# Specialist Bat (Chiroptera) Sensitivity Assessment

- **For the proposed Deep River Wind Energy Facility on Portion 4 & 16 of the farm Diepriviermond 358 and the remaining extent of Farm 891, near Humansdorp, Eastern Cape.**

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**PREPARED FOR:**


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***Ref: R-1012-08***

***Cover page photo:*** View of the site from the east.

## Terms of Reference

To assess the sensitivity of the study area with regards to bat (Chiroptera) fauna, in relation to the proposed wind energy facility and its associating impacts. The assessment aims to identify sensitive areas on the study site where bat activity may be the highest, and recommend applicable mitigation measures and recommendations to minimize negative impacts on bat fauna in the broader area. Impacts considered include foraging impacts, roost impacts and migration impacts.

## Appointment of Specialist

Animalia Zoological & Ecological Consultation CC was appointed by Savannah Environmental (Pty) Ltd to undertake a specialist bat sensitivity study for the proposed Deep River Wind Energy Facility on Portion 4 & 16 of the farm Diepriviermond 358 and the remaining extent of Farm 891, near Humansdorp, Eastern Cape.

## Independence:

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

## Applicable Legislation:

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

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; section 97): THREATENED OR PROTECTED SPECIES REGULATIONS:

All bats enjoy protection under this act. This act also calls for an environmental impact assessment for threatened and protected species.

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# 1. INTRODUCTION

## 1.1 Study Area

The site is located approximately 15km west of Humansdorp in the Eastern Cape, close to the junction of the R62 road and N2 highway (**figure 1**). Portion 4 & 16 of the farm Diepriviermond 358 and the remaining extent of Farm 891 is collectively referred to as the study site and is approximately 832 ha in size and located inside the quarter degree square S34E24BA. The Diep and Krom Rivers follows the eastern and southern borders of the site closely, creating relatively deep valleys and steep slopes in these areas of the site.

The wind turbines are proposed to be located mostly on the flatter higher lying parts of the site (**figure 2**). VentuSA Energy (Pty) Ltd is proposing a total of up to 50 wind turbines with a proposed total generating capacity of approximately 100 MW, with the broader site accommodating associated infrastructure which is required for such a facility. The wind turbines will have a hub height of 80 meters with concrete foundations and underground cabling (where practical) between them. An on-site substation to facilitate the connection between the wind energy facility and the grid will also be constructed, as well as new overhead power lines to connect to Eskom's existing Diep Rivier Substation (alternatively Melkhout Substation). Internal access roads to each turbine and a workshop area for maintenance and storage will also be located on the site.

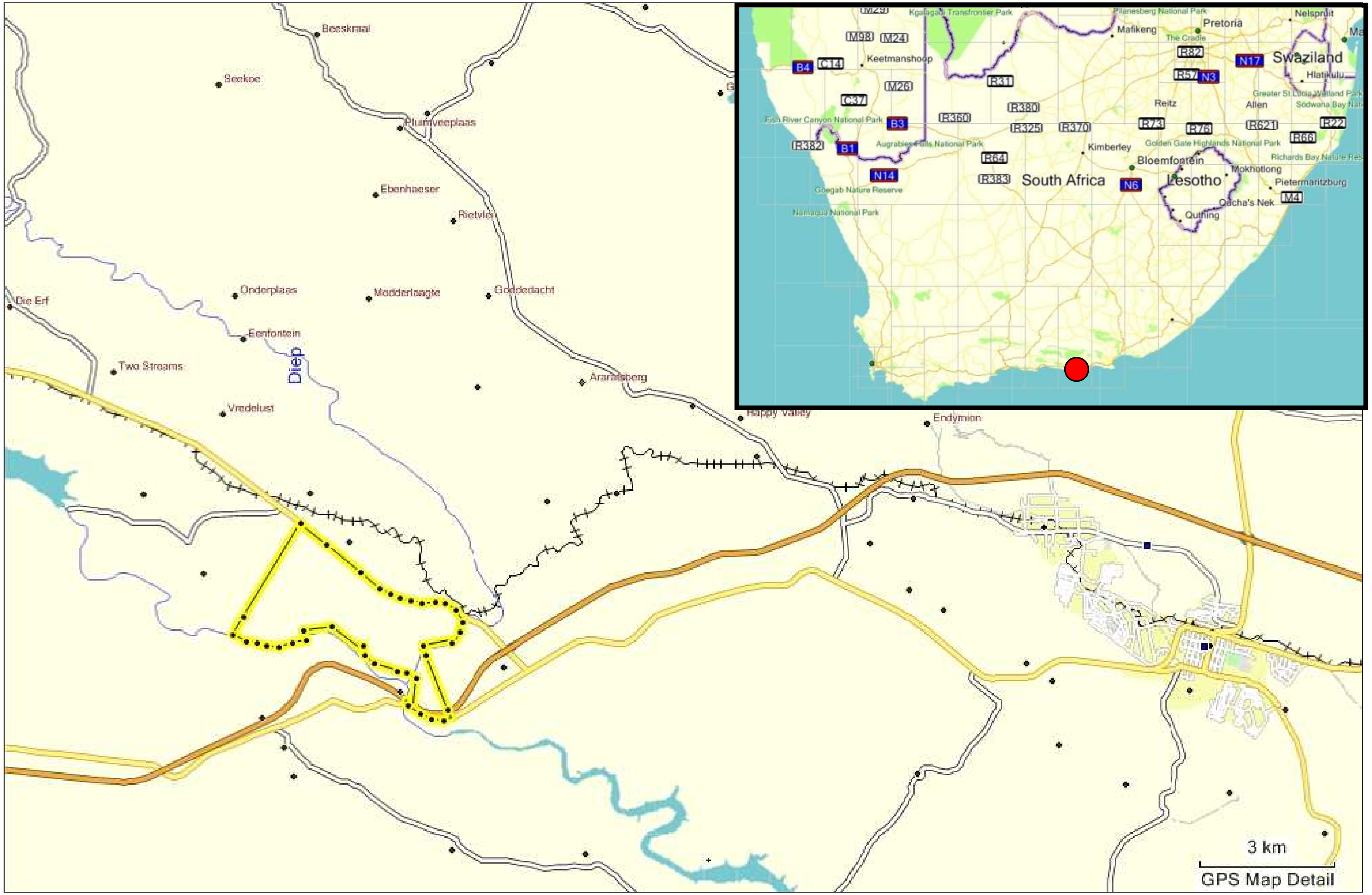



**Figure 1:** Road map with an indication of the site locality (yellow outline), and an overview map with the site locality (red dot).

