# Appendix G.5

## BAT REPORT

Confidential

# Bat Monitoring and Impact Assessment Report for the proposed Phefumula Emoyeni One Wind Energy Facility, Ermelo, Mpumalanga

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Compiled for: Phefumula Emoyeni One (Pty) Ltd

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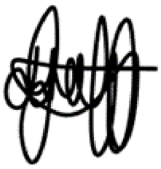
## Declaration of Independence

Inkululeko Wildlife Services (Pty) Ltd (IWS) is an independent consultancy. IWS has no legal or financial connection with the developer except for having fulfilled the tasks required for this assessment. Remuneration to IWS for conducting this assessment is not linked to the authorisation of the project by the competent authority. In addition, IWS has no interest or connection to any secondary or future development associated with the approval of this project. This report was compiled by Dominique Greeff, Myles Bushell, and Dr Caroline Lötter, who is registered with the South African Council for Natural Scientific Professions (SACNASP).

Signed for Inkululeko Wildlife Services (Pty) Ltd by:



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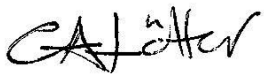

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## Executive Summary

Presented in this report is the Pre-construction Bat Monitoring and Impact Assessment for Phefumula Emoyeni One (Pty) Ltd's proposed Phefumula Emoyeni One Wind Energy Facility (WEF) near the town of Ermelo in Mpumalanga. The Assessment was based on a desktop review, 12 months of passive acoustic bat monitoring in the WEF site, multiple site visits to the study area involving, inter alia, extensive ground-truthing of potential bat important features, and knowledge from long-term bat monitoring conducted previously in the region by IWS team members.

The most salient findings from the monitoring are as follows:

- Signs of bat roosting were found onsite in both unoccupied and occupied farmhouses and outbuildings.
- The passive acoustic monitoring revealed that at least six bat species frequent the study area, *viz*. the Egyptian Free-tailed Bat (*Tadarida aegyptiaca*), Cape Serotine (*Laephotis capensis*), Natal Long-fingered Bat (*Miniopterus natalensis*), Mauritian Tomb Bat (*Taphozous mauritianus*), Midas' Free-tailed Bat (*Mops midas*), and Yellow-bellied House Bat (*Scotophilus dinganii*). Five of the six detected species have a High fatality risk of collision with turbines, while the Yellow-bellied House Bat has a Medium-High fatality risk of collision with turbines (MacEwan *et al*. 2020a).
- Although the Egyptian Free-tailed Bat was the dominant species in turbine rotor sweep height, the Cape Serotine and Natal Long-fingered Bat respectively contributed up to 39% and 18% of all bat calls recorded at 116 m and 65 m a.g.l. It is, therefore, anticipated that during operation of the WEF, most of the turbine-related bat fatalities will comprise Egyptian Free-tailed Bats and Cape Serotines, followed by Natal Long-fingered Bats. Mauritian Tomb Bats, Midas' Free-tailed Bats, Yellow House Bats, and possibly other species will likely also be killed during operation, but in fewer numbers.
- An overall average of 4.8 bat passes (bp) per night (or 0.4 bp per hour) at 116 m, 13.2 bp per night (1.1 bp per hour) at 65 m, and 88.6 bat passes (bp) per night (7.5 bp per hour) near ground level was recorded. The levels of bat activity recorded through eight of the nine microphones, was similar to analogous average values of bat activity at other proposed WEF sites in the Highveld grassland ecoregion. A distinct exception was the PH4 10 m station, where an extremely high average of 346 bp per night (or 29.1 bp per hour) was recorded, possibly due to its location amidst woody vegetation in proximity to at least one farmhouse where evidence of bat roosting was found.
- Nights when the highest total numbers of bat passes were recorded at height occurred during the months of March and April. On nights when the levels of Egyptian Free-tailed bat activity at 116 m can be 9.5 times higher than the average level of 4.8 bp per night at 116 m, fatalities will be likely without effective mitigation.
- Due to their protracted night-time activity, Egyptian Free-tailed Bats will be at risk of fatality from turbines throughout the night whenever favourable weather, insect, and other conditions prevail. In contrast, Cape Serotines will likely be at greatest risk of fatality for 1-3 hours after sunset, and in some areas (near roosts) for 1-3 hours before sunrise. These taxon-specific differences should be taken into consideration if/when fatality mitigation measures are implemented.
- Most (>95% of) bat activity in rotor sweep height was recorded during temperatures above 11 and below 25°C.Half of the time, bats were active onsite during wind speeds stronger than 4.5 m/s at 65 m or 6.5 m/s at 116 m a.g.l. If the bat fatality threshold is exceeded during operation, only 50% of activity of all bat species onsite would be protected below a cut-in wind speed of 4.5 m/s at 65 m or 6.5 m/s at 116 m a.g.l. should turbine curtailment be implemented.

A final bat sensitivity map for the WEF site was compiled, where:

- **High** bat sensitive areas include:
    - A 2.5 km buffer around the building roost near PH4, where exceptionally high levels of bat activity were recorded.
    - Other buildings where appreciable evidence of bat roosting was found, and a 1 km buffer around these.
    - Remaining buildings, where bats potentially roost and/or forage e.g. around lights at night, and a 500 m buffer around these.
    - Natural rock surfaces with cavities and crevices, which may provide roosting habitat for certain bat species, and a 500 m buffer around these.
    - Rivers, dams, wetlands, and pans, and a 200 m buffer around these.
    - Dense woody vegetation, and a 200 m buffer around this.
- **Medium-High** bat sensitive areas include:
    - A 2.5-5 km buffer around the building roost near PH4, for added protection of bats in this area where exceptionally high levels of bat activity were recorded.
    - Herbaceous wetlands in fallow lands and old fields, and a 200 m buffer around these.
    - Commercial irrigated crops, and a 200 m buffer around these.
    - Fallow and old fields with bushes or trees.
- **Medium** bat sensitive areas include:
    - Natural grassland.
    - Commercial rain-fed crops.
    - Flooded mine pits, and a 200 m buffer around these.
- Remaining areas were rated with **Low** sensitivity.

The sensitivity mapping should be interpreted as follows:

- **High** bat sensitive areas represent **No-Go** areas for the construction of WEF infrastructure especially turbines, substations, buildings, construction camps, laydown areas, and possible quarries (to avoid disturbing key bat roosting, foraging, and/or commuting habitat, and to avoid high bat fatalities in these areas where high bat activity is anticipated). No turbine, including its full rotor swept area and a 2 m pressure buffer around this, should occur in High sensitive areas. Consequently, turbines should be located a minimum of one blade length plus 2 m away from High sensitive areas. Construction of linear infrastructure such as roads and underground powerlines and cabling is only permissible in High Bat Sensitive Areas if this will not result in destruction or disturbance of bat roosts.
- **Medium-High** Bat Sensitive Areas represent areas where the construction of infrastructure and other disturbances should be avoided where possible (to avoid areas where bat activity is likely to be concentrated). Should turbines be proposed in Medium-High sensitive areas, IWS recommends that these should be curtailed for the first three hours after sunset, below a cut-in wind speed of 6 m/s when temperatures of 11-25 ˚C prevail (as measured at 65 m a.g.l.). Alternatively, if turbines in Medium-High sensitive areas are each fitted with a Wildlife Acoustics SMART bat detector, curtailment could be limited to specific turbines and periods when elevated bat activity is recorded.
- Disturbances in **Medium** sensitive areas should be minimized.

Potential impacts on bat species, habitats, and ecosystems services from wind energy development in the WEF site were assessed, and measures to mitigate these have been recommended. Potential impacts include: i) bat roost disturbance; ii) terrestrial habitat loss, and possible displacement of bats; iii) bat fatalities from collision with turbines, and possible population declines; and iv) compromised bat ecosystem services. The future cumulative impact on bats from several proposed WEF's in the region is of greatest concern.

Without mitigation, the proposed Phefumula Emoyeni One WEF may have a potential Very High impact in terms of bat fatalities from their collision with turbines, and a High impact on bat roosts, terrestrial (bat foraging) habitat, and bat ecosystem services.

With diligent mitigation as recommended in this report, the WEF is expected to have a Moderate impact in terms of bat fatalities, and on terrestrial habitat and bat eco-services, and a Low impact on bat roosts.

Recommended bat impact mitigation measures for the WEF include the following:

- **Avoid High sensitive areas**, including all bat significant features and the buffers around these. No turbine, including its full rotor swept area and a 2 m pressure buffer around this, should occur in High sensitive areas.
- **Avoid Medium-High sensitive areas where possible**, in particular, the 2.5-5 km buffer around the building roost near the PH4 monitoring location, where very high levels of bat activity were recorded. Should turbines be proposed in Medium-High sensitive areas, IWS recommends that these should be curtailed for the first three hours after sunset, below a cut-in wind speed of 6 m/s when temperatures of 11-25 ˚C prevail (as measured at 65 m a.g.l.). Alternatively, if turbines in Medium-High sensitive areas are each fitted with a Wildlife Acoustics SMART bat detector, curtailment could be limited to specific turbines and periods where and when elevated bat activity is recorded.
- **Minimise the length and breadth of proposed roads** to thus minimise the loss and fragmentation of terrestrial (bat foraging) habitat.
- **Minimize the number of proposed turbines** to potentially reduce the extent of the road network and the overall extent of the wind farm and thus, the extent of terrestrial habitat loss and possible displacement of bats.
- **Avoid blasting within 2 km of a confirmed roost.**
- **Consult a Bat Specialist if a bat roost is encountered** during any phase of the WEF, and refrain from disturbing the roost until appropriate advice has been obtained.
- **Minimise the degradation of terrestrial habitat** by implementing and maintaining effective dust, stormwater, erosion, sediment, and invasive alien plant control measures.
- **Rehabilitate disturbed terrestrial habitat** by comprehensively and diligently implementing effective rehabilitation measures based on consultation with an appropriate vegetation specialist.
- **Minimise artificial lighting on site** (excluding compulsory civil aviation lighting) – especially high-intensity, steady-burning, sodium vapour, quartz, halogen, and other bright lights at substations, offices, and turbines (to avoid disturbing roosts of certain sensitive bat species). All non-aviation lights should be hooded downward and directed to minimise horizontal and skyward illumination. Where possible, solar-powered motion-sensitive lights should be used.
- **Monitor bat fatalities as soon as the first turbine is operational** – as per the latest SABAA guideline for this (Aronson *et al*. 2020 or later) and the latest (2023 or later) IFC Good Practice Handbook on post-construction bird and bat fatality monitoring for onshore WEFs in emerging market countries. At the very least, bat fatality monitoring should be conducted during the WEF's first two years of

operation, and then every fifth year thereafter. The monitoring and data analysis are to be conducted to a high standard so that there is confidence in the estimated numbers of actual bat fatalities.

- **Conduct passive monitoring of live bat activity** as soon as the first turbine is operational, and whenever bat fatality monitoring is performed during the WEF's operation. The operational passive monitoring should represent a repeat of the pre-construction passive monitoring, so far as this is possible. This will allow for comparison of operational bat activity levels with pre-construction bat activity levels and operational bat fatalities, and it will help to assess the efficacy of any implemented bat fatality mitigation measures.
- **Mitigate bat fatalities adaptively** by consulting the latest SABAA guideline for this (Aronson *et al.* 2018 or later), and the best available relevant scientific information. Taxon-specific differences should be taken into consideration if/when fatality mitigation measures are implemented. The calculation of bat fatality thresholds (as described by MacEwan *et al.* 2018) is dependent, inter alia, on the final (constructed) layout of turbines. Adequate financial provision should be made to permit effective monitoring, management, and mitigation of bat fatalities throughout the life of the WEF.
- **Forward all (live and fatality) bat monitoring data** to the database recommended by the South African Bat Assessment Association (SABAA) to expand the scientific knowledge base for more informed decision making and mitigation.

**It should be noted that although the total number of turbines has decreased from 120 to 88, which is better for bats, there has been an increase in the number of turbines located in High or Medium-High sensitive areas from 37 to 45, which is worse for bats.** Specifically:

- Turbine 11, T12, T13, T27, T44, T47, T48, T49, T53, T56, T63, T68, T81, T82, and T88 have rotor sweep areas that encroach on High sensitivity buffers. **These turbines will have to be moved.**
- Turbine 7, T8, T21, T23, T25, T26, T28, T32, T33, T34, T35, T36, T37, T38, T42, T45, and T61 are proposed in the 2.5-5 km Medium-High sensitive buffer around the PH4 monitoring location, where very high bat activity was recorded. **To reduce bat fatalities at these turbines, the prescribed blanket curtailment must be implemented, unless SMART detectors are used for smart curtailment in response to real time bat activity.**
- Turbine 4, T29, T40, T51, T52, T59, T65, T66, T73, T79, T80, T83, and T84, which are located in other Medium-High sensitive areas, **will also require the prescribed blanket or smart curtailment.**
- Turbine 9, T14, T15, T16, T17, T20, T50, T55, T58, T70, T71, T75 and T85 which are positioned in Medium sensitive areas, have rotor sweep areas that encroach on Medium-High sensitive areas. **Where possible, these turbines should be shifted slightly to avoid encroachment into Medium-High sensitive areas.**

Given the high recorded level of bat activity around the PH4 bat monitoring location, and the rapid expansion of renewable energy developments in the immediate surrounds and further afield, **bat fatality mitigation is essential for the proposed Phefumula WEF. Going forward, the Client is strongly advised to carefully evaluate the feasibility of the prescribed curtailment and to ensure that there is adequate financial planning and provision for the curtailment. All bat impact mitigation measures recommended in this report must, so far as applicable, be followed and included in the Wind farm's Environmental Management Programme (EMPr). This includes the details of the prescribed curtailment, which must be diligently implemented as soon as each turbine starts spinning. Additionally, it must be explicitly stated in the EMPr that if smart curtailment is not successfully implemented, the affected turbine(s) must be prevented from spinning at night until a suitable alternative form of bat fatality mitigation, recommended by an appropriately experienced bat specialist, is fully operational.**

## Table of Contents

## List of Figures



## List of Tables

## 1. Introduction

Phefumula Emoyeni One (Pty) Ltd proposes to develop the Phefumula Emoyeni One (hereafter; PhE) Wind Energy Facility (WEF) near the mining town of Ermelo, in Mpumalanga, South Africa (**Figure 1**). To this end, Inkululeko Wildlife Services (IWS) was appointed to undertake 12 months of pre-construction bat monitoring and impact assessment as per the current South African guidelines on bat monitoring for proposed wind farms (MacEwan *et al*. 2020a).

Presented in this report is the Bat Monitoring and Impact Assessment for the proposed PhE WEF, based on a desktop review, 12 months of passive acoustic bat monitoring in the WEF site, multiple site visits to the study area involving, inter alia, extensive ground-truthing of potential bat important features, and knowledge from long-term bat monitoring conducted previously in the region by IWS team members. The desktop- and field-based Report findings include a bat species list, bat activity graphs, bat sensitivity map, and an assessment of potential impacts of wind energy development on local bat species, habitats, and ecosystem services, with recommended impact mitigation measures.

## 2. Site and Project Description

The PhE WEF site is approximately 33 660 ha in extent and is situated roughly 6 km north-west of Ermelo, 15 km north-east of Bethal, and 16 km south of Hendrina on the Mpumalanga Highveld. The natural environment is typified by grassland and hydrological features including rivers, pans, and herbaceous wetlands (**Figure 1**). Commercial crop (mainly maize) cultivation and livestock (cattle and sheep) farming are the predominant forms of land-use. Small, scattered coal mining and similar operations also occur in the study area.

The PhE WEF site will be accessed via the N11 and will have an internal network of 12-13 m-wide gravel roads. Three construction compounds each with a 4-7 ha batching plant and a 3 ha construction / laydown area including a site office are proposed. The WEF will have an export capacity of up to 550 MW and at the time when this report was compiled, the WEF was planned to comprise up to 120 (6-15 MW) turbines, each with a hub height up to 200 m, rotor diameter up to 200 m, and hard stand of approximately 75 m x 120 m (0.9 ha). A 33 kV / 132 kV collector substation (up to 5 ha) and adjoining office and maintenance buildings (OMBs up to 1.5 ha each) are proposed at three separate onsite locations, along with a single 200 MW / 800 MWh battery energy storage system (BESS) with a footprint up to 5 ha. The turbines will be connected to the onsite substations by 33 kV cabling to be laid underground where practical.

## 3. IWS Team

IWS has conducted bat (and bird) monitoring and impact assessments for over 60 (pre-construction and operational) wind farm developments in South Africa, three in Namibia, and one in Zambia, Malawi, and Zimbabwe. IWS team members were involved with the bat sensitivity analysis of the Strategic Environmental Assessment for South Africa's Renewable Energy Development Zones (REDZs), and have performed numerous specialist bat assessments for mines, power lines, the Square Kilometre Array, and other developments, as well as for caves, and protected areas.

Key IWS personnel are as follows.

**Dr Caroline Lötter**

Caroline, the IWS Managing Director and Senior Zoologist, has since 2011 been involved with numerous bat screening, scoping, monitoring, impact, and review studies for wind, solar, mining, infrastructure, and other projects in southern Africa. Caroline is a co-author of the current South African best practice guidelines for pre-construction bat monitoring studies at WEF developments (MacEwan *et al*. 2020a), and a peer-reviewed paper on bat activity and its implications for wind farm development in South Africa (MacEwan *et al*. 2020b).

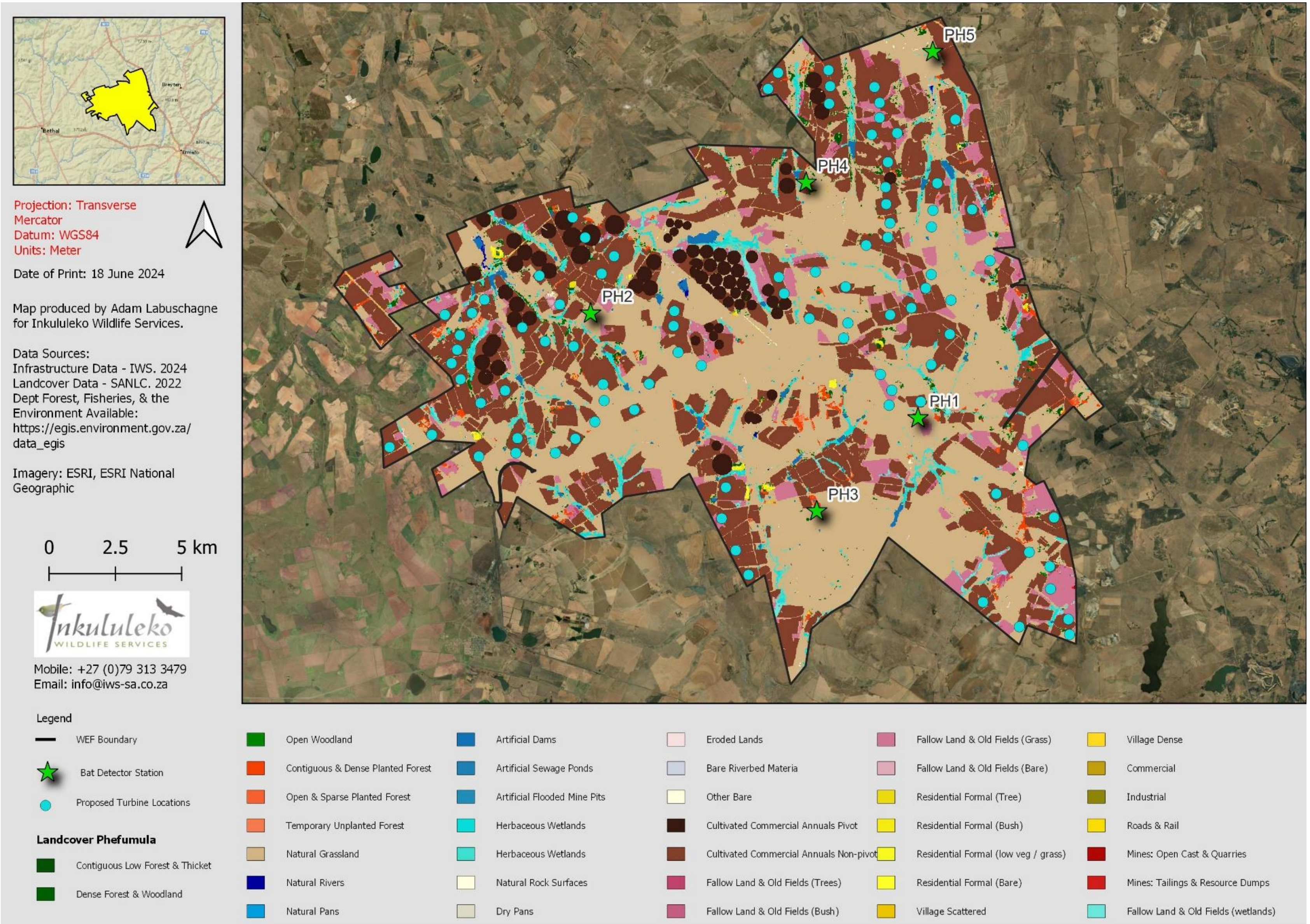



**Figure 1** **National landcover in the Phefumula Emoyeni One WEF site, including the locations of the five bat monitoring stations**

Caroline currently sits on the committees for the South African Bat Assessment Association (SABAA) and the Gauteng and Northern regions Bat Interest Group (GNorBIG). She has a PhD in Zoology and is a member of the Zoological Society of southern Africa and the South African Council for Natural Scientific Professions.

**Trevor Morgan**

Trevor has worked for more than 10 years as the IWS Senior Technician and Bat Data Analyst on all the various bat monitoring projects. For several years he served as an active member on the GNorBIG Committee. Trevor is very knowledgeable on South African bats and has extensive experience with bat detectors, their related software, mist-netting, and harp-trapping. By trade, Trevor is an electrician and an inventor, and has constructed his own harp trap and heterodyne bat detector. Trevor's considerable field-based involvement in all long-term bat monitoring and several bird monitoring studies has been invaluable. Trevor is also a co-author on the MacEwan *et al.* (2020b) article on bat activity and its implications for wind farm development in South Africa.

**Dominique Greeff**

Dominique holds a MSc in Ecology and Environmental Conservation and is an IWS Zoologist with bat specialist expertise spanning fieldwork, GIS mapping, data analysis, report writing, project management, social media, and more. Prior to joining IWS, Dominique spent nearly 2 years focused on bat research and conservation in Malawi, where she acquired a wealth of hands-on experience with mist-netting, harp-trapping, radio-tracking, hand-netting, and identifying a broad diversity of African bats. Prior to this, at the National Zoological Gardens in Pretoria, South Africa, Dominique acquired hands-on and laboratory-related research experience working with animals ranging from African elephants to sungazer lizards and bullfrogs.

**Dr Jarryd Alexander**

Jarryd holds a PhD in Ecological Sciences and is employed as a Zoologist with avian specialist expertise at IWS, where he contributes to fieldwork, report writing, project management, and more. Prior to joining IWS, Jarryd worked for the Mabula Ground Hornbill Project as the Research Manager where his focus was to manage the research outputs of the organisation and the national monitoring of the Endangered Southern Ground-hornbill. His work led to effective conservation action plans being developed and implemented for the species. During his time with the project, he was also involved as a specialist for species specific assessments at wind energy sites. During his time completing his PhD in ecological sciences Jarryd provided specialist consulting on environmental health; pre- and post-development, with specific focus on terrestrial- and avifauna but also including bats and herpetofauna. Jarryd was also contracted as a specialist avifaunal consultant for several environmental assessments post completing his PhD.

**Myles Bushell**

Myles is a new IWS Junior Zoologist who completed his BSc Honours in Wildlife Management at the University of Pretoria, where he investigated the partitioning of food resources among Meletse insectivorous bat species using stable isotope analysis as a proxy for diet. Myles then worked as a Research Assistant in the University's Centre for Viral Zoonoses, where he acquired useful experience with deploying bat equipment and catching live bats. Additionally, Myles has experience as a field guide, so is well versed with environmental management and a broad understanding of most ecological practices.

# 4. Legislation and Guidelines

## 4.1 International agreements

**Convention on Biological Diversity (CBD)**

It is recognized by the CBD that biological diversity is about more than plants, animals and micro-organisms and their ecosystems – it is about people and our need for food security, medicines, fresh air, clean water, shelter, and a healthy environment in which to live. It is an international convention signed by 150 leaders at the Rio 1992 Earth Summit. Namibia is a signatory. An important principle encompassed by the CBD is the precautionary principle which essentially states that where serious threats to the environment exist, lack of full scientific certainty should not be used as a reason for delaying management of these risks. The burden of proof that an impact will not occur lies with the proponent of the activity posing the threat.

**(Bonn) Convention on the Conservation of Migratory Species (CMS) of Wild Animals**

The CMS Convention, signed in 1979, serves to conserve terrestrial, marine and aerial migratory species throughout their range. South Africa is a party to this Convention, which affords protection to various migratory animals. These include a broad spectrum of taxa including certain bat species such as the migratory Natal Long-fingered Bat (*Miniopterus natalensis*), which occurs in the study region.

## 4.2 National legislation

**National Environmental Management: Biodiversity Act (NEM:BA)**

NEM:BA (Act 10 of 2004) provides, inter alia, for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act (Act 107 of 1998); the protection of species and ecosystems that warrant protection; and the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources. Under NEM:BA, the Threatened Or Protected Species (TOPS) Regulations provide for the listing and protection of national Threatened Or Protected Species. Presently no bat species is listed as a Threatened or Protected Species under NEM:BA.

## 4.3 Provincial legislation

**Mpumalanga Nature Conservation Act 10 of 1998**

This Act makes provision for nature conservation in the Mpumalanga province, and for matters connected therewith. While the Act does not specifically mention bats, it does aim to protect all wild and exotic animals that are not game from undue persecution.

## 4.4 Best practice guidance

**International Finance Corporation (IFC) Performance Standard 6 (PS6)**

The IFC Performance Standards (IFC 2012) provide guidance on how to identify sustainability risks and impacts and are designed to help avoid, mitigate, and manage them as a way of doing business in a more sustainable way. PS6 recognizes that "Biodiversity loss can result in critical reductions in the resources provided by the earth's ecosystems, which contribute to economic prosperity and human development. This is especially relevant in developing countries where natural resource-based livelihoods are often prevalent… protecting and conserving biodiversity, maintaining ecosystem services, and managing living natural resources adequately are fundamental to sustainable development." Clients should be aware that if a proposed WEF project does not meet IFC PS6, overseas lenders are likely to be reluctant to invest in the project.

**South African best practice guidelines for pre-construction bat monitoring at WEFs**

The document by MacEwan *et al.* (2020a) provides technical guidance on bat monitoring for proposed wind farms in South Africa. It is principally directed at ecological consultants and environmental impact assessment practitioners to ensure that pre-construction bat studies are sufficiently comprehensive for the evaluation of wind farm applications by authorities. The document includes, inter alia, a synopsis of wind farm impacts on bats, an outline of the minimum requirements for pre-construction bat studies, and methodological considerations for planning and executing these studies.

## 5. Methodology

### 5.1 Desktop review

The desktop review involved (but was not limited to) consultation and consideration of long-term bat monitoring information obtained previously from the region by IWS team members (MacEwan *et al.* 2020b; IWS unpubl. data); the latest bat species records and distribution maps for the region provided by Monadjem *et al.* (2020), the African Chiroptera Report (2021), and MammalMAP (FAIO 2023); and the current South African and global Red List status of the listed bat species (Child *et al.* 2016; IUCN 2022-2).

