Specialist Bat (Chiroptera) Sensitivity Assessment for the proposed Grahamstown Wind Energy Facility, near Grahamstown, Eastern Cape

Prepared by:	**Prepared for:**	**Prepared for:**
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EXECUTIVE SUMMARY

Plan8 (Pty) Ltd, a renewable energy company, plans to develop a wind powered electricity generation facility (known as a 'wind farm') approximately 30km outside of Grahamstown along the N2 in an easterly direction towards East London, in the Eastern Cape Province of South Africa. The proposed site is on the farms Gilead, Tower Hill and Peynes Kraal, situated approximately 30km east of Grahamstown. The proposed wind farm is planned to comprise up to a maximum of 32 turbines, each with a nominal power output ranging between 2 and MW (megawatts). The total potential generating capacity of the wind farm will be approximately 80MW, and will feed power into the national electricity grid (Figure 2-1).

The project area located in the quarter degree square S33E26BD, and the wind turbine localities are proposed to be on the higher elevation areas.

The site was visited in December 2011 to conduct the bat specialist assessment. The study aimed at identifying bat habitats in the project area that may be utilised for foraging and/or roosting, and predicts bat migrational routes to a certain extent. Although bat migration routes can be more accurately predicted in long-term monitoring studies.

The general bat activity in the project area is moderate and more concentration exits in certain areas such as the lower parts, valleys and drainage lines. These areas can draw elevated numbers of insects and will therefore be utilised by bats. High flying species such as *Tadarida aegyptiaca* and *Miniopterus natalensis* are the most at risk by wind turbines. These species will readily pass through, and even forage to some degree, in high lying areas where winds are stronger and insects less, motivating further for the implementation of mitigation measures.

The small watercourses and sheltered valleys have been assigned a 50 meter buffer. These buffer areas should be treated as sensitive and no turbines are allowed to be placed in the buffers. The area marked as having a Moderate Sensitivity are assigned as such due to topography and a higher amount of roosting space offered by the terrain in that area. Turbines located in the Moderate Sensitivity area should be prioritised during mitigation measures and must receive special attention during monitoring, although all turbines in the project area are subject to mitigation measures.

Since the possibility of the site being located in a migration path still exits, it is recommended that a long-term pre-construction monitoring study be undertaken to determine whether migrating cave bats may be at risk by the proposed wind farm. It is recommended that the curtailment mitigation measure be implemented on all turbines on the site, based on correlations found between wind speed and bat activities during the long-term study.

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MAP:	Mean Annual Precipitation
MAT:	Mean Annual Temperature
kHz:	Kilo-Hertz (sound frequency)

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

1.1.1 The bats of South Africa

Bats are mammals from the order Chiroptera, and are the second largest group of mammals after the rodents. There are approximately 117 species of bats in the Southern African sub-region, of which 5 species have a global Red list status of Vulnerable and 12 are classified as Near Threatened (Monadjem, et al. 2010). More than 50 bat species occur in South Africa (Taylor, 2000; Monadjem, et al. 2010).

Bats are the only mammals to have developed true powered flight and they have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are dramatically reduced and shortened to lessen the total body weight. This unique wing support frame allows bats to alter the camber of their wings in order to adapt the wing shape to different flight conditions while maximizing agility and manoeuvrability. This adaptability and versatility of the bat wing surpasses the more static design of the bird wings and enables bats to utilise a wide variety of food sources and diversity of insects (Neuweiler, 2000). The facial characteristics between species may differ considerably to suit the requirements of their life style especially with regard to their feeding and echolocation navigation strategies. The majority of South African bats are insectivorous, and can consume vast numbers of insects on a nightly basis (Taylor, 2000; Tuttle and Hensley, 2001), but may also consume other invertebrates, amphibians, fruit and nectar.

Insectivorous bats are therefore the only major predators of nocturnal flying insects in South Africa and contribute greatly in the control of their numbers. Their prey also includes agricultural insect pests, such as moths and vectors for diseases such as mosquitoes (Rautenbach, 1982; Taylor, 2000).

Urban development and agricultural practices have contributed to the decline in bat numbers globally. Public participation and funding of bat conservation are often hindered by the negative images of bats created by a lack of knowledge and certain misconceptions about bats. The fact that some species roost in domestic residences also contributes to the negative reputation of bats. Some species may occur in large numbers in buildings and besides being a nuisance, may become a health risk to the residents. Unfortunately, the negative association people have towards bats, obscures the fact that they are an essential component of the ecology and by en large beneficial to humans.

Many bat species roost in large aggregations and concentrate in small areas. Therefore, any major disturbance to that area can adversely impact many individuals of a population at the same time (Hester and Grenier, 2005). Secondly, the reproduction rates of bats are much lower than those of most other small mammals, because usually only one or two pups are born per female annually. According to O'Shea et al. (2003), bats may live for up to 30 years. Under natural circumstances, a population's numbers can build up over a long period of time, due to their longevity and the relatively low predation on bats, when compared to other small mammals. Therefore, the rate of recovery of bat populations is slow after major die-offs and roost disturbances.

1.1.2 Bats and wind turbines

Since bats have highly sophisticated navigation by means of their echolocation, it is puzzling as to why they would get hit by rotating turbine blades. It may be theorized that under natural circumstances their echolocation is designed to track down and pursue smaller insect prey or avoid stationary objects, not primarily focused on unnatural objects moving sideways across the flight path. Apart from physical collisions, a major cause of bat mortality at wind turbines is barotrauma. This is a condition where the lungs of a bat collapse in the low air pressure around the moving blades, causing severe and fatal internal haemorrhage. One study done by Baerwald, *et al*. (2008a) showed that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma.

Some studies propose that bats may be attracted to the large turbine structure as roosting space or that swarms of insects get trapped in low air pockets around the turbine and subsequently attract bats.

Whatever the reason for bat mortalities around wind turbines, the facts indicate this to be a very serious and concerning problem. During a study by Arnett, et al. (2009), 10 turbines monitored over a period of 3 months showed 124 bat fatalities in South-central Pennsylvania (America), which can cumulatively have a catastrophic long-term effect on bat populations, if such a rate is persistent. Most bat species only reproduce once a year, bearing one young per female, meaning their numbers are slow to recover. Mitigation measures are being researched and experimented with globally, but are still only effective on a small scale. An exception to this is a mitigation measure called curtailment, where the turbine cut-in speed is raised to a higher wind speed. This relies on the fact that bats will be less active in strong winds and therefore less likely to be impacted by a moving turbine blade, however this mitigation is not as effective yet to move this threat to a category of low concern. Correct turbine placement is also essential to help preventing bat mortalities.