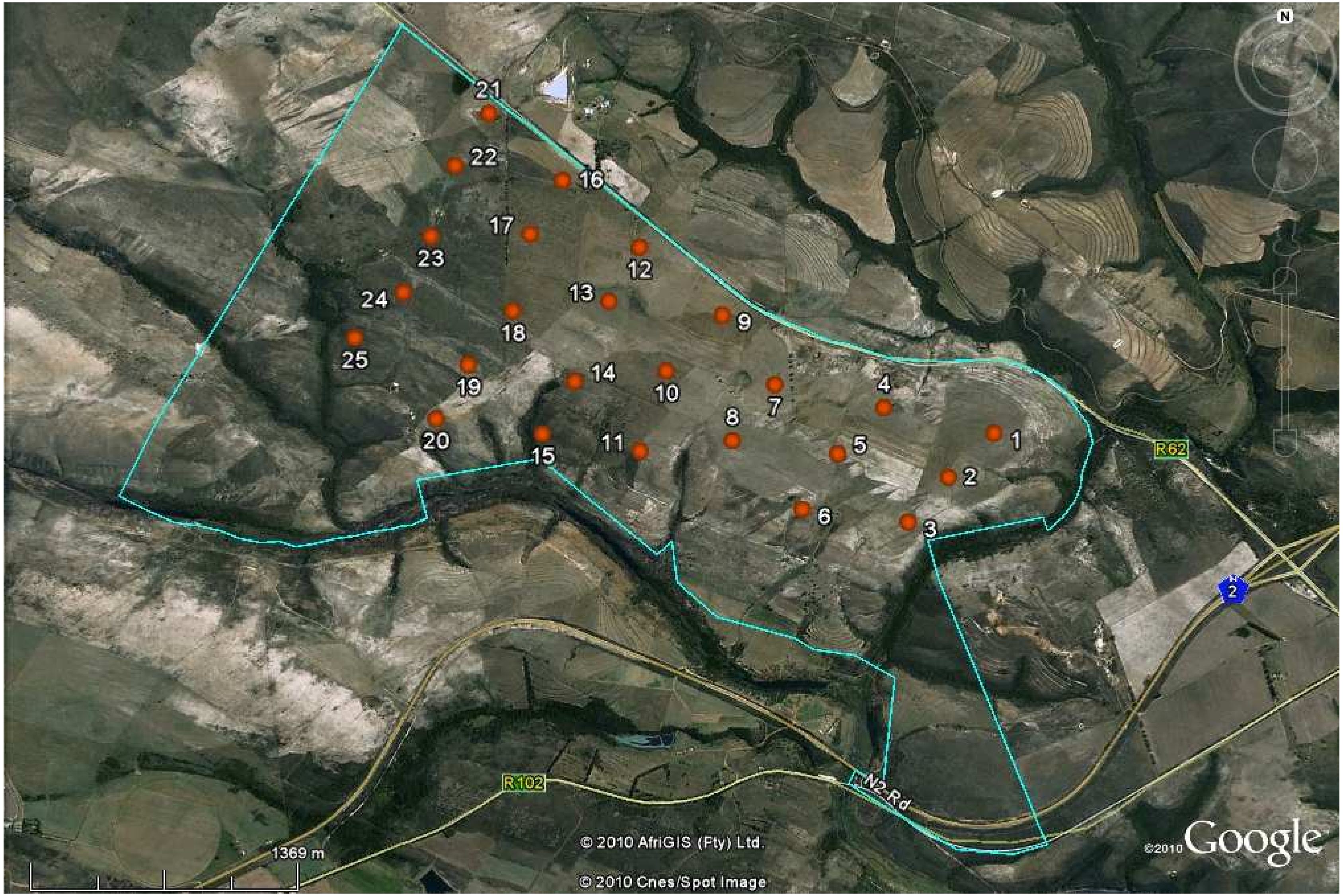



**Figure 2:** Satellite image of the site, the boundary is indicated in blue and proposed wind turbine localities as red dots. All satellite images taken by Image © DigitalGlobe, retrieved from Google Earth.

### 1.2 Land use and existing impacts on the site

The existing impacts on the site are limited to livestock and agricultural practices, with very little major modifications. The flatter higher lying part of the site is subdevided into numerous livestock camps, with levels of grazing impacts on the natural vegetation unti composition varying between the camps (**figure 3**).

**Figure 3:** The majority of the site is being used for livestock and agriculture (Top), compared to a more natural area to the west of the site where no livestock is kept (bottom). Both examples can offer foraging space for bats, but very little roosting space.,

