18 – 20 Nov 2020 (Met Mast) 13 – 15 Dec 2020 (Short Mast)
	Interim visit 1	11 – 13 January 2021
	Season 1 site visit	18 – 20 February 2021
	Interim visit 2	17 – 19 March 2021
	Interim visit 3	17 – 19 April 2021
	Season 2 site visit	26 – 29 May 2021
	Interim visit 4	11 – 13 June 2021
	Interim visit 5	28 – 31 July 2021
	Season 3 site visit	28 – 31 Aug 2021
	Interim visit 6	1 – 3 Oct 2021
	Interim visit 7	17 – 19 Nov 201
	Season 4 site visit	12 – 16 Dec 2021
Met mast passive bat detection systems	Quantity on site	1
	Microphone heights	10m, 55m, 110m
Short mast passive bat detection systems	Quantity on site	1
	Microphone height	7m

Type of passive bat detector	SM4BAT Full Spectrum
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)	1 000ms (1 second)
Microphone gain setting	12dB
Compression	W4V-8
Single memory card size (each system uses 4 cards)	64GB
Battery size	17Ah; 12V
Solar panel output	10 Watts
Solar charge regulator	6 - 8 Amp with low voltage/deep discharge protection
Other methods	Terrain was investigated during the day for habitat observations.

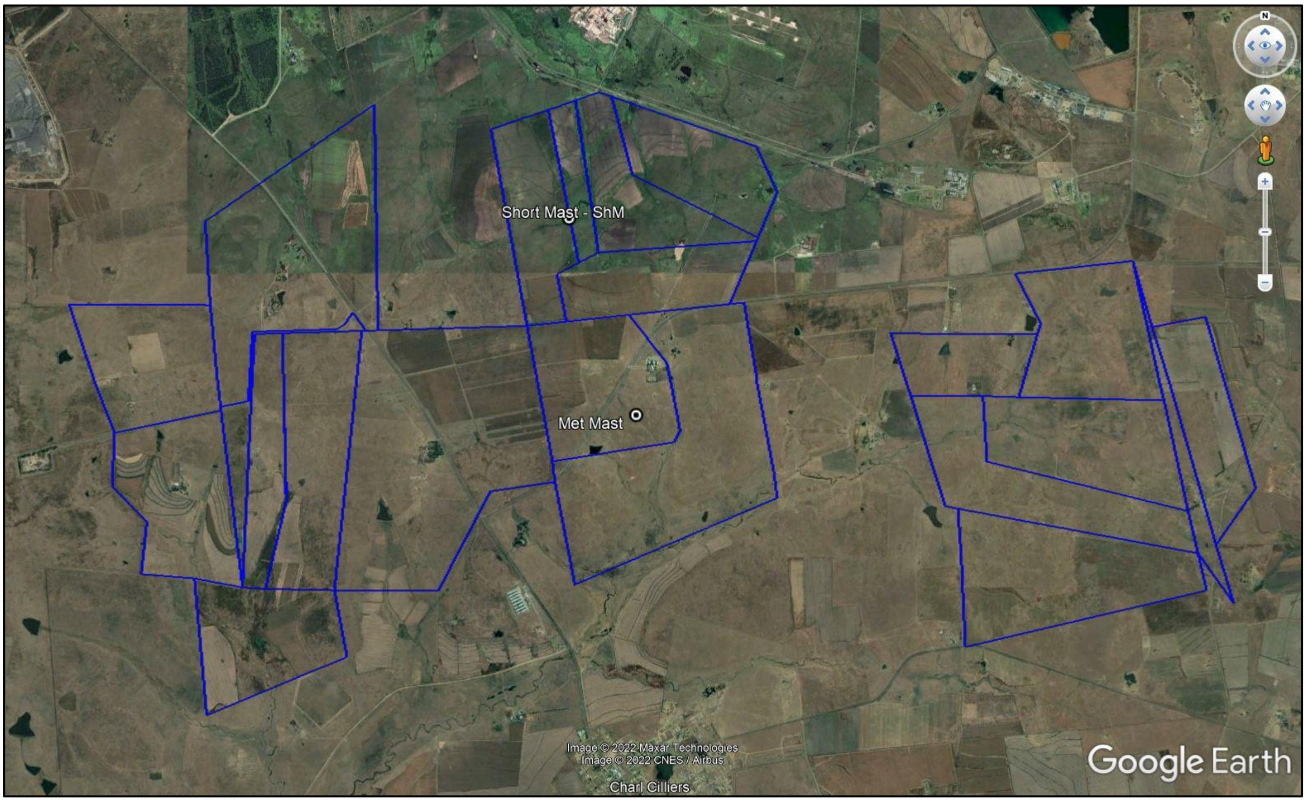

Figure 3-1. Positions of the passive bat detection systems on site: the short mast bat detection system (ShM) and meteorological mast (Met Mast)

3.3 Bat Sensitivity Mapping

Google Earth satellite imagery and verifications during site visits were used to spatially demarcate areas of the site with high and medium sensitivities relating to bat species ecology and habitat preferences. The map considers man-made structures and habitat alterations (such as dams), as well as natural terrain features that are likely to offer roosting and foraging opportunities for bat species found in the broader site area. Clumps of trees (as opposed to scattered or single trees) offer significantly better roosting and foraging habitat on this site; they have received priority during sensitivity mapping.

3.4 Assumptions and Limitations

As with any environmental study, there are certain assumptions and limitations that exist around the current knowledge we possess regarding bats and their behaviour, movements and distribution. Some important points are discussed briefly below:

- Distribution maps of South African bat species still require further refinement, thus the bat species proposed to occur on the site (and not detected in the area yet) should be considered precautionary. If a species has a distribution marginal to the site, it was assumed to occur in the area.
- The migratory paths of bats are largely unknown, thus limiting the ability to determine if the wind farm will have a large-scale effect on migratory species. This limitation is partially overcome with the 12-months pre-construction sensitivity assessment, however some uncertainty in this regard will remain until the end of operational monitoring of at least 2 years. Based on the currently available information, there is nothing to date that indicates that the site is the location of a migratory path.
- The sensitivity map is based partially on satellite imagery and from several site visits. However, there is always the possibility that what has been mapped may differ slightly to what is on the ground.
- 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 smaller portion of incorrect identifications or unknown identifications. In the last-mentioned 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 with transects or the passive monitoring systems. However, bat passes per night are internationally used and recognized as a comparative unit for indicating levels of bat activity in an area.
- 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.
- Periods of exceptional drought or rain during the pre-construction assessment study can influence bat numbers, causing measurements of lower or higher bat activity due to less open water sources, lower insect prey numbers, or higher insect numbers and more available water.

4 RESULTS AND DISCUSSION

4.1 Land Use, Vegetation, Climate and Topography

The proposed Mukondeleli WEF falls within the Grassland Biome, and the Mesic Highveld Grassland Bioregion. A single vegetation unit is found on site: **Soweto Highveld Grassland** (Mucina & Rutherford 2012).

4.1.1 Soweto Highveld Grassland

The Soweto Highveld Grassland vegetation unit is present across the entirety of the Mukondeleli WEF site and at least a 13km radius surrounding it. Soweto Highveld Grassland consists of slight to moderately undulating plains of short to medium-high dense grassland cover. Important taxa include *Elionurus*, *Heteropogon*, *Eragrostis*, *Themeda* and *Tristachya*. Some isolated rocky outcrops may occur, with associated sour grasses and certain woody species. The general geology for this vegetation unit on site includes dolerite, shales, sandstones and mudstones, which are not prone to cave formation suitable for roosting bats. Land use type is predominantly agricultural in nature and consists of grazing for livestock and ploughed soil for mixed crops. There is a strongly seasonal rainfall pattern; precipitation ranges from 650 – 900mm per annum, predominantly in the summer. Very limited areas of this vegetation unit are currently conserved in statutory reserves and overall, the unit is endangered (Mucina & Rutherford 2006).

4.2 Currently Confirmed, Previously Recorded and Literature-based Species Probability of Occurrence

Table 4-1 below indicates the species of bats which have been confirmed to occur on site, those unconfirmed species which may potentially occur on site, as well as those occurring in the broader area of the site based on literature review. For each species, the risk of impact by wind energy infrastructure was assigned by MacEwan *et al*. (2020) based on their distributions, altitudes at which they fly, and foraging ecology.

Table 4-1. Species currently confirmed on site, previously recorded in the area, or potentially occurring. Roosting and foraging habitats in the study area, conservation status and risk of impact are also briefly described per species (Monadjem *et al.* 2020).

Species	Common name	Occurrence in area*	Conservation status (SANBI & EWT, 2016)	Possible roosting habitat on site	Possible foraging habitat utilised on site	Risk of impact (MacEwan *et al.* 2020 for wind)
Tadarida aegyptiaca	**Egyptian free-tailed bat**	Confirmed on site	Least Concern (2016 Regional Listing)	Hollows in trees, and behind the bark of dead trees. The species has also taken to roosting in roofs of buildings.	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 habitats.	High
Mops (Chaerephon) pumilus	**Little free-tailed bat**	Confirmed on site	Least Concern (2016 Regional Listing)	Hollows in trees, and behind the bark of dead trees. The species has also taken to roosting in roofs of buildings.	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 habitats.	High
Laephotis (Neoromicia) capensis	**Cape serotine**	Confirmed on site	Least Concern (2016 Regional Listing)	Roosts in the roofs of houses and buildings, and also under the bark of trees.	It appears to tolerate a wide range of environmental conditions from arid semi-desert areas to montane grasslands, forests, and savannahs. Predominantly a medium height clutter edge forager on site.	High
Laephotis zuluensis	**Zulu serotine**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Roosts under the bark of trees, and possibly roofs of buildings.	Predominantly a medium height clutter edge forager on site.	Medium – High
Pipistrellus rusticus	**Rusty pipistrelle**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Roosts under the bark of trees, and possibly roofs of buildings.	Prefers vegetation edges and clutter with open water sources.	Medium – High

Pipistrellus hesperidus	**Dusky pipistrelle**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Roosts under the bark of trees, and possibly roofs of buildings.	Prefers vegetation edges and clutter with open water sources.	Medium – High
Miniopterus natalensis	**Natal long-fingered bat**	Confirmed on site, also Wonderboom Cave	Least Concern (2016 Regional Listing)	Caves and mine tunnels present in the larger area, may also take residence in suitable hollows such as culverts under roads.	Clutter-edge forager. May forage in more open terrain during suitable weather.	High
Eptesicus hottentotus	**Long-tailed serotine**	Confirmed on site	Least Concern (2016 Regional Listing)	It is a crevice dweller roosting in rock crevices in the larger area, as well as other crevices in buildings.	It generally seems to prefer woodland habitats, and forages on the clutter edge. But may still forage over open terrain occasionally.	Medium – High
Myotis tricolor	**Temmink's myotis**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Caves and mine tunnels present in the larger area, may also take residence in suitable hollows such as culverts under roads.	Clutter-edge forager. May forage in more open terrain during suitable weather.	Medium – High
Myotis welwitschii	**Welwitsch's bat**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Caves and mine tunnels present in the larger area, may also take residence in suitable hollows such as culverts under roads.	Clutter-edge forager. May forage in more open terrain during suitable weather.	Medium – High
Rhinolophus clivosus	**Geoffroy's horseshoe bat**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Caves and mine tunnels present in the larger area.	Vegetation clutter forager, clumps of trees on site.	Low
Scotophilus dinganii	**Yellow-bellied house bat**	Confirmed on site	Least Concern (2016 Regional Listing)	Roofs of buildings and other suitable hollows.	Clutter-edge forager. May forage in more open terrain during suitable weather.	High

Cloeotis percivali	**Percival's short-eared trident bat**	Confirmed in 100km radius, also Wonderboom Cave	Endangered (2016 Regional Listing)	Caves and mine tunnels present in the larger area.	Vegetation clutter forager, clumps of trees on site.	Low
Epomophorus wahlbergi	**Wahlberg's epauletted fruit bat**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Roosts in dense foliage of large, leafy trees in the larger area, and may travel several kilometres each night to reach fruiting trees.	Feeds on fruit, nectar, pollen and flowers. If and where available on or near site.	High
Eidolon helvum	**African straw-coloured fruit bat**	Possible as migrant	Least Concern (2016 Regional Listing) (Globally Near threatened)	Non-breeding migrant with sparse scattered records.	Feeds on fruit, nectar, pollen and flowers, if and where available on site.	High
Taphozous mauritianus	**Mauritian tomb bat**	Confirmed in 100km radius	Least Concern (2016 Regional Listing)	Prefers roosting on the walls of buildings and the trunks of large trees. Appears vigilant while roosting even during daytime.	Open-air forager that prefers grasslands where it hunts for moths and sometimes butterflies in the late afternoon.	High

*Occurrence of species records based on ACR 2020 and Monadjem *et al*. 2020

4.3 Ecology of bat species that may be impacted the most by the Mukondeleli WEF

There are several bat species in the vicinity of the site that occur commonly in the area. Some of these species are of special importance based on their likelihood of being impacted by the proposed WEF, due to high abundances and certain behavioural traits. They have also been dominating records of fatalities at wind energy facilities in South Africa. The relevant species are discussed below.

