UMMBILA EMOYENI RENEWABLE ENERGY FACILITY
MPUMALANGA, SOUTH AFRICA
BAT (CHIROPTERA) EIA REPORT

September 2022

Produced for
Windlab Developments South Africa (Pty) Ltd
Cape Town, South Africa

Produced by
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Amsterdam, Netherlands

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NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998) AND ENVIRONMENTAL IMPACT REGULATIONS, 2014 (AS AMENDED) - REQUIREMENTS FOR SPECIALIST REPORTS (APPENDIX 6)

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Appendix 2
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix 3
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 4
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 5.1, Section 6, Section 7
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 4
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 4
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 6
g) an identification of any areas to be avoided, including buffers;	Section 7
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Appendix 1 (Figure 5, Figure 6, Figure 7)
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, (including identified alternatives on the environment) or activities;	Section 5.2, Section 8.1

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	**Section of Report**
k) any mitigation measures for inclusion in the EMPr;	Section 7
l) any conditions for inclusion in the environmental authorisation;	Section 7
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 7
n) a reasoned opinion- i. (as to) whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 8
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	NA
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	NA
q) any other information requested by the competent authority.	NA
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	NA

1 INTRODUCTION

Emoyeni Renewable Energy Farm (Pty) Ltd is proposing the development of renewable energy facilities, collectively known as the Ummbila Emoyeni Renewable Energy Facility ("the project"), consisting of a commercial wind farm, a solar PV facility, and associated grid infrastructure, located approximately 6 km southeast of Bethal and 1 km east of Morgenzon in the Mpumalanga Province of South Africa.

1.1 Scope and Objective

This report presents a Bat (Chiroptera) Specialist Assessment for the Ummbila Emoyeni Renewable Energy Facility, forming part of the Environmental Impact Assessment (EIA) phase for Environmental Authorisation of the project. Collisions with wind turbine blades are one of the leading causes of bat mortality globally (Cryan, 2011; O'Shea et al., 2016). In contrast, there is notably less knowledge on the impacts of solar energy and powerline infrastructure on bats. Given the nature, scale and uncertainty of these impacts to bats, specialist studies are required to assess the risks of renewable energy infrastructure on bats (MacEwan et al. 2020b, SANBI 2020, Bennun et al. 2021).

The objectives of this assessment are to present the baseline ecological condition of the project for bats, and to use these characterisations to predict and assess the potential impact of the project on bat species and their habitats as well as to provide actions to mitigate impacts if required. The specific terms of reference that guided the compilation of this scoping report were:

- Describe the baseline environment of the project and its sensitivity relative to bats;
- Identify the nature of potential impacts of the proposed project on bats during construction, operation and decommissioning;
- Identify information gaps and limitations; and
- Identify potential mitigation or enhancement measures to minimise impacts to bats.

1.2 Project Technical Description

1.2.1 Ummbila Emoyeni Wind Energy Facility

A preferred project focus area has been identified by Emoyeni Renewable Energy Farm (Pty) Ltd as a technically suitable area for the development of the Ummbilla Emoyeni Wind Energy Facility with a contracted capacity of up to 666 MW of wind energy. Properties affected by the project include the following farm portions:

Parent Farm Number	Farm Portions
Farm 261 – Naudesfontein	15 R/E, 21
Farm 264 – Geluksplaats	0, 1, 3, 4, 5, 6 R/E, 8 R/E, 9R/E, 10, 11, 12
Farm 268 – Brak Fontein Settlement	6,7,10,11,12
Farm 420 – Rietfontein	8,9,10,11,12,15 R/E,16,18,19,22,32
Farm 421 - Sukkelaar	2, 2, 7, 9, 9 10, 10 11, 11 12, 12, 22 ,25 R/E, 34, 35, 36, 37, 37, 38, 39, 40, 42, 42
Farm 422 – Klipfontein	0, 2 R/E, 3 R/E, 4, 5, 6, 7, 8 R/E, 9, 10, 12, 13 R/E, 14 R/E, 16, 17, 18, 19, 20, 21, 22, 23
Farm 423 – Bekkerust	0 R/E, 1, 2 R/E, 4, 5 R/E, 6, 10, 11, 12, 13 14, 15, 17, 19 R/E, 20, 22, 23, 24,25
Farm 454 – Oshoek	4 R/E, 13, 18
Farm 455 – Ebenhaezer	0, 1, 2, 3
Farm 456 – Vaalbank	1, 2, 3, 4, 7, 8, 13, 15, 16, 17, 18, 19
Farm 457 – Roodekrans	0, 1, 4, 7, 22, 23, 23