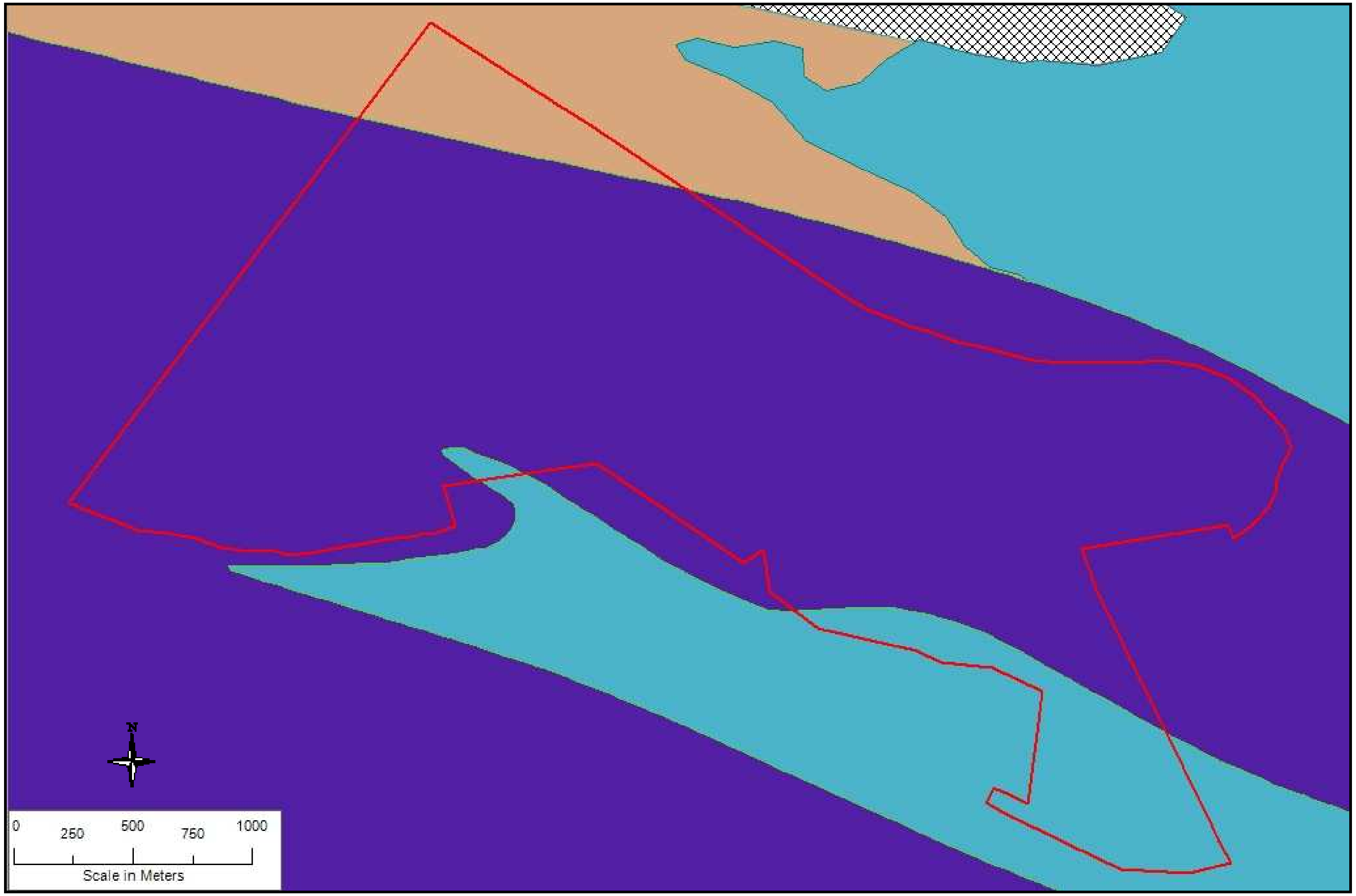
### 1.3 Vegetation unit, geology and climate

The majority of the site is classified as the vegetation unit Tsitsikamma Sandstone Fynbos with the northern corner consisting of Langkloof Shale Renosterveld and the south-eastern corner being Humansdorp Shale Renosterveld (**figure 4**).

The Tsitsikamma Sandstone Fynbos is found in the Western and Eastern Cape provinces from an altitude of 100 m to 1675 m on the Tsitsikamma Mountains from Uniondale to Cape St Francis, north of the Keurbooms River and south of Langkloof. This mountain range is relatively low with gentle and steep northern and southern slopes and a few high peaks. The vegetation of this unit is medium dense and tall proteoid over a dense ericoid-leaved shrubland (Mucina & Rutherford, 2006).

Geology consists of acidic lithosol soils derived from Ordovician sandstones of the Table Mountain Group (Cape Supergroup). And the climate have a fairly even rainfall throughout the year with a MAP (Mean Annual Precipitation) of 480 – 1230 mm, and mean daily maximum and minimum temperatures of 25.5°C and 5.8°C for February and July respectively.

Endemic taxa includes the shrubs: *Aspalathus teres* subsp. *Thodei, Erica trachysantha, E. zitzikammensis, Felicia tsitsikamae, Helichrysum outeniquense.* This unit is assigned a Vulnerable conservation status with a target of 23% to be conserved. Currently about 40% is statutorily conserved in the Tsitsikamma and Soetkraal National Parks as well as the proposed Garden Route National Park. Some 33% is transformed by cultivation and pine plantations (Mucina & Rutherford, 2006).




Portion boundary
Tsitsikamma Sandstone Fynbos
Humansdorp Shale Renosterveld
Langkloof Shale Renosterveld

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**Figure 4:** Vegetation units present on the site (Mucina & Rutherford, 2006).

## 1.4 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 maneuverability. 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.

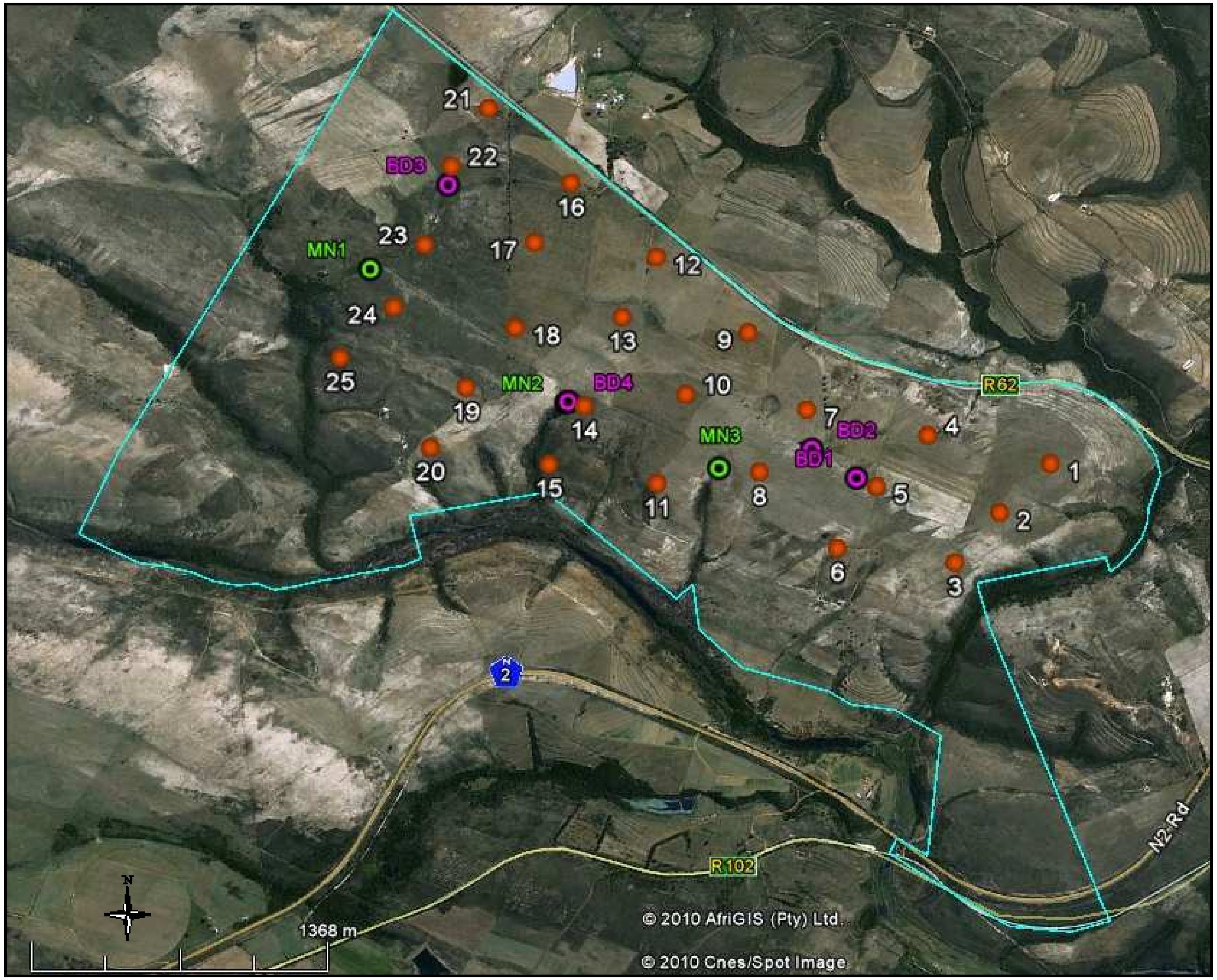
Many bat species roost in large aggregations and concentrate in small areas. Therefore, any major disturbance to that area can adversely impact many individuals of a population at the same time (Hester and Grenier, 2005). Secondly, the reproduction rates of bats are much lower than those of most other 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.