4.3.1 Tadarida aegyptiaca

The Egyptian free-tailed bat, *Tadarida aegyptiaca*, is a Least Concern species (SANBI 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*. 2020). This species is protected by national legislation in South Africa (ACR 2020).

Egyptian free-tailed bats 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. It has also adapted to roosting in buildings, in the roofs of houses in particular (Monadjem *et al*. 2020). Thus, 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*. 2020).

After a gestation of four months, a single pup 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.

The Egyptian free-tailed bat is considered to have a high risk of fatality on wind energy facilities due to turbine collisions (MacEwan *et al.* 2020). Due to the high abundance and widespread distribution of this species, high mortality rates due to wind turbines would be a cause for concern as these species have more significant ecological roles than the rarer bat species, and are currently displaying moderate to high numbers of mortalities at nearby operating wind farms.

4.3.2 ***Laephotis capensis***

Laephotis capensis is commonly called the Cape serotine (formerly *Neoromicia capensis*) and has a conservation status of Least Concern (SANBI 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 for concern as precisely because of its abundance. As such, it has a more significant role to play within local ecosystems than the rarer bat species.

The Cape serotine 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*. 2020). They do not undertake migrations and thus are considered residents of the site.

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 occur. 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).

They are tolerant of a wide range of environmental conditions as they survive and prosper across arid and semi-arid 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, but can occasionally forage in open spaces. They are thought to have a medium to high likelihood of fatality due to wind turbines (MacEwan *et al.* 2020) and are currently displaying moderate to high numbers of mortalities at operational wind farms in South Africa.

4.3.3 *Miniopterus natalensis*

Miniopterus natalensis, 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 Least Concern (Monadjem *et al*. 2020). 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*. 2020).

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.* 2020 & van de 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 (MacEwan *et al.* 2020). 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. If the site is located within a migratory path, the bat detection systems should detect higher numbers and activity of the Natal long-fingered bat in spring and autumn. This was examined over the course of the 12-month monitoring survey, and did not indicate any migration events.

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%).

MacEwan *et al.* (2020) 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. This species is known from Wonderboom Cave, within 100km of the site, (see **Figure 4-3)**. The species is currently displaying low to moderate numbers of mortalities at operational wind farms in South Africa.

4.3.4 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 the time of emergence and flight duration. It is also important to note that environmental factors are never isolated and therefore a combination of these 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.

If it is found during operation that the wind farm is causing unsustainable numbers of bat fatalities, an analysis can be performed to determine the wind speed and temperature range within which 80% of bat passes were detected. The results of such an analysis may be used, if necessary, to inform mitigation measures for turbines based on conserving 80% of detected bat passes. This is keeping in mind the synergistic or otherwise contradictory effects that the combination of wind speeds and temperatures can have on bat activity.

4.3.4.1 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 and operating wind facilities in the United States have documented discernibly lower bat activity during 'high' wind speeds (Arnett *et al*. 2010).

Wind speed and direction also affect 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 while at edges to the lee side of wind, bat activity may be greater.

4.3.4.2 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 insects (flies) 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.

4.4 Conservation and protected areas, known sensitivities and caves/roosts within 30km and 100km of the site

There are no protected or formally conserved areas within 30km of the Mukondeleli WEF site. The Devon Protected Environment is the nearest protected area, lying 38km from site at the closest point (see **Figure 4-1**). This has no bearing on the current site and will not be discussed further.

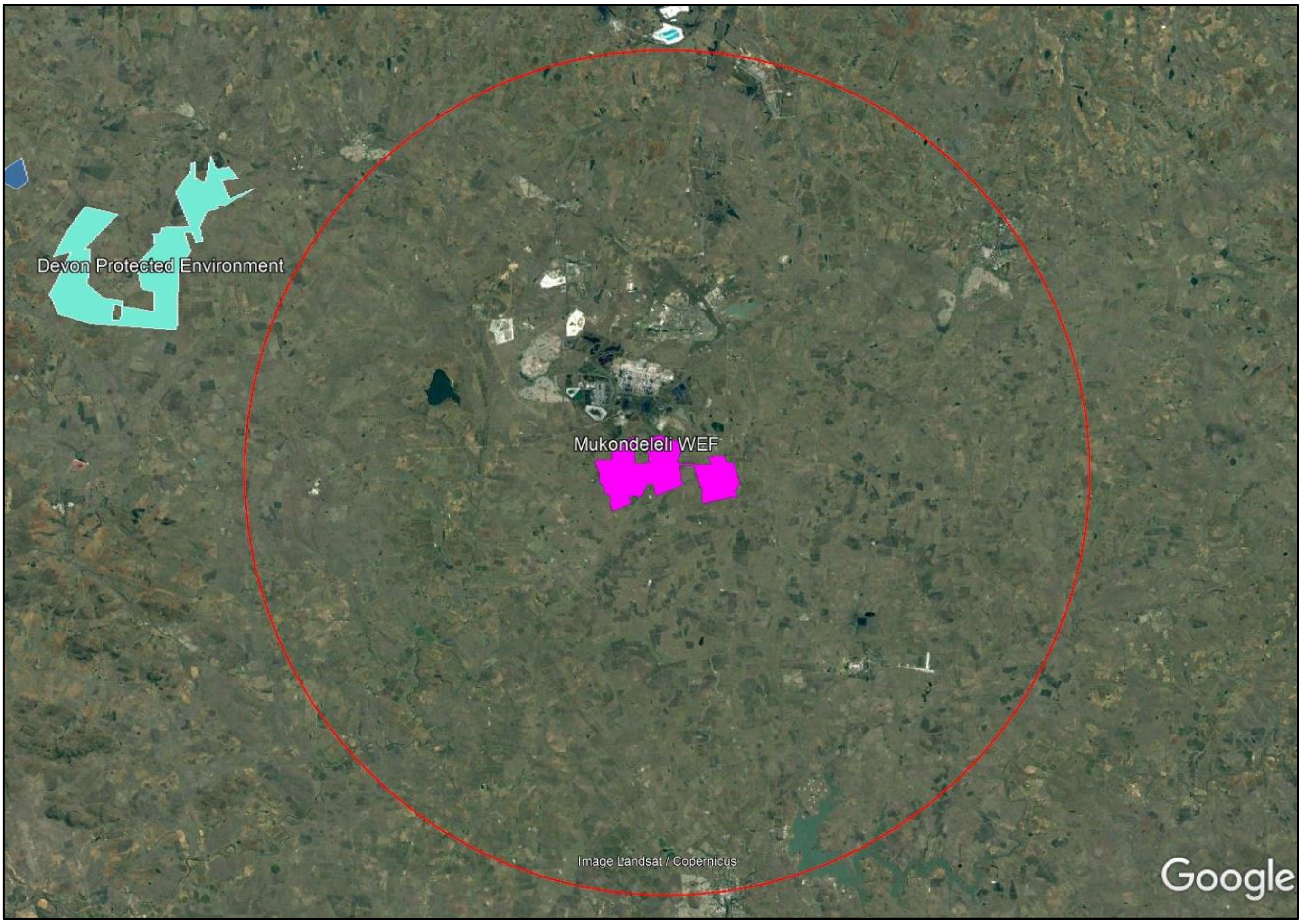

Figure 4-1. Protected areas within or surrounding a radius of 30km (red line) around the Mukondeleli Wind Energy Facility (fuschia polygon) (DEA, 2021)

Dolomite is known to be prone to good cave formation, and many bat colonies are supported in such caves in the country, particularly in the province of Gauteng. At its nearest, the dolomitic geology of the greater area extends to approximately 60km north-west of the WEF (**Figure 4-2**). Museum records of bats collected from one cave within approximately 100km of the site exist. Specimens of *Rhinolophus clivosus*, *Cloeotis percivali*, and *Miniopterus natalensis* were collected from Wonderboom cave (93km to the north), although the Strategic Environmental Assessment (SEA) wind energy buffer of 50km for large bat roosts does not extend to the area of influence around the proposed Impumelelo WEF. Should any possible cave/roost locations be found to be supporting large enough bat colonies within 50km of the proposed site, this will have implications for the development.