### 5.2 Fieldwork

It is important to note that the pre-construction bat monitoring study was designed by IWS on the understanding from the Client that the buildable area of the proposed PhE WEF is no more than 20 000 ha. The passive acoustic monitoring of local bat activity commenced during 6-9 September 2022, and ended during 11-14 September 2023. During the 12-month monitoring period, the study area was visited by IWS on six occasions to firstly install the monitoring equipment on the two onsite met. masts and three 10 m masts (**Figure 1**), secondly to check the equipment, download data, and to perform ground-truthing of potential bat important features, and finally to decommission the monitoring equipment.

On the two mets. mast, three Wildlife Acoustics SM4BAT detectors were installed in connection with three omni-directional SMM-U2 microphones, positioned at approximately 10-15 m, 65 m, and 116 m above ground level (a.g.l.) to monitor bat activity near ground level and in the turbine rotor sweep zone.

Day-time ground-truthing of potential bat important features (which included active searching for possible bat roosts) involved visual inspection and logging (with a GPS and camera) of a nearby rocky gorge, and onsite rocky outcrops, various buildings and ruins, and selected large culverts. The extent of IWS' ground-truthing efforts are indicated in **Figure 2**. No live bat catching was performed since this was not considered necessary.

### 5.3 Data analysis

Wildlife Acoustics Compressed (.wac) files of bat calls recorded by the SM4 detectors were converted to wave (.wav) and zero crossing (.zc) files using the Kaleidoscope software program (Wildlife Acoustics Inc., USA). The converted call data were analysed in AnalookW (Titley Scientific, Australia) and BatSound (Pettersson Elektronik, Sweden) to identify bat species based on their diagnostic call characteristics. Microsoft Excel was used to generate graphs from the recorded data. Wind speed and atmospheric temperature data from the two met. masts were used for comparison with the bat activity data recorded onsite.

### 5.4 Sensitivity mapping

Sensitivity mapping was based on the desktop review and observations during IWS' site visits, as well as the national web-based Environmental Screening Tool (https://screening.environment.gov.za/screeningtool/#/pages/welcome), and specifically took into consideration, within the study area (where present):

- Known significant bat roosts.
- Local buildings, including ruins (OpenBuildings dataset from Google).
- Landcover including rocky terrain, natural and artificial permanent, seasonal, and ephemeral surface water resources, woody vegetation, croplands, and more (SANLC 2020).

Buffering of identified bat important features was based on recommendations in the South African guidelines on bat monitoring for proposed wind farms (MacEwan *et al*. 2020a), and our professional judgement.

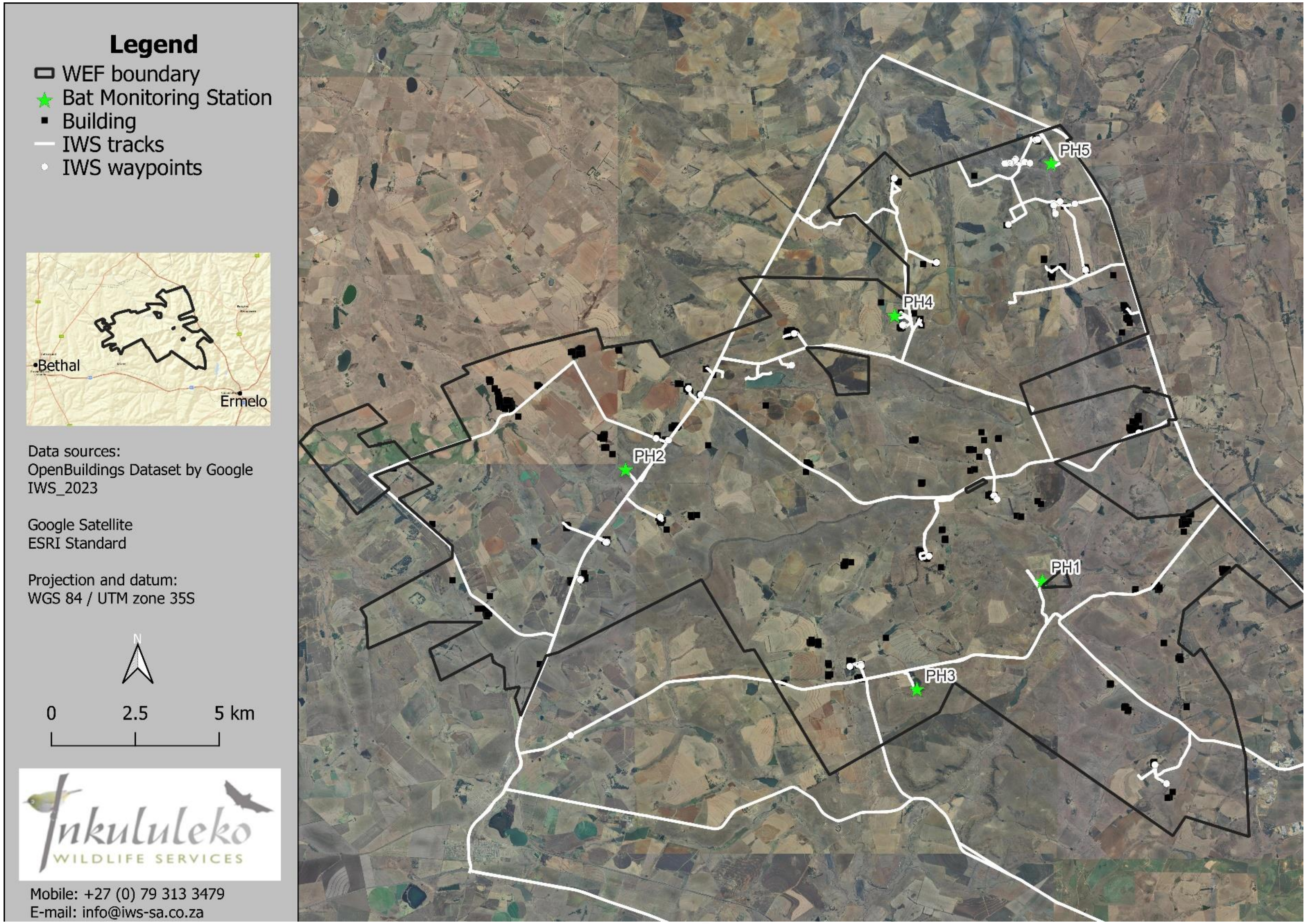



**Figure 2** **Extent of IWS' ground-truthing efforts in the study region**

## 5.5 Impact assessment and mitigation

Potential direct, indirect, and cumulative impacts on bats (including species, habitats, and ecosystem services) were assessed for the different project phases, with and without mitigation, using the methodology and templates for this, which were provided by the project Environmental Assessment Practitioner, WSP. As stipulated by WSP, IWS' mitigation recommendations follow the hierarchy of: avoid/prevent, minimise, rehabilitate/restore, offset and no-go - in successive order.

**Table 1 WSP impact assessment criteria and scoring system**

| CRITERIA | SCORE 1 | SCORE 2 | SCORE 3 | SCORE 4 | SCORE 5 |
|---|---|---|---|---|---|
| **Impact Magnitude (M)** The degree of alteration of the affected environmental receptor | Very low: No impact on processes | Low: Slight impact on processes | Medium: Processes continue but in a modified way | High: Processes temporarily cease | Very High: Permanent cessation of processes |
| **Impact Extent (E)** The geographical extent of the impact on a given environmental receptor | Site: Site only | Local: Inside activity area | Regional: Outside activity area | National: National scope or level | International: Across borders or boundaries |
| **Impact Reversibility (R)** The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change | Reversible: Recovery without rehabilitation | | Recoverable: Recovery with rehabilitation | | Irreversible: Not possible despite action |
| **Impact Duration (D)** The length of permanence of the impact on the environmental receptor | Immediate: On impact | Short term: 0-5 years | Medium term: 5-15 years | Long term: Project life | Permanent: Indefinite |
| **Probability of Occurrence (P)** The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation | Improbable | Low Probability | Probable | Highly Probability | Definite |
| **Significance (S)** is determined by combining the above criteria in the following formula: | $[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$ | | | | |
| **IMPACT SIGNIFICANCE RATING** | | | | | |
| **Total Score** | **4 to 15** | **16 to 30** | **31 to 60** | **61 to 80** | **81 to 100** |
| **Environmental Significance Rating (Negative (-))** | **Very low** | **Low** | **Moderate** | **High** | **Very High** |
| **Environmental Significance Rating (Positive (+))** | **Very low** | **Low** | **Moderate** | **High** | **Very High** |

## 5.6 Assumptions and Limitations

- Not all buildings on site were surveyed; this would have required considerable professional time.
- It should be noted that not all cave and (especially old) mine tunnel locations are necessarily known in the region.
- Information on bat migration in South Africa is limited.

## 6. Results and Discussion

### 6.1 Recording success

The recording success of the five onsite bat monitoring stations PH1-5 is shown in **Figure 3**. During the 12-month monitoring period, recording through the six microphones on the two met. masts was 100% successful. Only one night of data was lost from each of the three short masts (PH3, PH4, and PH5). Overall, the bat monitoring was extremely successful over the 12-month period.

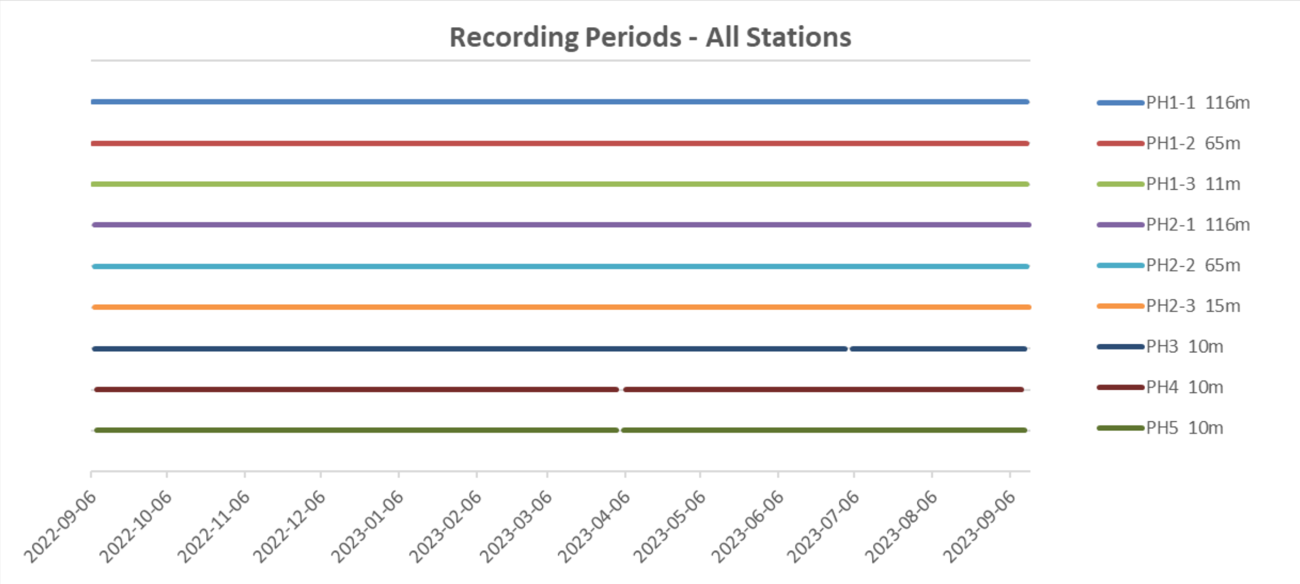



**Figure 3 Recording success through the nine microphones at bat monitoring stations PH1-PH5**

### 6.2 Potentially occurring and detected bat species and roosts

Based on available species records and published distribution maps, potentially 23 bat species occur in the region (hereafter referred to as "potentially occurring species"; **Table 2**). Of these, eight species have a High fatality risk of collision with turbines, and six have a Medium-High fatality risk (MacEwan *et al*. 2020a).

Of the 23 listed species, the following five species are regarded by IWS as Species of Conservation Concern (SCC):

- Percival's Short-eared Trident Bat (*Cleotis percivali*): Regionally Red Listed as Endangered (Child *et al.* 2016).
- Blasius's Horseshoe Bat (*Rhinolophus blasii*): Regionally Red Listed as Near Threatened (Child *et al.* 2016) and experiencing a global population decline (IUCN 2022-1).
- Sundevall's Leaf-nosed Bat (*Hipposideros caffer*): Currently not Red Listed but experiencing a global population decline (IUCN 2022-1).
- Midas Free-tailed Bat (*Mops midas*): Currently not Red Listed but experiencing a global population decline (IUCN 2022-1).
- Natal Long-fingered Bat (*M. natalensis*): known to roost in large numbers (sometimes hundreds or thousands of individuals) and to migrate hundreds of kilometres (Miller-Butterworth *et al*. 2003; Kearney *et al*. 2016; MacEwan *et al*. 2016).

Two of the five above-listed SCC have a High turbine fatality risk, namely, the Natal Long-fingered Bat and the Midas Free-tailed Bat. The remaining listed SCC have a Low turbine fatality risk (MacEwan *et al*. 2020a).

**Table 2 Bat species potentially occurring in the region, including those that were recorded locally**

| FAMILY | SPECIES | COMMON NAME | OCCURRENCE POTENTIAL[1,2,3,4] | RED LIST STATUS | | SPECIES OF CONSERVATION CONCERN[2,5] | TURBINE FATATLITY RISK[7] |
|---|---|---|---|---|---|---|---|
| | | | | Global[5] | Regional[6] | | |
| MOLOSSIDAE | *Tadarida aegyptiaca* | Egyptian Free-tailed Bat | Present (calls recorded) | LC(U) | LC | - | High |
| VESPERTILIONIDAE | *Laephotis capensis* | Cape Serotine | Present (calls recorded) | LC(S) | LC | - | High |
| MINIOPTERIDAE | *Miniopterus natalensis* | Natal Long-fingered Bat | Present (calls recorded) | LC (U) | LC | Migratory | High |
| EMBALLONURIDAE | *Taphozous mauritianus* | Mauritian Tomb Bat | Present (calls recorded) | LC(U) | LC | - | High |
| MOLOSSIDAE | *Mops midas* | Midas' Free-tailed Bat | Present (calls recorded) | LC(D) | LC | - | High |
| VESPERTILIONIDAE | *Scotophilus dinganii* | Yellow-bellied House Bat | Present (calls recorded) | LC(U) | LC | - | Medium – High |
| NYCTERIDAE | *Nycteris thebaica* | Egyptian Slit-faced Bat | Medium-High | LC(U) | LC | - | Low |
| RHINOLOPHIDAE | *Rhinolophus clivosus* | Geoffroy's Horseshoe Bat | Medium-High | LC(U) | LC | - | Low |
| PTEROPODIDAE | *Epomophorus wahlbergi* | Wahlberg's Epauletted Fruit Bat | Medium | LC(S) | LC | - | High |
| RHINOLOPHIDAE | *Rhinolophus simulator* | Bushveld Horseshoe Bat | Medium | LC(D) | LC | - | Low |
| VESPERTILIONIDAE | *Myotis tricolor* | Temminck's Myotis | Medium | LC(U) | LC | Migratory | Medium – High |
| HIPPOSIDERIDAE | *Hipposideros caffer* | Sundevall's Leaf-nosed Bat | Low | LC(D) | LC | - | Low |
| RHINONYCTERIDAE | *Cloeotis percivali* | Percival's Short-eared Trident Bat | Low | LC(U) | EN | - | Low |
| MOLOSSIDAE | *Mops pumilus* | Little Free-tailed Bat | Low | LC(U) | LC | - | High |
| PTEROPODIDAE | *Rousettus aegyptiacus* | Egyptian Rousette | Low | LC(S) | LC | - | High |
| RHINOLOPHIDAE | *Rhinolophus blasii* | Blasius's Horseshoe Bat | Low | LC(D) | NT | - | Low |
| RHINOLOPHIDAE | *Rhinolophus darlingi* | Darling's Horseshoe Bat | Low | LC(U) | LC | - | Low |
| VESPERTILIONIDAE | *Eptesicus hottentotus* | Long-tailed Serotine | Low | LC(U) | LC | - | Medium |
| VESPERTILIONIDAE | *Laephotis botswanae* | Botswana Long-eared Bat | Low | LC(U) | LC | Southern Africa Near-endemic | Low |
| VESPERTILIONIDAE | *Myotis welwitschii* | Welwitsch's Myotis | Low | LC(U) | LC | - | Medium – High |
| VESPERTILIONIDAE | *Pipistrellus hesperidus* | Dusky Pipistrelle | Low | LC(U) | LC | - | Medium – High |
| VESPERTILIONIDAE | *Pipistrellus rusticus* | Rusty Pipistrelle | Low | LC(U) | LC | - | Medium – High |
| VESPERTILIONIDAE | *Scotophilus viridis* | Green House Bat | Low | LC(U) | LC | - | Medium – High |

**Status:** D: Decreasing; LC: Least Concern; NT: Near Threatened; S: Stable; U: Unknown; VU: Vulnerable.

**Source:** [1]Monadjem *et al.* (2020); [2]African Chiroptera Report (2021); [3]FIAO (2023); [4]IWS (2022a, b, and unpubl. data); [5]IUCN (2022-2); [6]Child *et al.* (2016); [7]MacEwan *et al.* (2020a)

Roost searches during the various IWS site visits revealed (**Figure 4**):

- Evidence of bat roosting in multiple unoccupied and occupied farmhouses and outbuildings.
- Potential bat roosting habitat in the form of crevices and cavities where rocky outcrops occur.
- Suitable roosting habitat for bats in a rocky gorge located offsite near the N17.


Culvert


Outbuilding with guano (right)


Guano from roosting bats


Rocky outcrop with scattered crevices and cavities (right)


Crevice


Cavities


Farmhouse with wall stains (right)


Wall stains from bat excrement


Old quarry – not considered suitable for bat roosting


Rocky outcrop with scattered crevices and cavities (right)


Cavities


Crevice


Unoccupied farmhouse with guano and smudge marks (right)


Bat guano in unoccupied farmhouse


Smudge mark at bat roost entrance/exit


Unoccupied farmhouse with guano (right)


Guano


Offsite rocky gorge near the N17


Farmhouse with smudge marks (right)


Smudge mark at bat roost entrance/exit


Smudge mark at bat roost entrance/exit


Garage and farmhouse near PH4, with smudge marks and guano (right)


Smudge mark at bat roost entrance/exit


Guano at bat roost entrance/exit

**Figure 4 Examples of localities where potential bat roosting habitat or evidence of bat roosting was found**

The passive acoustic monitoring onsite (**Figure 5, Figure 6**) revealed that at least the following six insectivorous bat species frequent the study area:

- Egyptian Free-tailed Bat (*Tadarida aegyptiaca*)
- Cape Serotine (*Laeophotis capensis*)
- Natal Long-fingered Bat (*M. natalensis*)
- Mauritian Tomb Bat (*Taphozous mauritianus*)
- Midas' Free-tailed Bat (*M. midas*)
- Yellow-bellied House Bat (*Scotophilus dinganii*)

Five of the six detected species have a High fatality risk of collision with turbines, while the Yellow-bellied House Bat has a Medium-High fatality risk of collision with turbines (MacEwan *et al*. 2020a).

### 6.3 Bat species composition at different heights

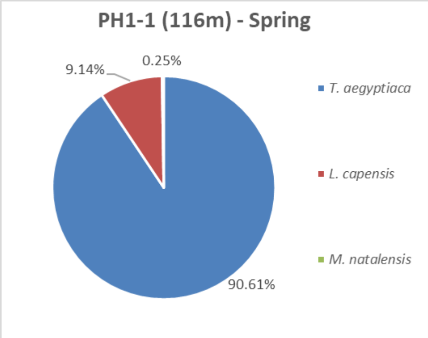
Of the six afore-mentioned bat species that were recorded onsite, all were recorded near ground level and at 65 m a.g.l., and five (excluding the Yellow-bellied House Bat) were recorded at 116 m a.g.l. (**Figure 5, Figure 6**). **These findings suggest that during operation of the WEF, turbine-related bat fatalities will comprise an appreciable diversity of bat species.**

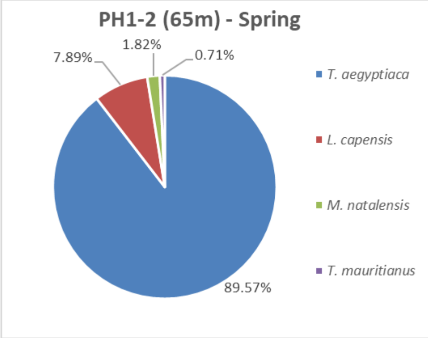
Through all four seasons of the year, the Egyptian Free-tailed Bat was the dominant species in turbine rotor sweep height. Calls made by this species contributed 71-96% of all bat calls recorded at 116 m a.g.l., and 57-93% of all bat calls recorded at 65 m a.g.l. The Cape Serotine contributed 0-26% and 5-39% of all bat calls recorded at 116 m and 65 m a.g.l., respectively. The Natal Long-fingered Bat contributed 0-7% and 0-18% of all bat calls recorded at 116 m and 65 m a.g.l., respectively. These findings suggest that **during operation of the WEF, most of the turbine-related bat fatalities will comprise Egyptian Free-tailed Bats and Cape Serotines, followed by Natal Long-fingered Bats.** This aligns with the general finding that the Egyptian Free-tailed Bat has accounted for most of the bat carcasses found at operational WEFs in South Africa to date, followed by the Cape Serotine and Natal Long-fingered Bat (Aronson 2022). **Mauritian Tomb Bats, Midas' Free-tailed Bats, Yellow House Bats, and possibly other species will likely also be killed during operation, but in fewer numbers.**

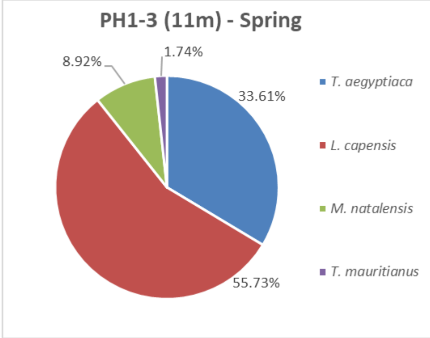
The Cape Serotine was generally the dominant species near ground level (i.e. at 10-15 m a.g.l.), where it contributed 21-97% of the recorded bat calls. The Egyptian Free-tailed Bat and Natal Long-fingered Bat, respectively, contributed 2-64% and 2-50% of all the bat calls recorded near ground level. **Certainly, a greater diversity (species richness and abundance) of bats will be at risk of fatality from turbines with blades that approach closer to ground level. The risk of fatalities of SCC (e.g. Midas' Free-tailed Bat, Natal Long-fingered Bat, and possibly others) will also increase with blades that approach closer to ground level.**

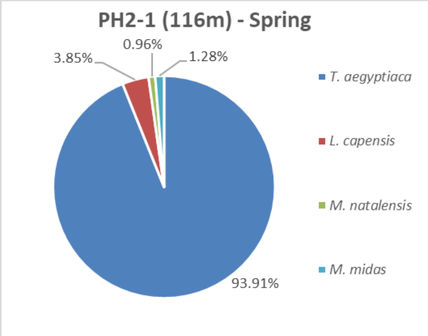
The species composition of the recorded bat call data was not surprising. The Egyptian Free-tailed Bat and Cape Serotine are widespread across South Africa (Monadjem *et al*. 2020), and the open-air foraging Egyptian Free-tailed Bat is typically more prevalent above the vegetation canopy, whereas calls of the clutter-edge foraging Cape Serotine and Natal Long-fingered Bat are more frequently recorded closer to ground level.

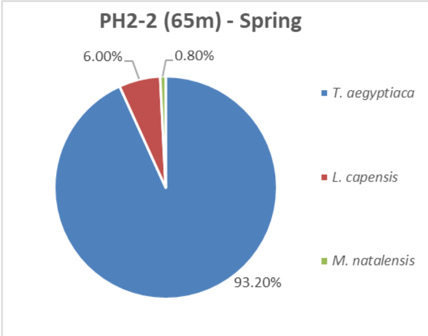
For a given monitoring (microphone) height, generally there appeared to be more variation in species composition of the recorded bat activity between seasons, as compared to between monitoring locations.