## 2. Methods

The site was visited on the 25th and 26th of November 2010 at night and during the day. In daylight the site was investigated for possible bat roosting localities and the general terrain was studied. At night, time expansion type bat detectors and mist nets were deployed at various localities on the site, focusing on areas where the turbines are proposed to be located or areas where some success with the various methods are expected (**figure 5**).
A bat detector (**figure 6**) 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. A time expansion type bat detector effectively slows an ultrasonic bat call down 10 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.

In general the mist nets were not deployed at turbine localities, because this would have significantly lowered the possibility of the nets being successful. This is due to the fact that the turbine localities are in open areas (**figure 6**) where light levels are relatively high, and not at any strategic points where bats may be drawn to, channeled or in habitual flight paths.

During the first night of sampling (25th) the weather conditions was very wet and a light rain combined with very strong wind made monitoring very challenging. The night of the 26th was more favourable for bat monitoring, although it was still very windy it was not overcast. Sampling localities were also influenced by accessibility and practicality issues.




Portion boundary

Proposed turbine localities

Mist net localities

Bat detector localities

**Figure 5**: Bat detector and mist net localities.

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**Figure 6: (top)** The time expansion type bat detector (BD2) set up with a field laptop and external long life battery to passively record bat echolocation calls; **(bottom)** the flat open areas of the site where the proposed turbines are to be located, such open terrains unsuitable for mist nets.

# 3. RESULTS

## 3.1 Species probability of occurrence

**Table 1:** Table of species that may be roosting on the site, the possible site specific roosts, and their probability of occurrence. LC = Least Concern; NT = Near Threatened (Monadjem *et al.*, 2010).

| Species | Common name | Probability of occurrence | Conservation status | Possible roosting habitat to be utilised on site |
|---|---|---|---|---|
| *Rousettus aegyptiacus* | Egyptian Rousette | Low | LC | Roosts gregariously in caves, no known caves close to the study site. |
| *Hipposideros caffer* | Sundevall's leaf-nosed bat | Medium | LC | Cavities, hollow tree trunks, aardvark burrows and culverts in riparian valley. |
| *Rhinolophus capensis* | Cape horseshoe bat | Low | NT | Roosts gregariously in caves, no known caves close to the study site. |
| *Rhinolophus clivosus* | Geoffroy's horseshoe bat | Low | LC | Roosts gregariously in caves, no known caves close to the study site. |
| *Rhinolophus simulator* | Bushveld horseshoe bat | Low - Medium | LC | Roosts in caves. Also cavities, culverts in wooded riparian valley. |
| *Rhinolophus swinnyi* | Swinny's horseshoe bat | Low - Medium | NT | Roosts in caves. Also cavities, culverts in wooded riparian valley. |
| *Taphozous mauritianus* | Mauritian tomb bat | Low | LC | Roosts on rock faces, walls, large tree trunks. Some rock faces in valley. |

| | | | | |
|---|---|---|---|---|
| *Nycteris hispida* | Hairy slit-faced bat | Low | LC | Dense bush, hollow trees that may be present in valley. Avoids open areas. |
| *Nycteris thebaica* | Egyptian slit-faced bat | High | LC | Cavities, hollow tree trunks, and culverts in valley. Aardvark burrows. |
| *Mops condylurus* | Angolan free-tailed bat | Low | LC | Mainly Bushveld crevice dweller. Limited rock crevices available. |
| *Tadarida aegyptiaca* | Egyptian free-tailed bat | Confirmed | LC | Crevices: bridge expansion joints, buildings, rock crevices in valley, under loose bark. |
| *Miniopterus fraterculus* | Lesser long-fingered bat | Low | LC | Roosts gregariously in caves, no known caves close to the study site. |
| *Miniopterus natalensis* | Natal long-fingered bat | Low | NT | Roosts gregariously in caves, no known caves close to the study site. |
| *Eptesicus hottentotus* | Long-tailed serotine | Confirmed | LC | Crevice dweller. Rock crevices in valley, expansion joints in bridge. |
| *Glauconycteris variegata* | Variegated butterfly bat | Low | LC | Dense foliage in riparian valley, although seldom encountered. |
| *Hypsugo anchietae* | Anchieta's pipistrelle | Medium | LC | In areas of the valley where open water is present, dense riparian thickets. |
| *Kerivoula argentata* | Damara woolly bat | Low | LC | Riparian forest. |

| | | | | |
|---|---|---|---|---|
| *Kerivoula lanosa* | Lesser woolly bat | Medium | LC | Riparian forest. |
| *Myotis tricolor* | Temmink's myotis | Confirmed | LC | Roosts gregariously in caves, no known caves close to the study site. |
| *Neoromicia capensis* | Cape serotine | Confirmed | LC | Under bark of trees and roofs of buildings |
| *Pipistrellus hesperidus* | Dusky pipistrelle | Confirmed | LC | Crevices such as loose bark, associated with riparian forests. |
| *Scotophilus viridis* | Green house bat | Low | Not Evaluated | Hollows in trees and buildings; more associated with warmer climates. |
| *Scotophilus dinganii* | Yellow-bellied house bat | Low | LC | Avoids open terrain, hollows in trees and buildings. Often associated with the Lowveld. |