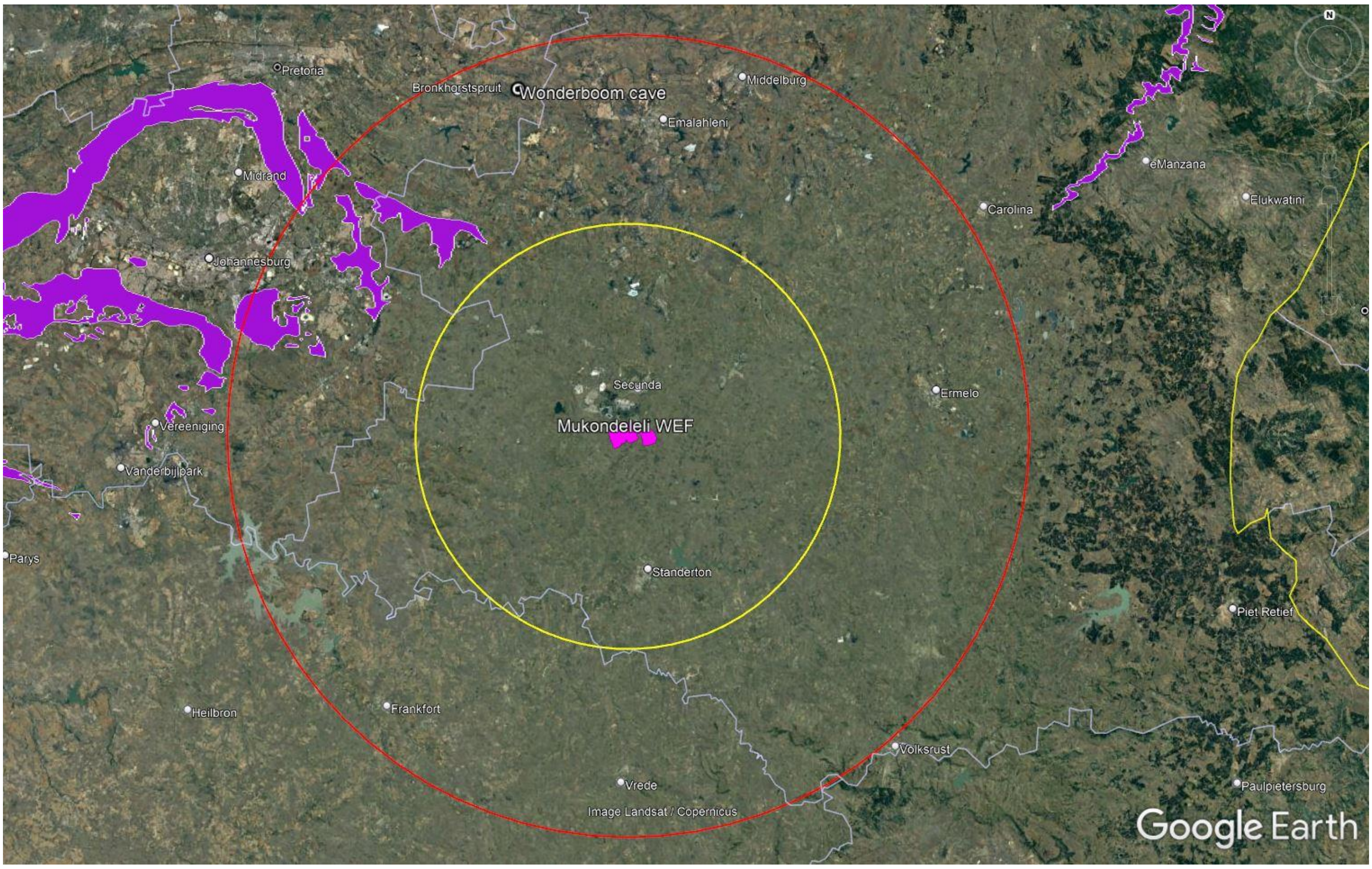

Figure 4-2. Approximate 100km radius (red circle) surrounding Mukondeleli Wind Energy Facility (fushia polygon). Dolomite geology represented in purple (SEA data), and known bat roosts depicted with white circles. Wonderboom Cave does not fall within 50km of site (yellow circle)

4.5 Passive bat monitoring data

Average hourly bat passes detected per night and the total number of bat passes detected over the monitoring period are displayed in **Figure 4-3** to **Figure 4-6**. Passive data are available from November 2020 to February 2022 on the Short Mast and from November 2020 to January 2022 on the Met Mast. Six bat species were positively identified on site, namely: *Eptesicus hottentotus, Tadarida aegyptiaca, Mops pumilus, Laephotis capensis, Miniopterus natalensis* and *Scotophilus dinganii*. Additionally, bat passes were recorded that are classified up to the family level Vespertilionidae. This is taxonomically a large family that includes many species that behave ecologically similarly with regards to their risk of collision with wind turbines. When the frequency of their vocalisations overlaps, these species are more difficult to distinguish from one another, and are grouped together. On this site, the seven vesper species encompassed within this grouping are *E. hottentotus*, *L. capensis*, *L. zuluensis*, *Myotis tricolor, Pipistrellus hesperidus, P. rusticus* and *S. dinganii*. It must be noted that some of these species can be identified from passive data recordings for the majority, but not all, of their vocalisations and they are well-represented in the data for the Mukondeleli WEF.

In general, *L. capensis* dominated at 10m at the Met Mast system, and *T. aegyptiaca* demonstrated the most passes at the 7m Short Mast (closely followed by *L. capensis*) and also dominated at both 55m and 110m at the Met Mast system. This relationship between height and abundance are typical and expected for these two species since *T. aegyptiaca* is an open-air forager and a larger bat that can utilise higher airspaces than the smaller *L. capensis* that forages on the edge of vegetation clutter. Considering all species, bat activity decreased as the height of the microphone increased. *Scotophilus dinganii* was only present at 7-10m at both low-height systems, and only infrequently. *Miniopterus natalensis* is a cave dwelling species, but may also take residence in smaller numbers in culverts and other suitable man-made hollows, this species did not show any abrupt peaks of activity that may indicate migration routes on site. The species was detected at all microphone heights, but was not common.

Bat passes at 7m (ShM1) totalled 4524, while at the comparable height on Met Mast 1 they totalled 6275 across the year of monitoring. At 55m (Met Mast 1), bat passes for the monitoring period totalled 3152, and at 110m, 1131 bat passes were recorded throughout the monitoring period.

Average hourly activity is useful since it considers only the nights in which the systems recorded successfully. Higher activity months are important to consider in case mitigation may be required during the operational phase. Considering all species, the average hourly bat passes recorded throughout monitoring were greatest at the Short Mast 1 system, and this in December 2020, at 4.3 passes/hour. In January 2022, the next highest peak in hourly activity was detected, with 3.4 passes/hour recorded at this height. At the 10m microphone at the Met Mast system, the greatest hourly bat pass rate of 2.3 was recorded. At the mid-height microphone (55m), the hourly activity was greatest in January 2021 (1.1 passes/hour) and in January and November 2021 for the top microphone (0.4 passes/hour). The trend of lower bat pass rates with increasing microphone height matches that of the total bat passes recorded.

It should be noted that the highest Met Mast 1 microphone (110m) failed in the spring period of 2021/2022, although one full year of data was collected (November 2020 – November 2021).

When considering hourly activity of the species separately, we see that peaks occur at slightly different times of the year; *T. aegyptiaca* activity generally peaked first, in October to December; *M. pumilus* activity peaked in December to February, and *L. capensis* had peak hourly activity in December to March. Activity is somewhat height dependent, with peaks differing by up to one month at different microphone heights (Met Mast systems).

Temporal distribution of bat activity graphs (**Figure 4-7** to **Figure 4-10**) display how the number of bat passes varied throughout the year of monitoring. For Met Mast 1, we see that *L. capensis* showed relatively high activity throughout the 2020/2021 and 2021/2022 summer months, with a bimodal trend in the first summer period at 10m. At the Short Mast system, *T. aegyptiaca* showed greater bat passes in the second summer period overall. Certain nights displayed strong activity, with 21 December 2021 showing the highest bat passes for both *T. aegyptiaca* and *M. pumilus* (83 and 72 passes respectively). While the general trend was that bat activity decreased over the winter period and with height, *T. aegyptiaca* showed peaks across certain nights in the winter or early spring months at the 110m microphone that were greater than at even the lowest microphone height. Which could have been influenced by insect emergences and weather conditions.

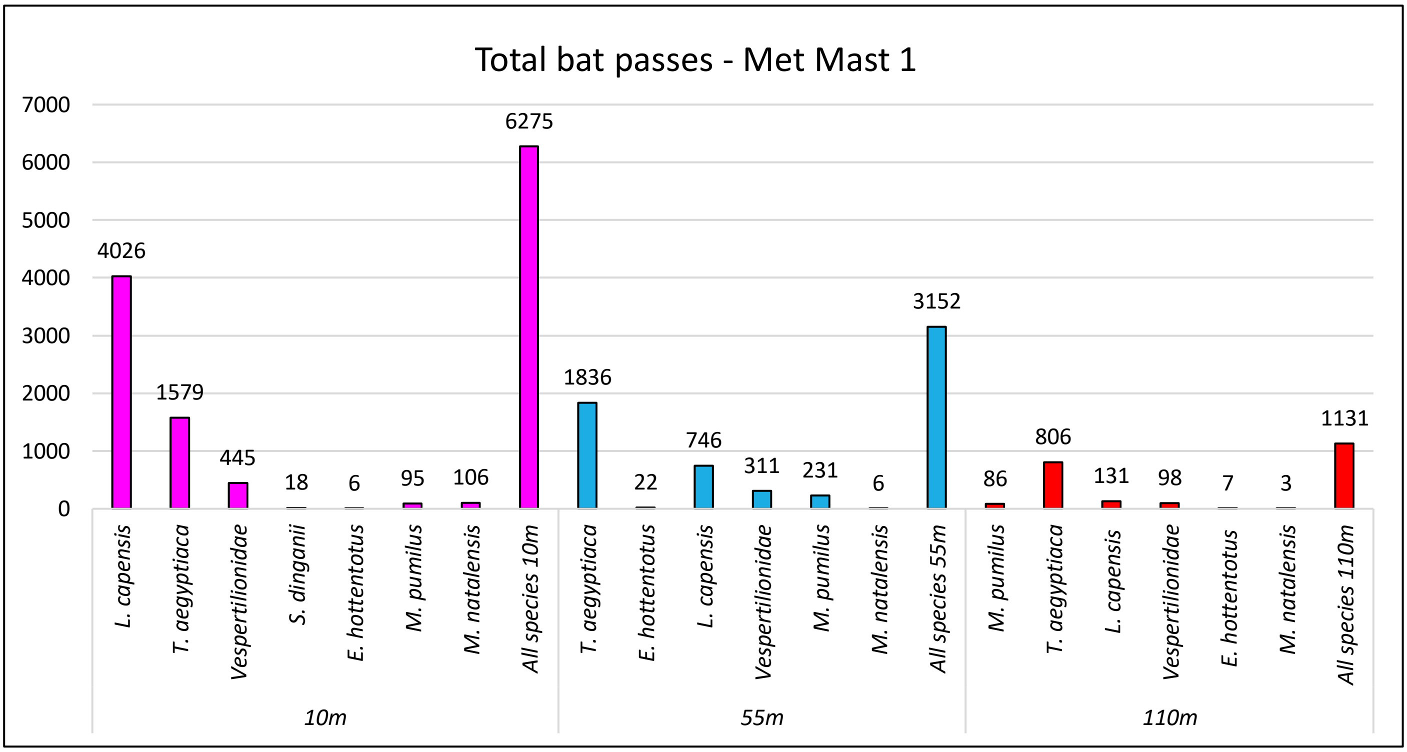

Figure 4-3. Total bat passes recorded over the 12-month monitoring period by Met Mast