1.2 OBJECTIVES/SCOPE OF THE BAT SENSITIVITY ASSESSMENT

The terms of reference for the bat impact assessment are as follows:

1. Provide a summary of the relevant legislation;
2. Conduct a site inspection
3. Determine the likelihood and significance with regards to bat (Chiroptera) fauna, in relation to the proposed wind energy facility and its associated impacts
4. Identify and map (where applicable) the location of any significant bat habitats or other;
5. Assess the sensitivity and significance of the site with regards to bat (Chiroptera) fauna;
6. Assess the significance of direct and cumulative impacts (including foraging impacts, roost impacts and migration impacts to a certain extent) of the proposed development and viable alternatives with regards to bat (Chiroptera) fauna;
7. Identify mitigatory measures to protect and maintain any habitats with regards to bat (Chiroptera) fauna;

Future long-term studies will be capable of predicting migration impacts more efficiently.

1.3 ASSUMPTIONS AND LIMITATIONS

Although considerable progress has been made on the research of the biology and behaviour of South African bats, there are still many gaps and unknowns in the data. This is even more evident in data required to effectively mitigate wind farm impacts in a local context (e.g. foraging distances of small insectivorous bats, average height of foraging for species, migrational routes, etc). The weather conditions during the site visit were relatively good for 2 nights but wind speeds were high for 1 night, but nevertheless the site visit was short in relation to the long-term study recommended.

1.4 THE SPECIALIST

The specialist study was conducted and lead by Werner Marais

Animalia Zoological & Ecological Consultation CC was founded in 2008 by Werner which is responsible for all management and highest level decision making, as well as supervision of selected subcontracted specialist projects since the closed corporation was founded. He was fully responsible for and completed in person all phases of more than 90% of the specialist studies conducted by Animalia (research, field assessments, interpretation of results, making of decisions, drafting of mitigations, compilations of sensitivity maps, future recommendations). He completed his MSc (Biodiversity & Conservation) in the potential of utilising insectivorous bats as a means of pest control and incorporated a strong ecological approach into the study. He is currently completing his PhD (Biodiversity & Conservation) in the ecological requirements of cave roosting bats and is incorporating strong conservational and ecological approaches into the study.

Werner Marais was involved and/or responsible for a number of scientific research projects relevant to Zoology.

Research papers presented at conferences:

- The potential of using insectivorous bats (Microchiroptera) as a means of insect pest control in agricultural areas. The Zoological Society of Southern Africa's 50th Anniversary Conference. July 2009.
- Inseketende vlermuise (Microchiroptera) en vlermuishuise in landbougebiede. Suid Afrikaanse Akademie vir Wetenskap en Kuns se 100 jaar Eufees kongres. October 2009.

Numerous popular/educational presentations of research findings have been given to the public, and Werner has been interviewed for two popular magazine articles on ecological aspects of bats.

He is also affiliated with the following relevant scientific organisations:

- South African Council for Natural Scientific Professionals (SACNASP)
    - *Pr.Sci.Nat* (Zoological Science).
- Bat Conservation International (BCI).
- Serving on the research committee of the Gauteng and Northern Regions Bat Interest Group (GNoRBIG) for more than 4 years.
- Zoological Society of Southern Africa (ZSSA).
- Entomological Society of Southern Africa (ESSA).

1.5 METHODOLOGY

1.5.1 Issues raised by I&APs

No issues relevant to bats have been raised.

1.5.2 Site Visit

The project area was visited from the 6th of December until the 9th of December 2011, allowing for three nights of bat activity surveys and three days of terrain exploration and roost location.

In daylight the site was investigated for possible bat roosting localities and the general terrain was studied. At night, a time expansion type bat detector was used to record ultrasonic bat echolocation calls, and subsequently bat activity, by doing transects through the project area where accessible within the timeframe. Mist nets were deployed in some valleys where they were predicted to be the most successful, aiming at providing additional groundtruthing for species present. Although the bat detector transects methodology were prioritized throughout the study.

A bat detector is a device capable of recording the ultrasonic echolocation calls of bats for analysis on a computer afterwards, and a mist net is a fine black net used to catch bats at strategic locations where they may fly regular paths. The time expansion type bat detector effectively slows an ultrasonic bat call down 16 times so that it is audible to the human ear, but still retains all the harmonics and other characteristics of the call. Although this type of bat detection technology is the most advanced currently commercially available, it is not necessarily possible to identify all bat species just by their echolocation calls. Recordings may be affected by the weather conditions and openness of the terrain, whereas the range of detecting a bat is dependent on the volume of the bat call. Nevertheless it is very accurate at recording and indicating bat activity.

2 PROJECT DESCRIPTION

2.1 LOCATION AND SITE DESCRIPTION OF THE PROPOSED DEVELOPMENT

Plan8(Pty) Ltd, a renewable energy company, plans to develop a wind powered electricity generation facility (known as a 'wind farm') approximately 30km outside of Grahamstown along the N2 in an easterly direction towards East London, in the Eastern Cape Province of South Africa. The proposed site is on the farms Gilead, Tower Hill and Peynes Kraal, situated approximately 30km east of Grahamstown. The proposed wind farm is planned to comprise up to a maximum of 32 turbines, each with a nominal power output ranging between 2 and MW (megawatts). The total potential generating capacity of the wind farm will be approximately 80MW, and will feed power into the national electricity grid. The site is approximately 2555 ha in size.

The Kap River is flowing parallel to the site about 3km to the South of the site boundary, the Doubldrift and Andries Vosloo Kudu Nature Reserves are loacted 13km to the North and the Waters Meeting li Nature Reserve 17km to the south west (Figure 2-1).

The project area located in the quarter degree square S33E26BD, and the wind turbine localities are proposed to be on the higher elevation areas.

Figure 2-1: Locality Plan indicating the location of the proposed Grahamstown Wind Energy Project.