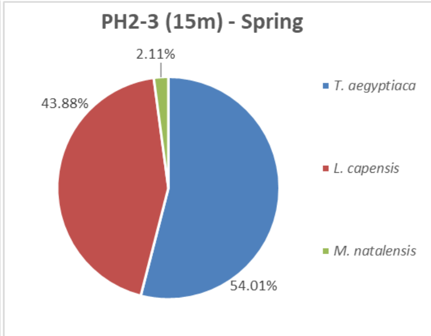

PH1-1 (116m) - Spring
9.14%
0.25%
90.61%
T. aegyptiaca
L. capensis
M. natalensis

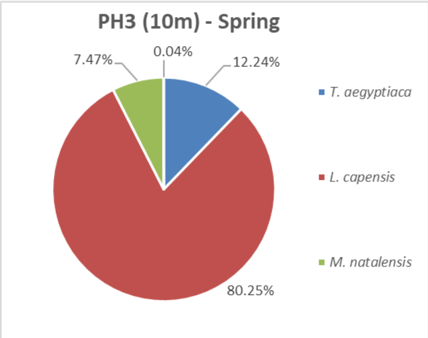

PH1-2 (65m) - Spring
7.89%
1.82%
0.71%
89.57%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus

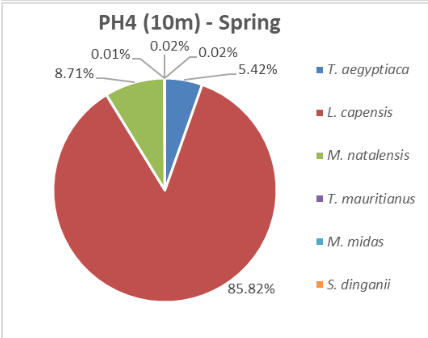

PH1-3 (11m) - Spring
8.92%
1.74%
33.61%
55.73%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus

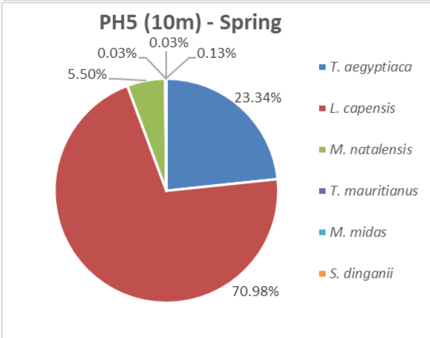

PH2-1 (116m) - Spring
3.85%
0.96%
1.28%
93.91%
T. aegyptiaca
L. capensis
M. natalensis
M. midas

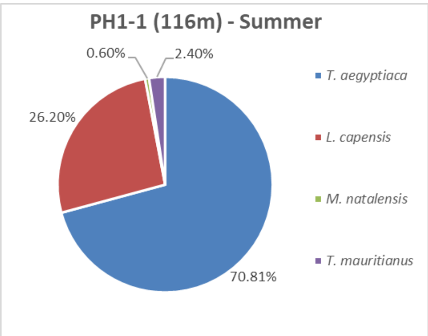

PH2-2 (65m) - Spring
6.00%
0.80%
93.20%
T. aegyptiaca
L. capensis
M. natalensis

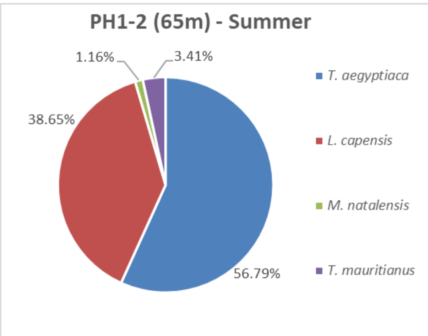

PH2-3 (15m) - Spring
2.11%
43.88%
54.01%
T. aegyptiaca
L. capensis
M. natalensis

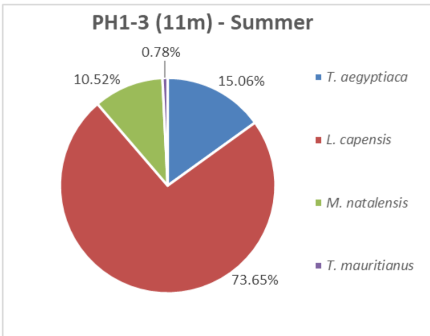

PH3 (10m) - Spring
7.47%
0.04%
12.24%
80.25%
T. aegyptiaca
L. capensis
M. natalensis

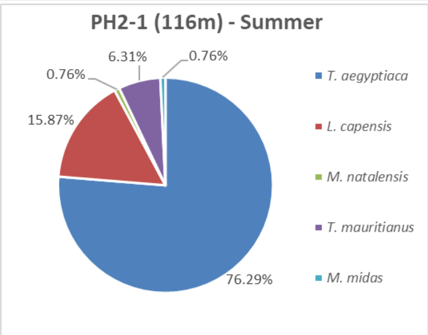

PH4 (10m) - Spring
0.01%
0.02%
0.02%
8.71%
5.42%
85.82%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii

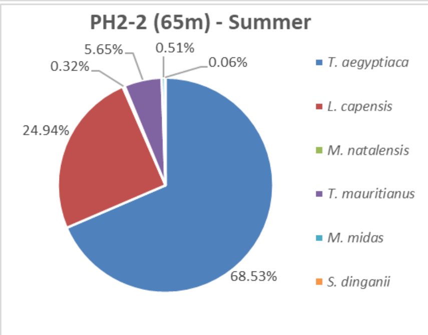

PH5 (10m) - Spring
0.03%
0.03%
0.13%
5.50%
23.34%
70.98%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii

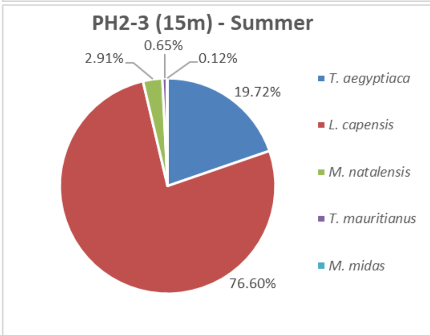

PH1-1 (116m) - Summer
0.60%
2.40%
26.20%
70.81%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus


PH1-2 (65m) - Summer
1.16%
3.41%
38.65%
56.79%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus


PH1-3 (11m) - Summer
0.78%
10.52%
15.06%
73.65%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus


PH2-1 (116m) - Summer
6.31%
0.76%
0.76%
15.87%
76.29%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas


PH2-2 (65m) - Summer
5.65%
0.51%
0.32%
0.06%
24.94%
68.53%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii


PH2-3 (15m) - Summer
0.65%
2.91%
0.12%
19.72%
76.60%
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas

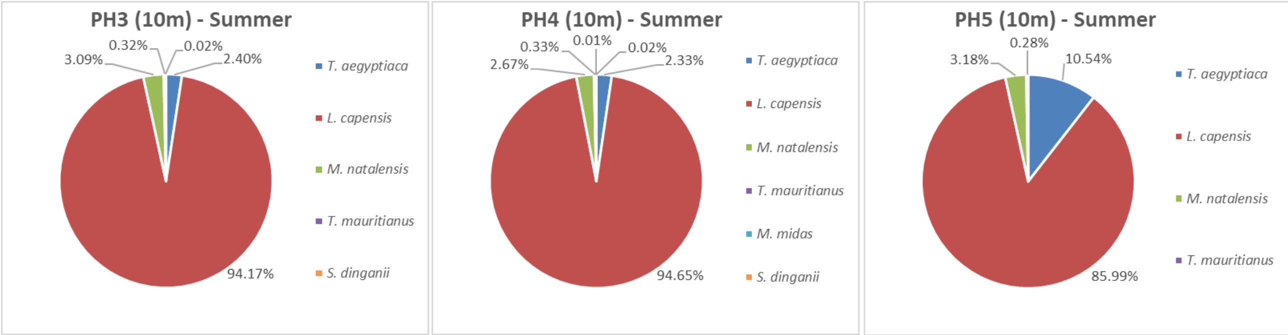



**Figure 5** **Species composition of bat calls recorded in spring and summer at PH1-PH5**

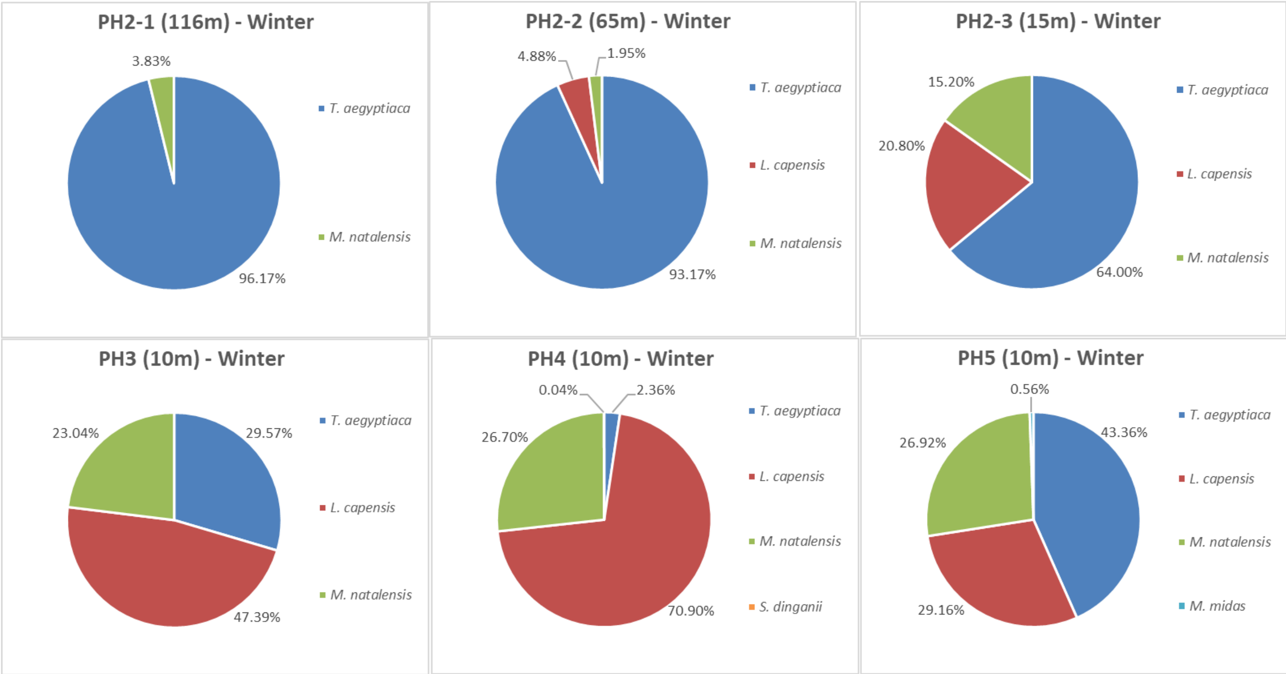



**Figure 6** **Species composition of bat calls recorded in autumn and winter at PH1-PH5**

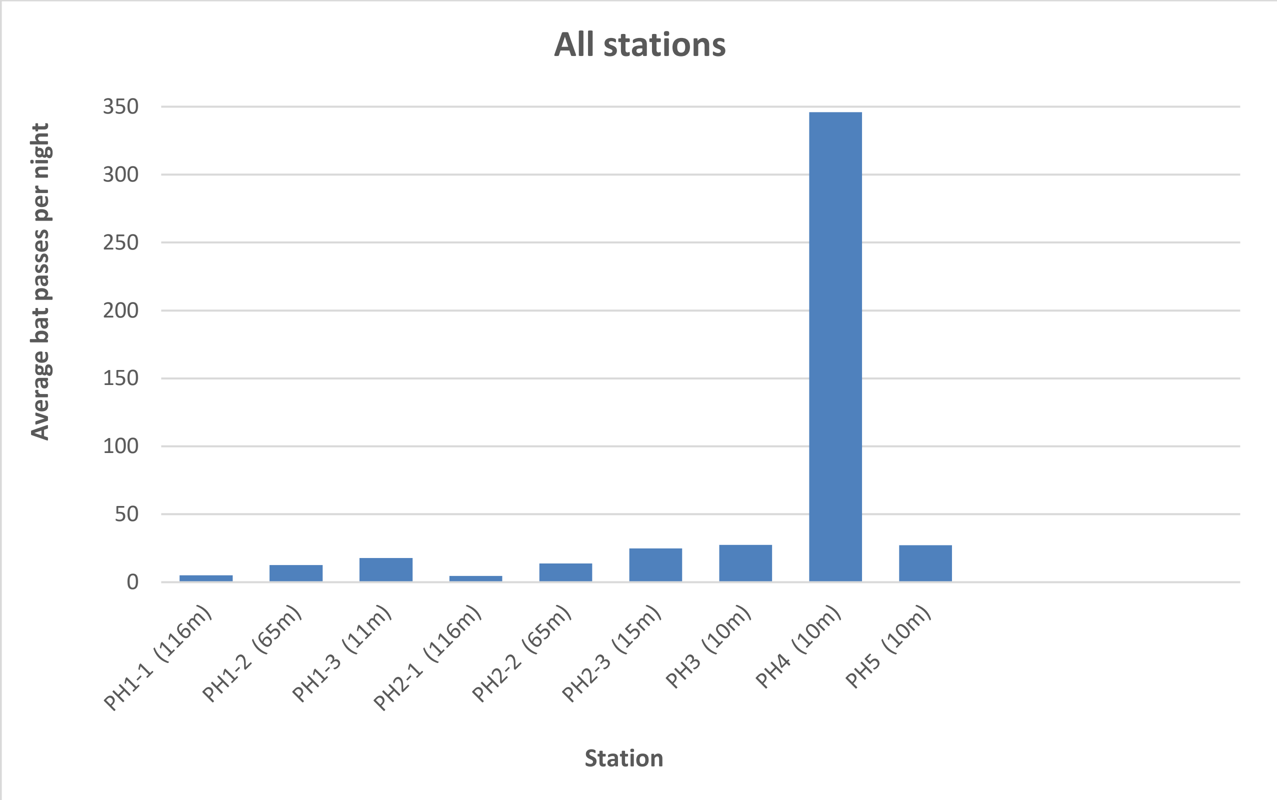
## 6.4 Bat activity at different heights and locations

An overall average of 4.8 bat passes (bp) per night (or 0.4 bp per hour) at 116 m, 13.2 bp per night (1.1 bp per hour) at 65 m, and 88.6 bat passes (bp) per night (7.5 bp per hour) near ground level was recorded (**Figure 7**). The decrease in bat activity with monitoring height / elevation is a typical occurrence (MacEwan *et al.* 2020b). **The levels of bat activity recorded through eight of the nine microphones, was similar to analogous average values of bat activity at other proposed WEF sites in the Highveld grassland ecoregion** (Dinerstein *et al*. 2017), where IWS recorded on average 1 bp per hour (range: 0-4 bp per hour) in rotor sweep (60 m), and 2 bp per hour (range: 0-7 bp per hour) near ground level (MacEwan *et al*. 2020b).

**A distinct exception was the PH4 10 m monitoring locality, where an extremely high average of 346 bp per night (or 29.1 bp per hour) was recorded.** Since all five monitoring stations were located in grassland / pasture near cultivated fields and dams, **the exceptional activity at PH4 is possibly explained by its location amidst woody vegetation in proximity (~200-400 m) to at least one farmhouse where evidence of bat roosting was found (in the form of smudge marks and guano on the walls near the roof; see Figure 4)**. For comparison, the other four monitoring locations were situated 900 m or further from buildings. **The exceptional activity at PH4 lends support for the need to: i) buffer all onsite buildings and woody vegetation / tree clumps with a minimum 200 m protective buffer, as prescribed by MacEwan *et al.* (2020) for confirmed and potential bat important features.**

## 6.5 Bat activity during different seasons

Bat activity recorded through each microphone was, on average, very similar between spring, summer, and autumn (**Figure 8**). During winter, there was a distinct decline in bat activity. This seasonal activity pattern is typical and reflects increased bat activity in association with warmer weather and increased insect activity. **If the numbers of operational bat fatalities are positively related to the levels of bat activity in rotor sweep (IWS unpubl. data), a similar broad seasonal pattern of fatalities may be expected.**



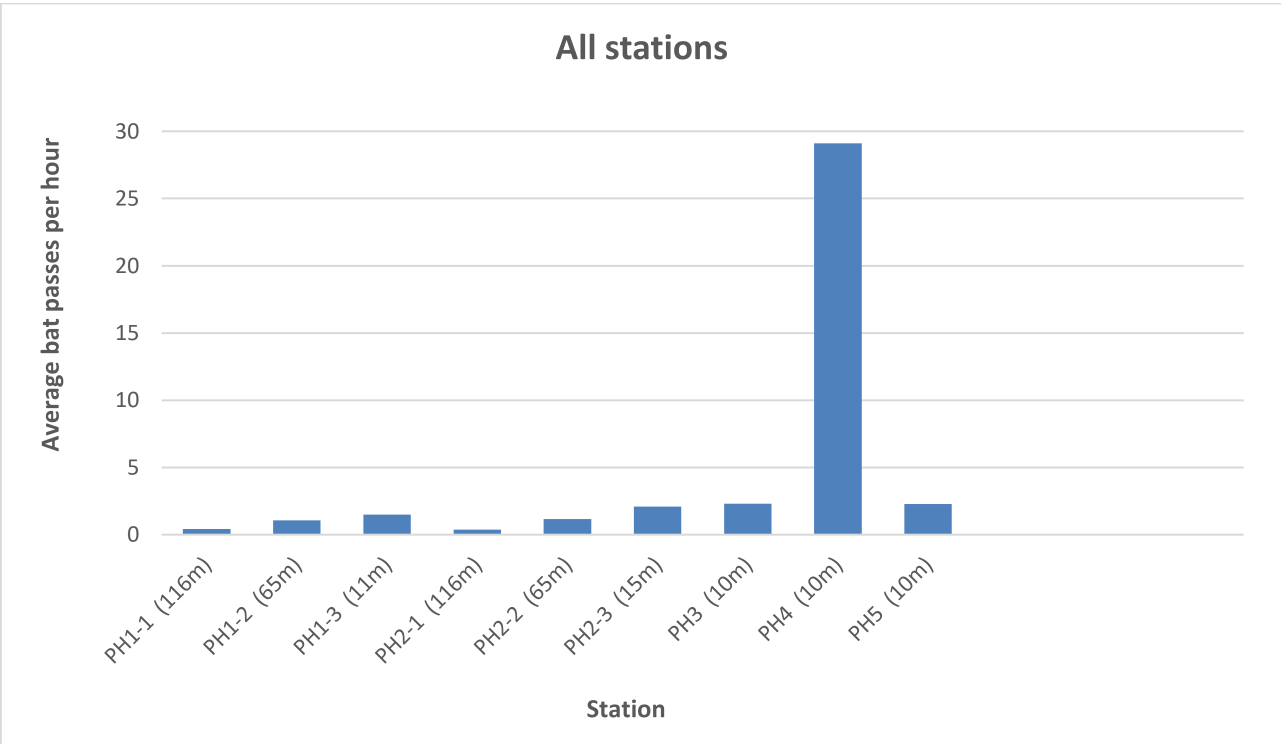




**Figure 7** **Average bat activity measured in passes per night (above) or per hour (below) recorded onsite**

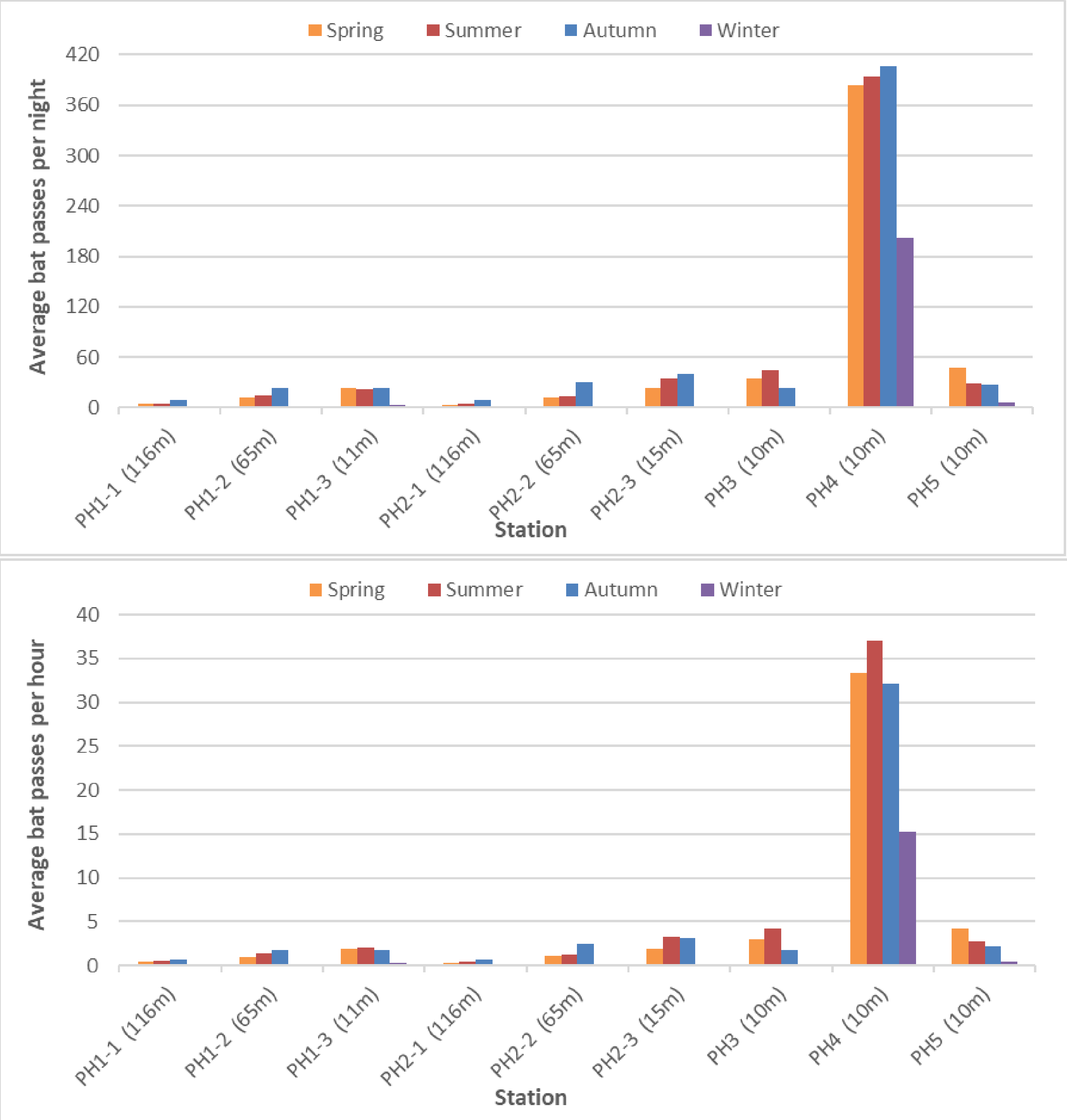



**Figure 8** **Average bat activity (measured in passes per night or per hour) recorded onsite during each season**

## 6.6 Activity of different bat families and species

Although overall bat activity levels were similar between spring, summer and autumn, the different bat taxa exhibited distinct seasonal patterns of activity (**Figure 9**). Egyptian Free-tailed Bats (of the Molossidae family) were generally most active in spring and autumn. Cape Serotines (of the Vesertilionidae family) were most active during summer, possibly because this is when females have pups to feed and wean (Monadjem *et al.* 2020). The Natal Long-fingered Bat (of the Miniopteridae family) exhibited the highest levels of activity mostly in autumn and winter, possibly due to their migratory patterns (Pretorius *et al*. 2020). The Mauritian Tomb Bat (of the Emballonuridae family) was distinctly most active in summer, followed by autumn, when females may have pups to feed or wean (Monadjem *et al.* 2020). Midas' Free-tailed Bat was most active in autumn, whereas the Yellow House Bat exhibited a similar level of activity across all four seasons. **These taxon-specific differences should be taken into consideration if/when fatality mitigation measures are implemented.**

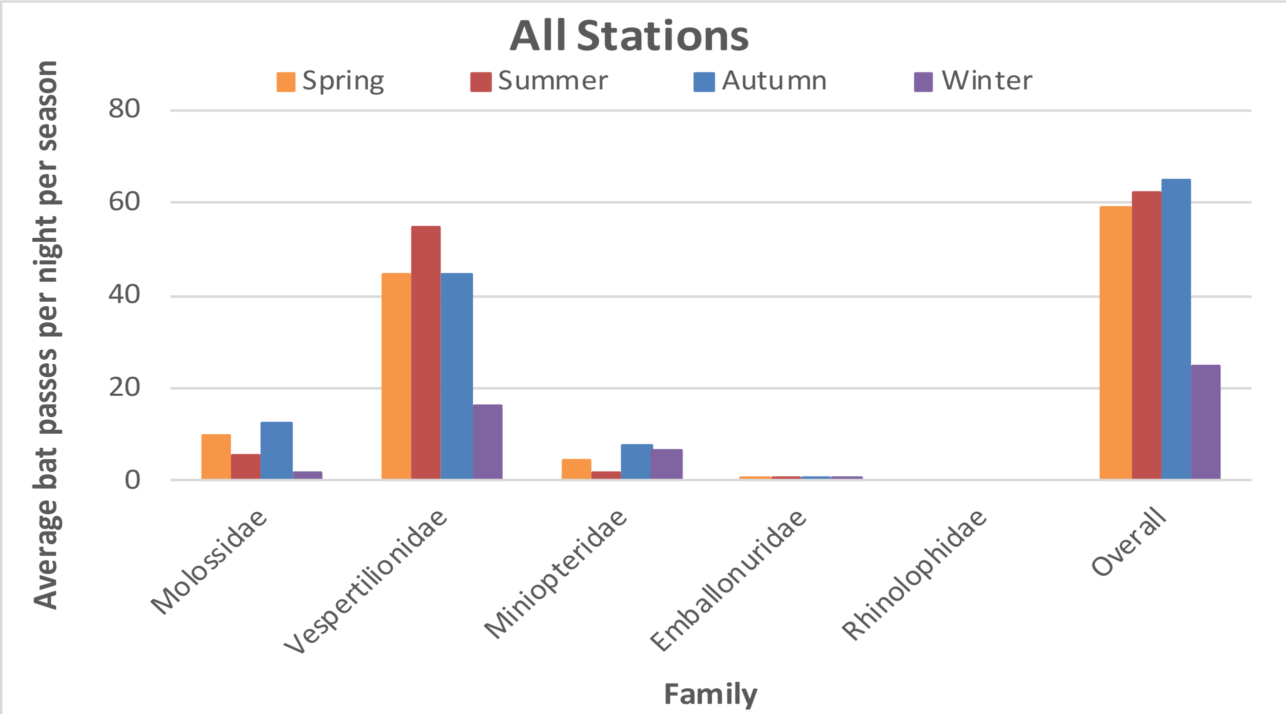



**Figure 9** Average activity (measured in passes per night per season) of the different bat families onsite

## 6.7 Nights when bat activity peaked

**Nights when the highest total numbers of bat passes were recorded at height occurred during the months of March and April**, as well as in October through the microphones near ground level (**Figure 10**). High numbers of passes during a night are indicative of an increase in bat activity and possibly also bat abundance.

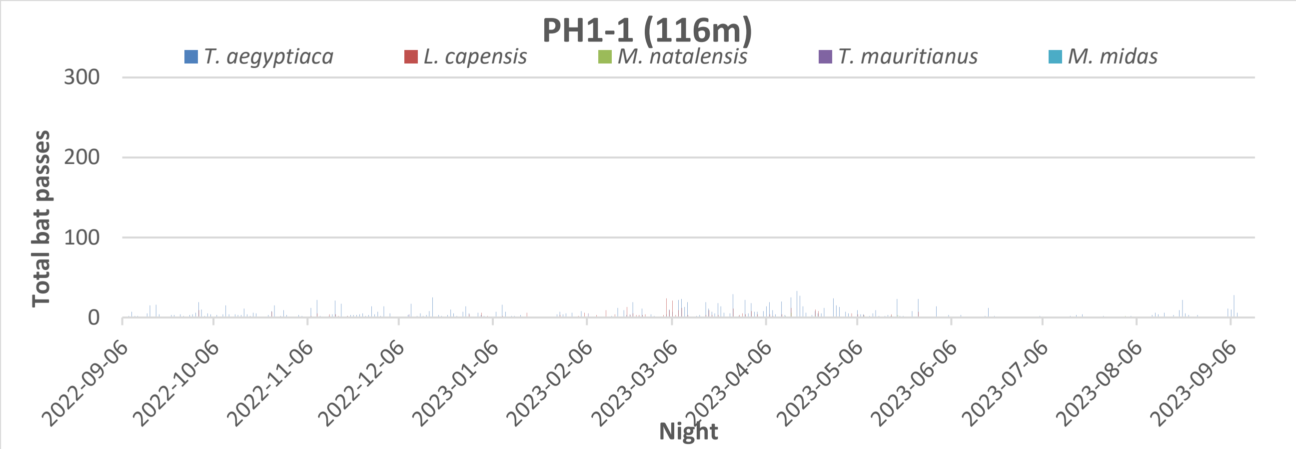
Egyptian Free-tailed Bat activity at height peaked on multiple nights in April, with the highest number (167 bp) recorded on 16 April 2023 at PH2 65 m. The comparatively lower nightly activity of the other bats species (included but not visible in **Figure 10**) is shown in **Figure 11**.