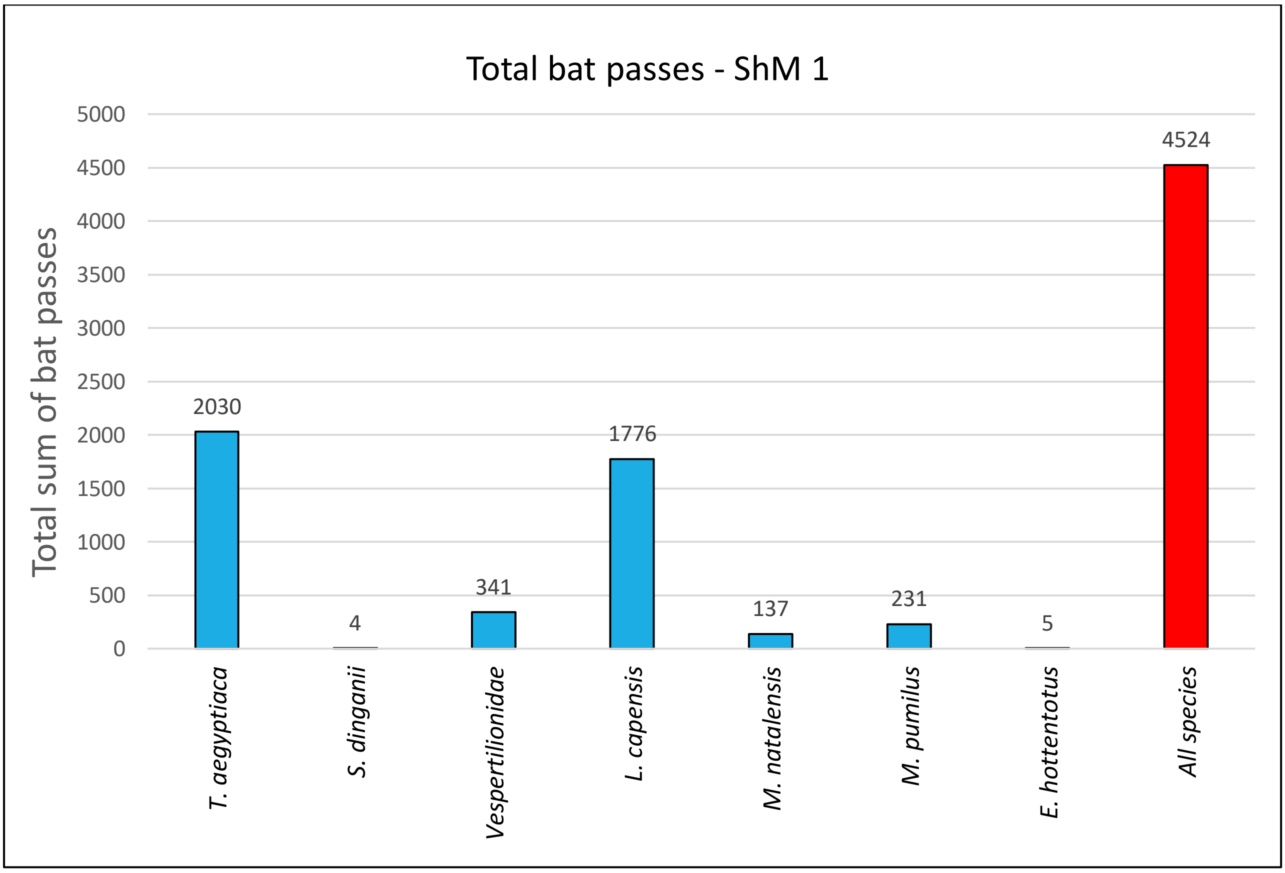

Figure 4-4. Total bat passes recorded over the 12-month monitoring period by ShM

Figure 4-5. Average hourly bat passes recorded per month by Met Mast

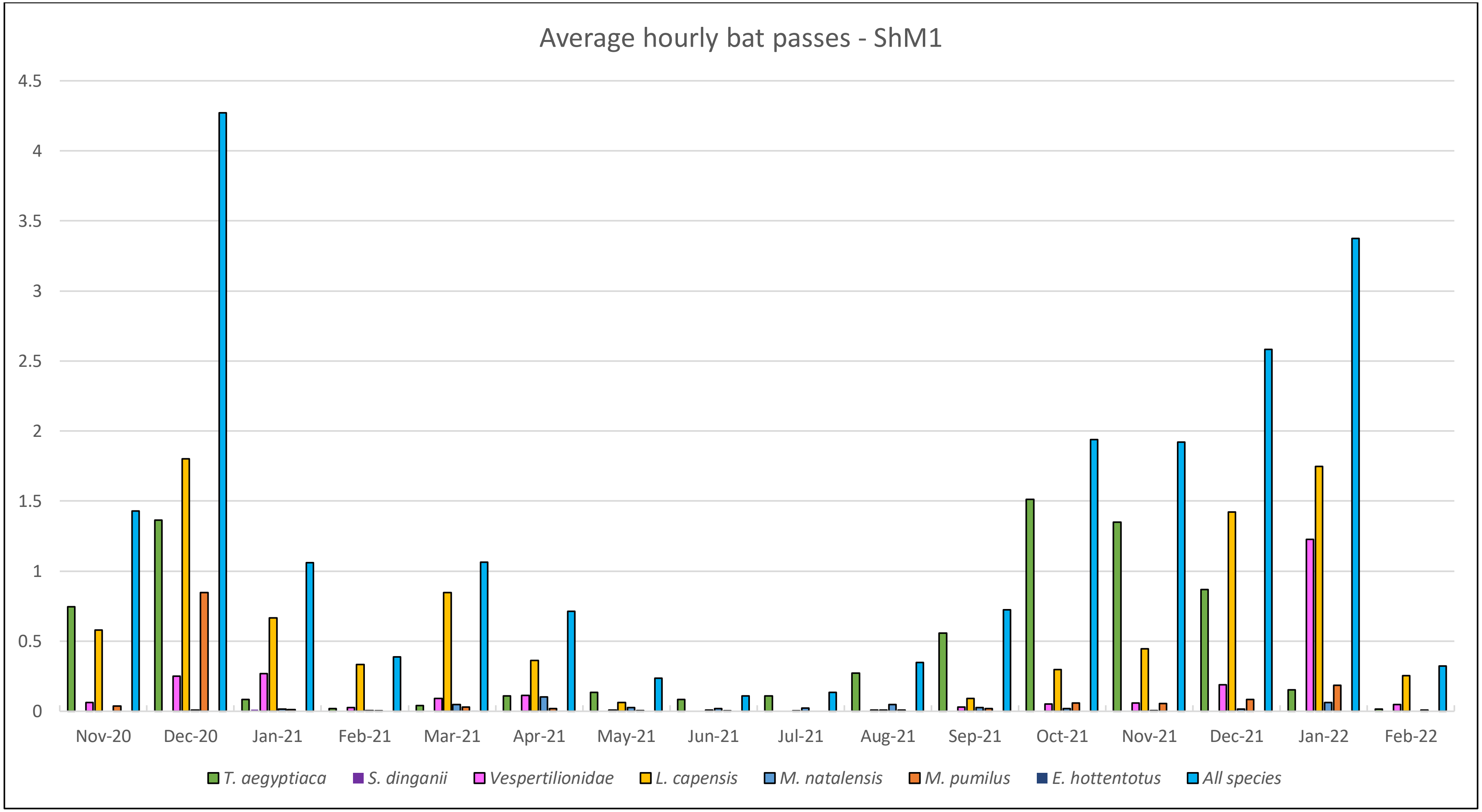

Figure 4-6. Average hourly bat passes recorded per month by ShM

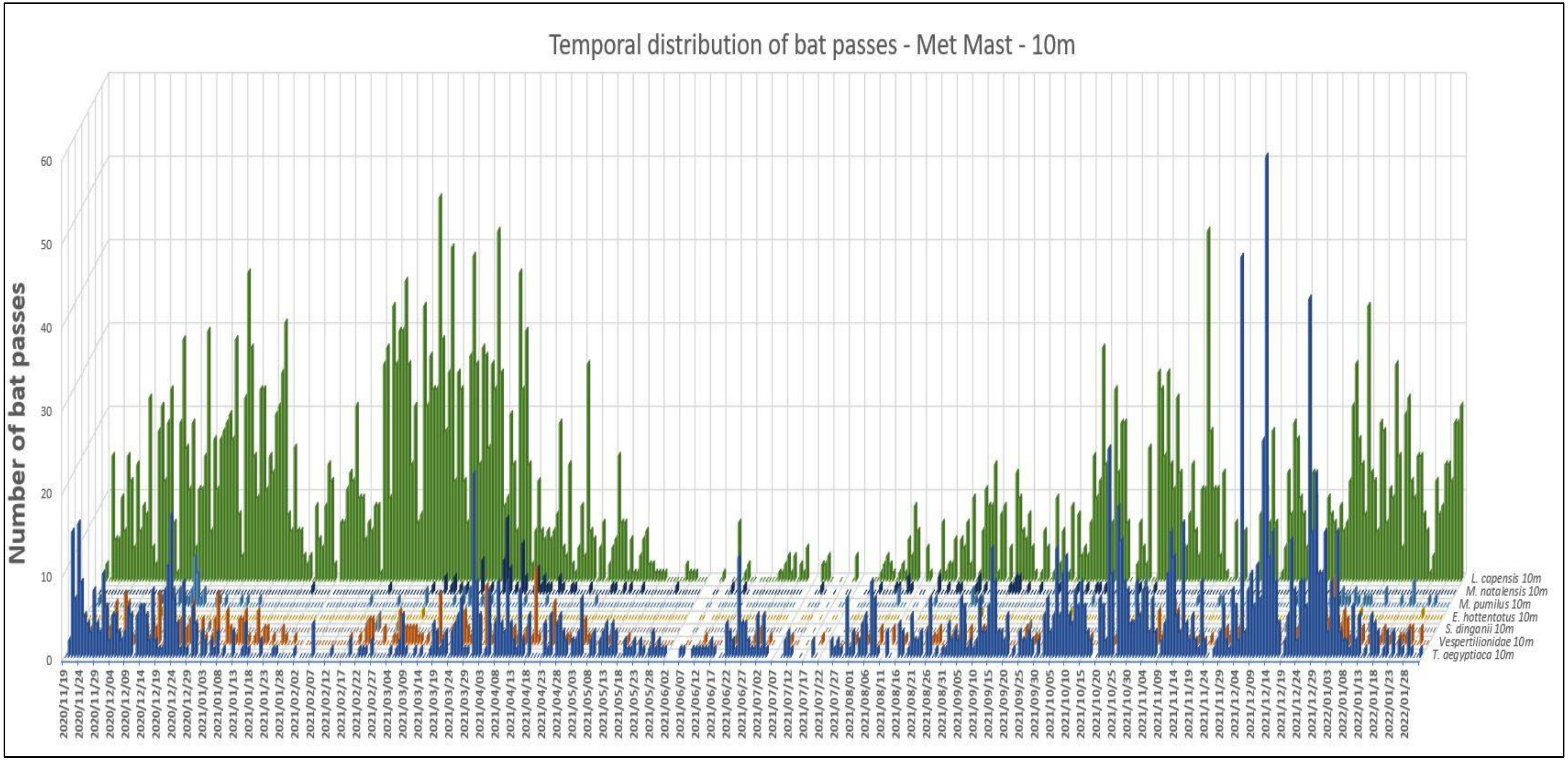

Figure 4-7. Temporal distribution of bat passes detected by Met Mast – 10m

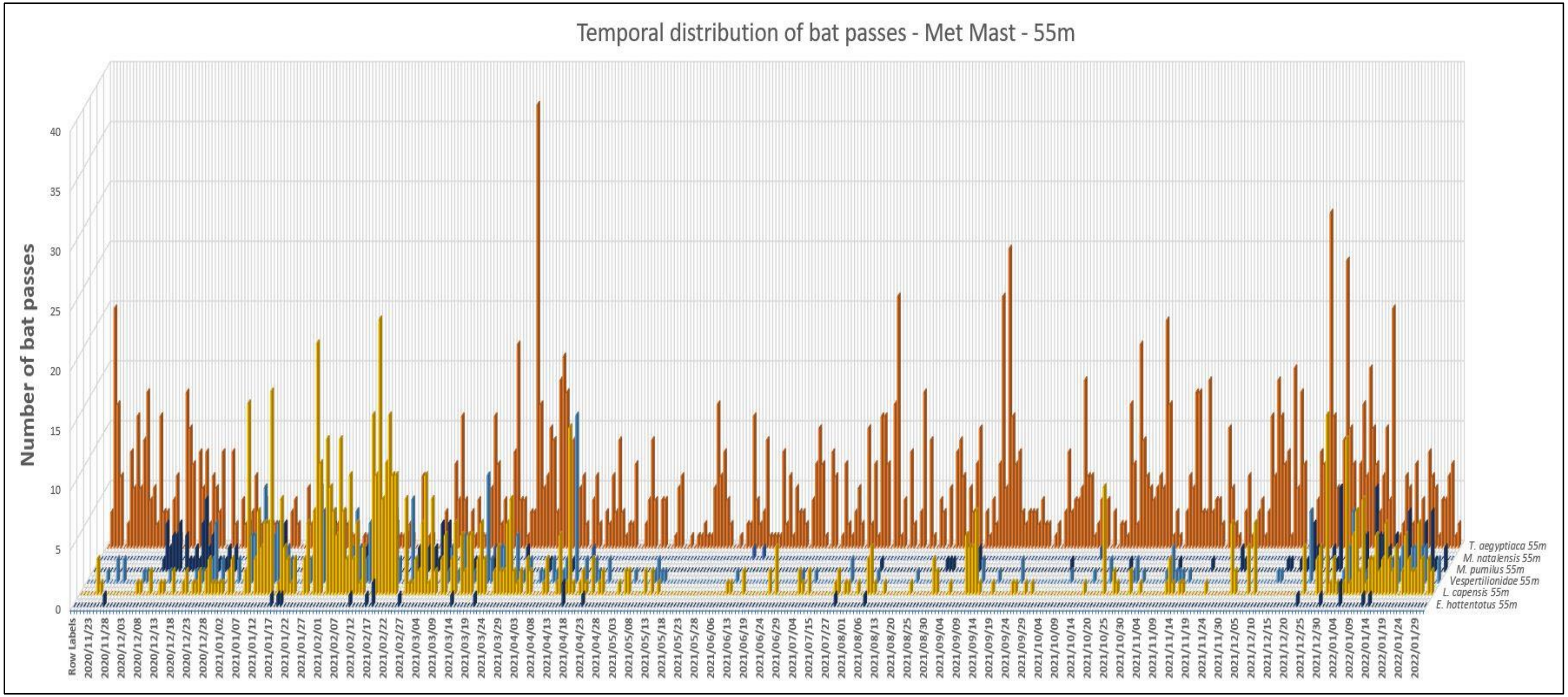

Figure 4-8. Temporal distribution of bat passes detected by Met Mast – 55m

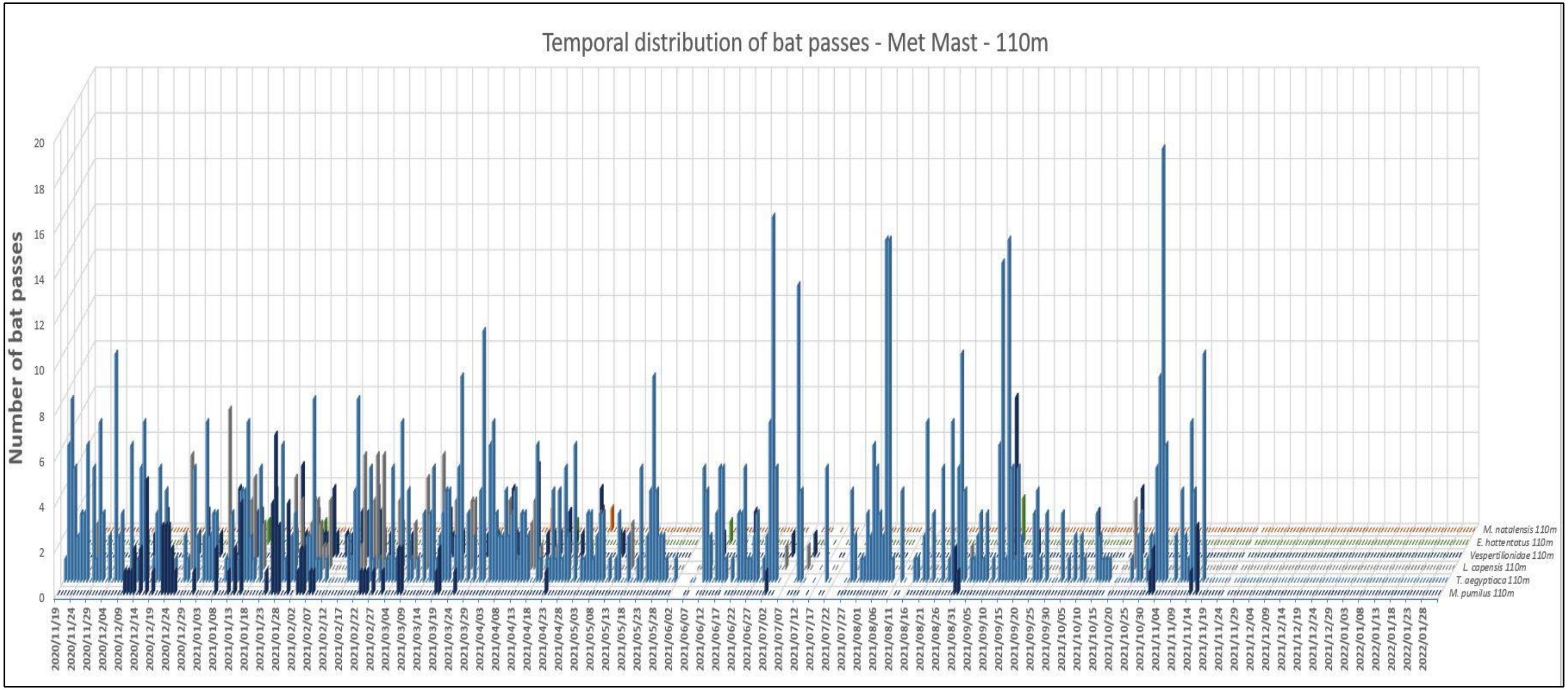

Figure 4-9. Temporal distribution of bat passes detected by Met Mast – 110m

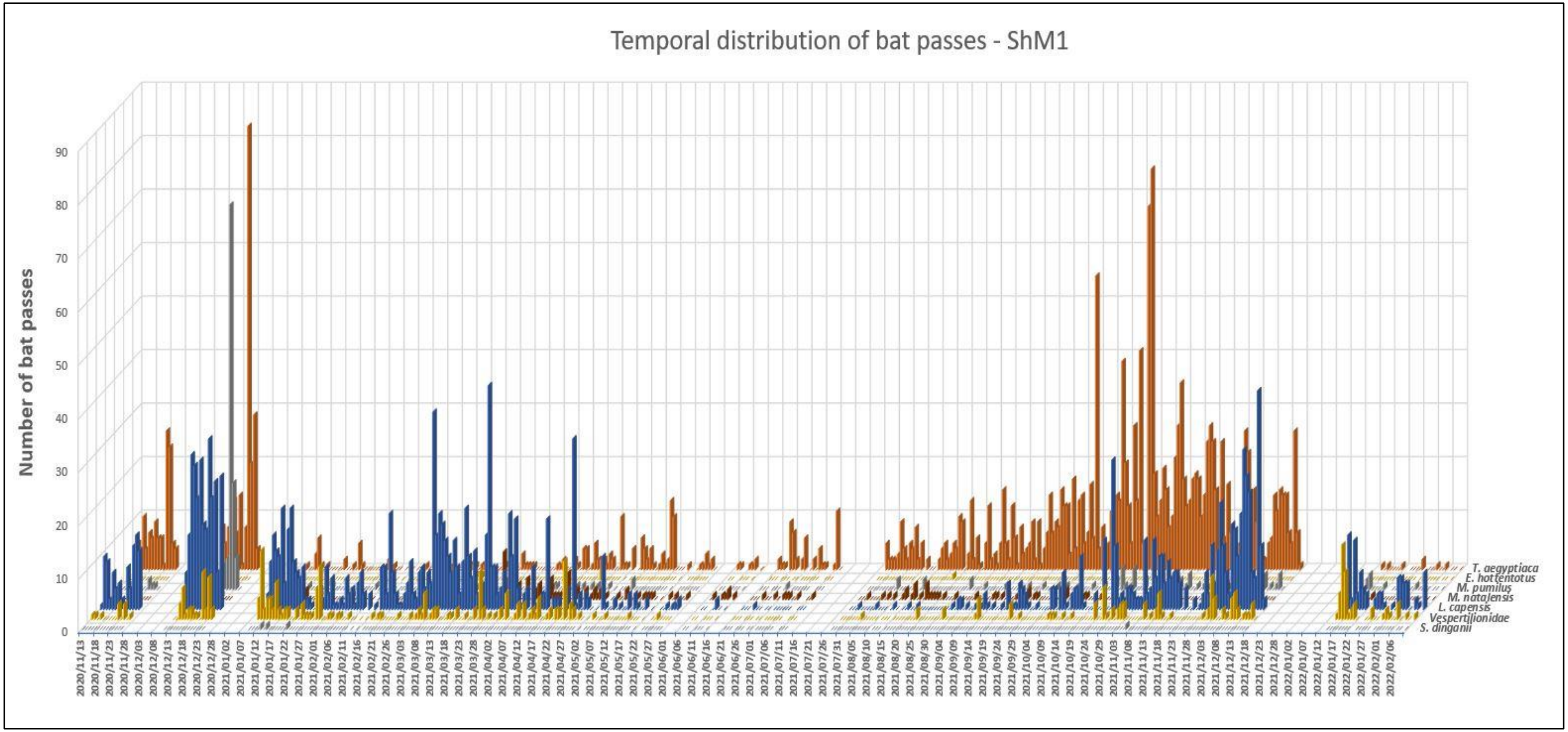

Figure 4-10. Temporal distribution of bat passes detected by ShM1

4.6 Sensitivity Mapping

4.6.1 DEA Screening tool

The Department of Environmental Affairs (DEA) Screening Tool (accessed 13/05/2022) was consulted for the "Bat" and "Wind" theme, to determine the environmental sensitivity ranking assigned to the site area and surrounds. While the Tool did not display any wind or solar developments with an approved Environmental Authorisation application under consideration within 30km of the proposed area, the specialist is aware of at least one other Wind Energy application within 30km from the site at this stage. This is the proposed Impumelelo Wind Energy Facility, for which the 12-month bat pre-construction monitoring has been completed.

For wind energy generation, the Tool denotes areas of the site as "High Sensitivity" with regards to being within 500m of a river and encompassing wetland area/s and their surrounds up to 500m; a "Medium Sensitivity" is also denoted with regards to the presence of croplands (see **Figure 4-11**).