3 DESCRIPTION OF RECEIVING ENVIRONMENT

The existing impacts on the site comprise livestock farming and some agricultural practices in the south, with little major modifications for most of the site (Figure3-1). The valleys on the site not modified by agriculture are considered to be in a pristine condition from a biodiversity point of view. The flatter high elevation areas seem to have a lower biodiversity (Plate 3-1).

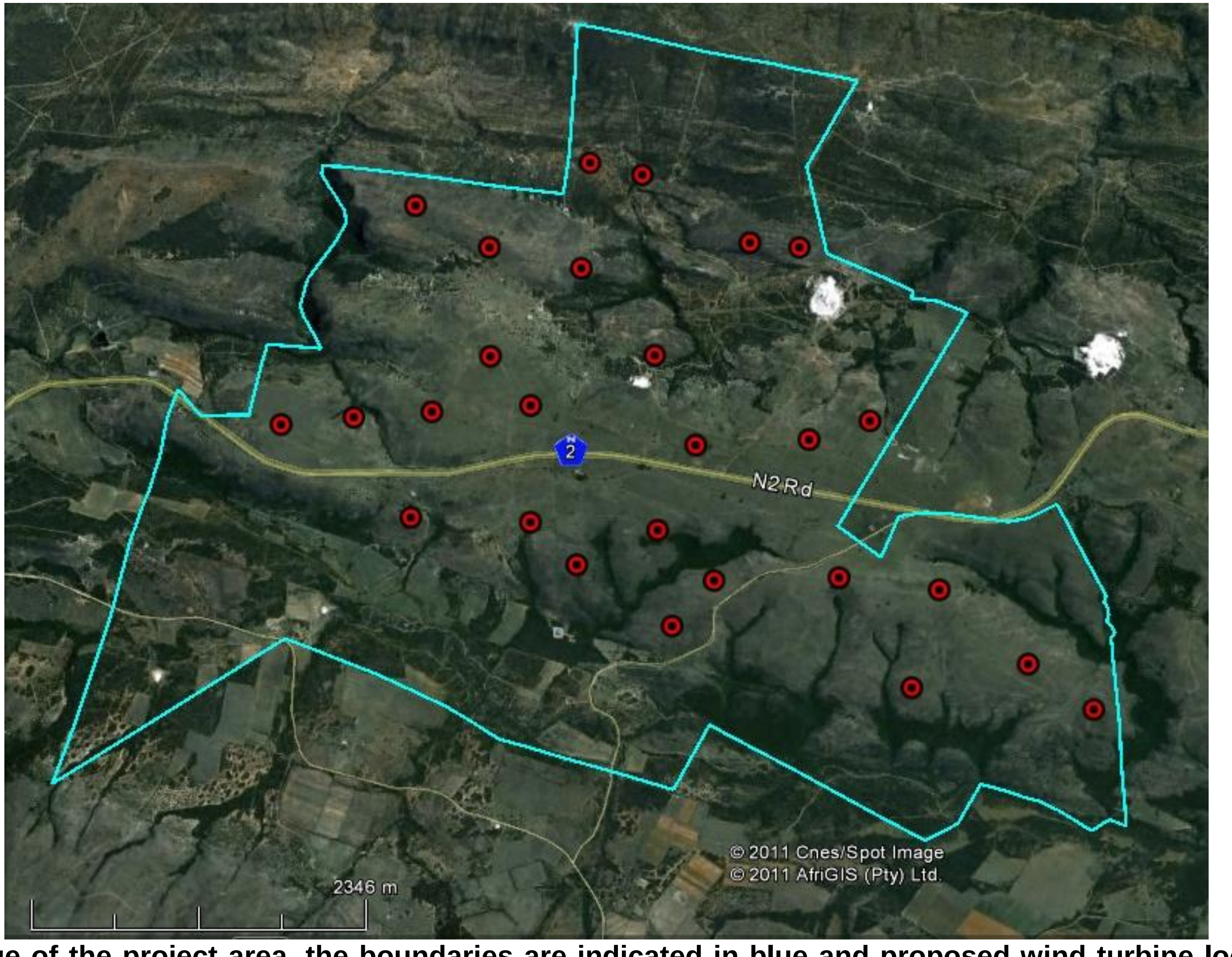


Figure 3-1: Satellite image of the project area, the boundaries are indicated in blue and proposed wind turbine localities as red dots. All satellite images taken by Image © DigitalGlobe, retrieved from Google Earth..

Plate 3-1: (Top) Photograph of a valley in the project area showing terrain capable of supporting high biodiversity and bat roosting space; (bottom) flat terrain predominantly found in the higher areas of the study area where the turbines are proposed to be located.

Two different vegetation units are present on the site namely the Kowie Thicket and the Bhisho Thornveld, with the Bhisho Thornveld bisecting the Kowie Thicket in an east westerly direction (Figure 3-2).

The Kowie Thicket vegetation unit is found in the Eastern Cape only at altitudes from 0-700m, it is associated with river valleys. Mainly on steep north facing slopes, with tall thickets dominated by euphorbias and aloes with a thick understory. The basic geology consists of sandstone and shale.

This unit has a non seasonal rainfall pattern with a slight increase in March and November. The Mean Annual Precipitation (MAP) is about 340-650. Mean daily maximum temperature for February is 35°C and mean daily minimum temperature for July is 5.6°C, with a frost incidence of 3 days. This vegetation unit has a Least Threatened conservation status (Mucina& Rutherford, 2006).

The Bhisho Thornveld is found on low mountains near Grahamstown and other areas of the Eastern Cape, its altitude is mostly 200-700m. Open savanna characterised by small *Acacia* trees with a short to medium dense sour grassy understory, on undulating to moderately steep slopes.

Summer rainfall with some rain in winter, with a MAP of 500-900mm. The mean daily maximum temperatures for January is 25°C and minimum for July is 3°C. Conservation status is Least Threatened (Mucina& Rutherford, 2006). The proposed turbines are roughly confined to this vegetation unit.