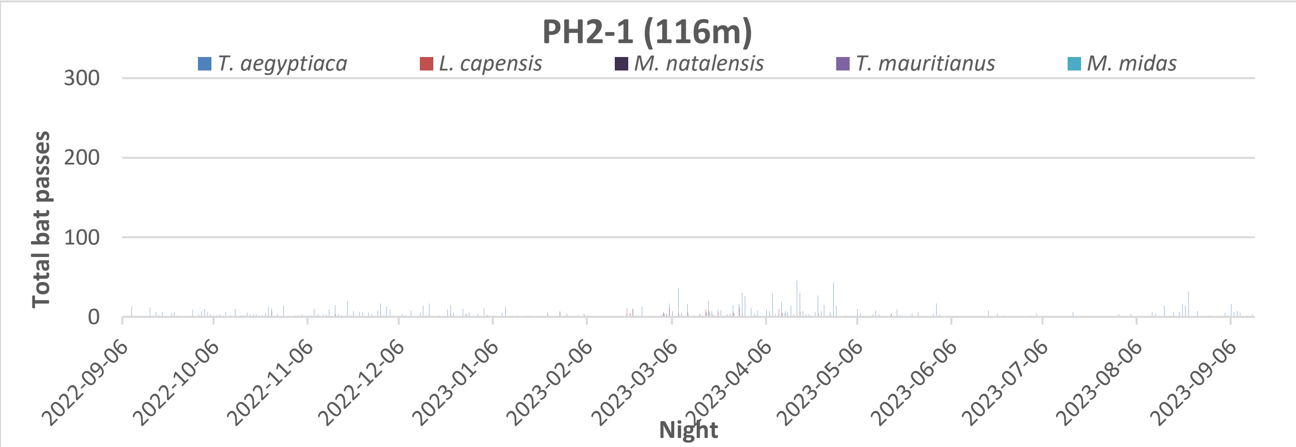
The PH4 monitoring station consistently recorded by far the highest number of bat calls throughout the 12-month monitoring period, with more than 1 200 Cape Serotine bat passes recorded on multiple nights especially in spring, summer, and autumn, and more than 200 Natal Long-fingered Bat passes recorded on multiple nights in autumn and winter. **This data suggest the presence of a Cape Serotine roost(s) nearby, and ideal foraging habitat and/or a roost(s) for Natal Long-fingered Bats perhaps slightly further away.**

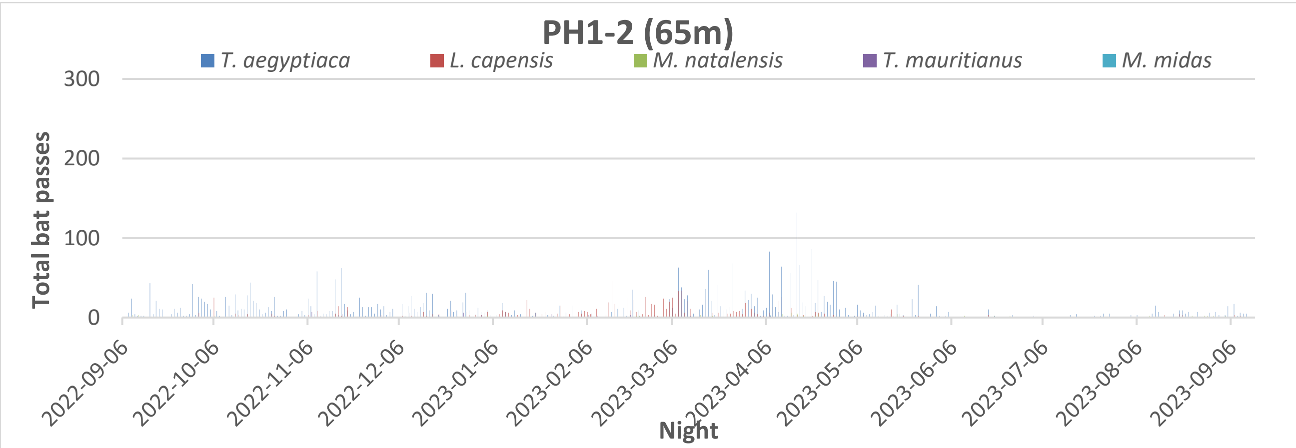
**On nights when the levels of Egyptian Free-tailed bat activity at 116 m can be 9.5 times higher than the average level of 4.8 bp per night at 116 m, fatalities will be likely without effective mitigation.**

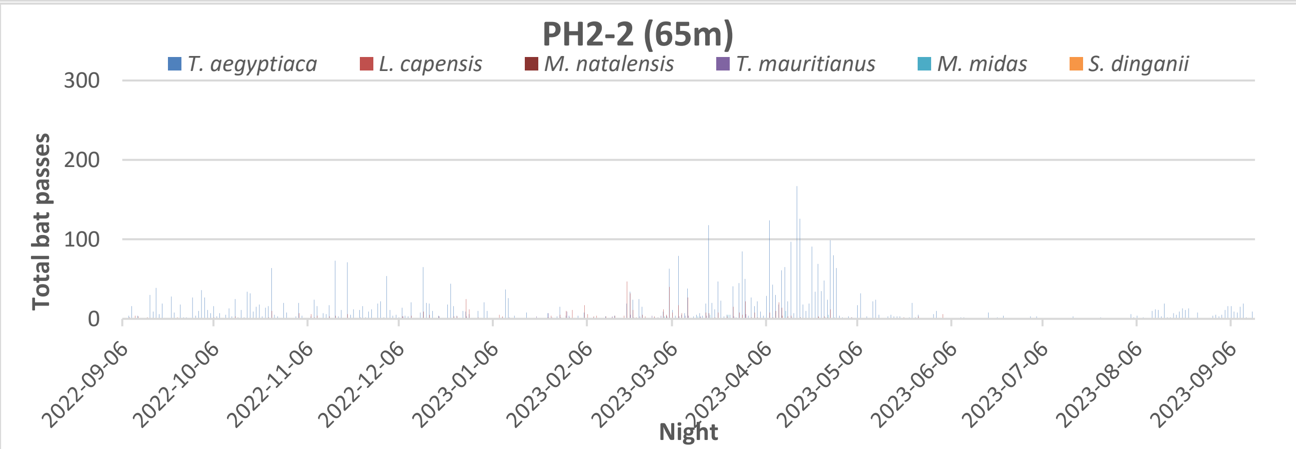
## 6.8 Key bat activity times

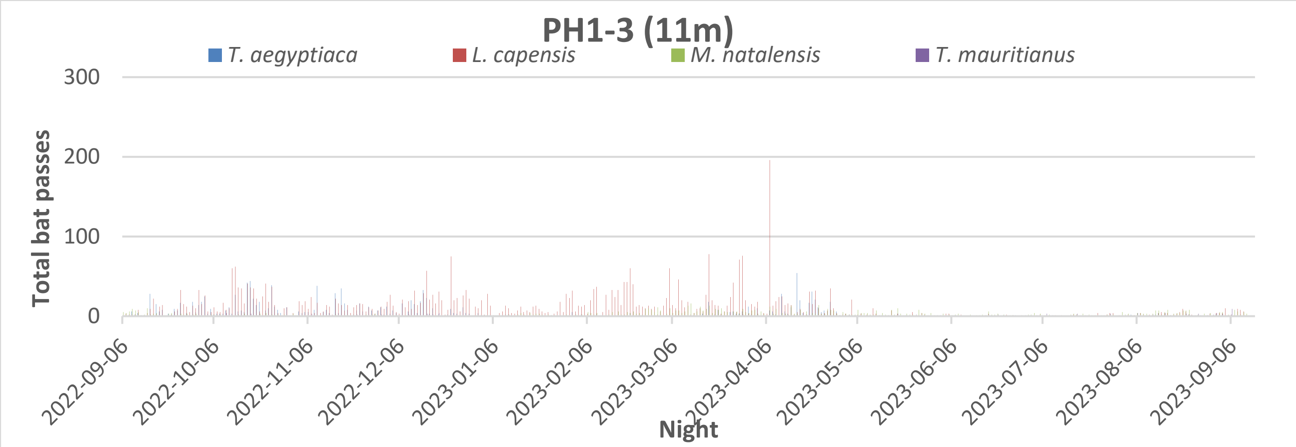
A distinct pattern in nightly activity was evident, especially from Egyptian Free-tailed Bats and Cape Serotines (**Figure 12**). From sunset there was a prompt increase in the activity of Egyptian Free-tailed Bats until circa (ca.) 20:00/20:30. From then, appreciable activity was recorded until ca. 04:00/05:00, whereafter activity declined by sunrise. Cape Serotine activity was recorded most often during the first 1-3 hours after sunset. **Due to their protracted night-time activity, Egyptian Free-tailed Bats will be at risk of fatality from turbines throughout the night whenever favourable weather, insect, and possible other (e.g. lunar) conditions prevail. In contrast, Cape Serotines will likely be at greatest risk of fatality for 1-3 hours after sunset, and in some areas (near roosts) for 1-3 hours before sunrise. Again, these taxon-specific differences should be taken into consideration if/when fatality mitigation measures are implemented.**

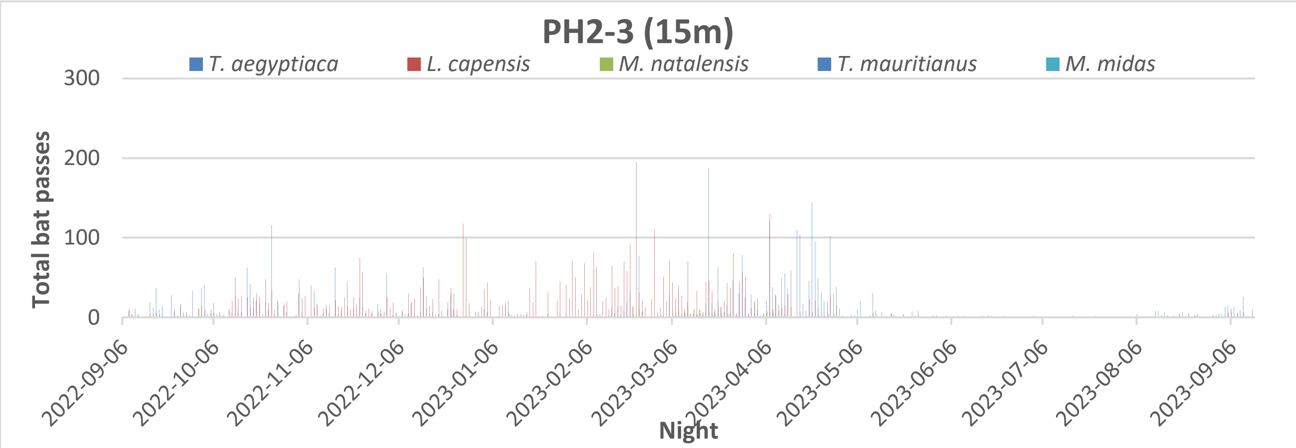

PH1-1 (116m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
300
200
100
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

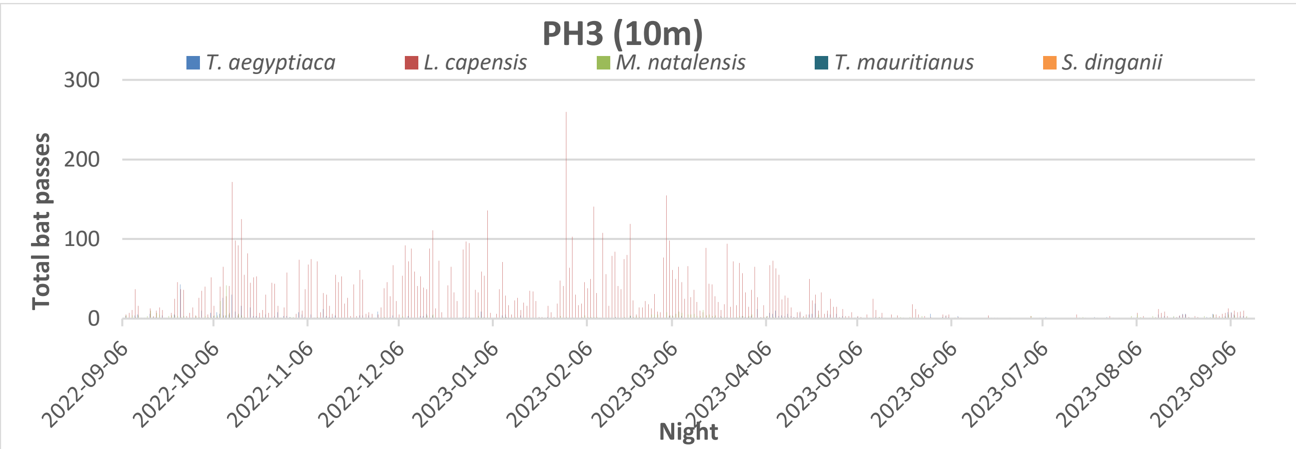

PH2-1 (116m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
300
200
100
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

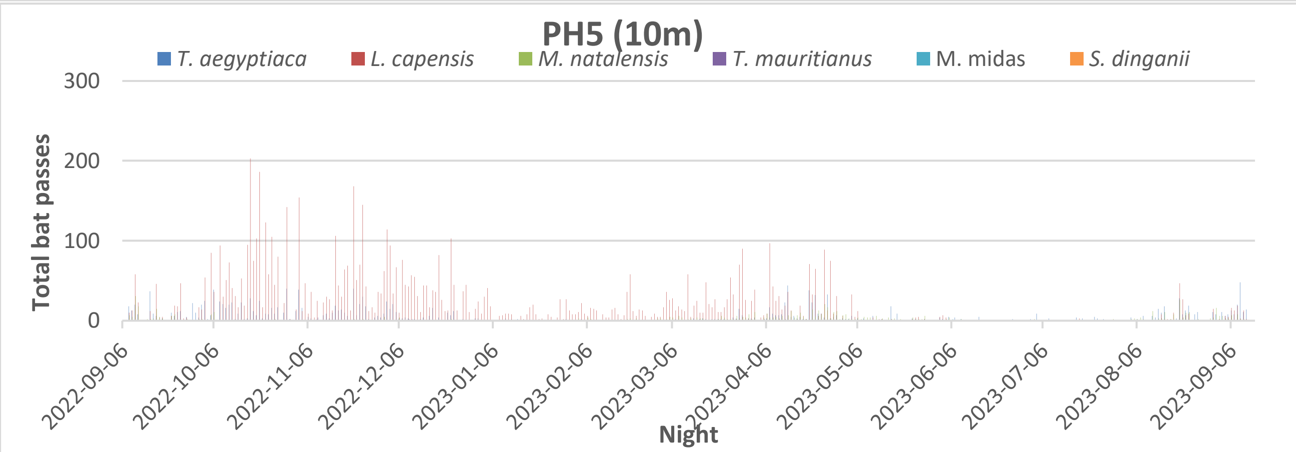

PH1-2 (65m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
300
200
100
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH2-2 (65m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii
Total bat passes
300
200
100
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH1-3 (11m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
300
200
100
0
Total bat passes
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH2-3 (15m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
300
200
100
0
Total bat passes
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH3 (10m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
S. dinganii
300
200
100
0
Total bat passes
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH5 (10m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii
300
200
100
0
Total bat passes
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

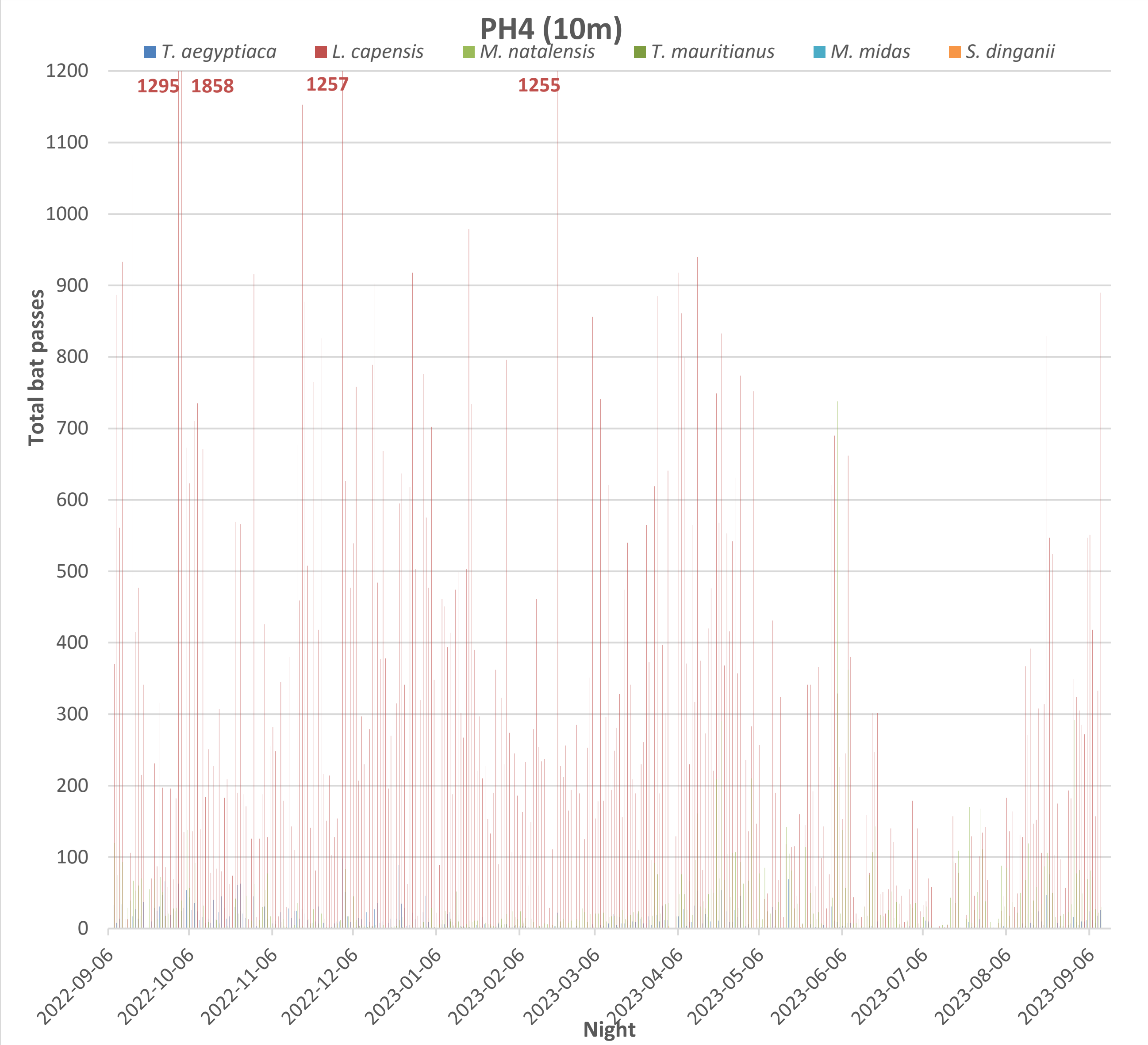
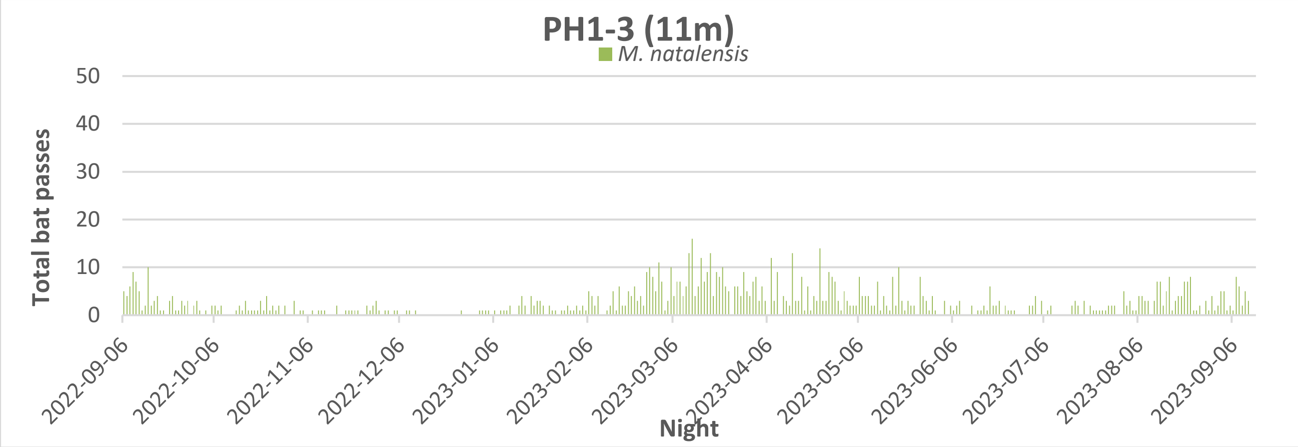
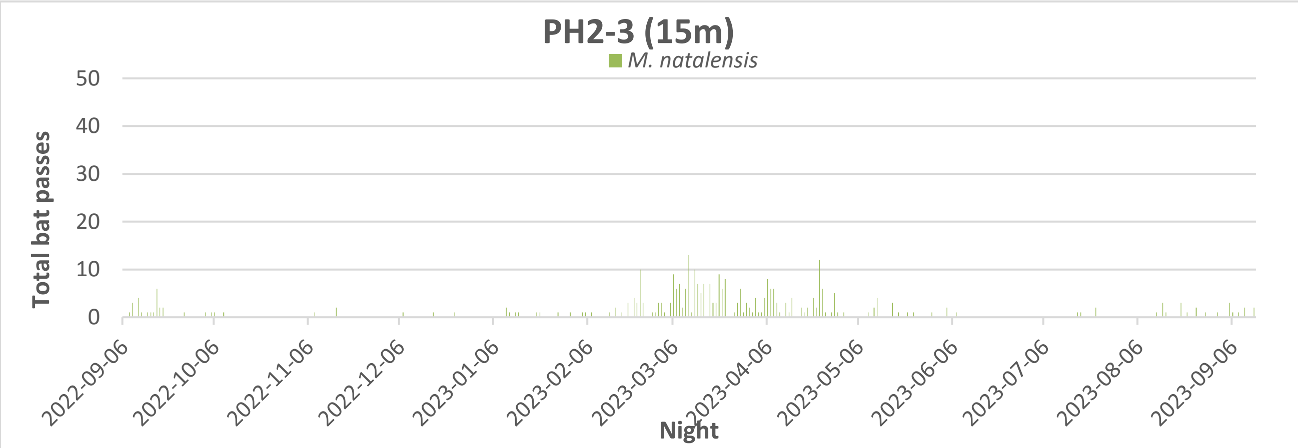
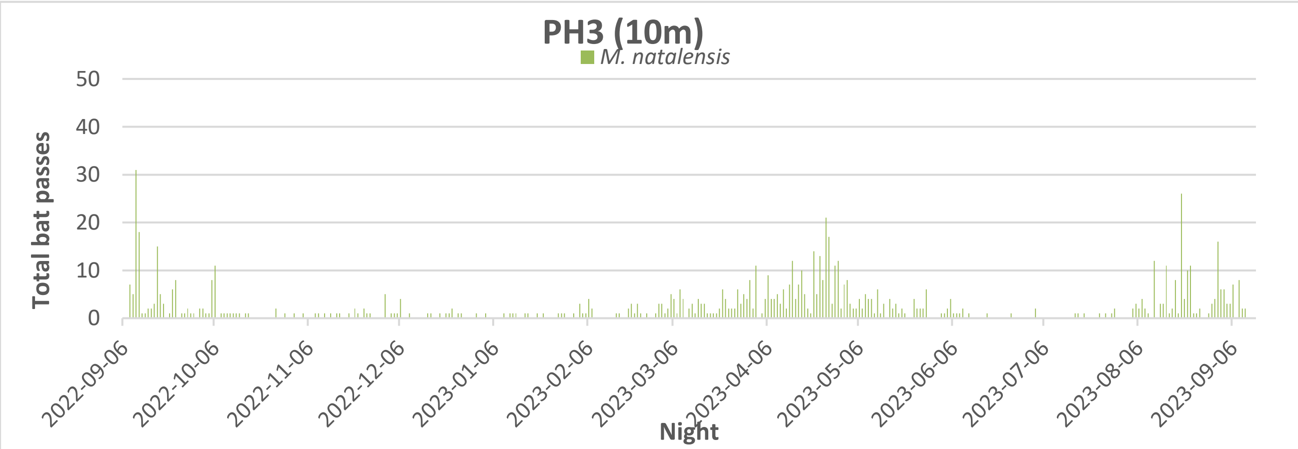
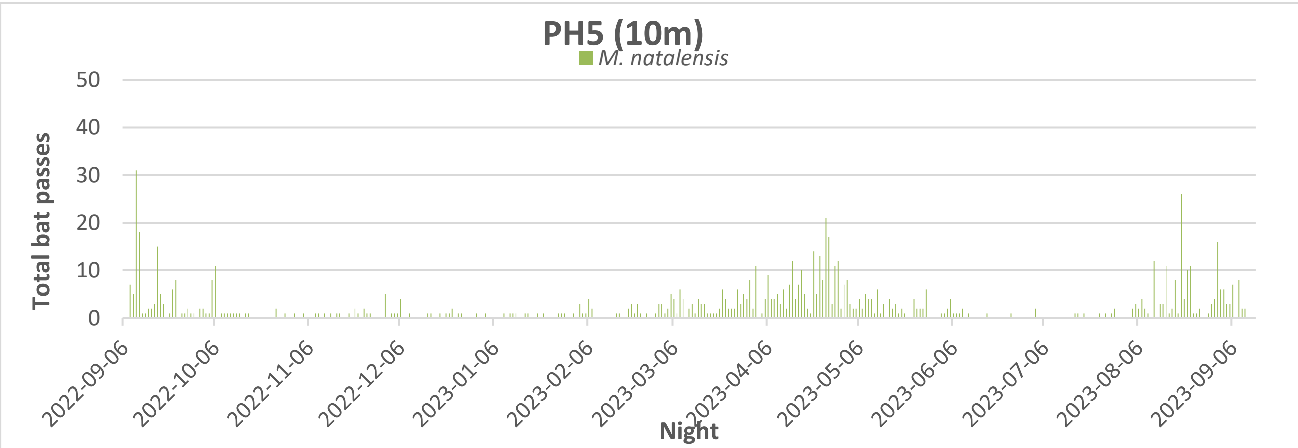