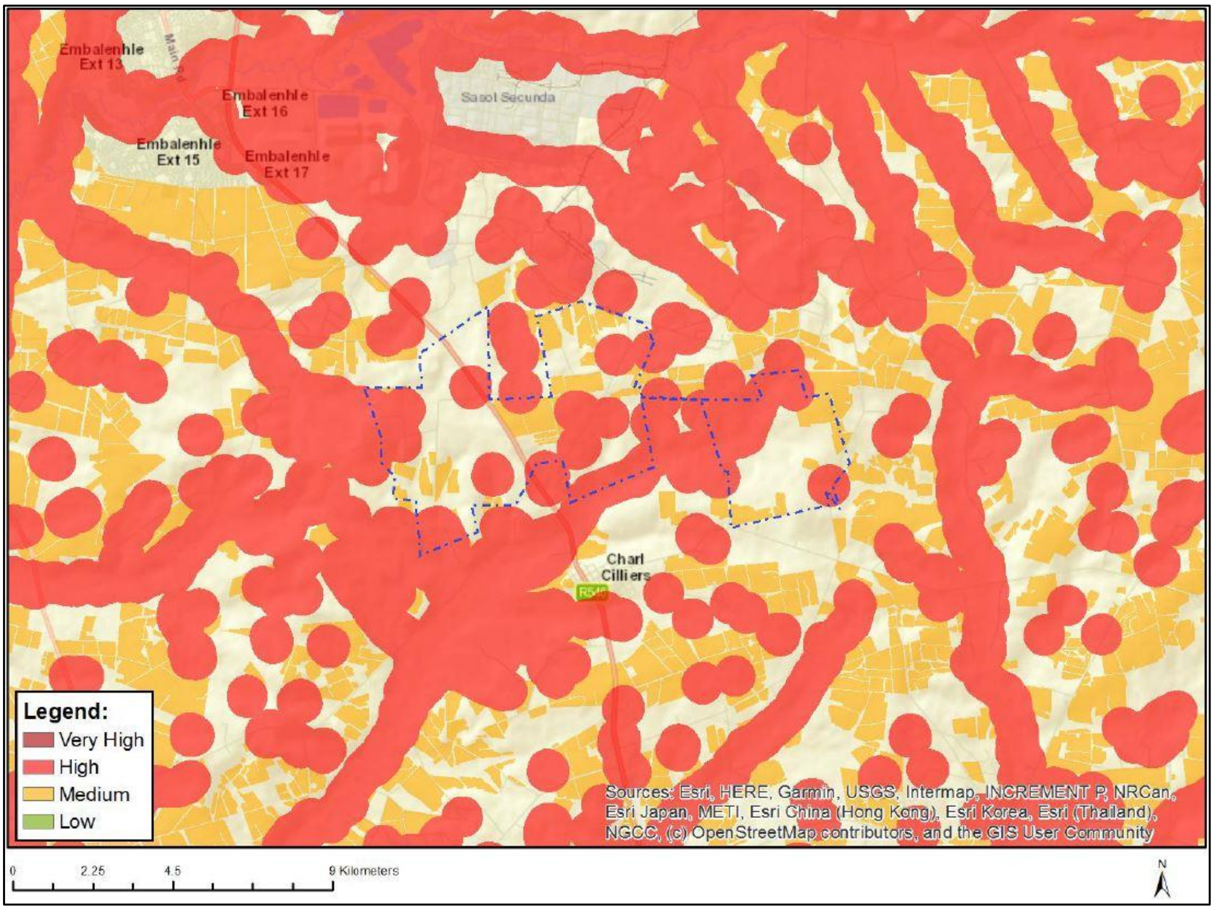

Figure 4-11. DEA Screening Tool for the "Bat" and "Wind" theme. The Mukondeleli WEF boundary is shown in a blue outline, with red and orange areas depicting high and moderate sensitivities in the area, respectively (DEA Screening Tool 13/05/2022)

4.6.2 Sensitivity map

Due to the extrapolated nature of the national Screening Tool, further Google Earth satellite imagery and verifications during site visits were used to spatially demarcate areas of the site with high and medium sensitivities relating to bat species ecology and habitat preferences, where high sensitivities and their buffers are no-go zones for turbines and turbine blade overhang (**Table 4-2**). In other words, no turbine blades may intrude into high sensitivity buffers. Medium sensitivities indicate areas of probable increased risk due to seasonal fluctuations in bat activity, but turbines are allowed to be constructed in medium sensitivity areas. **Figure 4-12** depicts the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are most likely to occur on site.

During the Scoping Phase a total of 10 turbines were intruding into high bat sensitivity buffer. The EIA Phase turbine layout is respecting the bat sensitivity map and turbine positions were adjusted by the applicant to avoid high bat sensitivity buffers. Therefore no turbines are intruding into any high bat sensitivity buffers with the EIA Phase layout.

Table 4-2. Description of parameters used in the development of the sensitivity map

Last revision	**August 2022**
High sensitivities and 200m buffers	Valley bottom wetlands
	Pans and depressions
	Dams
	Drainage lines capable of supporting riparian vegetation
	Other water bodies and other sensitivities such as manmade structures, buildings, houses, barns, sheds, stands of tall trees.
Moderate sensitivities and 150m buffers	Seasonal wetlands
	Seasonal drainage lines

Table 4-3. The significance of sensitivity map categories for each infrastructure component for the Mukondeleli WEF

Sensitivity	Turbines	Roads and cables	Internal overhead transmission lines	Buildings (including substation, battery storage facility and construction camp/yards)
High Sensitivity	These areas are 'no-go' zones and turbines may not be placed in these areas. Turbine blades (blade overhang) **may not** intrude into these areas.	Preferably keep to a minimum within these areas where practically feasible.	Allowed inside these areas.	Avoid these areas.
High Sensitivity buffer	These areas are 'no-go' zones and turbines may not be placed in these areas. Turbine blades (blade overhang) **may not** intrude into these areas.	Allowed inside these areas.	Allowed inside these areas.	Preferably keep to a minimum within these areas where practically feasible.
Moderate Sensitivity	Turbines within these areas may require 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.	Allowed inside these areas.	Allowed inside these areas.	Allowed inside these areas.
Moderate Sensitivity buffer	Turbines within these areas may require 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.	Allowed inside these areas.	Allowed inside these areas.	Allowed inside these areas.

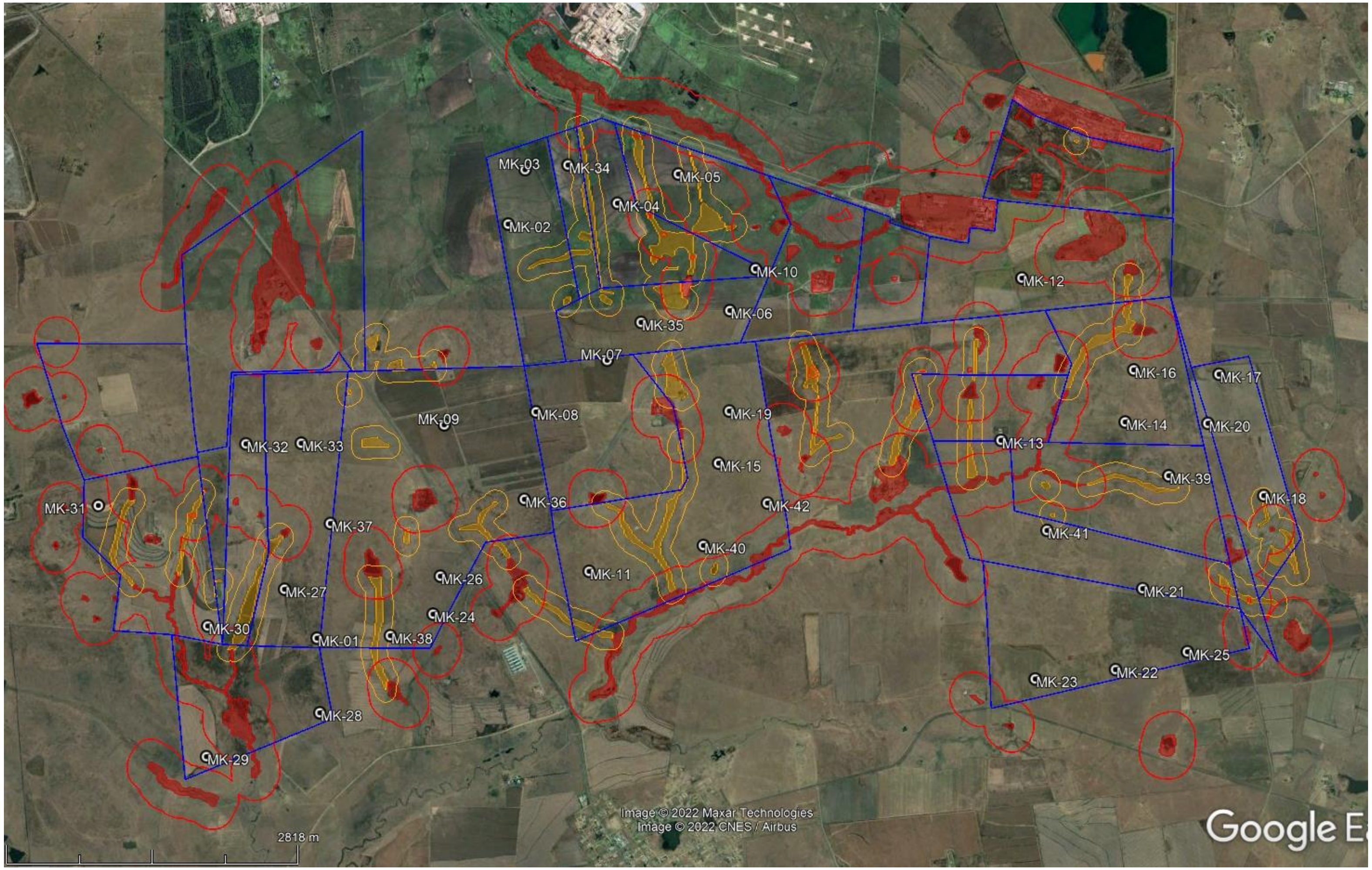

Figure 4-12. Bat sensitivity map of the site. Site area indicated in a blue boundary. Sensitivity polygons are provided in .kml format with this report. Shaded red = high sensitivity; Red line = 200m high sensitivity buffer; Shaded orange = moderate sensitivity; Orange line = 100m moderate sensitivity buffer.

4.7 Cumulative impact consideration within a 30km radius

One Wind Energy Facility within 30km of the Mukondeleli WEF is being proposed:

- Impumelelo Wind Energy Facility

One Solar PV Facility within 30km of the Mukondeleli WEF has been approved:

- 65.9 MW Tutuka Photovoltaic (PV) Energy Facility and Its associated Infrastructure on portion 4, 10, 11 and 12 of the Farm Pretorius Vley 374 near Standerton within Lekwa, Mpumalanga Province