### 3.2 Bat detection and mist netting

**Table 2:** Call parameters of the dominant frequencies in kHz (Kilo Hertz) of the echolocation calls detected by each bat detector. T.a = *Tadarida aegyptiaca* (Egyptiann free-tailed bat); E.h = *Eptesicus hottentotus* (Long-tailed serotine); N.c = *Neoromicia capensis* (Cape serotine); P.h = *Pipistrellus hesperidus* (Dusky pipistrelle); M.t = *Myotis tricolor* (Temmink's Myotis).

| BD 2 | | | | | |
|---|---|---|---|---|---|
| Sound recording | 1 | 2 | 3 | | |
| Dominant frequencies of 3 most powerful pulses | 21.7<br>21.7<br>21.7 | 23.0<br>22.2<br>21.1 | 28.1<br>31.9<br>27.8 | | |
| Average dominant freq. | 21.7 | 22.1 | 29.3 | | |
| Spieces | *T.a* | *T.a* | *E.h* | | |
| **BD3** | | | | | |
| Sound recording | 1 | 2 | 3 | 4 | |
| Dominant frequencies of 3 most powerful pulses | 38.0<br>38.2<br>38.5 | 51.9<br>50.2<br>50.7 | 36.4<br>35.2<br>36.4 | -<br>-<br>- | |
| Average dominant freq. | 38.2 | 50.9 | 36.0 | - | |
| Spieces | *N.c* | *P.h* | *N.c* | *Feeding Buzz* | |
| **BD 4** | | | | | |
| Sound recording | 1 | 2 | 3 | 4 | 5 |
| Dominant frequencies of 3 most powerful pulses | 22.8<br>21.2 | 22.8 | 21.1<br>21.1 | 28.3<br>28.3<br>27.9 | 47.6<br>49.3<br>48.9 |
| Average dominant freq. | 22.0 | 22.8 | 21.1 | 28.2 | 48.6 |
| Spieces | *T.a* | *T.a* | *T.a* | *Unknown* | *M.t* |

A bat call consists of a series of ultrasonic sound pulses, with each species calling at a different sound frequency (**figure 7**). 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.

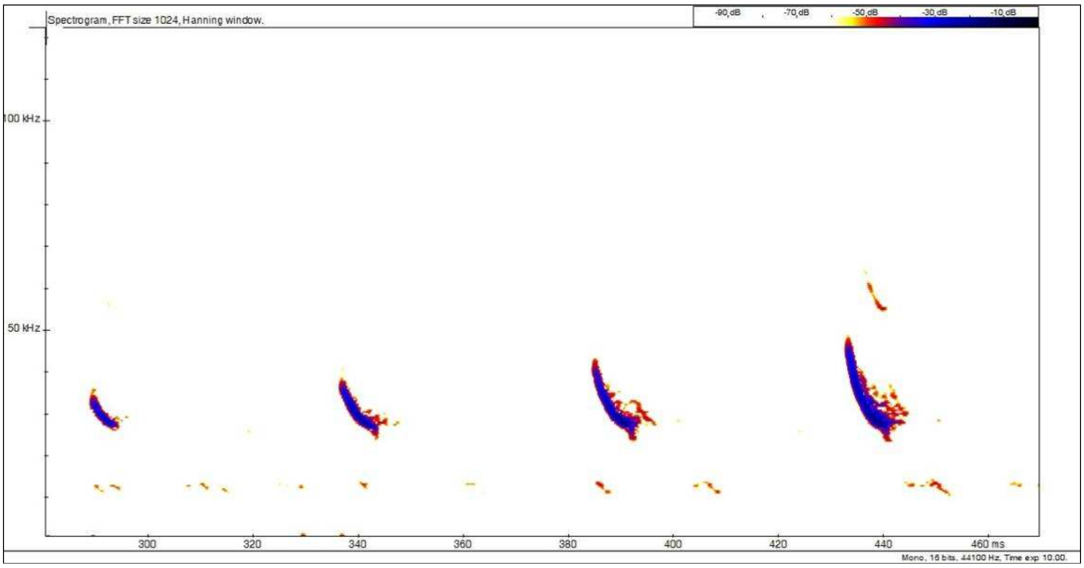



**Figure 7:** Spectrogram of four pulses of the *Eptesicus hottentotus* (Long-tailed serotine bat) call recorded by BD2 (Bat Detector 2). Note that the pulses are becoming louder and more complete as the bat approaches the bat detector.