Parent Farm Number	Farm Portions
Farm 458 - Goedgedacht	0, 2, 3, 4, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 21, 22, 23, 25, 26 R/E, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43
Farm 467 - Twee Fontein	0 R/E, 1 R/E, 4 R/E, 5, 6, 7 R/E, 8, 10
Farm 469 - Klipkraal	5 R/E, 6, 7, 8
Farm 548 - Durabel	0

The wind farm is proposed to accommodate the following infrastructure:

- Up to 111 wind turbines with a maximum hub height of up to 200 m. The tip height of the turbines will be up to 300 m.
- 33 kV cabling to connect the wind turbines to the onsite collector substations, to be laid underground where practical.
- 3 x 33 kV / 132 kV onsite collector substations (IPP Portion) each being 5ha.
- Battery Energy Storage System (BESS)
- Cabling between turbines, to be laid underground where practical
- Construction compounds including site office (approximately 300m x 300m in total but split into 3ha each of 150m x 200m):
  - Batching plant of 4 ha to 7 ha
  - 3 x O&M office of approximately 1.5ha each adjacent to each collector substation
  - 3 x construction compound / laydown area, including site office of 3ha each (150m x 200m each).
- Laydown and crane hardstand areas (approximately 75 m x 120 m)
- Access roads of 12-13 m wide, with 12 m at turning circles.

1.2.2 Ummbila Emoyeni Solar Energy Facility

The facility will have a contracted capacity of up to 150MW and includes the following infrastructure:

- PV modules in the range of 330Wp to 450Wp mounted on either a fixed tilt or single axis tracker structure, dependent on optimisation, technology available and cost.
- Inverters and transformers.
- 33kV cabling to connect to the onsite collector substation, to be laid underground where practical.
- 33kV/132kV onsite collector substation (IPP Portion).
- Battery Energy Storage System (BESS).
- Cabling between project components.
- Access roads (up to 12m wide) and internal distribution roads (up to 12m wide).
- Laydown and O&M hub (approximately 300m x 300m):
  - Construction compound (temporary).
  - Maintenance office.

Properties affected by the Ummbila Emoyeni Solar Energy Facility include the following farm portions:

Parent Farm Number	Farm Portions
Farm 264 - Geluksplaats	0, 11
Farm 423 - Bekkerust	0 R/E, 1, 5 R/E, 22,
Farm 420 - Rietfontein	8, 9, 10, 32

A summary of the details and dimensions of the planned infrastructure associated with the solar energy facility is provided below:

Infrastructure	Footprint and dimensions
Number of Panels	To be determined
Panel Height	Up to 5m
Technology	Use of fixed-tilt, single-axis tracking, and/or double-axis tracking PV technology. Monofacial or bifacial panels are both considered.
Contracted Capacity	Up to 150MW
Area occupied by the solar array	255.2ha
Area occupied by the on-site facility substation (IPP Portion)	~5ha
Capacity of on-site facility substation (IPP Portion)	33kV/132kV
Underground cabling between the PV array and the onsite substation	Cabling will be installed underground where feasible at a depth of up to 1.5m to connect the PV panels to the on-site facility substation. Where not technically feasible to place cabling underground, this will be installed above-ground. The cabling will have a capacity of up to 33kV.
Laydown and Operations and Maintenance (O&M) hub	~ 300m x 300m, comprising: * Construction compound (temporary) of approximately 6 ha. * O&M office of approximately 1.5ha.
Area occupied by laydown area	~75m x 120m
Access and internal roads	Wherever possible, existing access roads will be utilised to access the project site and development area. It is unlikely that access roads will need to be upgraded as part of the proposed development. Internal roads of up to 12-13m in width will be required to access the PV panels and the on-site substation.
Grid connection	The grid connection infrastructure will include a 400/132kV Main Transmission Substation (MTS), to be located between Camden and SOL Substations, which will be looped in and out of the existing Camden-Sol 400kV transmission line; on-site switching stations (132kV in capacity) at each renewable energy facility (Eskom Portion); 132kV power lines from the switching stations at each renewable energy facility to the new 400/132kV MTS; and a collector substation with 2 x 132kV bus bars and 4 x 132kV IPP feeder bays to onsite IPP Substation The grid connection infrastructure will be assessed as part of a separate Environmental Impact Assessment process in support of an application for Environmental Authorisation.
Temporary infrastructure	Temporary infrastructure, including laydown areas, hardstand areas and a concrete batching plant, will be required during the construction phase. All areas affected by temporary infrastructure will be rehabilitated following the completion of the construction phase, where it is not required for the operation phase.