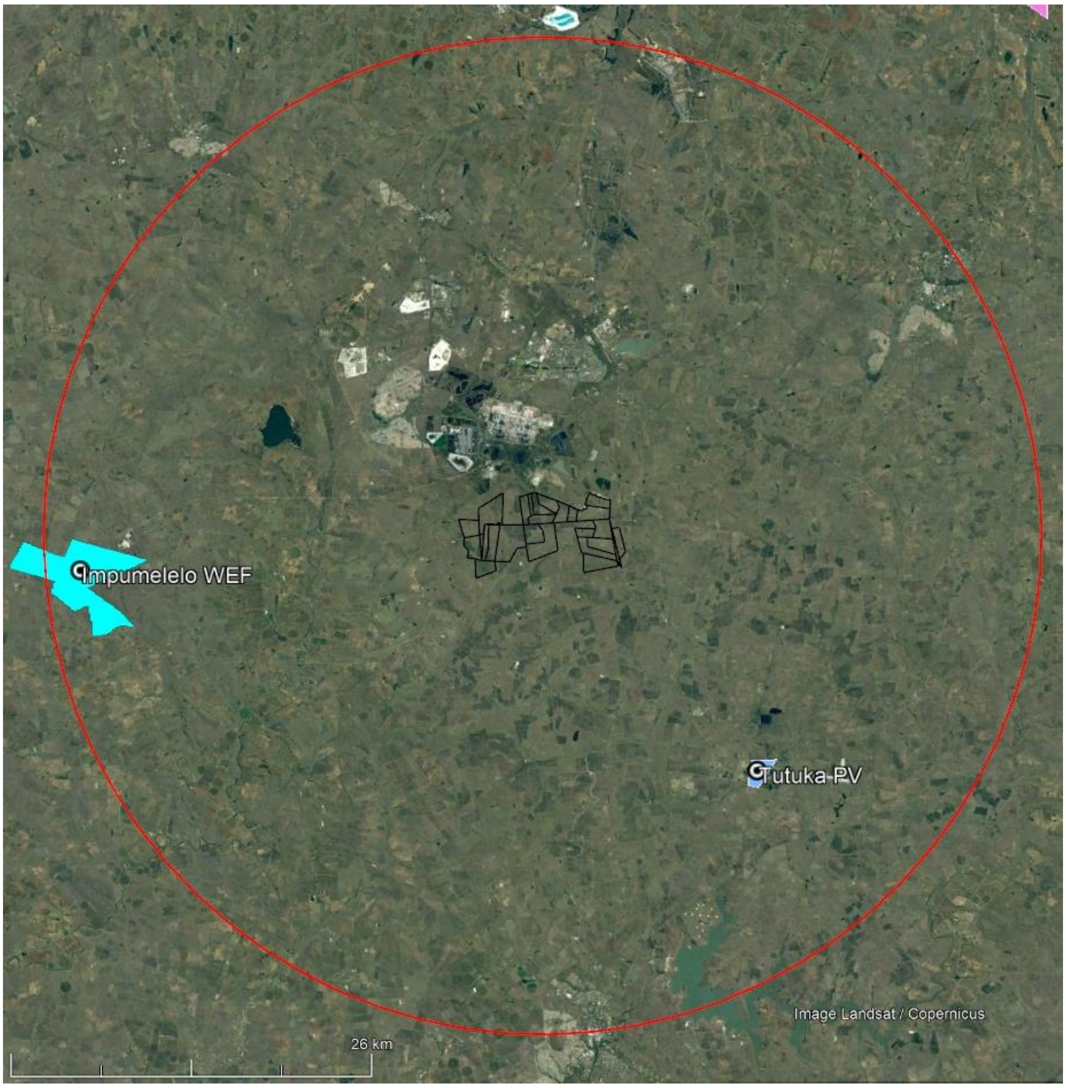

Figure 4-13. The proposed Impumelelo WEF (black boundary) in relation to the proposed Impumelelo WEF and approved Tutuka PV facilities.

Significant (unmitigated) light pollution is a relevant cumulative impact that may be created by both the Impumelelo and Tutuka Facilities. Wind turbine impacts will be a relevant cumulative impact for the proposed Mukondeleli WEF.

5 IMPACT ASSESSMENT

Tables 5-1 to 5-4 below indicate the identified and assessed impacts associated with the proposed Mukondeleli WEF during the construction and operational phases. No significant impacts are identified for the decommissioning phase, as well as cumulatively for the construction phase.

5.1 Construction and Operational phases

Table 5-1: Identified potential impacts of the proposed Mukondeleli WEF project as well as recommended mitigation measures.

Potential impact	**Recommended mitigation**
	Construction phase
Loss of foraging habitat by clearing of vegetation.	Adhere to the sensitivity map criteria (already implemented). Rehabilitate cleared vegetation where possible at areas such as laydown yards.
Roost destruction during earthworks.	Adhere to the sensitivity map criteria (already implemented).
	Operational phase
Bat mortalities during foraging.	Turbine layout adjustments to adhere to the sensitivity map (already implemented), and where needed, reducing blade movement at selected turbines during high-risk bat activity times/weather conditions. Acoustic deterrents are developed well enough to be trialled. The WEF should measure its bat mortality impact during operation and ensure that the WEF impact remain within sustainable levels.
Bat mortalities during migration.	Reducing blade movement at selected turbines if a migration route is discovered. Acoustic deterrents are developed well enough to be trialled.
Increased bat mortalities due to light attraction and habitat creation.	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. This will be at turbine bases (if applicable, and other infrastructure buildings). For buildings, avoid tin roofs and roof structures that offer

entrance holes into the roof cavity. The stormwater management plan should prevent the creation of any artificial wetlands and open water sources within 300m of any turbine bases.

Table 5-2: Assessed potential impacts of the proposed Mukondeleli WEF project during the construction and operational phases

CONSTRUCTION PHASE																			
Impact nr	**Aspect**	**Description**	**Stage**	**Character**	**Ease of Mitigation**	**Pre-Mitigation**							**Post-Mitigation**						
						(M+	**E+**	**R+**	**D)x**	**P=**	**S**	**Rating**	**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**	**Rating**
Impact 1:	Loss of foraging habitat by clearing of vegetation.	Bat foraging habitat will be destroyed during construction, however the relative footprint is small.	Construction	Negative	Easy	1	1	3	2	4	**28**	**N2**	1	1	3	2	3	**21**	**N2**
					Significance	**N2 - Low**							**N2 - Low**						
Impact 2:	Roost destruction during earthworks.	Bat roosts in trees and ~~buidlings~~buildings may be destroyed during construction, this can cause bat mortalities or permanent disturbances to roosts.	Construction	Negative	Easy	4	1	3	2	2	**20**	**N2**	4	1	3	2	1	**10**	**N1**
					Significance	**N2 - Low**							**N1 - Very Low**						
OPERATIONAL PHASE																			
Impact nr	**Receptor**	**Description**	**Stage**	**Character**	**Ease of Mitigation**	**Pre-Mitigation**							**Post-Mitigation**						
						(M+	**E+**	**R+**	**D)x**	**P=**	**S**		**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**	
Impact 1:	Bat mortalities during foraging.	Foraging bats can be killed by colliding with turbine blades, or by suffering barotrauma	Operational	Negative	Hard	4	2	3	4	5	**65**	**N4**	4	2	3	4	3	**39**	**N3**
					Significance	**N4 - High**							**N3 - Moderate**						

Impact 2:	Bat mortalities during migration.	Migrating bats influence several ecosystems since they are cave dwelling species, also over a larger area due to the distances that may be travelled. If turbines are placed within a migration path, a larger area and higher diversity of ecosystems may be impacted.	Operational	Negative	Hard	4	3	3	4	4	**56**	**N3**	4	3	3	4	2	**28**	**N2**
					Significance	**N3 - Moderate**							**N2 - Low**						
Impact 3:	Increased bat mortalities due to light attraction and habitat creation.	Floodlights and other lights at turbine bases or nearby buildings, will attract insect eating bats and therefore significantly increase the likelihood of these bats being impacted on by moving turbine blades. Habitat creation in the roofs of nearby buildings, creation of wetlands or open water sources due to stormwater drainage can cause a similar increased risk factor.	Operational	Negative	Easy	4	2	3	4	5	**65**	**N4**	4	2	3	4	2	**26**	**N2**
					Significance	**N4 - High**							**N2 - Low**						

5.2 Cumulative impact

Table 5-3: Identified potential cumulative impacts of the proposed Mukondeleli WEF project, as well as recommended mitigation measures.

Potential impact	**Recommended mitigation**
	Operational phase
Bat mortalities during foraging.	Each WEF adhere to its respective sensitivity map criteria (already implemented at Mukondeleli WEF). Turbine layout adjustments to adhere to the sensitivity maps, and where needed reducing blade movement at selected turbines and high-

	risk bat activity times/weather conditions. Acoustic deterrents are developed well enough to be trialled. Each WEF should measure its bat mortality impact during operation and ensure that the WEF impacts remain within sustainable levels.
Bat mortalities during migration.	Reducing blade movement at selected turbines if a migration route is discovered. Acoustic deterrents are developed well enough to be trialled. Each WEF should measure its bat mortality impact during operation and ensure that the WEF impacts remain within sustainable levels.
Increased bat mortalities due to light attraction and habitat creation.	Each WEF to 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. This will be at turbine bases (if applicable and other infrastructure buildings). For buildings, avoid tin roofs and roof structures that offer entrance holes into the roof cavity. The stormwater management plan should prevent the creation of any artificial wetlands and open water sources within 300m of any turbine bases.

Table 5-4: Assessed potential cumulative impacts of the proposed Mukondeleli WEF project.

Impact nr	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
						(M+	E+	R+	D)x	P=	S		(M+	E+	R+	D)x	P=	S	
Impact 1:	**Bat mortalities during foraging.**	**Bat mortalities over long periods of time can negatively impact species genetic diversity in a population. If this occurs over a larger area of several wind farms, it decreases the chances of bat populations recovering to a prior state. Bats play an important role in controlling insect numbers, certain species of insects may increase in numbers over a larger area if bats are negatively impacted.**	**Cumulative**	**Negative**	**Hard**	**4**	**3**	**3**	**4**	**4**	56	N3	**4**	**3**	**3**	**4**	**3**	42	N3
					Significance	N3 - Moderate							N3 - Moderate						

Impact 2:	**Bat mortalities during migration.**	**Bat mortalities over long periods of time can negatively impact species genetic diversity in a population. If this occurs over a larger area of several wind farms, it decreases the chances of bat populations recovering to a prior state. Bats play an important role in controlling insect numbers, certain species of insects may increase in numbers over a larger area if bats are negatively impacted. For migrating bats the area of influence are dependent on the migration routes, and may therefore involve WEF's not in the immediate larger area.**	**Cumulative**	**Negative**	**Hard**	**4**	**4**	**3**	**4**	**4**	60	N3	**4**	**4**	**3**	**4**	**2**	30	N2
					Significance	N3 - Moderate							N2 - Low						
Impact 3:	**Increased bat mortalities due to light attraction and habitat creation.**	**Floodlights and other lights at turbine bases or nearby buildings, will attract insect eating bats and therefore significantly increase the likelihood of these bats being impacted on by moving turbine blades. Habitat creation in the roofs of nearby buildings or by creating wetlands or open water sources due to stormwater drainage can cause a similar increased risk factor. Considering several WEF's, the overall mortality rate will be significantly higher with an increased likelihood of impact.**	**Cumulative**	**Negative**	**Easy**	**4**	**3**	**3**	**4**	**3**	42	N3	**4**	**3**	**3**	**4**	**2**	28	N2
						N3 - Moderate							N2 - Low						

6 RECOMMENDED MITIGATION OPTIONS PERTAINING TO THE EMPr

Addition~~al~~ to the mitigation of turbine placement (adhering to a bat sensitivity map), the available options to minimise bat mortalities are discussed in this section. Details on how each option must be implemented is explained in the step-by-step Mitigation Action Plan in Section 7.

6.1 Minimisation of light pollution and artificial habitat creation

A mitigation to consider in the design of the Mukondeleli WEF is to keep artificial lighting to a minimum on the infrastructure (O&M buildings and on wind turbines), while still adhering to safety and security requirements. For example, this can be achieved by having floodlights down-hooded, installing passive motion sensors onto lights around buildings and possibly utilising lights with lighting colours (also referred to as lighting temperatures) that attract fewer insects. Light pollution will impact bat feeding habits and species compositions negatively, by artificially discouraging photophobic (light averse) species and favouring species that readily forage around insect-attracting lights.

Stormwater management should also avoid creating artificial wetlands and open water sources in the turbine zones (less than 300m from any turbine base), as this will increase insect and bat activity around turbines.

The likelihood of bats being killed by moving turbine blades increases significantly when they are attracted to their proximity when it has become an improved foraging airspace due to the presence of artificial light or artificial water sources.

6.2 Curtailment to prevent freewheeling

Freewheeling occurs when the turbine blades are rotating in wind speeds below the generator cut-in speed (also called the **manufacturer's cut-in speed**), thus no electricity is being produced and only some blade momentum is maintained.