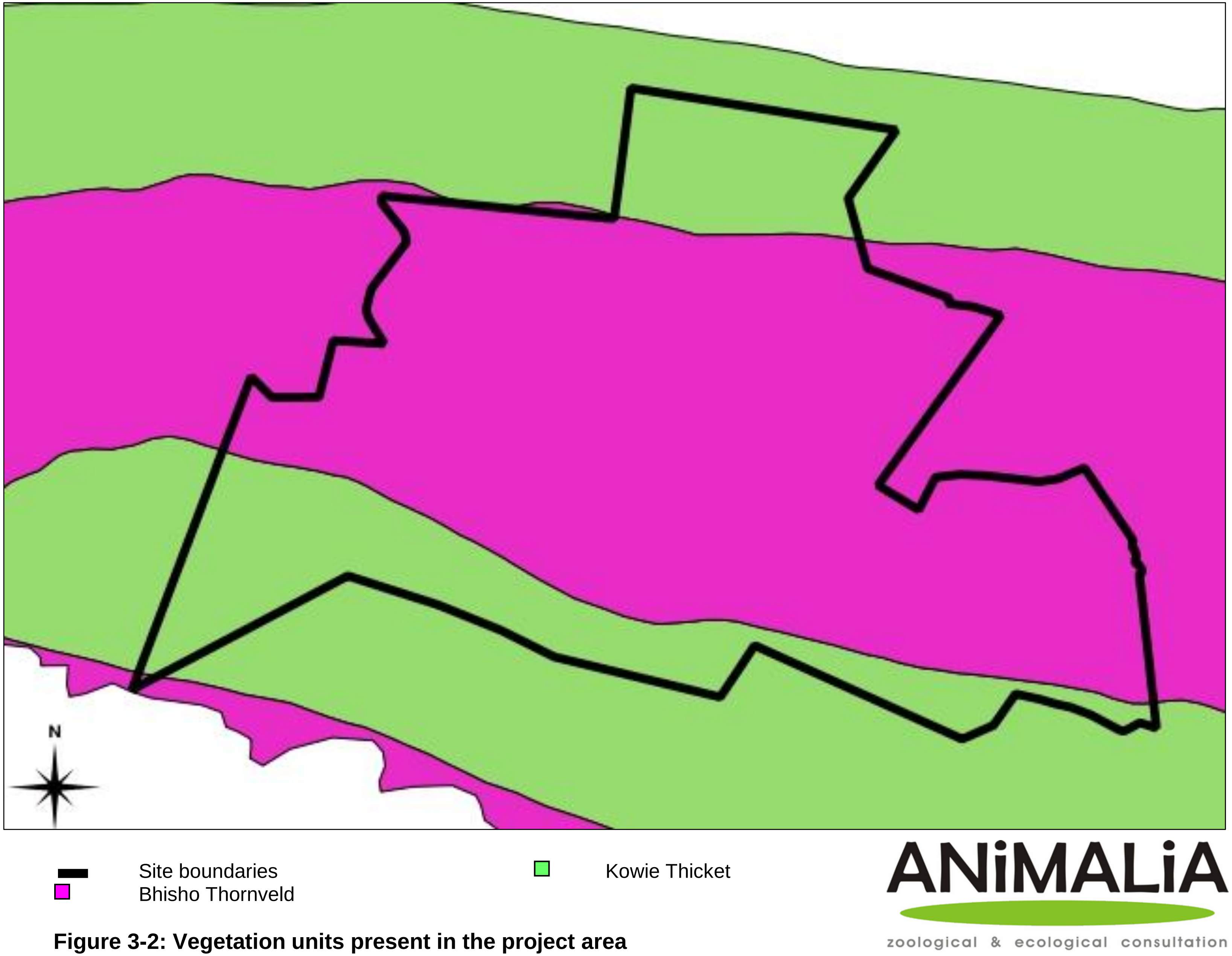


Figure 3-2: Vegetation units present in the project area

4 RESULTS

4.1 SPECIES CONFIRMED AND PROBABILITY OF OCCURRENCE

Table 4-1: Table of species that are confirmed in the project area and that may be roosting on the site, the possible site specific roosts, and their probability of occurrence. LC = Least Concern; NT = Near Threatened; V = Vulnerable (Monadjem et al., 2010).

Species	Common name	Probability of occurrence	Conservation status	Possible roosting habitat to be utilised on site
Rousettus aegyptiacus	Egyptian Rousette	Medium	LC	Roosts gregariously in caves, possibility of cave/s in area. Restricted to rivers due to large fruiting trees.
Epomophorus wahlbergi	Wahlbergs Epauletted fruit bat	Medium	LC	May be found at large fruiting trees in lower laying areas. Restricted to rivers and dense valleys.
Cleotis percivali	Percival’s short-eared trident bat	Very low	**V**	At edge of predicted distribution (not known distribution), roosts in caves and caves may be present in area, scarce and uncommon bat. No specimens ever found south of northern Kwa-Zulu Natal. Woodland species. Geology can offer hollows.
Hipposideros caffer	Sundevall’s leaf-nosed bat	Medium	LC	On edge of distribution but may be found in the cluttered valley habitats.
Rhinolophus capensis	Cape horseshoe bat	High	**NT**	Roosts gregariously in caves, caves may be present in area, well within known distribution. Geology can offer hollows.
Rhinolophus clivosus	Geoffroy’s horseshoe bat	High	LC	Roosts gregariously in caves, caves may be present in area, well within distribution. Geology can offer hollows.
Rhinolophus darlingi	Darling’s horseshoe bat	Medium	LC	Roosts gregariously in caves, caves may be present in area, on edge of

				distribution. Geology can offer hollows
Rhinolophus swinnyi	Swinny's horseshoe bat	High	**NT**	Roosts in caves. Also cavities and culverts. Well within distribution.
Taphozous mauritianus	Mauritian tomb bat	Medium	LC	Roosts on rock faces, walls, large tree trunks.
Nycteris thebaica	Egyptian slit-faced bat	High	LC	Cavities, hollow tree trunks, and culverts.
Tadarida aegyptiaca	Egyptian free-tailed bat	**Confirmed**	LC	Crevices: bridge expansion joints, culvert joints, buildings, rock crevices, under loose bark.
Miniopterus fraterculus	Lesser long-fingered bat	Low	LC	Roosts gregariously in caves, may be caves present in area. On edge of distribution with one single record from larger area.
Miniopterus natalensis	Natal long-fingered bat	**Confirmed**	**NT**	Roosts gregariously in caves, may be caves present in area.
Eptesicus hottentotus	Long-tailed serotine	Medium	LC	Crevice dweller. Rock crevices, expansion joints in bridges and culverts.
Kerivoula lanosa	Lesser Woolly bat	Medium	LC	Little know about roosting habits. Riparian forests and afromontane forests.
Myotis tricolor	Temmink's myotis	**Confirmed**	LC	Roosts gregariously in caves, found roosting in culvert, caves may be present in area.
Neoromicia capensis	Cape serotine	**Confirmed**	LC	Under bark of trees and roofs of buildings. Very common bat.
Pipistrellus hesperidus	Dusky pipistrelle	High	LC	Crevices such as loose bark, associated with riparian forests.
Scotophilus dinganii	Yellow-bellied house bat	Medium	LC	Avoids open terrain, hollows in trees and buildings. Often associated with the

				Lowveld. But specimens recorded in larger area.