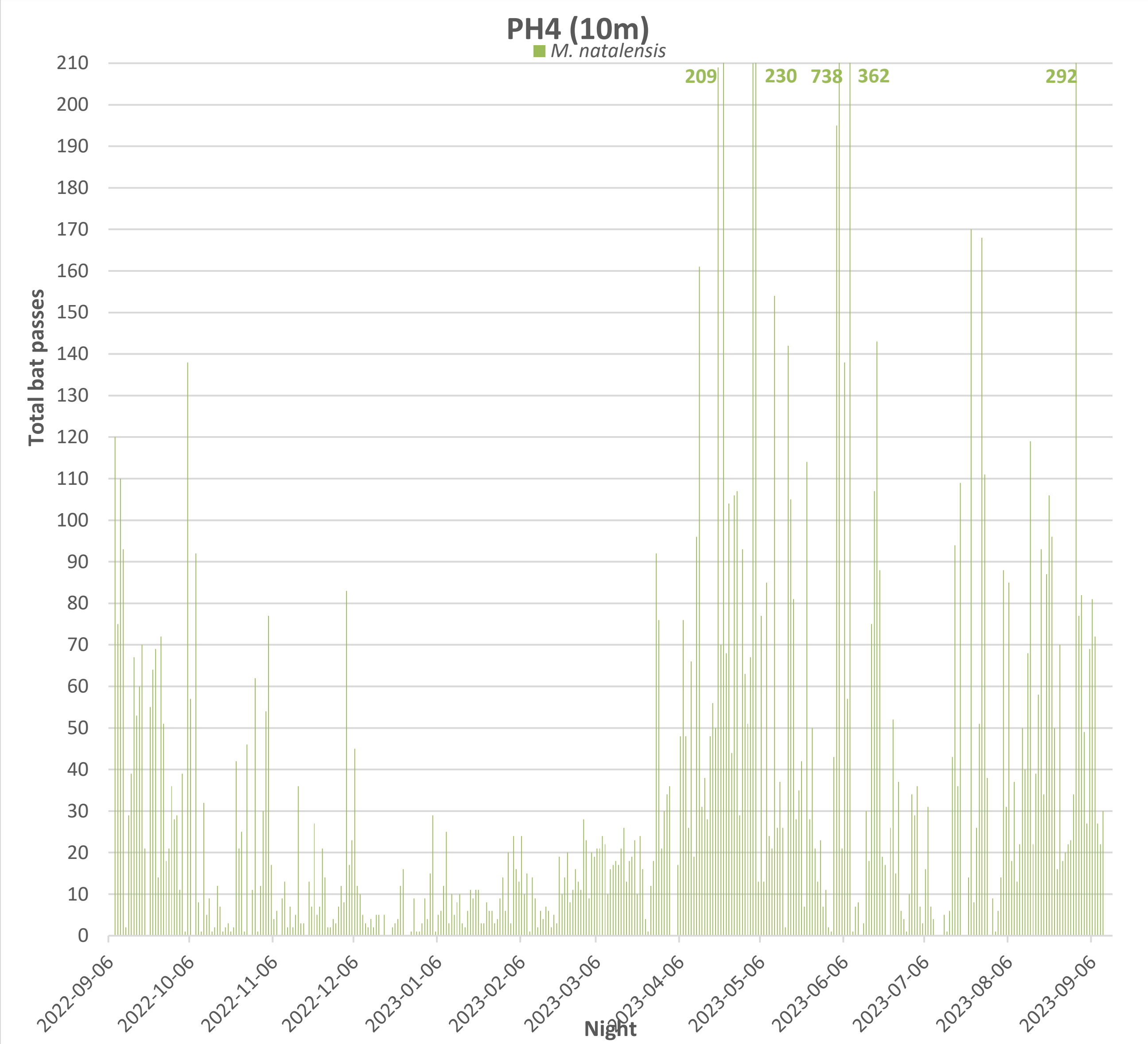

**Figure 10** **Total bat passes recorded nightly at different heights at the Phefumula WEF bat monitoring stations**

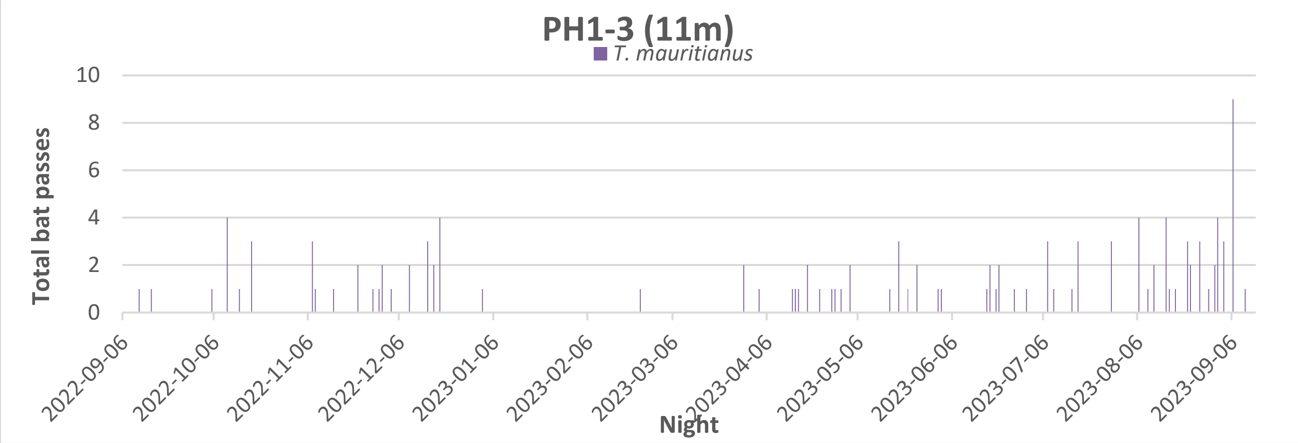

PH1-3 (11m)
M. natalensis
Total bat passes
50
40
30
20
10
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

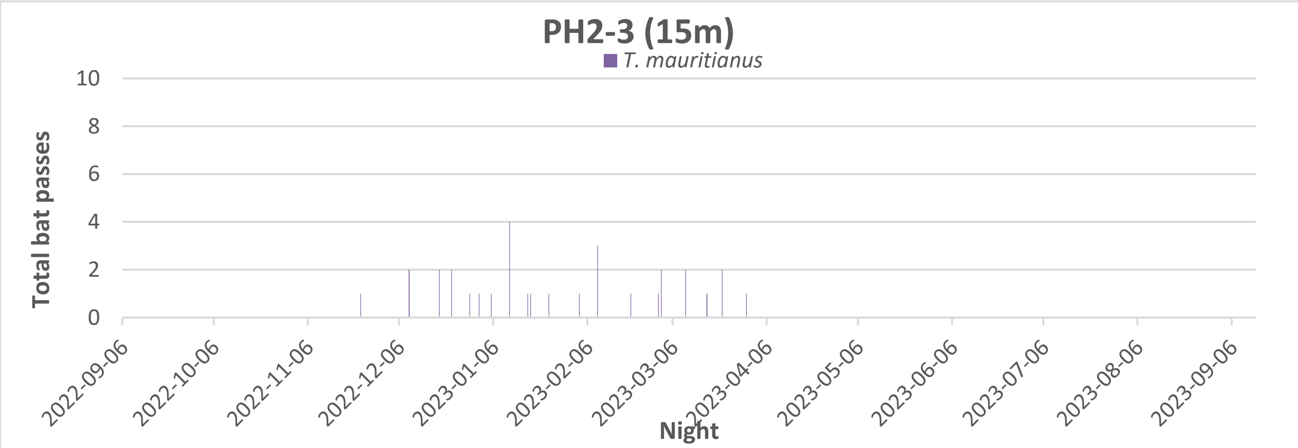

PH2-3 (15m)
M. natalensis
Total bat passes
50
40
30
20
10
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

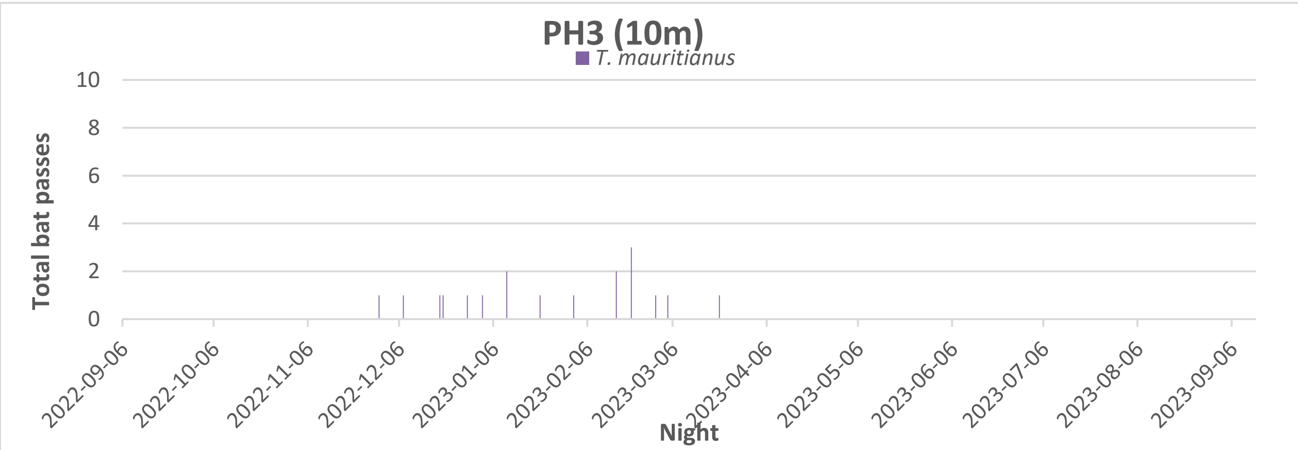

PH3 (10m)
M. natalensis
Total bat passes
50
40
30
20
10
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

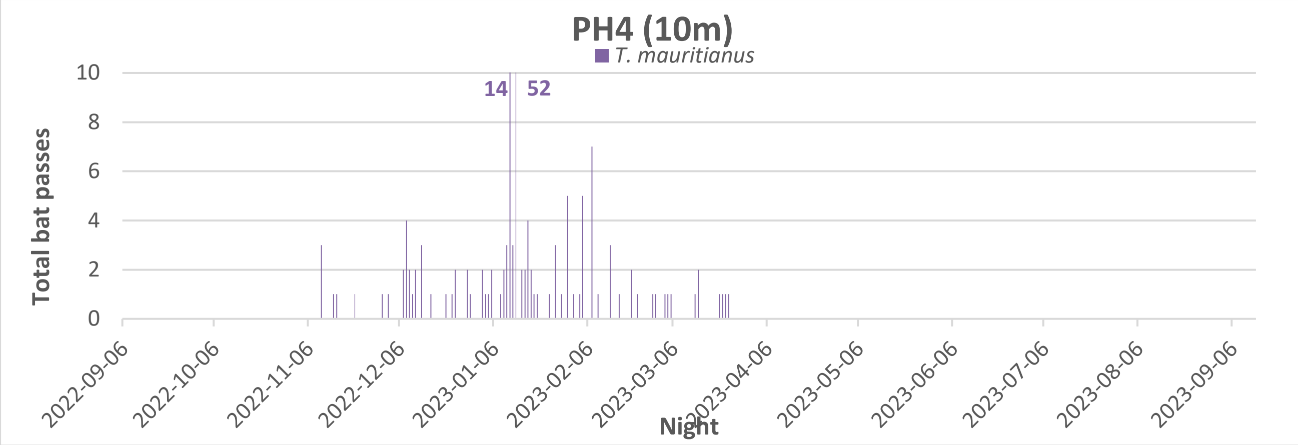

PH5 (10m)
M. natalensis
Total bat passes
50
40
30
20
10
0
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

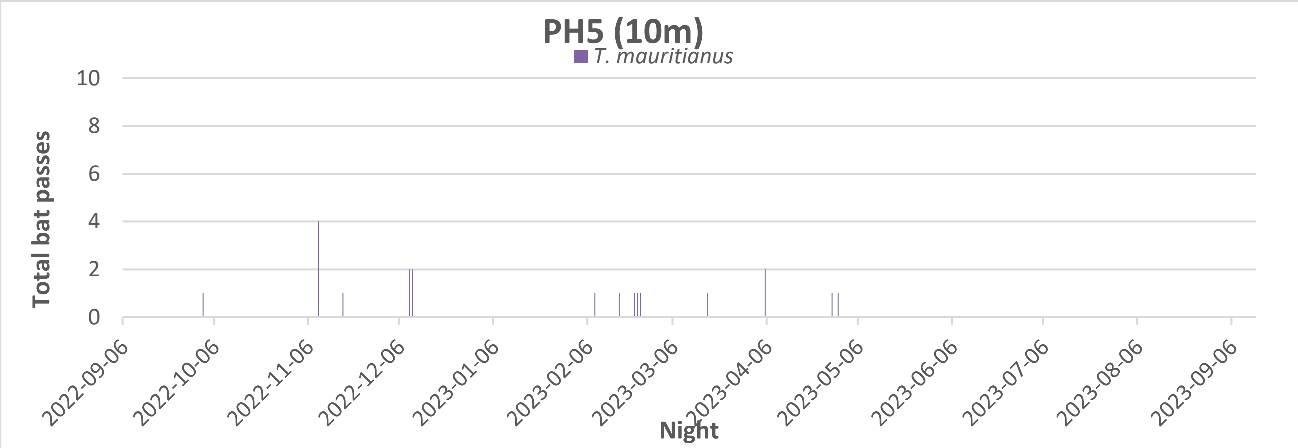

PH4 (10m)
M. natalensis
Total bat passes
Night
209
230
738
362
292
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06

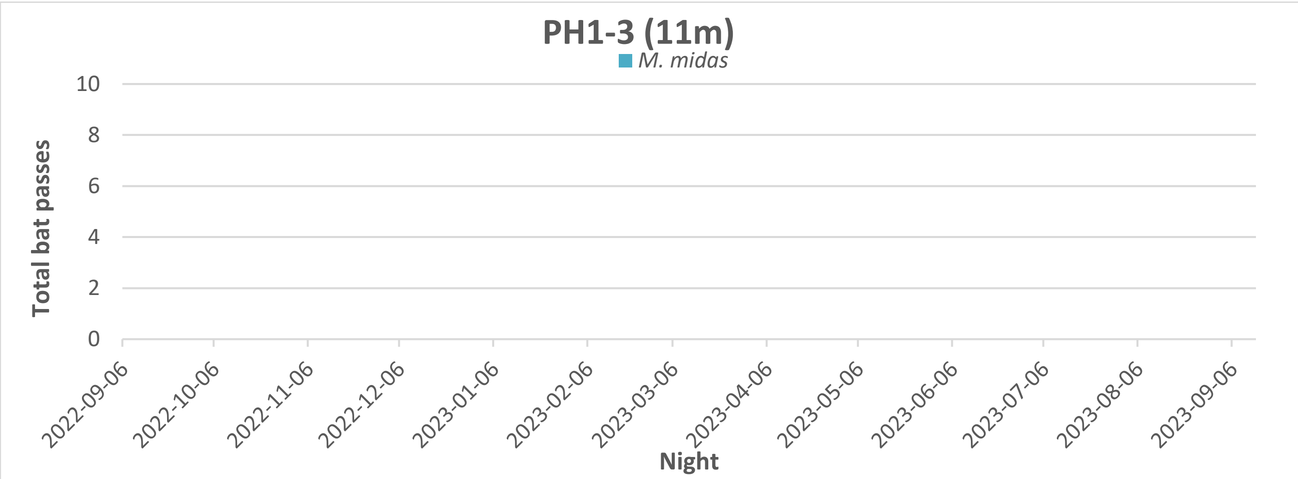

PH1-3 (11m)
T. mauritianus
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

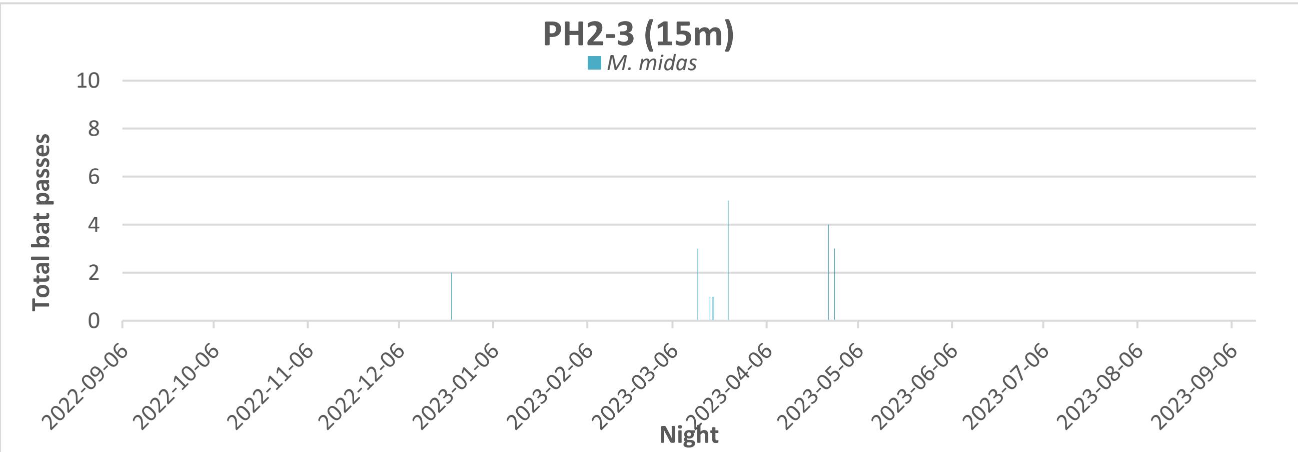

PH2-3 (15m)
T. mauritianus
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

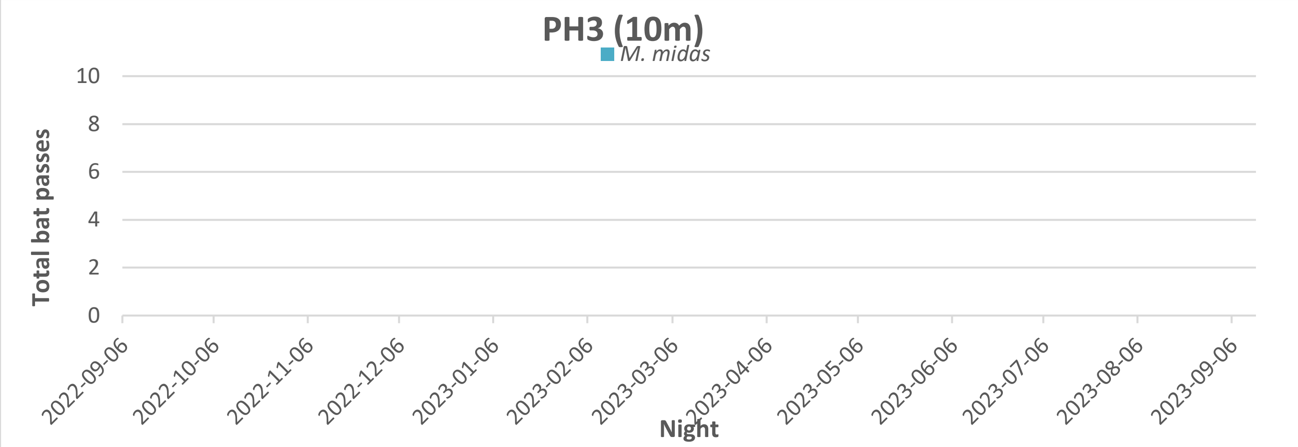

PH3 (10m)
T. mauritianus
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

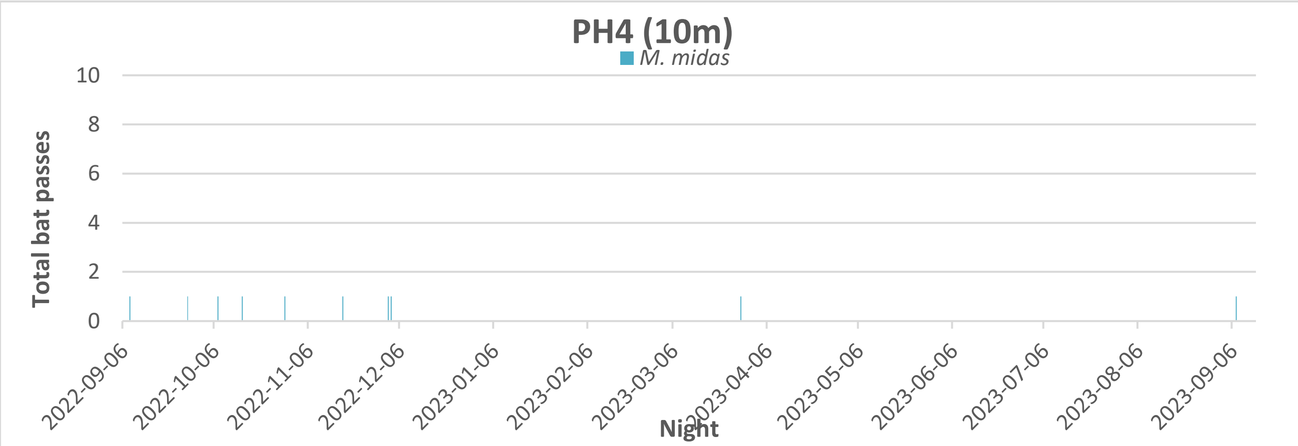

PH4 (10m)
T. mauritianus
14
52
Total bat passes
Night

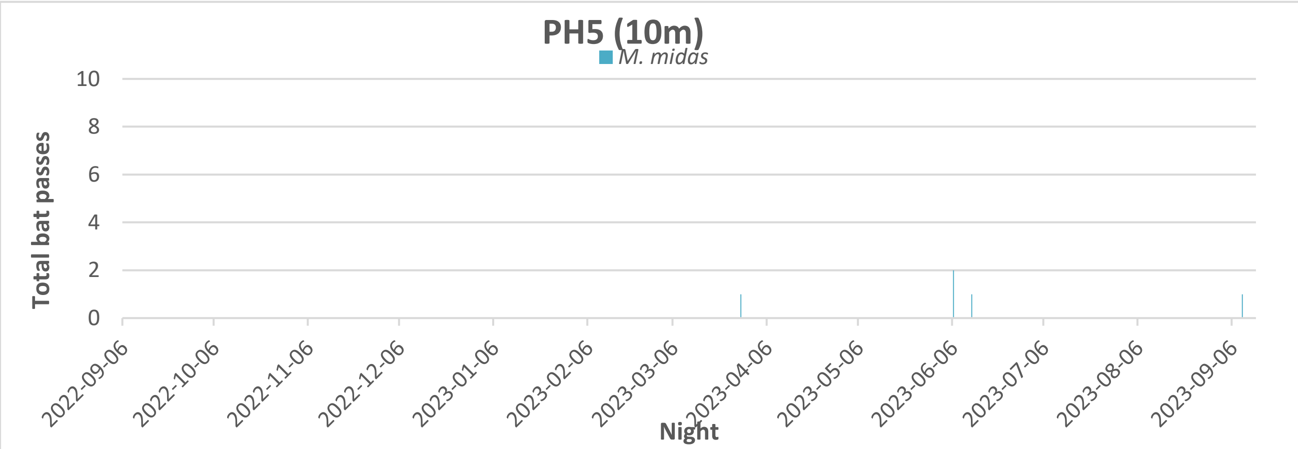

PH5 (10m)
T. mauritianus
Total bat passes
Night

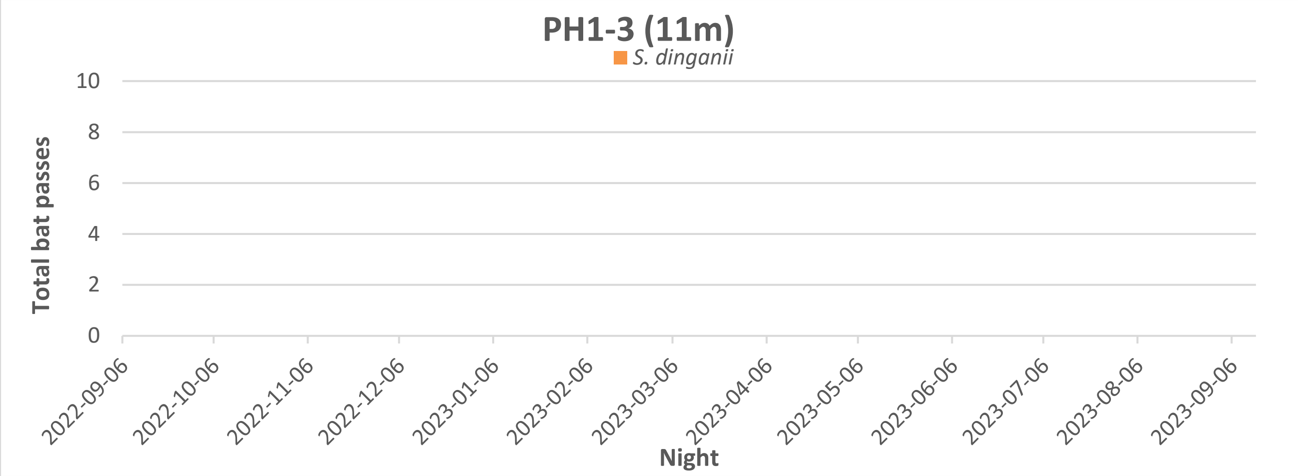

PH1-3 (11m)
M. midas
Total bat passes
Night

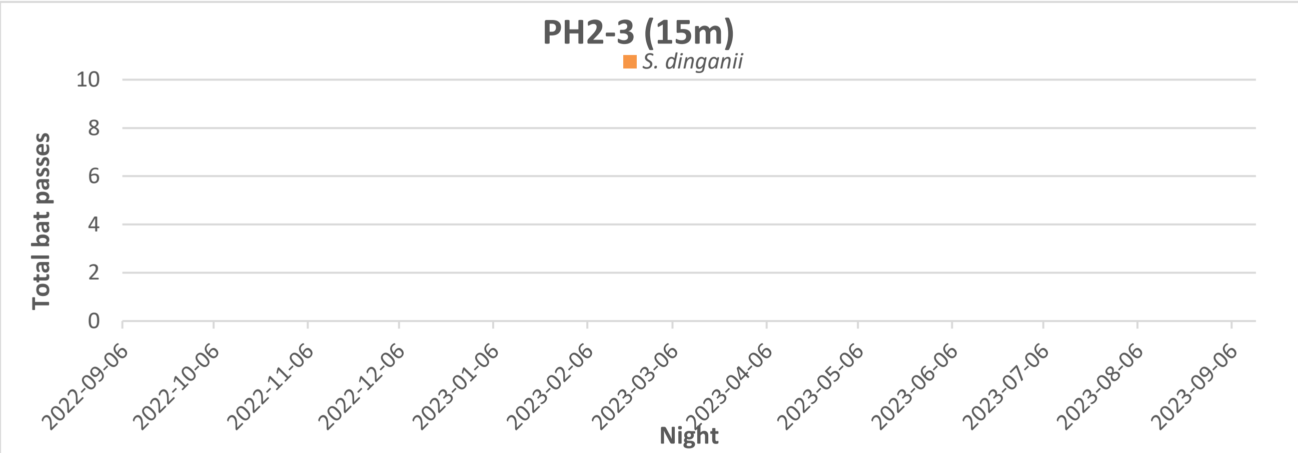

PH2-3 (15m)
M. midas
Total bat passes
Night

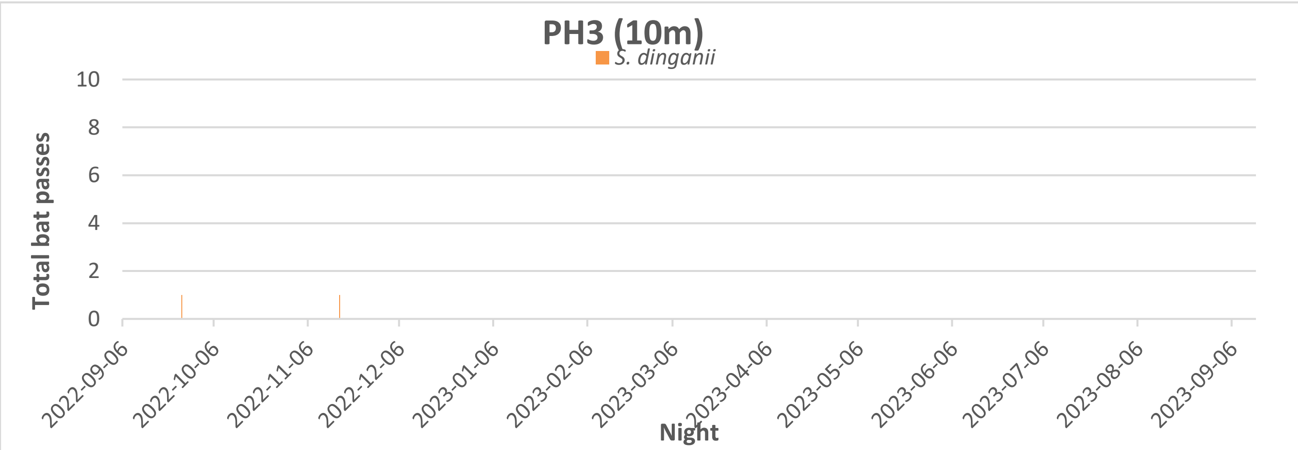

PH3 (10m)
M. midas
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night

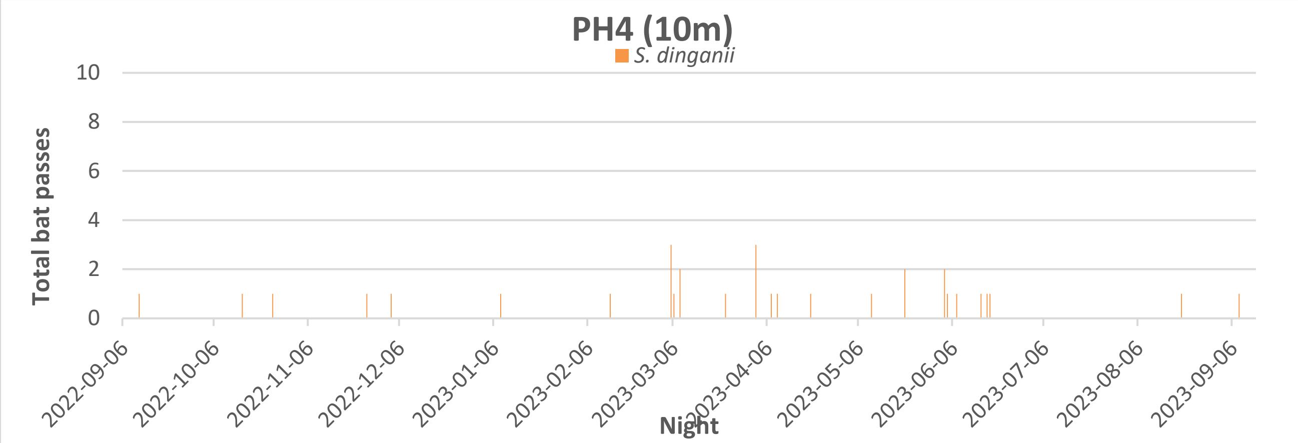

PH4 (10m)
M. midas
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH5 (10m)
M. midas
Total bat passes
0
2
4
6
8
10
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06
Night