Since bat activity tends to be negatively correlated with wind speed, it means that high numbers of bats are likely to be flying and impacted on in low wind speeds where freewheeling may occur. If turbine blades are feathered below the generator cut-in speed to prevent freewheeling, it can result in a very significant reduction of bat mortalities with minimal energy production loss.

6.3 Curtailment that increases the cut-in speed

The activity levels of South African bats generally decrease in weather conditions with increased wind speeds. However, in scenarios where an unsustainable number of bats is being killed, and these bats fly in wind speeds above the turbine manufacturer's cut-in speed, the turbine's computer control system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) can be programmed to a cut-in speed higher than the manufacturer's set speed. The new cut-in speed will then be referred to as the **mitigation cut-in speed** and can be determined from studying the relationship between long term (12-month) bat activity patterns on site and wind speed. This sustainable threshold of bat mortalities will be calculated according to the *South African Bat Fatality Threshold Guidelines* (MacEwan, *et al.*, Edition 2, October 2018).

Turbines are curtailed in this manner by means of blade feathering, to render the blades motionless in wind speeds below the mitigation cut-in speed.

6.4 Acoustic bat deterrents

This technology is developed well enough to be tested on site and may be recommended during operational monitoring, if mortality data indicate bat mortalities above the sustainable threshold for the wind farm. This threshold will be calculated according to the *South African Bat Fatality Threshold Guidelines* (MacEwan, *et al.*, Edition 2, October 2018). Initial experiments with this technology on wind farms in South Africa are yielding promising results that may indicate the effectiveness of the devices in the correct scenarios.

Current data on the South African trials is still limited to a small sample set, and the technology will not necessarily be effective in all mitigation scenarios and for all bat species. Therefore, it should be considered and tested on a case-by-case basis if possible, and it is highly recommended that adequate monitoring continues concurrently, to assess the effectiveness of the devices in reducing bat mortalities.

7 MITIGATION ACTION PLAN FOR INCLUSION INTO THE EMPr

7.1 Step 1: Minimisation of light pollution and artificial habitat creation (refer to Section 6.1)

During the planning phase for the Mukondeleli WEF it must become mandatory to 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, where practically possible without compromising security requirements. This applies to the turbine bases (if applicable) and other infrastructure/buildings. Aviation lights should remain as required by aviation regulations. Floodlights should be down-hooded and where possible, lights with a colour (lighting temperature) that attract less insects should be used. This mitigation step is a simple and cost-effective strategy to effectively decrease the chances of bat mortality on site.

Bi-annual visits to the facility at night must be conducted for the operational lifetime of the facility by operational staff of the facility, to assess the lighting setup and whether the passive motion sensors are functioning correctly. The bat specialist conducting the operational bat mortality monitoring must conduct at least one visit to site during nighttime to assess the placement and setup of outside lights on the facility. When lights are replaced and maintenance on lights is conducted, this Mitigation Action Plan must be consulted.

The storm water drainage plan must avoid creations of artificial ponds/open water sources or wetlands in turbine zones (less than 300m from any turbine base), as these will increase insect activity and therefore bat activity in the area. This can result in turbines that were previously assessed as having a low risk to be financially and biologically costly high-risk turbines.

7.2 Step 2: Appointment of bat specialist to conduct operational bat mortality monitoring

As soon as the Mukondeleli WEF facility becomes operational, a bat specialist must be appointed to conduct a minimum of 2 years of operational bat mortality monitoring. The methodology of this monitoring must comply with the *South African Good Practice Guidelines for Operational Monitoring for Bats at Wind Energy Facilities - 2nd Edition June 2020* (Aronson *et al.* 2020), or any newer version of the applicable guidelines that may be in force at the start of operation of the facility.

The results of the bat mortality study may be used to develop mitigation measures focused on specific problematic turbines. The results of the operational monitoring must be made available, on request, to other bat specialists conducting operational and preconstruction monitoring on WEF's in South Africa.

7.3 Step 3: Curtailment to prevent freewheeling (refer to Section 6.2)

For the lifetime of the facility, curtailment must be applied to all turbines by ninety-degree feathering of blades below the **manufacturer's cut-in speed**, so it is exactly parallel to the wind direction and minimises freewheeling blade rotation as much as possible without locking the blades. The time-period of the year for this blade feathering is determined from the 12 months bat activity data as 1 October – 30 April. This can significantly lower probability of bat mortalities. Influence on productivity is minimal since no power is generated below the manufacture's cut-in speed.

7.4 Step 4: Additional mitigation by curtailment or acoustic deterrents (refer to Sections 6.3 and 6.4)

If mitigation steps 1 – 3 are followed, and the bat mortality monitoring study detects bat mortalities that are above the sustainable threshold for the Mukondeleli WEF, then additional mitigation will need to be implemented to bring bat mortalities to or below the sustainable threshold. According to the *South African Bat Fatality Threshold Guidelines* (MacEwan, *et al.*, Edition 2, October 2018), this threshold is calculated by considering the hectare size of the WEF area of turbine influence and the value of 2% of bats/10ha/year for the ecoregions that the WEF is located in, to give an annual number of sustainable bat mortalities that is acceptable for the WEF. The area of turbine influence of a wind farm is dictated by the turbine layout and is a tight fitting polygon around the turbine layout. The site is located in the Highveld Grasslands ecoregion according to Olson *et al.* (2012), and this ecoregion is not covered in the threshold guidelines. Therefore, the number of sustainable bat mortalities cannot be calculated at this stage, and operational mortality monitoring data should contribute to calculating this threshold. If an updated version of the threshold guidelines are available during the WEF operation, it must be consulted.

Such additional mitigation measures may be to curtail problematic turbines according to the **mitigation cut-in speed** (Section 6.3), and/or to utilise acoustic deterrents on problematic turbines (Section 6**Error! Reference source not found.**.4).

The time-period of the year for additional mitigation is determined from the 12 months bat activity data as 1 October – 30 April and must be applied to any turbines or group of turbines identified as causing the wind farm's mortalities to be above the sustainable threshold levels. This time period is based on high bat activity months as detected during the 12-month preconstruction study.

The bat specialist conducting the operational bat monitoring may recommend other time periods for additional mitigation, based on robust mortality data. If required, the bat specialist may make use of climatic data to allow for an active and adaptable mitigation schedule.

7.5 Step 5: Auditing of bat mortalities for the lifetime of the facility

During the implementation of mitigation Steps 1 – 4, it is crucial for the facility to determine and monitor bat mortalities in order to implement, maintain and adapt mitigations as efficiently as possible. For the duration of the lifetime of the facility, the impacts on bats must be audited/monitored by reliable methods of carcass searching and/or electronic devices capable of automatically counting bat mortalities. Such auditing should occur every 5 years (after the end of the initial 2-year operational study) for all turbines on site, and continuously for turbines where mitigations discussed in Step 4 (Sections **Error! Reference source not found.**~~6.3~~ and **Error! Reference source not found.**~~6.4~~) are implemented.

8 CONCLUSION

This 12-month Pre-construction Bat Environmental Impact Assessment Report considered information gathered from site visits between November 2020 and December 2021, the scientific literature, and satellite imagery. The bat species most likely to be impacted on by the proposed Impumelelo WEF are *Miniopterus natalensis, Laephotis* (formally *Neoromicia*) *capensis* and *Tadarida aegyptiaca*. These species are of special importance based on their likelihood of being impacted by the proposed WEF, due to high abundances and certain behavioural traits. They have also been dominating records of fatalities at wind energy facilities in South Africa. These more 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.

Roosting and foraging habitats may be significantly impacted during the construction phase of this project. This is primarily due the fact that such facilities require large areas of land to be cleared, and in some cases, earthworks are required for levelling purposes. This can result in habitat that is suitable for micro roosts, such as clumps of trees and certain vegetation being destroyed, which can also be fatal to bats residing in such roosts. Natural vegetation can support higher insect food quantities and diversity than cleared land, therefore foraging habitat can also be displaced.

At its nearest, the dolomitic geology of the greater area extends to approximately 48km north-west of the WEF. Dolomite is known to be prone to good cave formation, and many bat colonies are supported in such caves in the country, particularly in the province of Gauteng. Museum records of bats collected from one cave within approximately 100km of the site exist. Specimens of *Rhinolophus clivosus*, *Cloeotis percivali*, and *Miniopterus natalensis* were collected from Wonderboom cave (95km to the north), although the Strategic Environmental Assessment (SEA) wind energy buffer of 50km for large bat roosts does not extend to the area of influence around the proposed Impumelelo WEF. Should any possible cave/roost locations be found to be supporting large enough bat colonies within 50km of the proposed site, this will have implications for the development.

The High Bat Sensitivity areas designated by the specialist in the Sensitivity Map supplied with this report 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. Avoidance is the most effective mitigation measure for reducing the impact on bats, and should be implemented as the first layer of mitigation. No turbine blades may intrude into high sensitivity buffers, therefore turbine base points must be a minimum of 100m from the high bat sensitivity buffer edge (considering the proposed 200m rotor diameter). Medium sensitivities indicate areas of probable increased risk due to seasonal fluctuations in bat activity, but turbines are allowed to be constructed in medium sensitivity areas. **Table 4-3** provides details on the significance of the sensitivity criteria on each infrastructure type. The bat sensitivity map has been respected and turbine layouts adjusted by the applicant to avoid high bat sensitivity buffers.

The site is located in the Highveld Grasslands ecoregion according to Olson *et al.* (2012), and this ecoregion is not covered in the pre-construction guidelines. Therefore, the bat mortality risk cannot be assigned according to the guidelines in MacEwan *et al.* (2020) utilising median average hourly bat passes, and the probability of active mitigations being required during operation need to be determined by the results of the operational mortality monitoring.

The most effective and required method of mitigation (after adhering to the sensitivity map) can be determined from pre-construction acoustic bat activity data, climatic data and the results from the operational bat mortality monitoring. The operational bat mortality monitoring will determine the need for mitigation. If required, the specific turbines to be mitigated, in combination with the data from the pre-construction and operational studies, will enable a detailed mitigation schedule to be implemented as needed. The months when mitigation is most likely to be necessary, are indicated by the data to be 1 October – 30 April. The prominent bat activity peaks detected across all systems for certain are likely to be due to weather conditions being favourable to bats and their insect prey during such months. Such favourable weather conditions may occur when low wind speeds coincide with higher temperatures.

The presence of security lights on and around these facilities creates significant light pollution that can impact bat feeding habits and species compositions negatively, by artificially discouraging photophobic (light averse) species and favouring species that readily forage around insect-attracting lights. Additionally, if the buildings and associated infrastructure for these facilities are placed close to wind turbines, the light pollution at these buildings can attract photophilic bat species, thereby significantly increasing their chances of being killed by moving blades of turbines within close proximity.

Cumulative impacts at Mukondeleli WEF can be mitigated by the same mitigation applied to the Impumelelo WEF for most identified impacts. This should be considered during the turbine layout design phase of the Impumelelo WEF.

The pre-construction bat monitoring has now been completed and informs the EIA phase; passive bat activity data has been gathered, which provides comparative bat activity and species assemblages across all seasons as well as various habitats, terrain and/or areas of the site. If the proposed WEF is approved, a minimum of 2 years of operational bat mortality monitoring should be conducted from the start of the operation of the facility.

From a bat impact perspective, if all recommended mitigation measures are adhered to and included in the EMPr and operational monitoring is carried out, no reasons have been identified for the ~~Impumelelo~~ Mukondeleli WEF development not to receive Environmental Authorisation

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