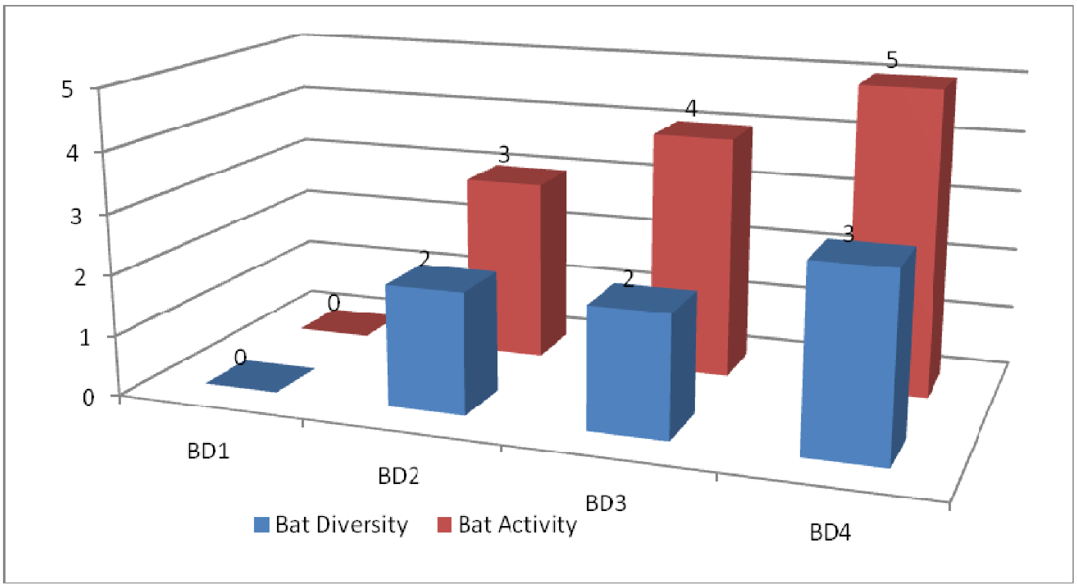
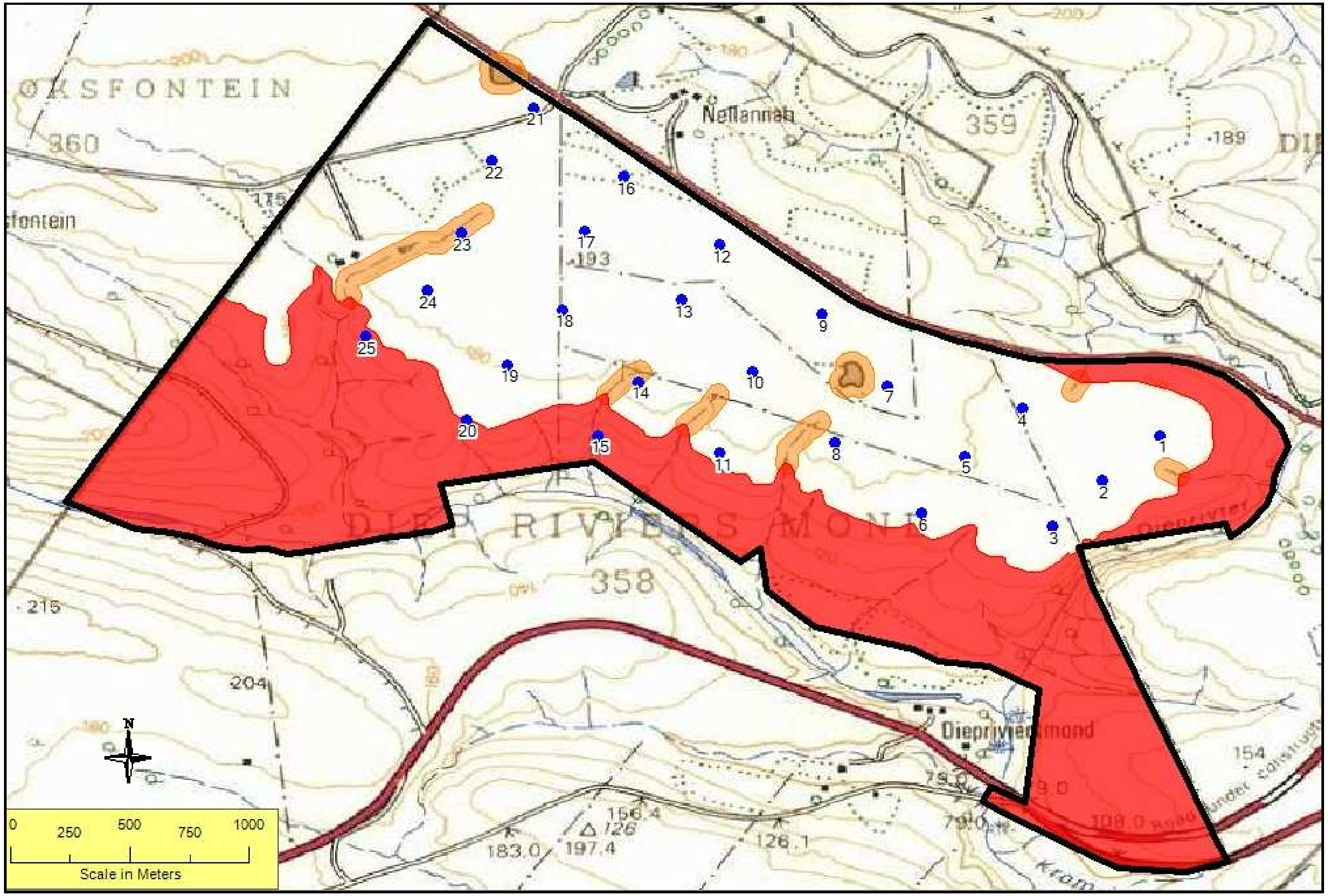



**Figure 8:** Summary of bat activity and bat diversity at each bat detector sampling locality.

None of the mist nets caught any bats, primarily due to the relatively low bat activity, relatively short sampling time and lack of strategic placement localities in the open terrain of the site.

### 3.3 Bat sensitivity map




Portion Boundary
Proposed Turbine Localities
High Bat Sensitivity
Moderate Bat Sensitivity