4.2 BAT DETECTION AND MIST NETTING

A bat call consists of a series of ultrasonic sound pulses, with each species calling at a different sound frequency (Figure 4-1). It is used for navigational and hunting purposes, comparable to but more sophisticated than modern sonar. Pulses within a bat call can also vary in their sound frequency and characteristics, although this variation is within a certain range associated with a certain bat species. Certain call parameters are used to identify a bat species from its echolocation call: These include pulse length, pulse bandwidth, pulse interval and pulse dominant frequency (loudest frequency), of which dominant frequency are the most commonly used. The dominant frequencies of the three loudest pulses were chosen since the loudest pulse would be the one where the bat was the closest to the bat detector, limiting the ramifications that the Doppler Effect can have on the results of sound waves emitted by a moving bat. A feeding buzz is the common term used to describe the change in echolocation call when a bat is approaching its prey. A feeding buzz is a series of very short pulses that dramatically become more rapid as the bat is closing in on the insect prey, giving it a clear image of the prey. A feeding buzz is a proof of bats actively foraging.

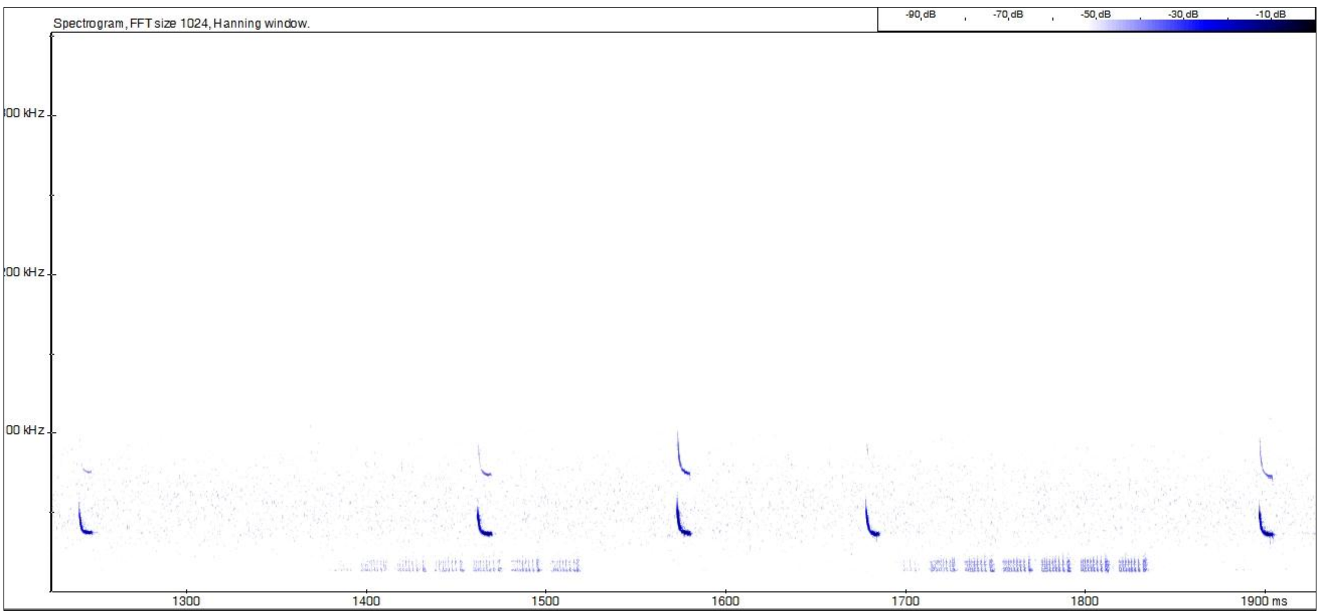


Figure 4-1: Spectrogram of pulses of a *Neoromicia capensis* (Cape Serotine) call recorded on site.