PH1-3 (11m)
S. dinganii
Total bat passes
0
2
4
6
8
10
Night
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06


PH2-3 (15m)
S. dinganii
Total bat passes
0
2
4
6
8
10
Night
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06


PH3 (10m)
S. dinganii
Total bat passes
0
2
4
6
8
10
Night
2022-09-06
2022-10-06
2022-11-06
2022-12-06
2023-01-06
2023-02-06
2023-03-06
2023-04-06
2023-05-06
2023-06-06
2023-07-06
2023-08-06
2023-09-06



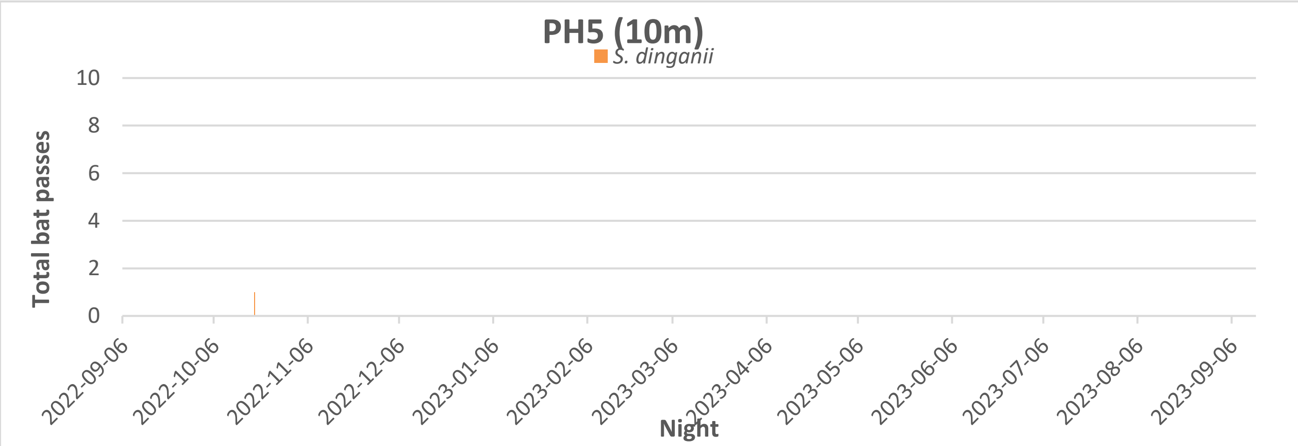
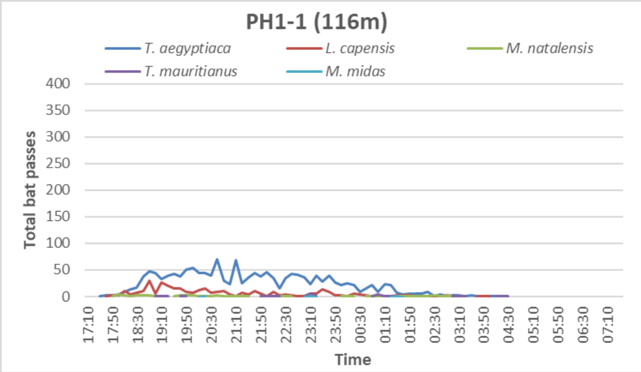
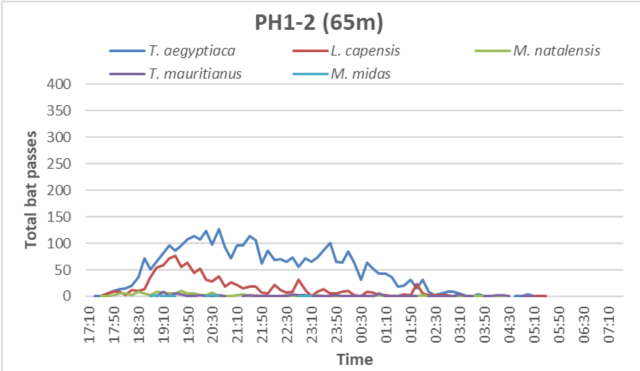
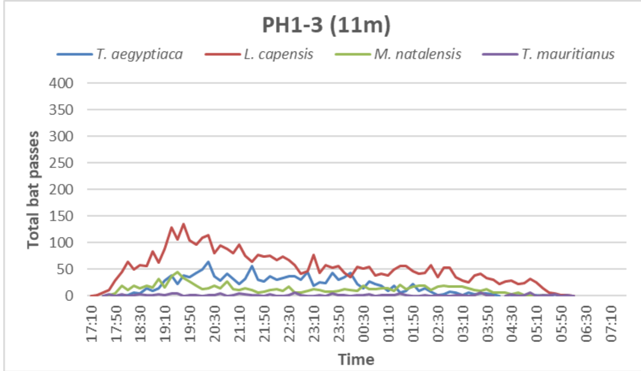
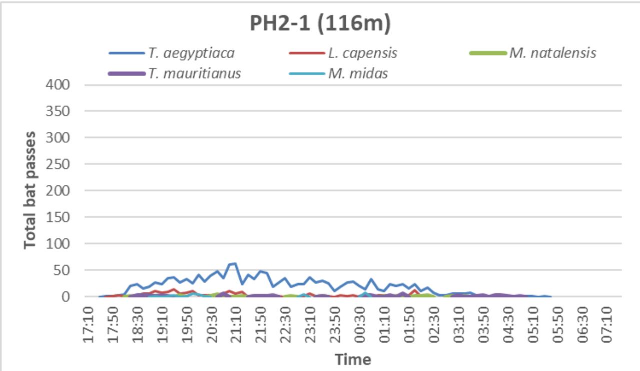



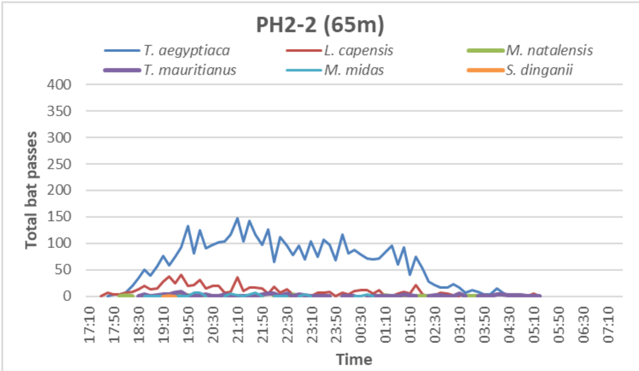

**Figure 11 Total Natal Long-fingered Bat, Mauritian Tomb Bat, Midas' Free-tailed Bat, and Yellow House Bat passes recorded nightly at ~10 m at the onsite bat monitoring stations**

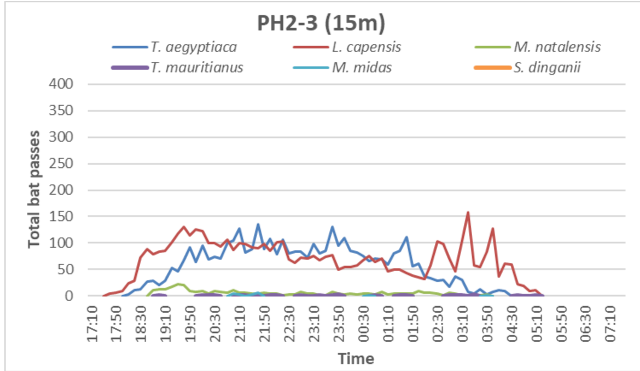

PH1-1 (116m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
Time

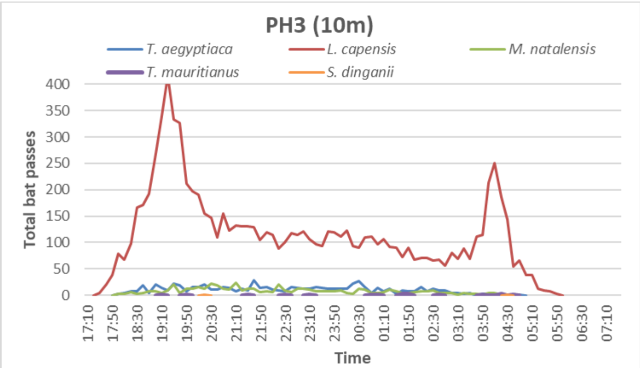

PH1-2 (65m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
Time

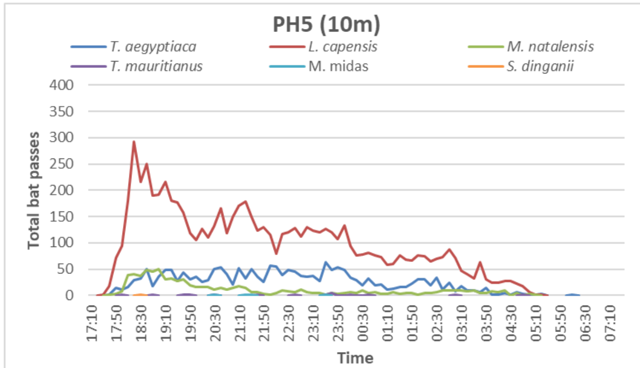

PH1-3 (11m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
Total bat passes
Time


PH2-1 (116m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
Total bat passes
Time


PH2-2 (65m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii
Total bat passes
Time


PH2-3 (15m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii
Total bat passes
Time


PH3 (10m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
S. dinganii
Total bat passes
Time


PH5 (10m)
T. aegyptiaca
L. capensis
M. natalensis
T. mauritianus
M. midas
S. dinganii
Total bat passes
Time

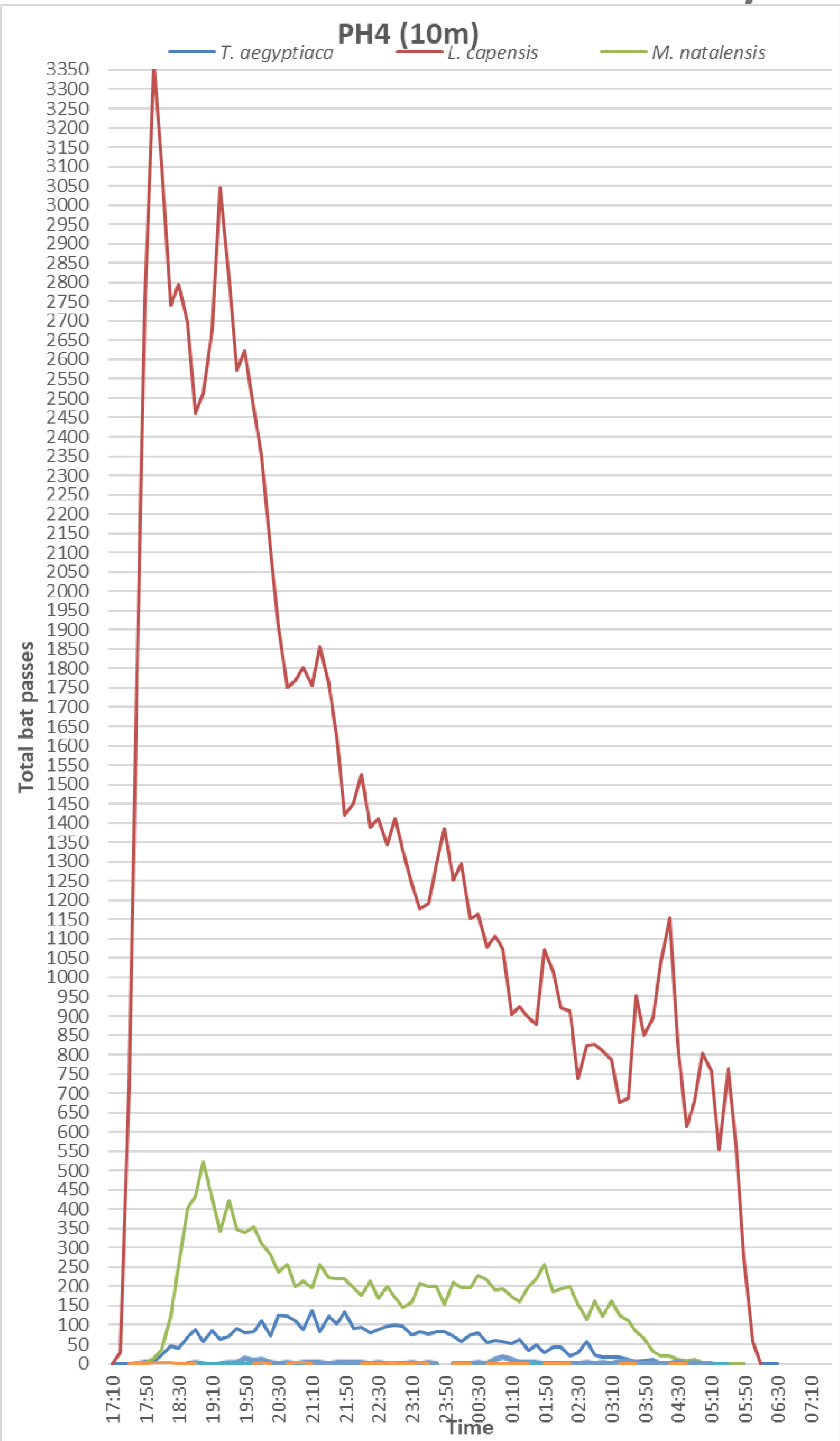



**Figure 12** **Night-time activity of bat species recorded onsite**

## 6.9 Bat activity in relation to weather

The total numbers of bat passes recorded during different wind speeds and atmospheric temperatures in rotor sweep onsite are shown in **Figure 13** and **Figure 14**, respectively. The cumulative and percentage bat passes recorded during different wind speeds and atmospheric temperatures in rotor sweep at PH1 and PH2 are shown in **Figure 15** and **Figure 16**, respectively. Based on the data from PH1 and PH2, most (>95% of) bat activity in rotor sweep height was recorded during temperatures above 11 and below 25°C.

At 116 m a.g.l. approximately:

- 50% of bat activity was recorded during wind speeds below 6.5 m/s.
- 60% of bat activity was recorded during wind speeds around 7 m/s.
- 70% of bat activity was recorded during wind speeds below 8 m/s.
- 80% of bat activity was recorded during wind speeds below 9 m/s.
- 90% of bat activity was recorded during wind speeds below 10 m/s.
- 100% of bat activity was recorded during wind speeds below 16.5 m/s.

At 65 m a.g.l. approximately:

- 50% of bat activity was recorded during wind speeds around 4.5 m/s.
- 60% of bat activity was recorded during wind speeds around 5.5 m/s.
- 70% of bat activity was recorded during wind speeds around 6 m/s.
- 80% of bat activity was recorded during wind speeds below 7 m/s.
- 90% of bat activity was recorded during wind speeds around 8 m/s.
- 100% of bat activity was recorded during wind speeds below 13.5 m/s.

**These results indicate that half of the time, bats were active onsite during wind speeds stronger than 4.5 m/s at 65 m or 6.5 m/s at 116 m a.g.l. If the bat fatality threshold is exceeded during operation, only 50% of activity of all bat species onsite would be protected below a cut-in wind speed of 4.5 m/s at 65 m or 6.5 m/s at 116 m a.g.l. should turbine curtailment be implemented.** The calculation of bat fatality thresholds (as described by MacEwan *et al.* 2018) is dependent, inter alia, on the final (constructed) layout of turbines.

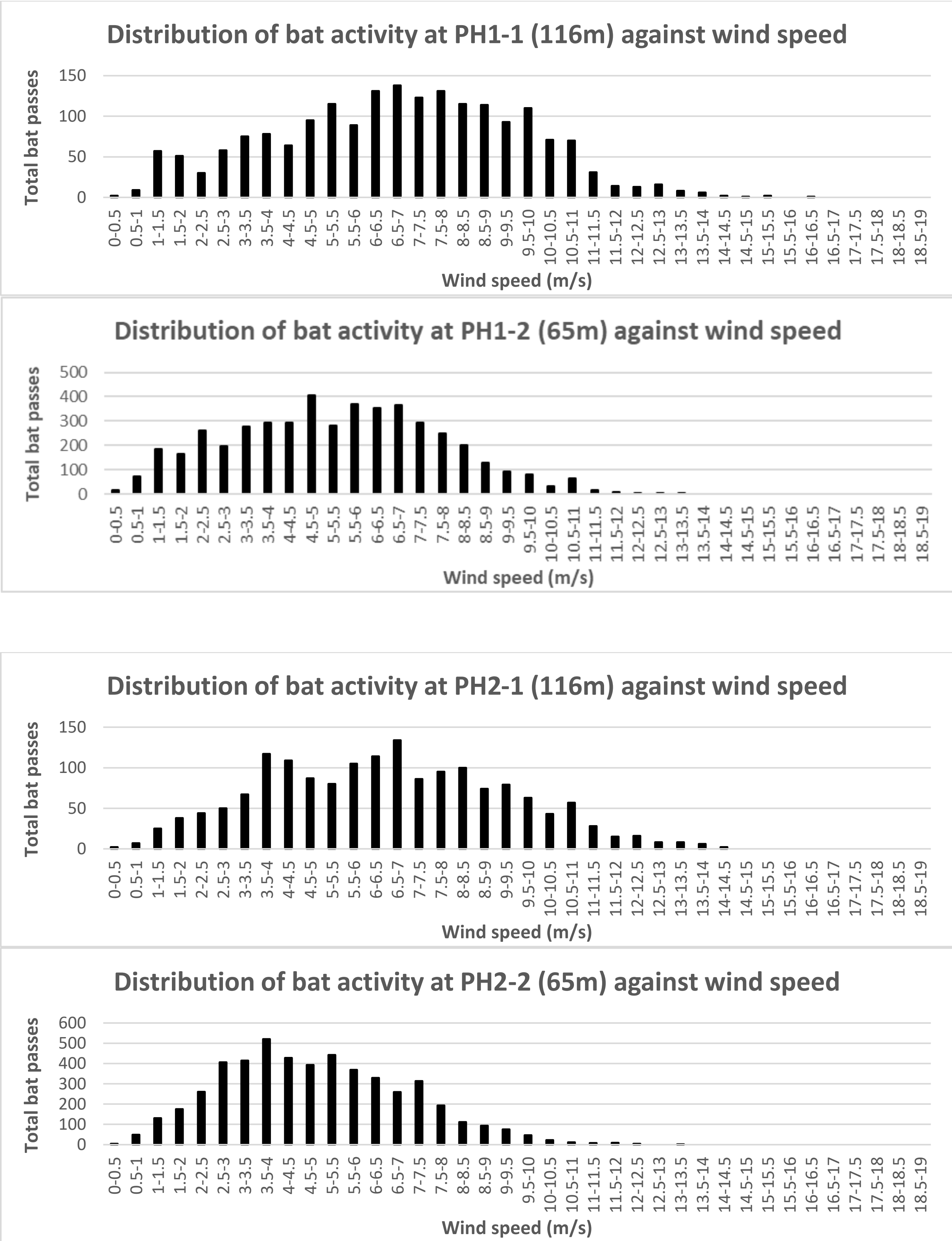
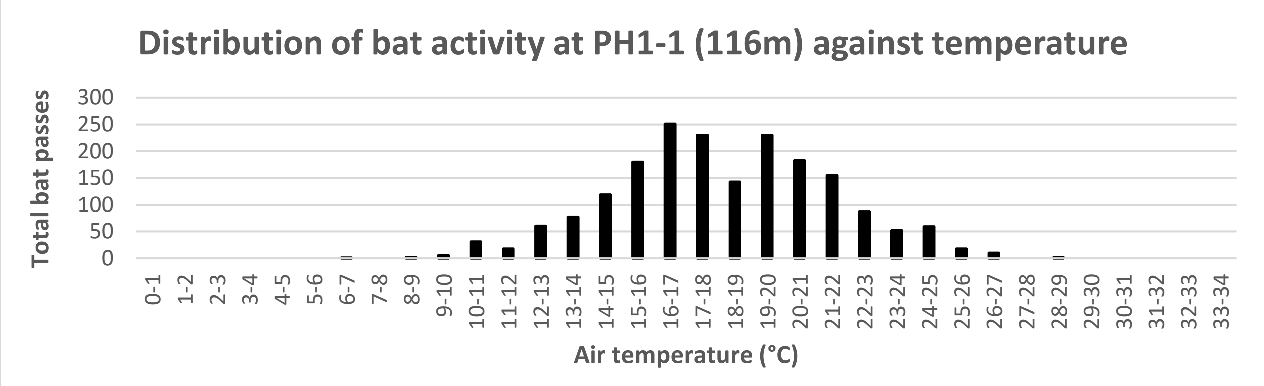



**Figure 13** **Distribution of bat activity in relation to wind speed in rotor sweep at PH1 and PH2**



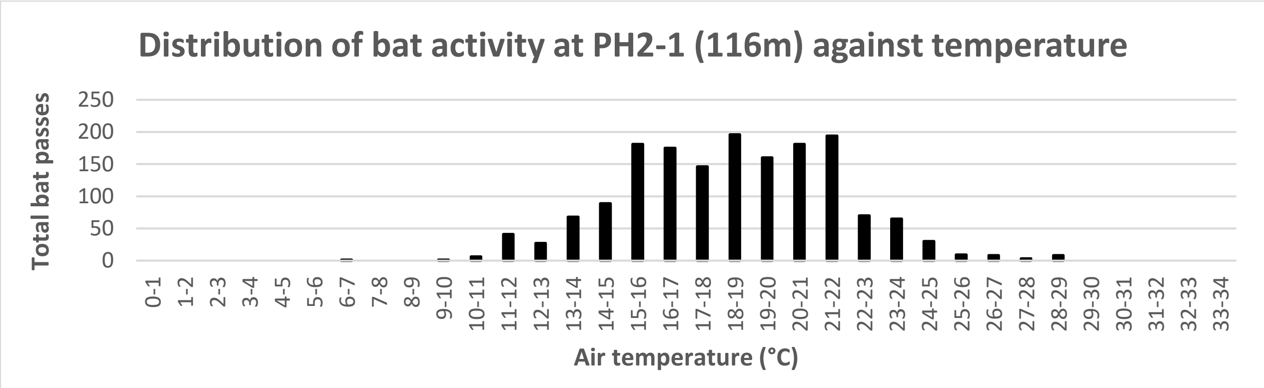
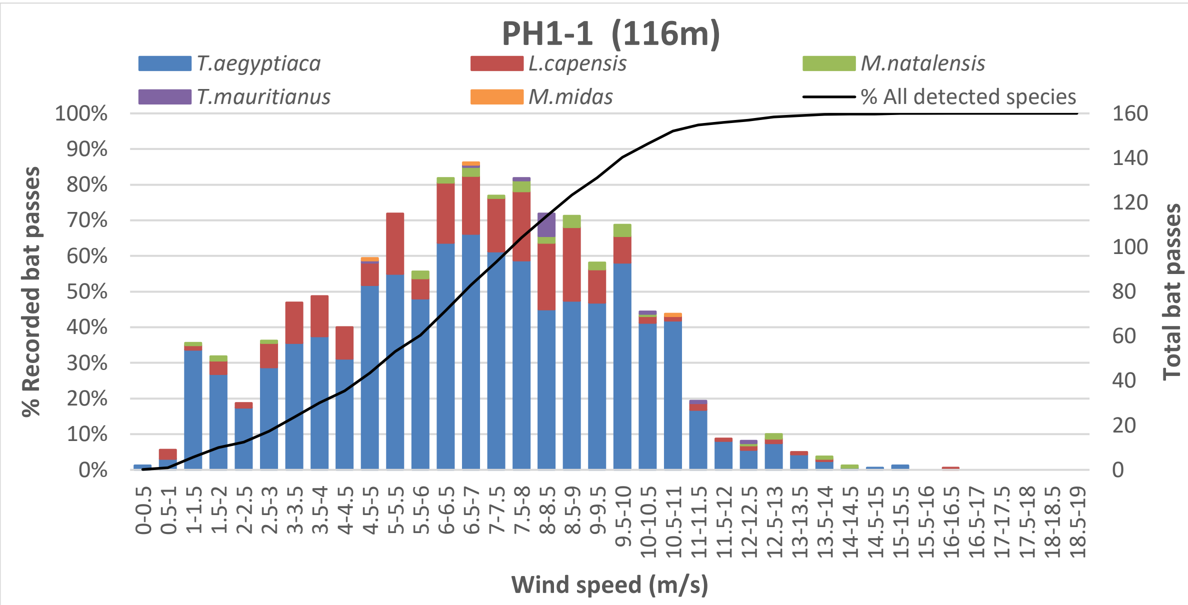
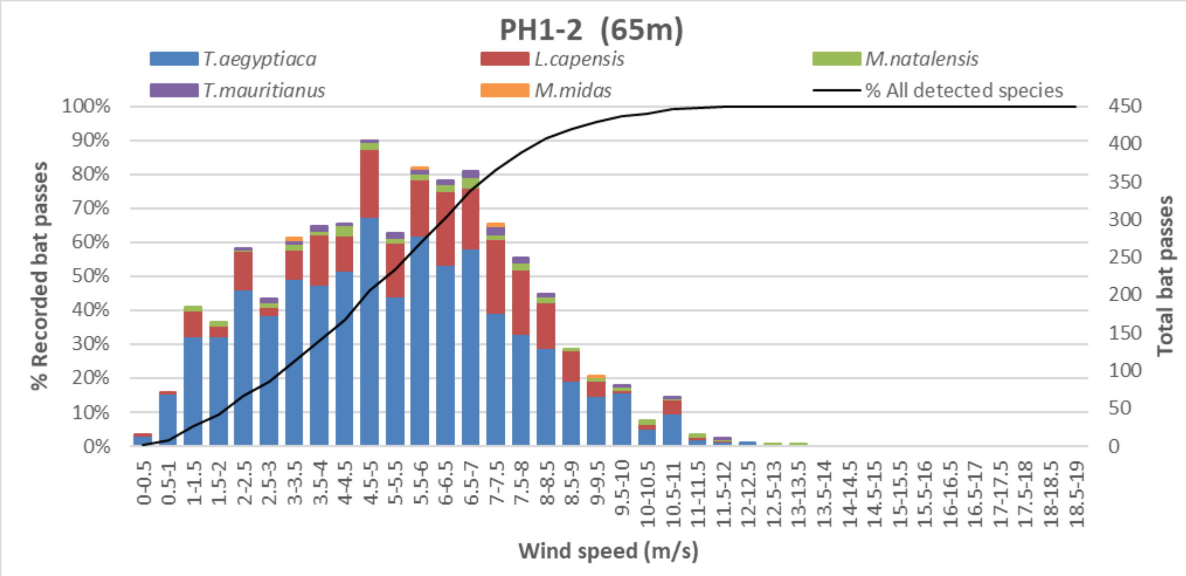
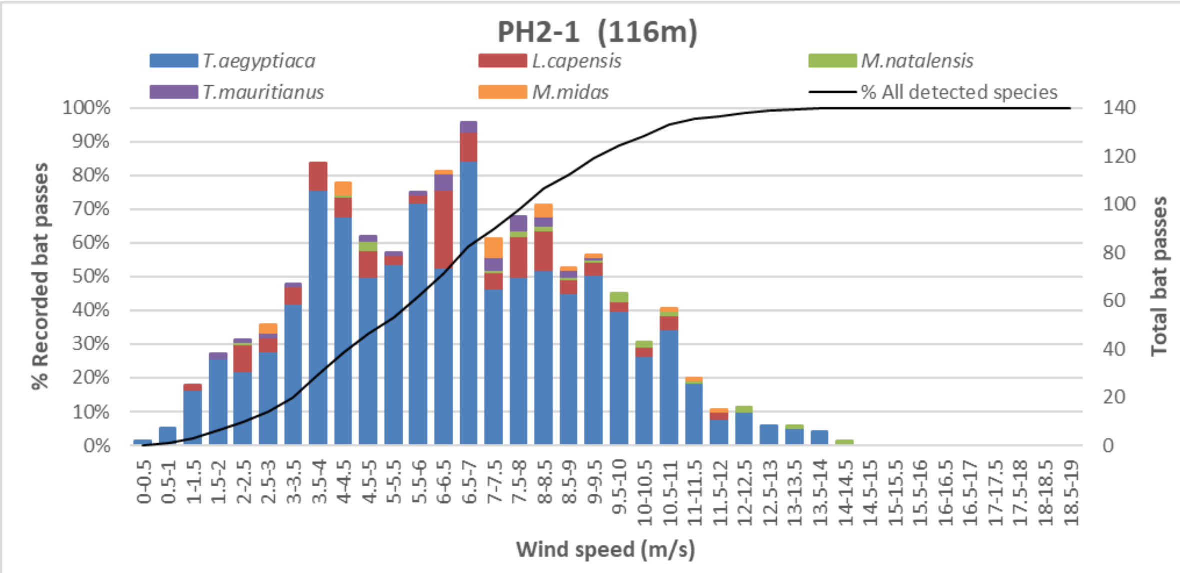