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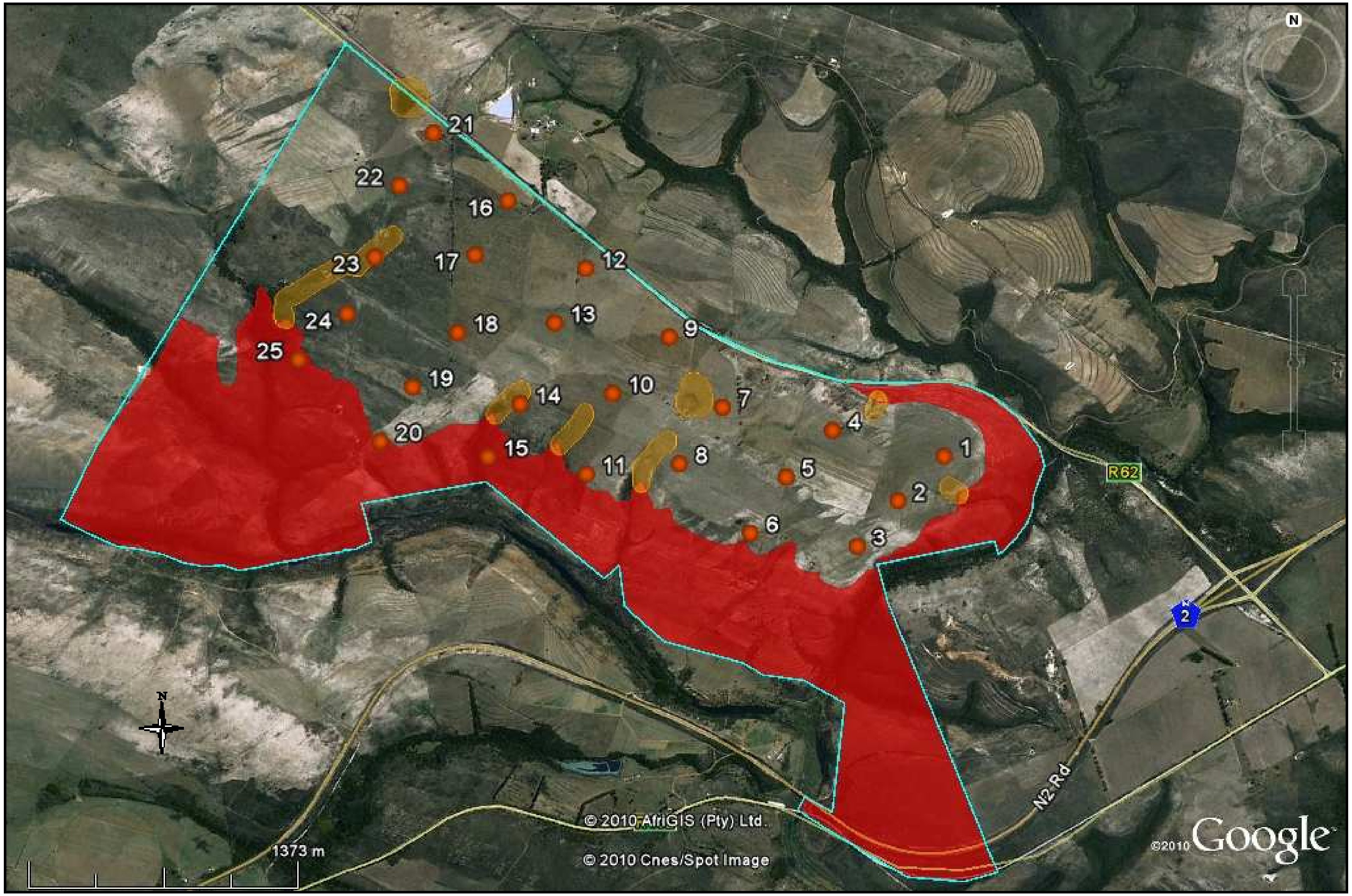
**Figure 9:** Sensitive areas on the site where the highest bat activity and roosting is expected.




Portion Boundary
Proposed Turbine Localities
High Bat Sensitivity
Moderate Bat Sensitivity

**Figure 10:** Satellite image of sensitive areas on the site where the highest bat activity and roosting is expected.

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According to personal field observations and Arnett (June, 2005), bats are known to suppress their activity during periods of rain, low temperatures and strong winds, especially if these factors are combined. Since insect numbers are usually elevated at open water bodies, wetlands and riparian areas, it is logical that insectivorous will prefer to forage over such areas. In this specific case the deep valleys of the Diep and Krom Rivers provide shelter against strong winds and supports elevated numbers of insects, relative to the flat and windy higher parts of the site. Additionally the steep slopes are rocky in some places and the riparian vegetation consists of dense trees, both offering roosting space to several possible bat species (**figure 11**).

Therefore the topography of the site was used to designate the riparian valleys and their slopes as having a High Bat Sensitivity. The areas assigned a Moderate Bat Sensitivity are the drainage channels and moist areas (**figures 9 & 10**). These areas were designated as such due to their higher likelihood of supporting insects, and thereby attracting bats.

Although there are no South African guidelines for the consideration of bats in relation to wind farm developments, 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.

For the purpose of this study a buffer of 50 meter is used around the drainage channels and moist areas. The areas designated as having a High Bat Sensitivity must be treated as sensitive, implicating that no turbines are allowed to be placed in this zone due to the elevated impacts it can have on bat mortalities. Placement of turbines in areas with Moderate Bat Sensitivity should preferably be avoided, if this is not possible such turbines must receive special attention and preference with regards to bat monitoring and implementation of mitigations during the operational phase. Turbines 15, 20 and 25 are within the High Bat Sensitivity area, and turbines 14 and 23 within Moderate Sensitivity (**figure 9**).

**Figure 11:** Section of the Diep River where it flows underneath the R62 bridge.

# 4. IMPACTS OF THE PROPOSED OPERATION and PROPOSED MITIGATION MEASURES AND RECOMMENDATIONS

### 4.1 Bat mortalities due to blade collisions and barotrauma during foraging

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 hemorrhage. One study done by Baerwald, *et al*. (2008) showed that 90% of bat fatalities around wind turbines involved internal hemorrhaging 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.

<u>Proposed mitigatory measures or recommendations</u>

The correct placement of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area. The proposed turbine placements indicated in figure 9 must be critically revised, with the key objective of moving Turbines 15, 20 and 25 to alternative localities. These three turbines are to close the Krom River valley, its woody and dense slopes and associated drainage. It is highly likely that bat foraging activity is constantly elevated in this area 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 very low 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. (2008) 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), and combined with bat mortality monitoring during the operational phase to quantify the effects of this mitigation. 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.

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, 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 during the functional stage of the wind farm, it can lessen the impacts of the wind farm on bat populations.

Due to the lack of knowledge on the impacts of wind farms on bats in the local context, bat monitoring during the operational phase over four seasons is highly recommended for this site.

### 4.2 Bat mortalities due to blade collisions and barotrauma during migration

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, although no caves are known to be in close proximity to the site, and the site is not located in any direct line of path between major caves.

Proposed mitigatory measures or recommendations

Nevertheless, it will be beneficial to collaborate with academic institutions to promote research on the subject, quantifying the risks more accurately.

### 4.3 Destruction of foraging habitat

Some foraging habitat will be destroyed by the construction of the turbines and associated infrastructure. This impact will be effective during the lifespan of the wind farm.