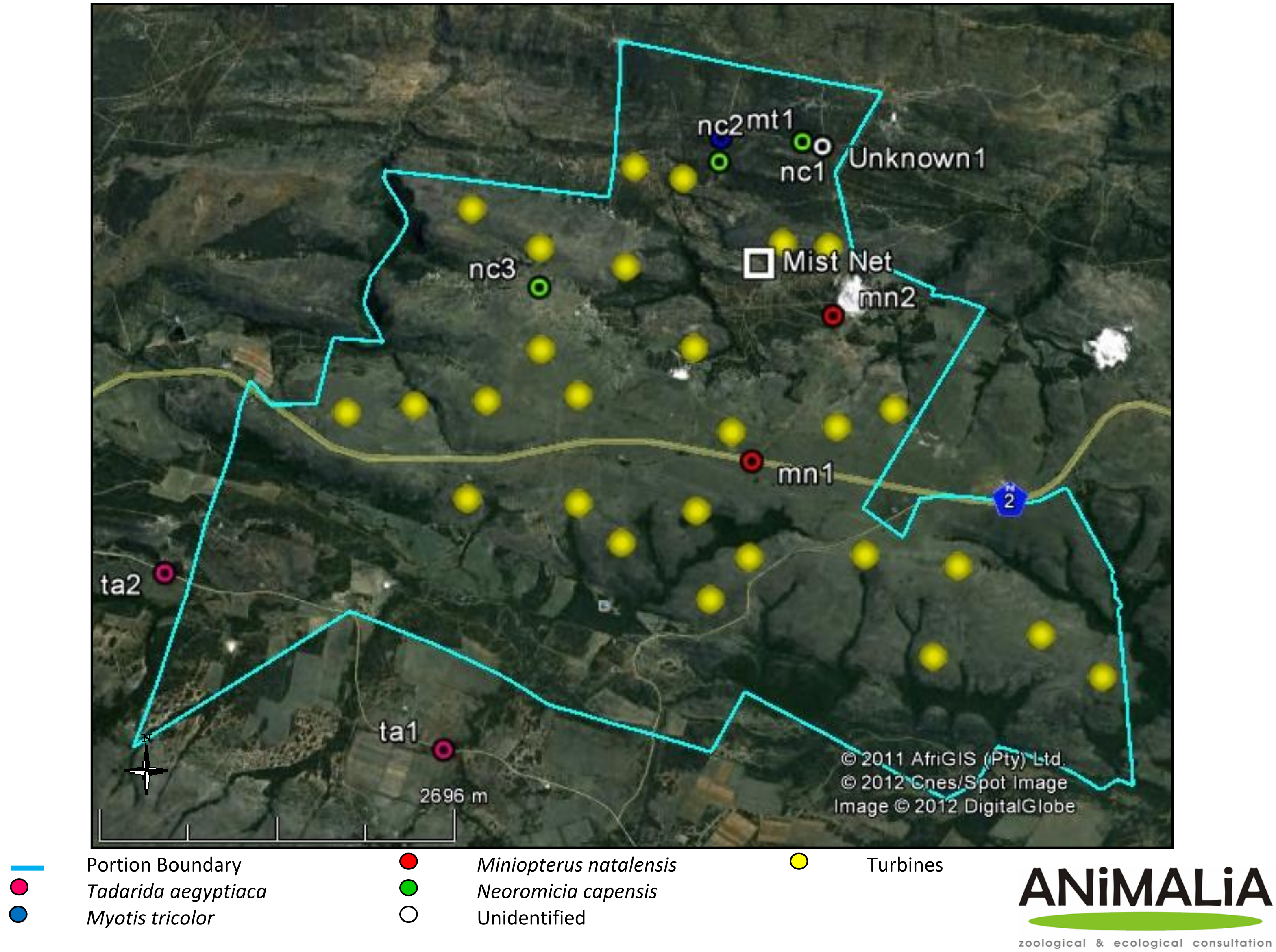
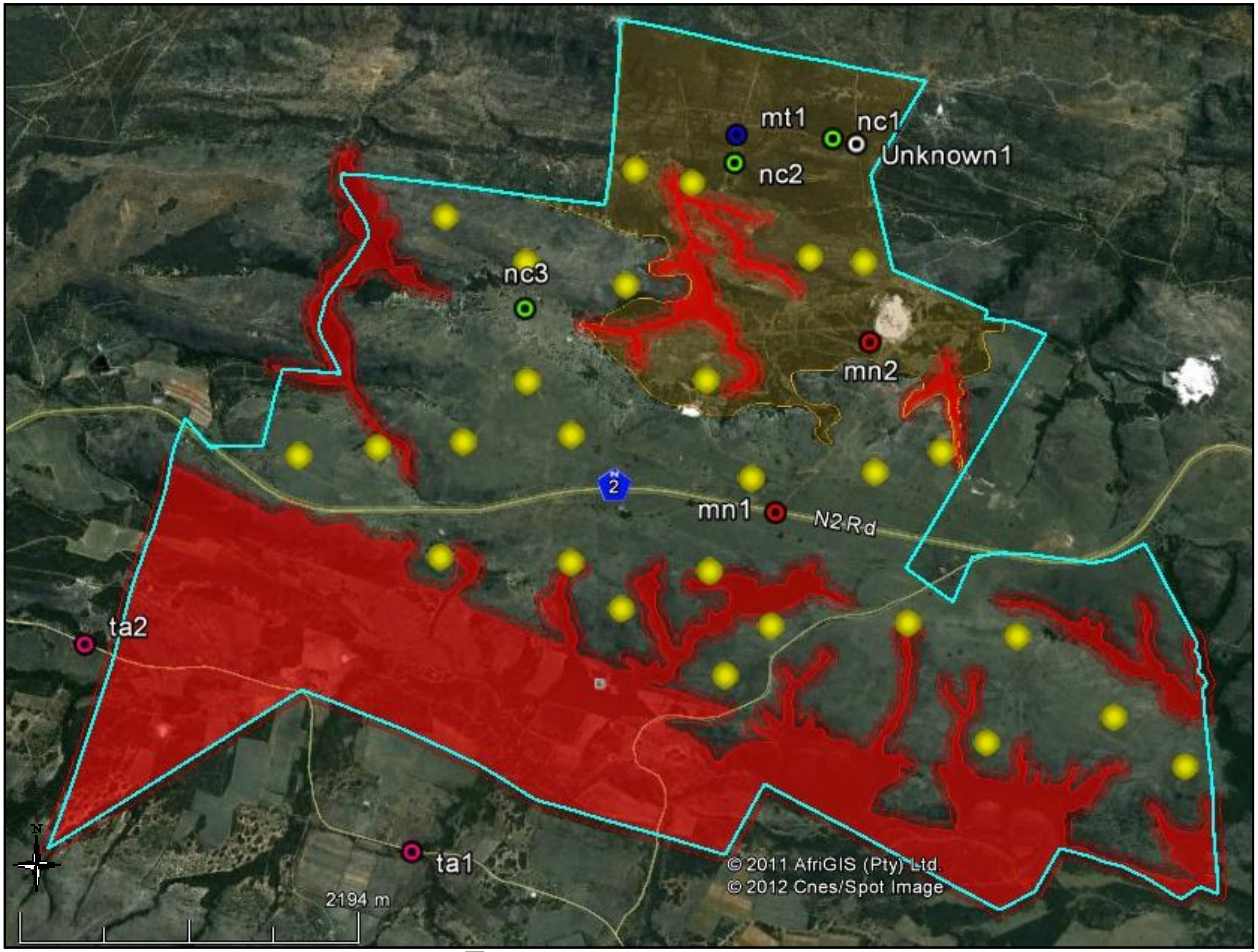


Figure 4-2: Bat activity and species recorded in the project area

It can be seen from Figure 4-2 that most bat activity was encountered at the streams, drainage gulleys and lower lying areas, with the one exception being the *Miniopterus natalensis* recorded on the high ground. This can be contributed to the fact that insect numbers are usually higher in moister areas. Additionally wind speeds may be lower in valleys, easing flight for flying insects and bats on windy nights.