1.2.3 Ummbila Emoyeni Electrical Grid Infrastructure

Emoyeni Renewable Energy Farm (Pty) Ltd is proposing the development of Electrical Grid Infrastructure (EGI) to support the Ummbila Emoyeni Renewable Energy Farm, which aims to export energy to the national electricity grid. Properties affected by the Ummbila Emoyeni EGI include the following farm portions:

Parent Farm Number	Farm Portions
Farm 261 – Naudesfontein	15 R/E, 21
Farm 264 – Geluksplaats	0, 1, 3, 4, 5, 6 R/E, 8 R/E, 9R/E, 10, 11, 12
Farm 268 – Brak Fontein Settlement	6,7,10,11,12

Farm 420 - Rietfontein	8,9,10,11,12,15 R/E,16,18,19,22,32
Farm 421 - Sukkelaar	2, 2, 7, 9, 9 10, 10 11, 11 12, 12, 22 ,25 R/E, 34, 35, 36, 37, 37, 38, 39, 40, 42, 42
Farm 422 - Klipfontein	0, 2 R/E, 3 R/E, 4, 5, 6, 7, 8 R/E, 9, 10, 12, 13 R/E, 14 R/E, 16, 17, 18, 19, 20, 21, 22, 23
Farm 423 - Bekkerust	0 R/E, 1, 2 R/E, 4, 5 R/E, 6, 10, 11, 12, 13 14, 15, 17, 19 R/E, 20, 22, 23, 24,25
Farm 454 - Oshoek	4 R/E, 13, 18
Farm 455 - Ebenhaezer	0, 1, 2, 3
Farm 456 - Vaalbank	1, 2, 3, 4, 7, 8, 13, 15, 16, 17, 18, 19
Farm 457 - Roodekrans	0, 1, 4, 7, 22, 23, 23
Farm 458 - Goedgedacht	0, 2, 3, 4, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 21, 22, 23, 25, 26 R/E, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43
Farm 467 - Twee Fontein	0 R/E, 1 R/E, 4 R/E, 5, 6, 7 R/E, 8, 10
Farm 469 - Klipkraal	5 R/E, 6, 7, 8
Farm 548 - Durabel	0

The grid connection infrastructure will include:

- A new 400/132kV Main Transmission Substation (MTS), to be located on the Camden SOL Lines.
- Two 400kV loop-in loop-out power lines to the existing Camden-Sol 400kV transmission line.
- On-site switching stations (Eskom Portion) (132kV in capacity) at each renewable energy facility.
- Collector substation with 2 x 132kV bus bars and 4 x 132kV IPP feeder bays to onsite IPP S/Ss.
- 132kV power lines from the switching stations to the new MTS.
- Access roads up to 8m wide.

A summary of the details and dimensions of the planned infrastructure associated with the grid connection is provided below:

Infrastructure	Footprint and dimensions
Onsite substations (Eskom Portion)	» Development footprint: 3 IPP collector substations of 5ha each » Capacity: 33kV/132kV
Collector Substation	» Collector substation with 2 x 132kV bus bars and 4 x 132kV IPP feeder bays to onsite IPP substation.
132kV power lines	» Servitude width: 18m » Height: up to 40m » Length: approximately 40 km » Corridor width for assessment in EIA: 300m
Main Transmission Substation	» Development footprint: 600m x 600m » Capacity: 400/132kV » Height: Up to 30m
Power line connection to national grid	» Capacity and circuit: 400kV loop-in loop-out » Servitude: 55m per line » Height: Up to 40m » Corridor width for assessment in EIA: 300m
Height of the power line towers (pylons)	40m

Access and internal roads	Access will likely be via the main road between Bethal and Morgenzon. This is the R35, a tarred and provincial road. Existing roads on the affected properties will be used where feasible and practical to provide direct access to the EGI. Where necessary, new access roads (up to 12 wide) will be established to provide access to the Main Transmission Substation (MTS). During construction, a permanent access road along the length of the power line corridor (300m wide) between 4 -6m wide will be established to allow for large crane movement. This track will then be utilised for maintenance during operation.
Temporary infrastructure	Temporary infrastructure, including laydown areas and a concrete batching plant, will be required during the construction phase. All temporary infrastructure will be rehabilitated following the completion of the construction phase, where it is not required for the operation phase.

2 ASSUMPTIONS AND LIMITATIONS

The core techniques used to assess bat activity in this study are acoustic monitoring and roost surveys both of which have several limitations which will influence the findings and recommendations of this study.