Proposed mitigatory measures or recommendations

Construction of any associated infrastructure in the areas designated as having a High Bat Sensitivity should be strongly avoided.

### 4.4 Destruction of roosts

During the construction phase of the project bat roosts may be significantly impacted by earthworks and large machinery. Diggings related to the placement of underground cables can also damage bat roosts.

Proposed mitigatory measures or recommendations

All diggings and earthworks must be kept to a minimum especially in rocky outcrop areas, and blasting should be avoided.

**Bat Impact Assessment Tables**

| ***Nature of Impact:*** Bat mortalities due to blade collisions and barotrauma during foraging (operational phase) | | |
|---|---|---|
| | **Without mitigation** | **With mitigation** |
| ***Extent*** | Medium (3) | Low (2) |
| ***Duration*** | Long term (4) | Long term (4) |
| ***Magnitude*** | High (8) | Low (3) |
| ***Probability*** | Highly probable (4) | Probable (3) |
| ***Significance*** | **60 (Medium)** | **27 (Low)** |
| ***Status (positive or negative)*** | Negative | Negative |
| ***Reversibility*** | None | Medium |
| ***Irreplaceable loss of resources?*** | Yes | No |
| ***Can impacts be mitigated?*** | Yes | |
| ***Mitigation:*** See Section 4.1 | | |
| ***Cumulative impacts:*** Bat population numbers are slow to recover from major mortalities. If the activities are allowed to continue without mitigation for a long period of time, the mortality rate is highly likely to exceed the reproduction rates of local bat populations, causing a high cumulative impact. | | |
| ***Residual Impacts:*** If bat populations are under stress, the local insect numbers in the area will elevate. If bat populations need to recover from a small amount of individuals after major mortalities, it will take several years to reach the original population status. | | |

| ***Nature of Impact:*** Bat mortalities due to blade collisions and barotrauma during migration (operational phase) | | |
|---|---|---|
| | **Without mitigation** | **With mitigation** |
| ***Extent*** | High (5) | High (5) |
| ***Duration*** | Long term (4) | Long term (4) |
| ***Magnitude*** | High (6) | Low (3) |
| ***Probability*** | Probable (3) | Improbable (2) |
| ***Significance*** | **45 (Medium)** | **24 (Low)** |
| ***Status (positive or negative)*** | Negative | Negative |
| ***Reversibility*** | None | Medium |
| ***Irreplaceable loss of resources?*** | Yes | No |
| ***Can impacts be mitigated?*** | Yes | |

| | | |
|---|---|---|
| ***Mitigation:*** See Section 4.2 | | |
| ***Cumulative impacts:*** Bat population numbers are slow to recover from major mortalities. If the activities are allowed to continue without mitigation for a long period of time, the mortality rate is highly likely to exceed the reproduction rates of impacted bat populations, causing a high cumulative impact. Migrating bats have been recorded to migrate several hundred kilometres in South Africa, therefore the cumulative impact of numerous wind farms operating without mitigation along migration paths over a long period of time will be catastrophic to the migrating bat population. Mitigation is of uttermost importance. | | |
| ***Residual Impacts:*** If bat populations are under stress, the local insect numbers in the area will elevate. If bat populations need to recover from a small amount of individuals after major mortalities, it will take several years to reach the original population status. If migrating bat populations are impacted, the residual impacts will be regional. | | |

| ***Nature of Impact:*** Destruction of foraging habitat due to turbine and infrastructure construction (during construction phase, operational phase and decommissioning). | | |
|---|---|---|
| | **Without mitigation** | **With mitigation** |
| ***Extent*** | Low (1) | Low (1) |
| ***Duration*** | Medium-term (3) | Medium-term (3) |
| ***Magnitude*** | Low (3) | Minor (2) |
| ***Probability*** | Highly probable (4) | Highly probable (4) |
| ***Significance*** | **28 (Low)** | **24 (Low)** |
| ***Status (positive or negative)*** | Negative | Negative |
| ***Reversibility*** | None | None |
| ***Irreplaceable loss of resources?*** | Yes | Yes |
| ***Can impacts be mitigated?*** | Yes, turbine placement | |
| ***Mitigation:*** See Section 4.3 | | |
| ***Cumulative impacts:*** None | | |
| ***Residual Impacts:*** Small areas of natural vegetation and foraging habitat will be replaced by infrastructure and turbines for the duration of the project and after decommissioning, until sufficiently rehabilitated. | | |

| ***Nature of Impact:*** Destruction/disturbance of roosts (construction and decommissioning phases). | | |
|---|---|---|
| | **Without mitigation** | **With mitigation** |
| ***Extent*** | Low (1) | Low (1) |

| | | |
|---|---|---|
| ***Duration*** | Very short duration (1) | Very short duration (1) |
| ***Magnitude*** | Low (3) | Minor (2) |
| ***Probability*** | Probable (3) | Improbable (2) |
| ***Significance*** | **15 (Low)** | **8 (Low)** |
| ***Status (positive or negative)*** | Negative | Negative |
| ***Reversibility*** | Low | High |
| ***Irreplaceable loss of resources?*** | Yes | No |
| ***Can impacts be mitigated?*** | Yes | |
| ***Mitigation:*** See Section 4.4 | | |
| ***Cumulative impacts:*** None | | |
| ***Residual Impacts:*** Once a specific natural roost is destroyed it can't be rehabilitated with high success. Roost disturbances will not have a significant residual impact if the disturbance is of a short duration. | | |

## 5. CONCLUSION

All of the species recorded on the site is vulnerable to the potentially fatal impacts of wind turbines. Although the sampling time was limited and technically insufficient to quantify the risks completely, it is still most probable that bat activity will be elevated in the riparian valleys, its associated vegetation, slopes, drainage and moist areas. Therefore the sensitivity map presented in **figures 9 & 10** should be strongly adhered to, and no turbines may be placed in the area indicated as having a High Bat Sensitivity. The localities of turbines 15, 20 and 25 should be revised and alternatives proposed.

Turbines located in areas of Moderate Bat Sensitivity should preferably be considered to be moved to alternative locations, but if not possible they must at least be prioritized in post construction monitoring and implementation of mitigation measures.

The proposed mitigation measures and recommendations described in Section 4 should be implemented and their practicality and effectiveness researched with high priority at all turbines on this site. Post construction monitoring of bat fatalities during the operational phase is recommended for at least four seasons at the proposed wind energy facility.

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