**Figure 14** Relationship between bat activity and temperature in rotor sweep at PH1 and PH2




PH1-2 (65m)
T.aegyptiaca
L.capensis
M.natalensis
T.mauritianus
M.midas
% All detected species
% Recorded bat passes
Total bat passes
Wind speed (m/s)


PH2-1 (116m)
T.aegyptiaca
L.capensis
M.natalensis
T.mauritianus
M.midas
% All detected species
% Recorded bat passes
Total bat passes
Wind speed (m/s)

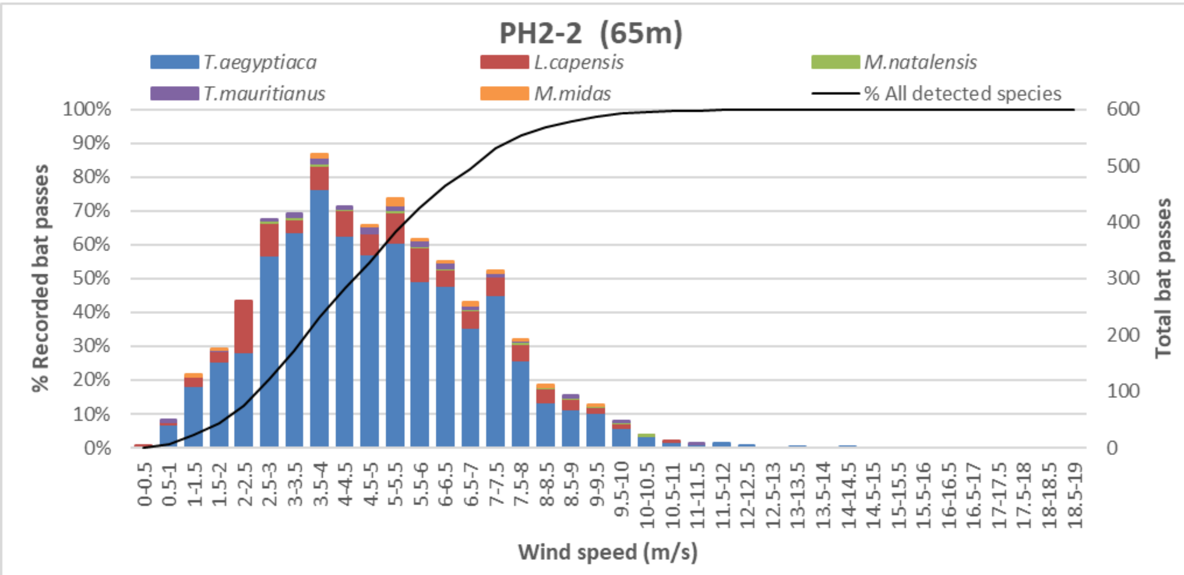

PH2-2 (65m)
T.aegyptiaca
L.capensis
M.natalensis
T.mauritianus
M.midas
% All detected species
% Recorded bat passes
Total bat passes
Wind speed (m/s)

**Figure 15** Relationship between bat activity and wind speed in rotor sweep at PH1 and PH2

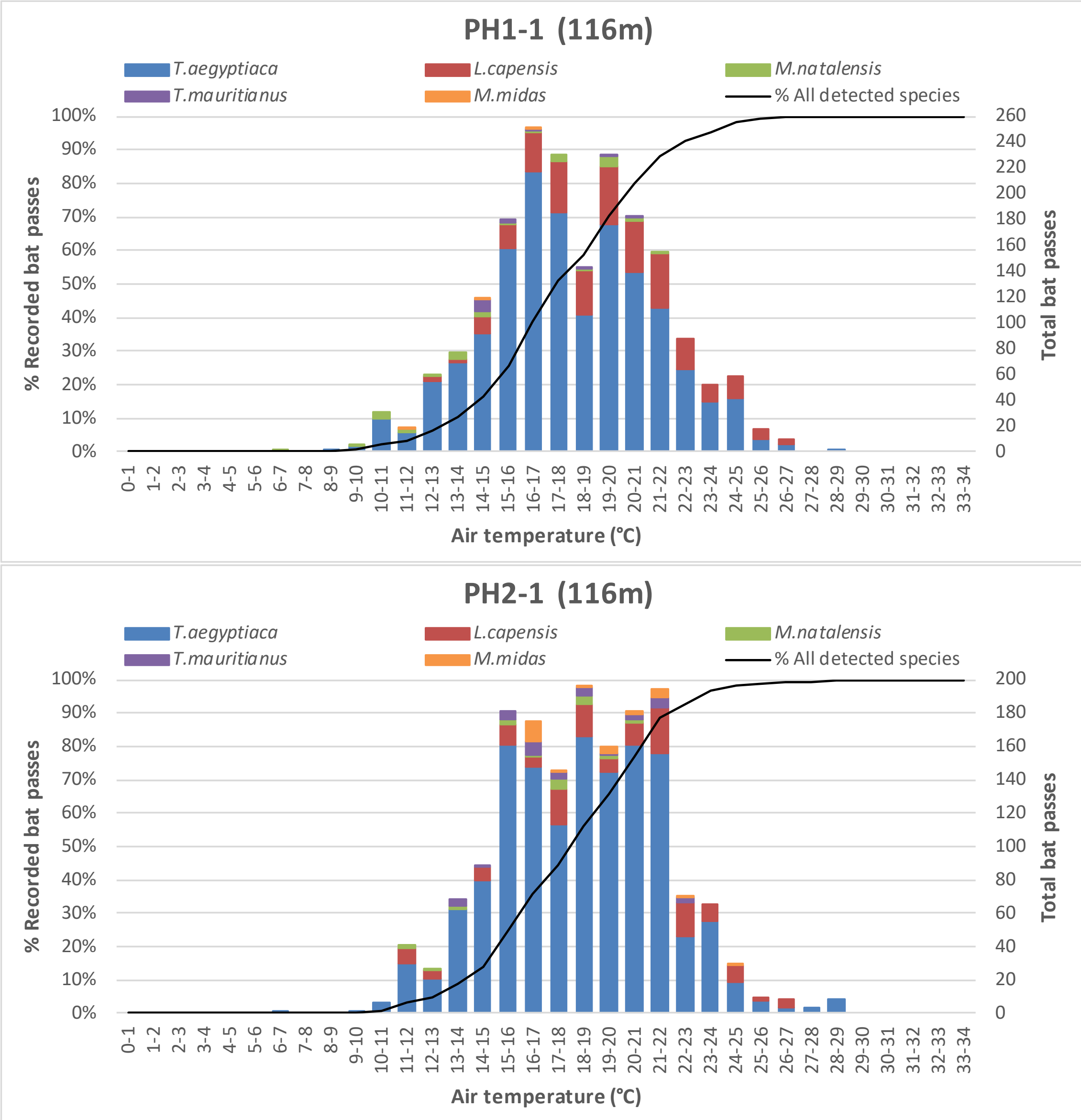



**Figure 16** Relationship between bat activity and temperature in rotor sweep at PH1 and PH2

## 7. Bat Sensitivity Map

According to the spatial data and other information sources that were consulted by IWS, the nearest known major bat roosts are located:

- ~95 km south-east in old mine tunnels referred to as Yzermyn. Here, sizeable populations of the migratory Natal Long-fingered Bat (*M. natalensis*), Geoffroy's Horseshoe Bat (*Rhinolophus clivosus*), Temminck's Myotis (*Myotis tricolor*) and the regionally Vulnerable (Child *et al.* 2016) Swinny's Horseshoe Bat (*Rhinolophus swinnyi*) have been recorded (NSS 2013).
- ~50 km north-east at "Kalkoenkrans Cave", ~60 km north in "River Cave", ~70 km north-east in a mine tunnel at "Waterval Farm", and ~115 km east at "Barites Mine" as reported in the Animalia (2022) report for the approved Camden I WEF located south-east of Ermelo town.

Given these (≥50 km) distances, the proposed PhE WEF is considered unlikely to have a major significant impact on these known bat roosts in the broader region.

Within a 100 km radius around the WEF site, there are multiple protected areas (**Figure 17**). The closest of these is the Rietvlei Private Nature Reserve located ~10 km to the south of the WEF site, and the Ahlers Private Nature Reserve located ~15 km to the south-east. The Chrissiesmeer Protected Environment extends from ~24 km east of the WEF site, and the Langcarel Private Nature Reserve is located ~27 km to the south-east.

Given these (≤27 km) distances, the proposed PhE WEF could impact bat populations from these areas if it causes significant bat fatalities during operation.

Described in **Table 3** and shown in **Figure 18,** is the relative sensitivity (i.e. the conservation importance for bats) of different natural and artificial habitats in the study region, and the recommended buffers around these as stipulated in the South African guidelines on bat monitoring for proposed wind farms (MacEwan *et al.* 2020a) and based on our professional judgement.

**Table 3 Sensitivity and buffering of different features and land-cover in and around the proposed WEF site**

| FEATURE | | | BUFFER | |
|---|---|---|---|---|
| **Type** | **Description** | **Sensitivity** | **Sensitivity** | **Size** |
| Buildings near PH4 | With obvious guano and/or smudge marks, and exceptionally high bat activity recorded at PH4 | High | High | 2.5 km |
| | | | Medium-High | 2.5-5 km |
| Buildings | With obvious guano and/or smudge marks | High | High | 1 km |
| Buildings | Where bats potentially roost and/or forage | High | High | 500 m |
| **LANDCOVER** | | | **BUFFER** | |
| **Class (SALCC_2)** | **Name** | **Sensitivity** | **Sensitivity** | **Size** |
| Forested land | Contiguous low forest and thicket | High | High | 200 m |
| Forested land | Dense forest and woodland | High | High | 200 m |
| Forested land | Open woodland | High | | |
| Forested land | Contiguous and dense plantation forest | High | High | 200 m |
| Forested land | Open and sparse plantation forest | High | | |
| Forested land | Temporary unplanted (clear-felled) plantation forest | High | | |
| Grassland | Sparsely wooded grassland | Medium – High | | |
| Grassland | Natural grassland | Medium | | |
| Waterbodies | Natural rivers | High | High | 200 m |
| Waterbodies | Natural pans (flooded at observation times) | High | High | 200 m |
| Waterbodies | Artificial dams (including canals) | High | High | 200 m |

| | LANDCOVER | | BUFFER | |
|---|---|---|---|---|
| Class (SALCC_2) | Name | Sensitivity | Sensitivity | Size |
| Waterbodies | Artificial flooded mine pits | Medium | Medium | 200 m |
| Wetlands | Herbaceous wetlands (currently mapped) | High | High | 200 m |
| Wetlands | Herbaceous wetlands (previously mapped) | High | High | 200 m |
| Barren Land | Natural rock surfaces | High | High | 500 m |
| Barren Land | Dry pans | High | High | 200 m |
| Barren Land | Eroded lands | Low | | |
| Barren Land | Bare riverbed material | High | High | 200 m |
| Barren Land | Other bare | Low | | |
| Cultivated | Commercial annual crops pivot irrigated | Medium-High | Medium-High | 200 m |
| Cultivated | Commercial annual crops non-pivot irrigated | Medium-High | Medium-High | 200 m |
| Cultivated | Commercial annual crops rain-fed / dryland | Medium | | |
| Cultivated | Fallow land and old fields (trees) | Medium – High | | |
| Cultivated | Fallow land and old fields (bush) | Medium – High | | |
| Cultivated | Fallow land and old fields (grass) | Low | | |
| Cultivated | Fallow land and old fields (bare) | Low | | |
| Cultivated | Fallow land and old fields (wetlands) | Medium – High | Medium - High | 200 m |
| Built-up | Residential formal (tree) | High | | |
| Built-up | Residential formal (bush) | High | | |
| Built-up | Residential formal (low veg / grass) | Low | | |
| Built-up | Residential formal (bare) | Low | | |
| Built-up | Residential informal (tree) | High | | |
| Built-up | Residential informal (low veg / grass) | Low | | |
| Built-up | Residential informal (bare) | Low | | |
| Built-up | Village scattered (bare and low veg/ grass combo) | Low | | |
| Built-up | Village dense (bare and low veg / grass combo) | Low | | |
| Built-up | Commercial | Low | | |
| Built-up | Industrial | Low | | |
| Built-up | Roads and rails (major linear) | Low | | |
| Mines and Quarries | Mines: extraction pits, quarries | Low | | |
| Mines and Quarries | Mine: tailings and resource dumps | Low | | |

A final bat sensitivity map for the WEF site was compiled, where:

- **High** bat sensitive areas include:
  - A 2.5 km buffer around the building roost near the PH4 monitoring location, where exceptionally high levels of bat activity were recorded, based on the 2.5 km buffer recommendation for a medium roost of 50-499 bats representing a Species of Conservation Concern (SCC) and/or bats with a Medium, Medium-High, or High Turbine Fatality Risk, or a large roost of 500-1999 Least Concern and/or Low Fatality Risk bats (MacEwan *et al*. 2020a).
  - Other buildings where appreciable evidence of bat roosting was found (in the form of smudge marks and/or significant guano on floors and/or walls), and a 1 km buffer around these, based on the 1 km buffer recommendation for a small roost of 1-49 bats with a Medium, Medium-High, or High Turbine Fatality Risk (MacEwan *et al*. 2020a).

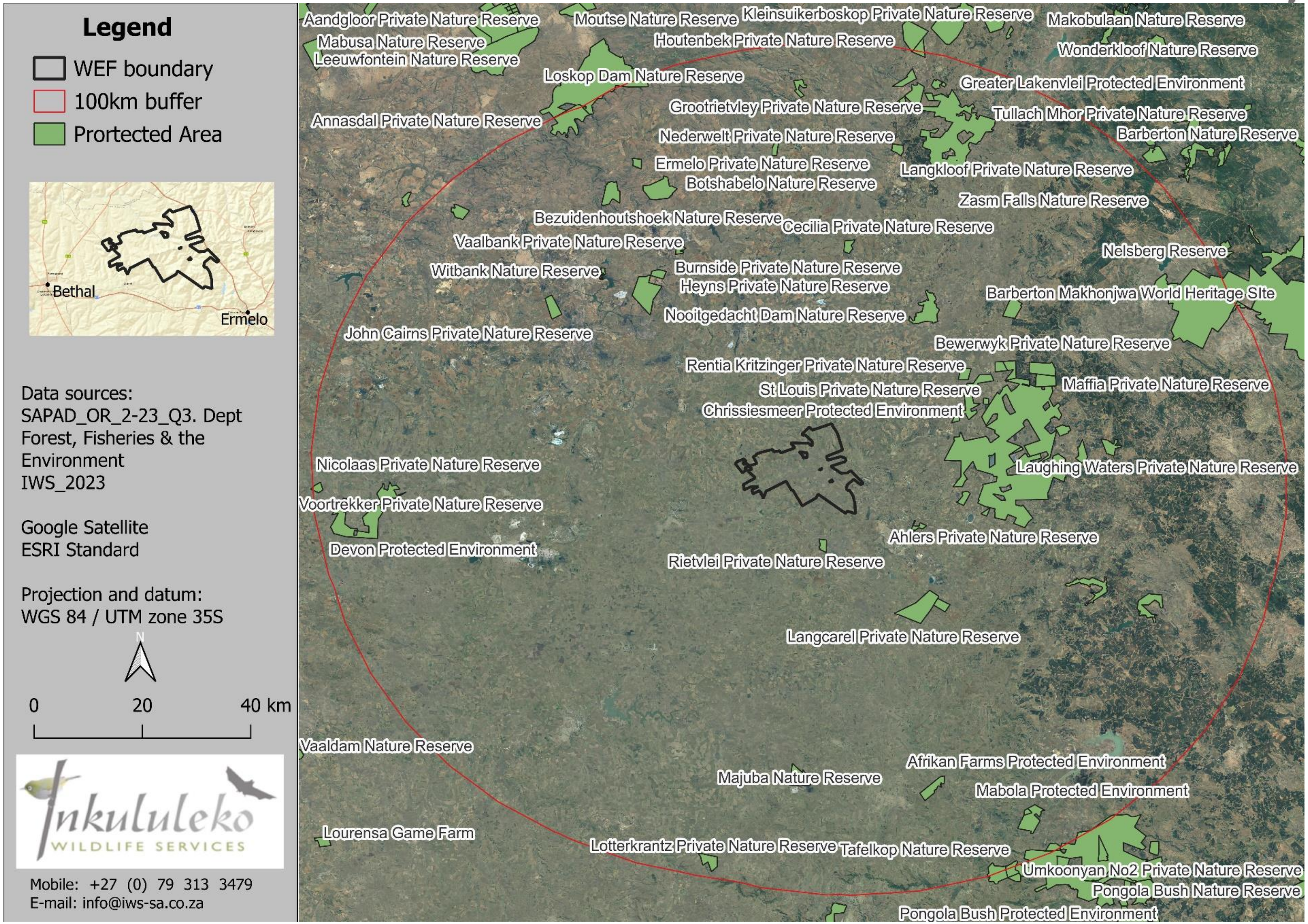



**Figure 17** **Protected areas within a 100 km radius around the proposed Phefumula Emoyeni One WEF site**

- Remaining buildings, where bats potentially roost and/or forage e.g. around lights at night, and a 500 m buffer around these, based on the 500 m buffer recommendation for a small roost of 1-49 Least Concern and/or Low Turbine Fatality Risk bats (MacEwan *et al*. 2020a).
- Natural rock surfaces with cavities and crevices, which may provide roosting habitat for certain bat species, and a 500 m buffer around these.
- Rivers, dams, wetlands, and pans, and a 200 m buffer around these, based on the minimum 200 m buffer recommendation for all potential bat important features (MacEwan *et al.* 2020a).
- Dense woody vegetation, and a 200 m buffer around this.

- **Medium-High** bat sensitive areas include:
  - A 2.5-5 km buffer around the building roost near the PH4 monitoring location, for added protection of bats in this area where exceptionally high levels of bat activity were recorded.
  - Herbaceous wetlands in fallow lands and old fields, and a 200m buffer around these.
  - Commercial irrigated crops, and a 200 m buffer around these, based on the minimum 200 m buffer recommendation for potential bat important features (MacEwan *et al.* 2020a).
  - Fallow and old fields with bushes or trees.
- **Medium** bat sensitive areas include:
  - Natural grassland.
  - Commercial rain-fed crops.
  - Flooded mine pits, and a 200 m buffer around these.
- Remaining areas were rated with **Low** sensitivity.

The sensitivity mapping should be interpreted as follows:

- **High** bat sensitive areas represent **No-Go** areas for the construction of WEF infrastructure especially turbines, substations, buildings, construction camps, laydown areas, and possible quarries (to avoid disturbing key bat roosting, foraging, and/or commuting habitat, and to avoid high bat fatalities in these areas where high bat activity is anticipated). No turbine, including its full rotor swept area and a 2 m pressure buffer around this, should occur in High sensitive areas. Consequently, turbines should be located a minimum of one blade length plus 2 m away from High sensitive areas. Construction of linear infrastructure such as roads and underground powerlines and cabling is only permissible in High Bat Sensitive Areas if this will not result in destruction or disturbance of bat roosts.
- **Medium-High** Bat Sensitive Areas represent areas where the construction of infrastructure and other disturbances should be avoided where possible (to avoid areas where bat activity is likely to be concentrated). Should turbines be proposed in Medium-High sensitive areas, IWS recommends that these should be curtailed for the first three hours after sunset, below a cut-in wind speed of 6 m/s when temperatures of 11-25 ˚C prevail (as measured at 65 m a.g.l.). Alternatively, if turbines in Medium-High sensitive areas are each fitted with a Wildlife Acoustics SMART bat detector, curtailment could be limited to specific turbines and periods where and when elevated bat activity is recorded.
- Disturbances in **Medium** sensitive areas should be minimized.

**Based on the identified bat sensitivities (Figure 18), IWS agrees with the "High" overall sensitivity rating of the site as per the National Screening Tool.** However, this is not only due to the presence of various hydrological features and croplands onsite, but due to the collective presence of hydrological features, croplands, woody vegetation, rocky terrain, buildings (many of which were found to harbour bat roosts), *and* a monitoring location where exceptionally high levels of bat activity were recorded.

The 120 proposed turbine positions avoid High sensitive features but:

- Turbine 12, T13, T16, T19, T30, T34, T44, T47, T49, T62, T63 and T83 have rotor sweep areas that encroach on High sensitivity buffers. **These turbines will have to be moved.**
- Turbine 7, T8, T11, T21, T23, T25, T26, T27, T28, T32, T33, T35, T36, T37, T38, T42, T45, and T61 are proposed in the 2.5-5 km Medium-High sensitive, buffer around the PH4 monitoring location, where very high bat activity was recorded. **To reduce bat fatalities at these turbines, the prescribed blanket curtailment must be implemented, unless SMART detectors are used for smart curtailment in response to real time bat activity.**
- Turbine 40, T51, T52, T65, T80, T84, and T85, which are located in other Medium-High sensitive areas, **will also require the prescribed blanket or smart curtailment.**
- Turbine 4, T9, T15, T17, T29, T39, T55, T56, T58, T59, T68, T70, T71, T72, T73, T77, T78, T79, T88, which are positioned in Medium sensitive areas, have rotor sweep areas that encroach on Medium-High sensitive areas. **Where possible, these turbines should be shifted slightly to avoid encroachment into Medium-High sensitive areas.**

## 8. Bat Impact Assessment and Recommended Mitigation

### 8.1 Current impacts

Within the study area, bats have been negatively and positively impacted by anthropogenic activities. Extensive commercial cultivation of maize especially has caused widespread loss of natural grassland, where a higher richness of different bat species would be expected. Certain bat species have possibly benefitted, however, from predation of crop pests in the cultivated fields. Urban settlement has also resulted in habitat loss and degradation. While buildings and other infrastructure (such as bridges, culverts, and possible old mine tunnels) provide roosting habitat for Cape Serotine and other bat species, bats have likely also been subject to eviction or persecution by people. Light pollution has possibly benefited certain bat species, but adversely impacted others. Invasive and other alien trees have replaced natural grassland in various places but can provide roosting habitat for tree-roosting bat species, and foraging habitat for clutter- and clutter-edge foraging bat species. Widespread generalist species (such as the Egyptian Free-tailed Bat and Cape Serotine) are more likely to have benefitted from anthropogenic activities than rarer specialist bat taxa.

### 8.2 Potential impacts without and with mitigation

Presented in **Table 4** - **Table 7** is the assessment of each potential impact on bats, their habitats, or ecosystem services, without and with mitigation. A discussion of each potential impact including recommended impact mitigation measures, follows.