Nothing was caught in the mist net.

The presence of *Miniopterus natalensis* (Natal Clinging bat) suggests that a cave or deep hollow must be present on or near the project area. Although on foot searches for such a deep cave inhabited by *M. natalensis* proofed unsuccessful.



Portion boundary
Moderate bat sensitivity
High bat sensitivity
High sensitivity 50m buffer

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Figure 4-3: Sensitive areas on the site where the highest bat activity and roosting is expected

The sensitivity map indicated by Figures 4-3 is based on the bat activity detected by the bat detector as well as the probability of certain areas and features to be used as foraging space and roosting space. An exceptional limitation exists with monitoring for *Nycteris thebaica*, since this species is not easily picked up by bat detectors. However their presence can be easily noted if a roost is discovered. Species such as *Nycteris thebaica* and *Rhinolophus* sp. Are low flying foragers and are believed to be less at risk than high flying species such as *Tadarida aegyptiaca.* Insect numbers tend to be increased at moist or sheltered areas (Plate 4-1) and would therefore attract insectivorous bats on a nightly basis.

Although there are no South African guidelines for the consideration of bats in relation to wind farm developments and buffers, however, international guidelines such as the Eurobats Guidance and the Natural England Technical Note (Mitchell-Jones & Carlin 2009) give some indication of buffer zones which may be applicable. The Eurobats Guidance (Rodrigues et al. 2008) proposes a minimum distance of 200m to forest edges where tree felling is necessary to establish a wind farm. The Natural England Interim Guidance suggests a 50 meter buffer from blade tip to the nearest feature important to bats. The water bodies, valleys and drainage lines were assigned a 50 meters buffer.

The area in the north is assigned a moderate sensitivity due to an increased availability of roosting space and increased diversity in this area.

Plate 4-1: Photograph of a valley and rocky cliffs in the project area showing terrain capable of supporting high biodiversity and bat roosting due to its sheltered and moister characteristics.

5 IMPACTS ON THE CONSTRUCTION PHASE

5.1 IMPACT 1: DESTRUCTION OF BAT FORAGING HABITAT

Cause and Comment

Bat foraging habitat will indefinitely be destroyed during the construction phase and this impact will be present to a lesser extent during the lifetime of the wind farm. When turbines are constructed in areas designated as sensitive for bat foraging habitat, larger trees and riparian/dense valley vegetation will be destroyed. Such areas are higher in moisture and will therefore support more insects, which in turn will attract more insectivorous bats.

Mitigation and Management

Correct turbine placement is empirical to avoid destruction of bat foraging habitat. The areal footprint of the wind farm should be kept to a minimum, and areas designated as having a high sensitivity be avoided.

Significance Statement

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Construction phase										
Without mitigation	Long term	3	Study Area	2	Slight	1	May Occur	2	**8**	**MODERATE -**
With mitigation	Long term	3	Study Area	2	Slight	1	Unlikely	1	**7**	**LOW -**
No-Go										
Without mitigation	N/A		N/A		N/A		N/A			**N/A**
With mitigation	N/A		N/A		N/A		N/A			**N/A**

5.2 IMPACT 2: DESTRUCTION OF BAT ROOSTS

Cause and Comment

Bat roosting habitat will indefinitely be destroyed during the construction phase and this impact will be present to a lesser extent during the lifetime of the wind farm. When turbines are constructed in areas designated as sensitive for bat roosting habitat, larger trees and riparian/dense valley vegetation will be destroyed. Such areas can provide many roosting spaces under tree bark and any other hollows/crevices.

Mitigation and Management

Correct turbine placement is empirical to avoid destruction of bat roosting habitat. The areal footprint of the wind farm should be kept to a minimum, and areas designated as sensitive be avoided.

Significance Statement

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Construction phase										
Without mitigation	Long term	3	Study area	2	Moderate	2	Probable	3	**10**	**MODERATE -**
With mitigation	Long term	3	Study area	2	Slight	1	Unlikely	1	**7**	**LOW -**
No-Go										
Without mitigation	N/A		N/A		N/A		N/A			**N/A**
With mitigation	N/A		N/A		N/A		N/A			**N/A**

6 IMPACTS ON THE OPERATION PHASE

6.1 IMPACT 1: BAT MORTALITIES DURING FORAGING BY TURBINE BLADES

Cause and Comment

Since bats have highly sophisticated navigation by means of their echolocation, it is puzzling as to why they would get hit by rotating turbine blades. It may be theorized that under natural circumstances their echolocation is designed to track down and pursue smaller insect prey or avoid stationary objects, not primarily focused on unnatural objects moving sideways across the flight path. Apart from physical collisions, a major cause of bat mortality at wind turbines is barotrauma. This is a condition where the lungs of a bat collapse in the low air pressure around the moving blades, causing severe and fatal internal haemorrhage. One study done by Baerwald, et al. (2008a) showed that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma.

Some studies propose that bats may be attracted to the large turbine structure as roosting space, or that swarms of insects get trapped in low air pockets around the turbine and subsequently attract bats.

Whatever the reason for bat mortalities around wind turbines, the facts indicate this to be a very serious and concerning problem. During a study by Arnett, et al. (2009), 10 turbines monitored over a period of 3 months showed 124 bat fatalities in South-central Pennsylvania (America), which can cumulatively have a catastrophic long-term effect on bat populations, if such a rate is persistent. Most bat species only reproduce once a year, bearing one young per female, meaning their numbers are slow to recover.

Mitigation and Management

The **correct placement** of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area. The localities of turbines within the areas marked as sensitive should be critically revised. These turbines are too close to drainage valleys, their woody and dense slopes and associated drainage. It is highly likely that bat foraging activity is constantly elevated in these areas compared to the rest of the site.

During the operational phase **curtailment** can be implemented as a mitigation measure to lessen bat mortalities. Curtailment is when a turbine is kept stationary at a lower wind speed and then allowed to rotate once the wind exceeds a specific speed. The theory behind curtailment is that there is a negative correlation between bat activity and wind speed, causing bat activity to decrease as the wind speed increases.