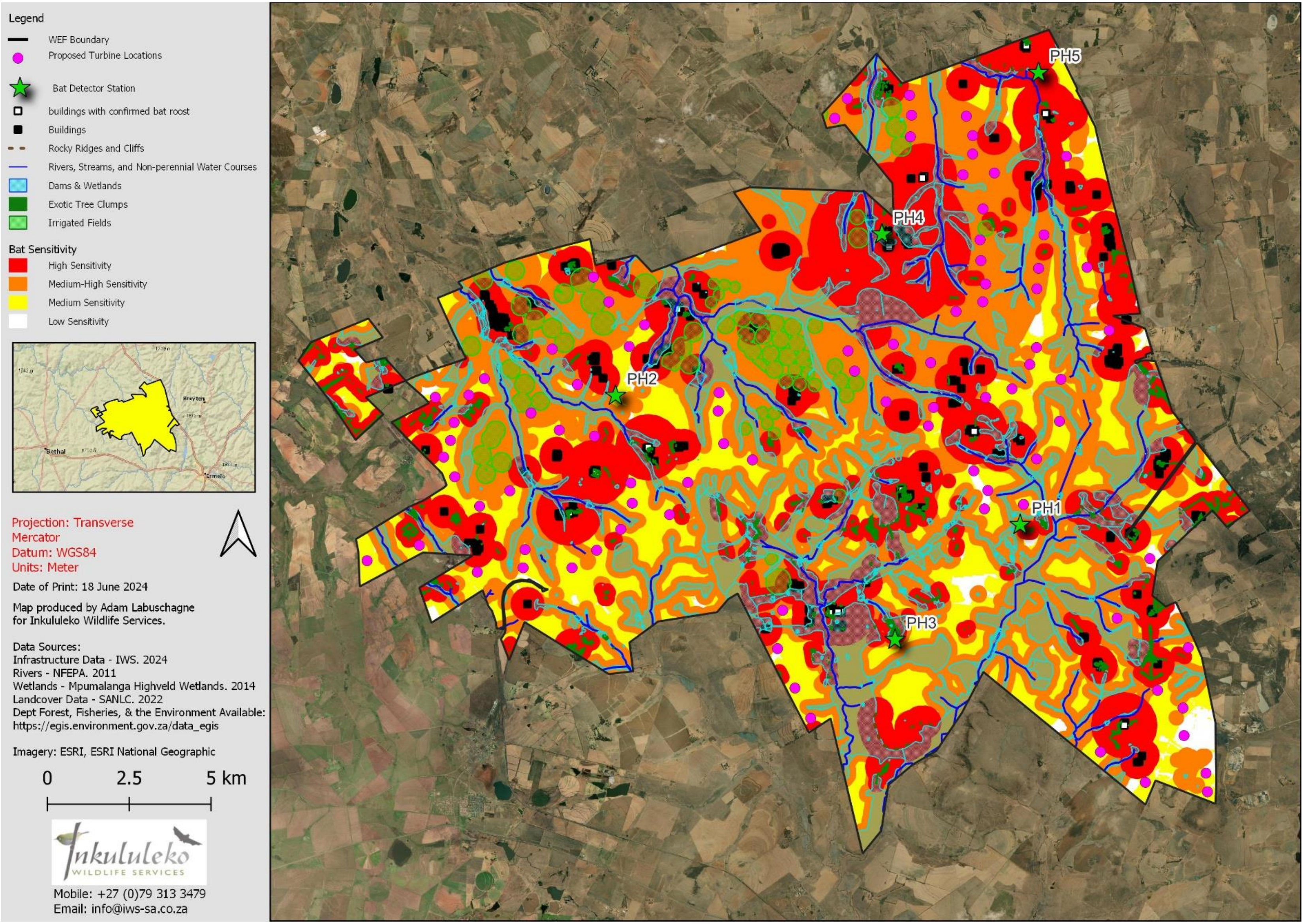



**Figure 18** **Bat sensitivity map for the Phefumula Emoyeni One WEF site, including the proposed layout of infrastructure including 120 turbines**

Table 4 Assessment of potential impacts during construction

| CONSTRUCTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Impact number | Aspect | Description | Stage | Character | Ease of Mitigation | Pre-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | Rating |
| Impact 1: | Bat roosts | Disturbance of bat roosts | Construction | Negative | Moderate | 5 | 3 | 3 | 5 | 4 | 64 | N4 |
| | | | | | Significance | N4 - High | | | | | | |
| Impact 2: | Bat habitat | Terrestrial habitat loss, and possible displacement of bats | Construction | Negative | Moderate | 4 | 2 | 3 | 4 | 5 | 65 | N4 |
| | | | | | Significance | N4 - High | | | | | | |
| | | | | | | Post-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | Rating |
| | | | | | | 3 | 2 | 3 | 4 | 2 | 24 | N2 |
| | | | | | | N2 - Low | | | | | | |
| | | | | | | 2 | 1 | 3 | 3 | 5 | 45 | N3 |
| | | | | | | N3 - Moderate | | | | | | |

Table 5 Assessment of potential impacts during operation

| OPERATIONAL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Impact number | Receptor | Description | Stage | Character | Ease of Mitigation | Pre-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| Impact 1: | Bat fatalities | Bat fatalities from collision with turbines, and possible population declines | Operational | Negative | Low | 5 | 3 | 5 | 4 | 5 | 85 | N5 |
| | | | | | Significance | N5 - Very High | | | | | | |
| Impact 2: | Ecosystem services | If high bat fatalities lead to declines in certain species populations, the ecosystem services that these populations provide will be compromised. | Operational | Negative | Moderate | 5 | 3 | 3 | 4 | 5 | 75 | N4 |
| | | | | | Significance | N4 - High | | | | | | |
| | | | | | | Post-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| | | | | | | 3 | 2 | 3 | 4 | 5 | 60 | N3 |
| | | | | | | N3 - Moderate | | | | | | |
| | | | | | | 2 | 3 | 3 | 4 | 3 | 36 | N3 |
| | | | | | | N3 - Moderate | | | | | | |

### Table 6 Assessment of potential impacts during decommissioning

| DECOMISSIONING | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Impact number | Receptor | Description | Stage | Character | Ease of Mitigation | Pre-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| Impact 1: | Bat roosts | Disturbance of bat roosts | Construction | Negative | Moderate | 5 | 3 | 3 | 5 | 4 | 64 | N4 |
| | | | | | Significance | N4 - High | | | | | | |
| Impact 2: | Bat habitat | Terrestrial habitat loss, and possible displacement of bats | Construction | Negative | Moderate | 4 | 2 | 3 | 4 | 5 | 65 | N4 |
| | | | | | Significance | N4 - High | | | | | | |
| | | | | | | Post-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| | | | | | | 3 | 2 | 3 | 4 | 2 | 24 | N2 |
| | | | | | | N2 - Low | | | | | | |
| | | | | | | 2 | 1 | 3 | 3 | 3 | 27 | N2 |
| | | | | | | N2 - Low | | | | | | |

### Table 7 Cumulative impact assessment

| CUMULATIVE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Impact number | Receptor | Description | Stage | Character | Ease of Mitigation | Pre-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| Impact 1: | Other WEFs | Cumulative impact of renewable energy developments in the area | Cumulative | Negative | Low | 5 | 4 | 5 | 5 | 5 | 95 | N5 |
| | | | | | Significance | N5 - Very High | | | | | | |
| | | | | | | Post-Mitigation | | | | | | |
| | | | | | | (M+ | E+ | R+ | D)x | P= | S | |
| | | | | | | 3 | 4 | 3 | 4 | 4 | 56 | N3 |
| | | | | | | N3 - Moderate | | | | | | |

### 8.2.1. Roost disturbance or destruction

During construction of the proposed WEF, bat roosts (roosting bats and/or roost sites) in buildings, rocky outcrops, and/or woody vegetation, could be disturbed or destroyed (e.g., from vegetation clearing, demolishment of old buildings, blasting, excavation works, human activity, and noise) if overlooked and/or not adequately avoided. Given the presence of multiple well-established roosts on site, this potential impact was rated with **High** significance, without mitigation ( **Table 4**; **Table 6**).

Recommended mitigation:

To reduce mainly the potential magnitude and probability of this impact to overall **Low** significance, the following is recommended:

- **Avoid High sensitive areas**, in particular, buildings with confirmed roosts, and potential roosts in other buildings, rocky outcrops, and dense woody vegetation, and the prescribed buffers around these.
- **Avoid Medium-High sensitive areas where possible**, in particular, the 2.5-5 km buffer around the building roost near the PH4 monitoring location, where very high levels of bat activity were recorded.
- **Avoid blasting within 2 km of a confirmed roost.**
- **Minimise artificial lighting on site** (excluding compulsory civil aviation lighting) – especially high-intensity, steady-burning, sodium vapour, quartz, halogen, and other bright lights at substations, offices, and turbines (to avoid disturbing roosts of certain sensitive bat species). All non-aviation lights should be hooded downward and directed to minimise horizontal and skyward illumination. Where possible, solar-powered motion-sensitive lights should be used.
- **Consult a Bat Specialist if a bat roost is encountered** during any phase of the WEF, and refrain from disturbing the roost until appropriate advice has been obtained.

### 8.2.2. Destruction, degradation, and fragmentation of and displacement from foraging habitat

Construction of the WEF will cause widespread destruction, degradation, and fragmentation of terrestrial habitat (potentially including threatened grassland), which support insect populations that the predominant aerial-foraging insectivorous bat species prey upon. Without careful planning, there could during construction also be destruction or disturbance of drainage lines and wetland areas, which currently provide bats with essential drinking water, concentrated insect prey, and/or which may represent important beacons or pathways for bat navigation and commuting (Serra-Cobo *et al*. 2000; Salata 2012; Sirami *et al.* 2013). Furthermore, during operation, certain bats may be displaced from foraging areas if they avoid the WEF (e.g. due to light pollution or obstruction to movement) or suffer fatality from collision with turbines. This impact was rated with **High** significance in the absence of mitigation ( **Table 4**; **Table 6**).

Recommended mitigation:

To reduce mainly the extent and magnitude of this impact to overall **Moderate** significance, the following is recommended:

- **Avoid High sensitive areas**, in particular, hydrological features and woody vegetation, and the prescribed buffers around these.
- **Avoid Medium-High sensitive areas where possible**, in particular, remaining patches of threatened, native grassland, and the 2.5-5 km buffer around the PH4 monitoring location where very high levels of bat activity were recorded.
- **Minimise the length and breadth of proposed roads** to thus minimise the loss and fragmentation of terrestrial (bat foraging) habitat.

- **Minimize the number of proposed turbines** to potentially reduce the extent of the road network and the overall extent of the wind farm and thus, the extent of terrestrial habitat loss and possible displacement of bats.
- **Minimise the degradation of terrestrial habitat** by implementing and maintaining effective dust, stormwater, erosion, sediment, and invasive alien plant control measures.
- **Minimise artificial lighting on site** (excluding compulsory civil aviation lighting) – especially high-intensity, steady-burning, sodium vapour, quartz, halogen, and other bright lights at substations, offices, and turbines (to avoid disturbing roosts of certain sensitive bat species). All non-aviation lights should be hooded downward and directed to minimise horizontal and skyward illumination. Where possible, solar-powered motion-sensitive lights should be used.
- **Rehabilitate disturbed terrestrial habitat** by comprehensively and diligently implementing effective rehabilitation measures based on consultation with an appropriate vegetation specialist.

#### 8.2.3. Bat fatalities from collision with turbines, and potential population declines

During operation of the WEF, there will be inevitable fatality of bats from their collision with turbines and possibly to some extent, from barotrauma. If the fatality rate of impacted species exceeds their rate of successful reproduction and survival, population declines will occur. This inevitable impact was rated with **Very High** significance considering: i) the large size and large number of proposed turbines; ii) that five of the six bat species recorded on site have a High risk of collision with turbines, and the remaining species has a Medium-High turbine fatality risk; and iii) that exceptionally high levels of bat activity were recorded at the PH4 monitoring location (**Table 5**).

<u>Recommended mitigation:</u>

To reduce mainly the magnitude and extent of this impact to overall **Moderate** significance, the following is recommended:

- **Avoid High sensitive areas**, including all bat significant features and the buffers around these. No turbine, including its full rotor swept area and a 2 m pressure buffer around this, should occur in High sensitive areas.
- **Avoid Medium-High sensitive areas where possible**, in particular, the 2.5-5 km buffer around the PH4 monitoring location where very high levels of bat activity were recorded. Should turbines be proposed in Medium-High sensitive areas, IWS recommends that these should be curtailed for the first three hours after sunset, below a cut-in wind speed of 6.5 m/s when temperatures of 11-25 ˚C prevail (as measured at 65 m a.g.l.). Alternatively, if turbines in Medium-High sensitive areas are each fitted with a Wildlife Acoustics SMART bat detector, curtailment could be limited to specific turbines and periods where and when elevated bat activity is recorded.
- **Minimise artificial lighting on site** (excluding compulsory civil aviation lighting) – especially high-intensity, steady-burning, sodium vapour, quartz, halogen, and other bright lights at substations, offices, and turbines (to avoid disturbing roosts of certain sensitive bat species). All non-aviation lights should be hooded downward and directed to minimise horizontal and skyward illumination. Where possible, solar-powered motion-sensitive lights should be used.
- **Monitor bat fatalities as soon as the first turbine is operational** – as per the latest SABAA guideline for this (Aronson *et al*. 2020 or later) and the latest (2023 or later) IFC Good Practice Handbook on post-construction bird and bat fatality monitoring for onshore WEFs in emerging market countries. At the very least, bat fatality monitoring should be conducted during the WEF's first two years of

operation, and then every fifth year thereafter. The monitoring and data analysis are to be conducted to a high standard so that there is confidence in the estimated numbers of actual bat fatalities.

- **Conduct passive monitoring of live bat activity** as soon as the first turbine is operational, and whenever bat fatality monitoring is performed during the WEF's operation. The operational passive monitoring should represent a repeat of the pre-construction passive monitoring, so far as this is possible. This will allow for comparison of operational bat activity levels with pre-construction bat activity levels and operational bat fatalities, and it will help to assess the efficacy of any implemented bat fatality mitigation measures.
- **Mitigate bat fatalities adaptively** by consulting the latest SABAA guideline for this (Aronson *et al.* 2018 or later), and the best available relevant scientific information. Taxon-specific differences should be taken into consideration if/when fatality mitigation measures are implemented. The calculation of bat fatality thresholds (as described by MacEwan *et al.* 2018) is dependent, inter alia, on the final (constructed) layout of turbines. Adequate financial provision should be made to permit effective monitoring, management, and mitigation of bat fatalities throughout the life of the WEF.
- **Forward all (live and fatality) bat monitoring data** to the database recommended by the South African Bat Assessment Association (SABAA) to expand the scientific knowledge base for more informed decision making and mitigation.

#### 8.2.4. Decline or loss of bat ecosystem services

If bat populations in the study area start declining because of roost disturbance, loss of and/or displacement from foraging habitat, and/or high bat fatalities, the ecosystem services that the bats provide will be impacted. Local bat eco-services possibly include population control of maize pest and various other insect species. The plant pollination, seed dispersal, and habitat regeneration services provided by fruit bats could be impacted if the WEF causes fatalities of fruit bats – which might not reside but could possibly commute through the area. Without mitigation, a potential decline or loss of these services was rated with **High** significance (**Table 5**).

<u>Recommended mitigation:</u>

This potential impact could be reduced to overall **Moderate** significance by implementing all **mitigation measures** that have been prescribed for potential bat roost disturbance, terrestrial habitat loss and possible displacement of bats, and bat fatalities from collision with turbines, and possible population declines.

#### 8.2.5. Cumulative impact

Of greatest concern is the potential cumulative impact on bats on the Mpumalanga Highveld from expanding and intensifying anthropogenic forms of land-use in the region, particularly, commercial crop cultivation (involving e.g. pesticide spraying), coal mining and burning (involving e.g. blasting, excavations, and water pollution), urban settlement (involving e.g. persecution of bats in rooves, and light pollution), and rapidly expanding renewable energy development including several approved solar and wind energy facilities (**Figure 19**). The WEFs include: i) the Ummbila Emoyeni WEF (up to 900 MW; DFFE Ref: 14/12/16/3/3/2/2160) located ~10 km to the southwest; ii) the Hendrina North and South WEFs (up to 200 MW each; DFFE Ref: 14/12/16/3/3/2/2160 and 2161) located ~16 km to the northwest; iii) the Camden I and II WEFs (up to 200 MW each; DFFE Ref: 14/12/16/3/3/2/2137 and 2135) located ~28 km and 35 km to the southeast, respectively; and iv) the Haverfontein WEF (DFFE Ref: 12/12/20/2018/AM2) located ~40 km north-east.

Without very diligent monitoring and mitigation of bat fatalities and other impacts (e.g. roost disturbance) at all WEFs in the region, their potential cumulative impact on bat habitats, populations, and ecosystem services was rated with **Very High** significance. Only with proper bat fatality monitoring and adaptive management of bat fatalities using turbine curtailment and other secondary mitigation measures, may the cumulative impact of these WEFs on bats be reduced to **Moderate** significance (**Table 7**).

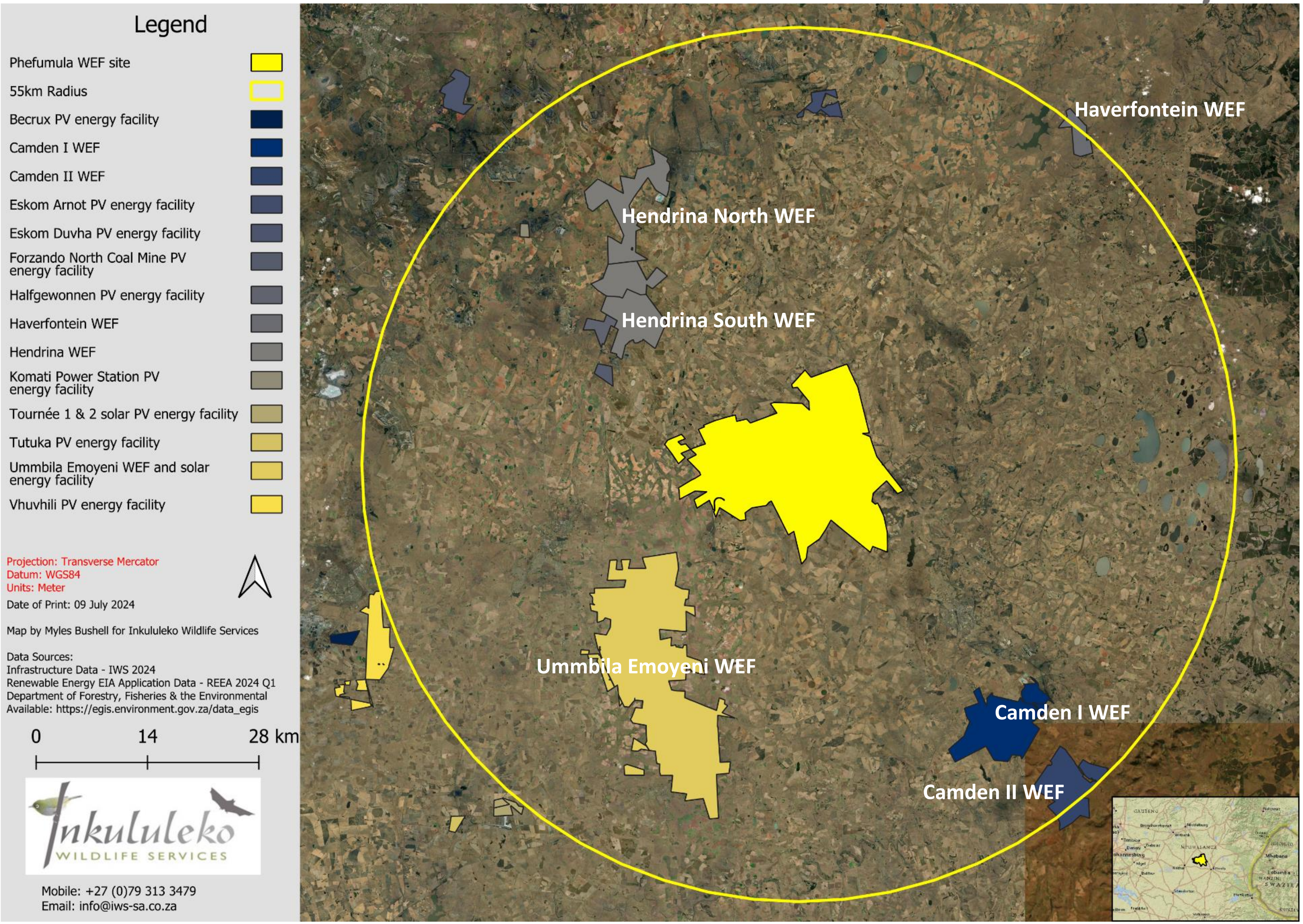



**Figure 19** Renewable energy development applications (REEAs) within (and beyond) a 55 km radius of the Phefumula Emoyeni One WEF site

## 9. Conclusion

**Following the first submission of this report, the proposed layout of infrastructure for the Phefumula Emoyeni One WEF was revised to comprise up to 88 (not 120) turbines, as shown in Figure 20.** The turbine dimensions and other infrastructure details described in **Section 2** have remained unchanged.

The 88 proposed turbine positions avoid High sensitive features but:

- Turbine 11, T12, T13, T27, T44, T47, T48, T49, T53, T56, T63, T68, T81, T82, and T88 have rotor sweep areas that encroach on High sensitivity buffers. **These turbines will have to be moved.**
- Turbine 7, T8, T21, T23, T25, T26, T28, T32, T33, T34, T35, T36, T37, T38, T42, T45, and T61 are proposed in the 2.5-5 km Medium-High sensitive buffer around the PH4 monitoring location, where very high bat activity was recorded. **To reduce bat fatalities at these turbines, the prescribed blanket curtailment must be implemented, unless SMART detectors are used for smart curtailment in response to real time bat activity.**
- Turbine 4, T29, T40, T51, T52, T59, T65, T66, T73, T79, T80, T83, and T84, which are located in other Medium-High sensitive areas, **will also require the prescribed blanket or smart curtailment.**
- Turbine 9, T14, T15, T16, T17, T20, T50, T55, T58, T70, T71, T75 and T85 which are positioned in Medium sensitive areas, have rotor sweep areas that encroach on Medium-High sensitive areas. **Where possible, these turbines should be shifted slightly to avoid encroachment into Medium-High sensitive areas.**

**It should be noted that although the total number of turbines has decreased from 120 to 88, which is better for bats, there has been an increase in the number of turbines located in High or Medium-High sensitive areas from 37 to 45, which is worse for bats.**

Given the high recorded level of bat activity around the PH4 bat monitoring location and the rapid expansion of renewable energy developments in the immediate surrounds and further afield, **bat fatality mitigation is essential for the proposed Phefumula Emoyeni One WEF.** Turbine curtailment remains the most effective means of mitigating bat fatalities at WEFs (Arnett *et al.* 2013; Adams *et al.* 2021; Bennett *et al.* 2022). If done correctly, curtailment can have a minor or even negligible impact on energy generation by a WEF (Arnett *et al*. 2016; Hayes *et al.* 2019; Bennett *et al.* 2022). **IWS advises that it will be most sensible and feasible to install bat deterrents on problematic turbines only if/when the operational bat fatality data reveal specific turbines which are most problematic (Good *et al.* 2022) – if these will adequately mitigate fatalities.**

**Going forward, the Client is strongly advised to carefully evaluate the feasibility of the prescribed curtailment and to ensure that there is adequate financial planning and provision for the curtailment. All bat impact mitigation measures recommended in this report must, so far as applicable, be followed and included in the Wind farm's Environmental Management Programme (EMPr). This includes the details of the prescribed curtailment, which must be diligently implemented as soon as each turbine starts spinning.** Additionally, it must be explicitly stated in the EMPr that if smart curtailment is not successfully implemented, the affected turbine(s) must be prevented from spinning at night until a suitable alternative form of bat fatality mitigation, recommended by an appropriately experienced bat specialist, is fully operational.

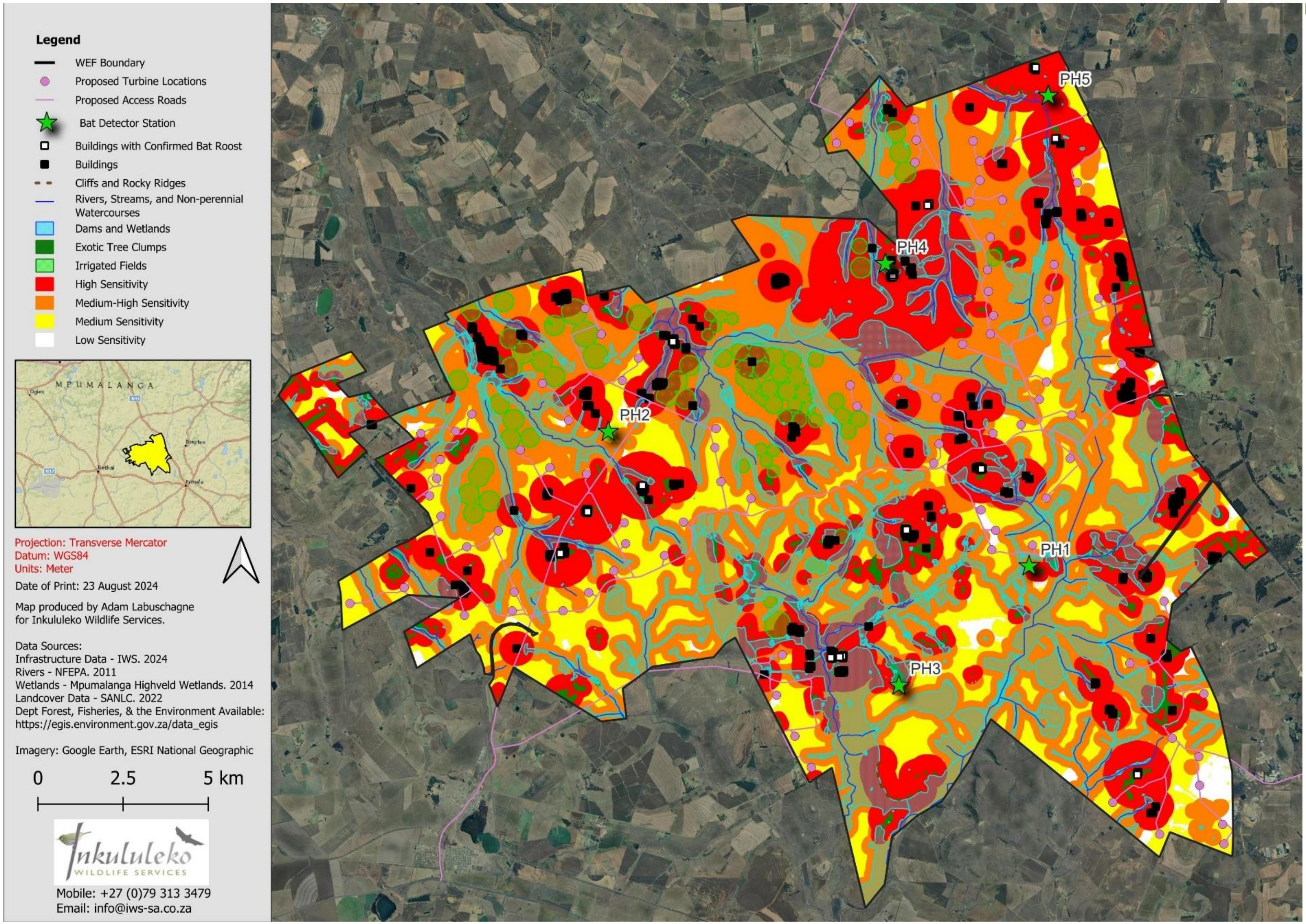



**Figure 20 Bat sensitivity map for the Phefumula Emoyeni One WEF site, including the proposed layout of infrastructure including 88 turbines**

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## 11. Appendix: CV of Dr Caroline Lötter

| | |
|---|---|
| *Name*: | **DR CAROLINE ANGELA LöTTER (NEÉ YETMAN)** |
| *Name of Firm:* | Inkuluteko Wildlife Services (Pty) Ltd |
| *Position:* | Managing Director and Senior Zoologist |
| *Date of Birth:* | 6 November 1979 |
| *Nationality:* | South African |
| *Languages:* | English, Afrikaans |

### QUALIFICATIONS & PROFESSIONAL REGISTRATION

- PhD – Zoology (University of Pretoria: 2003-2011)
- MSc – African Mammalogy (University of Pretoria: 2002)
- BSc Hons – Zoology (University of Pretoria: 2001)
- BSc – Ecology (University of Pretoria: 1998-2000)
- Registered with SACNASP (no. 400182/09) as a Professional Natural Scientist in the field of Zoology

### KEY EXPERIENCE

- **Specialist Assessments:**
  - Long-term bat monitoring at more than 70 wind farm sites in southern Africa, including field work, desktop research, report writing, and project management.
  - Surveys and impact assessments for the Square Kilometre Array project and several bat caves.
  - Baseline and impact assessments for fauna in general at over 100 sites in South Africa.
  - Biodiversity Management Plans for large South African mining complexes.
  - Specialist Giant Bullfrog assessments for more than 50 proposed development sites.

### EMPLOYMENT EXPERIENCE

- **Inkululeko Wildlife Services, Johannesburg (June 2019 – present)**
  Position Title: Managing Director
  - Bat project management
  - Proposals
  - Desktop research
  - Field work
  - Reporting and report reviews
  - Analysis and reporting of data for peer-review publication
  - Co-author of South African pre-construction bat monitoring guidelines (MacEwan *et al*. 2020a)
  - Co-author of article on bat activity in South Africa and its implications for wind farm development (MacEwan *et al.* 2020b)

- **Natural Scientific Services, Johannesburg (November 2011 – April 2019)**
  Position Title: Senior Zoologist
  - Bat, faunal, and general biodiversity (i.e. faunal, flora, wetland and aquatic) project management
  - Proposals
  - Desktop research
  - Field work
  - Reporting and report reviews
  - Analysis and reporting of data for peer-review publication