A test done by Baerwald et al. (2008b) where they altered the wind speed trigger of 15 turbines at a site with high bat fatalities in south-western Alberta, Canada, during the peak fatality period, showed a reduction of bat fatalities by 60%. Under normal circumstances the turbine would turn slowly in low wind speeds but only starts generating electricity when the wind speed reaches 4 m/s. During the experiment the Vestas V80 type turbines were kept stationary during low wind speeds and only allowed to start turning and generate electricity at a cut-in speed of 5.5 m/s. Another strategy used in the same experiment involved altering blade angles to reduce rotor speed, meaning the blades were near motionless in low wind speeds which resulted in a significant 57.5% reduction in bat fatalities.

Long-term field experiments and studies done by Arnett et al. (2010) in Somerset County, Pennsylvania, showed a 44 – 93% reduction in bat fatalities with marginal annual power generation loss, when curtailment was implemented. However, when using a cut-in speed of 6.5 m/s the annual power loss was 3 times higher than when using a 5.0 m/s cut-in speed. Their study concluded that curtailment can be used as an effective mitigation measure to reduce bat fatalities at wind energy facilities.

It is strongly recommended that the curtailment mitigation measure be implemented at all turbines on the site (prioritizing the ones in areas of Moderate Bat Sensitivity), combined with bat mortality monitoring during the operational phase to quantify the effects of this mitigation and subsequently make adjustments as needed. Although the optimum cut-in speed to reduce bat fatalities and keep power loss at a minimum needs to be researched and determined in the local context, a cut-in wind speed of 5.0 m/s to 5.5 m/s (meters per second) is preliminarily recommended. During the long-term pre-construction monitoring, general bat activities and activity patterns of different species can be compared to meteorological data gathered to determine the most effective cut-in speed/weather conditions that may result in low numbers of bat mortalities and marginal power generation loss.

This mitigation measure is significant and applicable to ALL turbines in the project area, regardless of the level of sensitivity of the area they are proposed to be located.

An ultrasonic deterrent device is a device emitting ultrasonic sound in a broad range that is not audible to humans. The concept behind such devices is to repel bats from wind turbines by creating a disorientating or irritating airspace around the turbine. Research in the field of ultrasonic deterrent devices is progressing and yielding some promising results, although controversy about the effectiveness and a lack of large scale experimental evidence exists.

Nevertheless, a study done by Szewczak& Arnett (2008), who compared bat activity using an acoustic deterrent with bat activity without the deterrent, showed that when ultrasound was broadcasted only 2.5-10.4% of the control activity rate was observed. A lab test done by Spanjer (2006) yielded promising results, and a field test of such devices done by Horn et al. (2008) indicated that many factors are influencing the effectiveness of the device although it did deter bats significantly from turbines.

It may be feasible to install such devices on selected functional turbines (such as those in the Moderate Sensitivity area), and the results being monitored by an appropriately qualified researcher. If collaboration with local academic and research institutions is established to monitor and improve such devices/methods during the functional stage of the wind farm, it can lessen the impacts of the wind farm on bat populations.

Significance Statement

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Operation phase										
Without mitigation	Long Term	3	Study Area	2	Severe	4	Probable	3	**12**	**HIGH -**
With mitigation	Long Term	3	Study Area	2	Slight	1	May Occur	2	**9**	**MODERATE -**
No-Go										
Without mitigation	N/A		N/A		N/A		N/A			**N/A**
With mitigation	N/A		N/A		N/A		N/A			**N/A**

6.2 IMPACT 2: BAT MORTALITIES DURING MIGRATION BY TURBINE BLADES, A CUMULATIVE IMPACT

Cause and Comment

The migration paths of South African bats in the Eastern Cape Province are virtually unknown. Cave dwelling species like *Miniopterus natalensis* and *Myotis tricolor* undertakes annual migrations, and since these species were recorded in the project area there is a high probability of a cave being present in the area. The project area is not in any direct line of a known migration route, but literature data on exact South African bat migration routes are insufficient to accurately assess this impact at this stage of the study. With the increased amount of wind farms proposed to be concentrated in certain parts of the country, the cumulative impacts on cave dwelling bats migration long distances (up to 260 km according to Van der Merwe, 1973) can be detrimental if no mitigations or precautions are taken

Mitigation and Management

Long-term pre-construction monitoring studies can provide some insight on migration paths of these species, and provide valuable information on their seasonal variations in migration activities.
Turbine localities should be revised after the analysis of the long-term monitoring data if any turbines are located in suspected migration paths. If the project area falls within the path of a migration route, aggressive seasonal mitigations would be essential.

Significance Statement

Impact	Effect						Risk or Likelihood		Total Score	Overall Significance
	Temporal Scale		Spatial Scale		Severity of Impact					
Operation phase										
Without mitigation	Long Term	3	National	3	Severe	4	May Occur	2	**12**	**HIGH -**
With mitigation	Long Term	3	National	3	Slight	1	Unlikely	1	**8**	**MODERATE -**
No-Go										
Without mitigation	N/A		N/A		N/A		N/A			**N/A**
With mitigation	N/A		N/A		N/A		N/A			**N/A**

7 CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSIONS

The general bat activity in the project area is moderate and more concentration exits in certain areas such as the lower parts, valleys and drainage lines. These areas can draw elevated numbers of insects and will therefore be utilised by bats. High flying species such as *Tadarida aegyptiaca* and *Miniopterus natalensis* are the most at risk by wind turbines. These species will readily pass through, and even forage to some degree, in high lying areas where winds are stronger and insects less, motivating further for the implementation of mitigation measures.

The small watercourses and sheltered valleys have been assigned a 50 meter buffer. These buffer areas should be treated as sensitive and no turbines are allowed to be placed in the buffers. The area marked as having a Moderate Sensitivity are assigned as such due to topography and a higher amount of roosting space offered by the terrain in that area. Turbines located in the Moderate Sensitivity area should be prioritised during mitigation measures and must receive special attention during monitoring, although all turbines in the project area are subject to mitigation measures.

7.2 RECOMMENDATIONS

Since the possibility of the site being located in a migration path still exits, it is recommended that a long-term pre-construction monitoring study be undertaken to determine whether migrating cave bats may be at risk by the proposed wind farm. It is recommended that the curtailment mitigation measure be implemented on all turbines on the site, based on correlations found between wind speed and bat activities during the long-term study.

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