Acoustic monitoring allows for rapid, passive collection of a large volume of bat activity data which can help identify the bat species present within a particular location and their associated relative spatio-temporal activity patterns. In the context of wind farms, acoustic monitoring is therefore a useful technique however, there are several constraints that must be acknowledged. These are discussed in detail by Voigt et al. (2021), Adams et al. (2012), and Kunz et al. (2007a) and fundamentally, include that acoustic monitoring cannot provide an indication of bat abundance or population size at a site. In addition, population demographics such as age and sex of bats cannot generally be determined from echolocation data. Due to the large volume of data collected by bat detectors it is impractical and prohibitively time-consuming to inspect each file for echolocation calls and to identify the associated bat species. Specialised statistical software uses bat call reference libraries to automate the identification process. Developing such libraries is challenging given the variation individual species display in their echolocation call structure and because of overlap in echolocation call structure and parameters between species. This study used the Wildlife Acoustics library “Bats of South Africa Version 5.4.0”, but this excludes reference calls for most South African species thus these may have been overlooked. However, given the duration of the monitoring and spatial coverage of the detectors, the acoustic data provides a reasonable inventory of the species present, and a good indication of the relative magnitude of bat activity. Lastly, bat activity is notably variable in response to several factors such as land use change, climactic variability, variations in prey abundance and meteorological conditions which can vary over different time scales. Since this study is limited to 12 months, the baseline conditions presented here may not be representative of activity over longer time frames such as that which might occur during the lifespan of the facility once operational meaning risk may be misinterpreted.

The major limitation with roost surveys is finding roosting bats. Bats use a diversity of roosting sites including trees, buildings, crevices, and underground sites (caves and mines). The presence of these features at a site can help to target roost searches but evidence of bats may not always be apparent even if bats are present. Importantly, the absence of bat evidence in these situations does not equate to evidence of bat absence (Collins 2006). Thus, this study uses a precautionary approach and will apply buffers to roosts (largely buildings and tree clumps) even if bats were not located given their potential role in supporting roosting bats.

Risk to bats was determined based on median bat activity per night derived from the bat activity dataset collected with acoustic monitoring. Median values were compared to those in Table 5 in MacEwan et al. (2020b) which provides height-specific fatality risk categories (high, medium, low) based on bat activity sampled in different South African terrestrial ecoregions. The PAOI is situated in the Highveld Grasslands ecoregion (Dinerstein et al. 2019) however reference values are not available for this ecoregion in MacEwan et al. (2020b). Instead, median values were compared to reference values for the Drakensberg Grasslands, Woodlands and Forest ecoregion. While bat activity levels differ between these two ecoregions this difference is small (MacEwan et al. 2020a). The lack of a direct reference for the Highveld Grasslands ecoregion is therefore not a major limitation and the comparison is suitable to provide an evaluation of risk.

Finally, it is difficult to assess the risk to bats during operation of the proposed facility based on acoustic data collected during pre-construction surveys. For example, Hein et al. (2013) showed that pre-construction bat activity was not a significant indicator of collision risk. Lintott et al. (2016) argued that environmental impact assessments do not predict the risks to bats accurately. This may partly be because it is hypothesized that bats may be attracted to wind turbines (Cryan and Barclay 2009, Guest et al. 2022) which some evidence suggests may be the case (Horn et al. 2008, Richardson et al. 2021). While this report makes predications about the potential risk to bats posed by the project, these carry a degree of uncertainty and must be verified by using post-construction surveys to ensure that the predictions are accurate and bat behaviour has not altered from pre-construction levels (Lintott et al. 2016).

3 LEGAL REQUIREMENTS AND GUIDELINES

There are various international, regional and local legislation, policies, regulations, guidelines, conventions, and treaties in place for the protection of biodiversity, under which bats would also be protected. These include:

- Convention on the Conservation of Migratory Species of Wild Animals (1979)
- Convention on Biological Diversity (1993)
- Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)
- National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998)
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
- Mpumalanga Nature Conservation Act (Act No. 10 of 1998)
- The Equator Principles (2013)
- The Red List of Mammals of South Africa, Swaziland and Lesotho (2016)
- National Biodiversity Strategy and Action Plan (2005)
- South African Good Practise Guidelines for Surveying Bats in Wind Energy Facility Developments – Pre-Construction (2020)
- South African Good Practise Guidelines for Operational Monitoring for Bats at Wind Energy Facilities (2020)

4 ASSESSMENT METHODOLOGY

The Project Area of Influence (PAOI) was defined as the AoI plus a 10 km buffer given that bats are volant mammals (Scottish Natural Heritage 2019). This area was studied at a desktop level to determine which bat species (i.e., impact receptors) are likely to occur at the project, to provide information on their natural history and conservation status, and to contextualise the project site within the larger social-ecological environment with respect to bats.

Bats were also studied through field surveys in the AoI. Bat activity was sampled at eight locations (Figure 1, Table 1) within the AoI with Wildlife Acoustics, Inc. SM4 bat detectors. At six locations (UE1 – UE6), SMM-U2 microphones were positioned at the top of a 10 m aluminium mast. At the remaining two locations (UE7 and UE8), microphones were positioned on meteorological towers at 60 m and 120 m respectively.

Sampling took place nightly from sunset to sunrise, commencing 18 May 2021 and will continue for 12 months. This report is based on data collected between 18 May 2021 and 31 January 2022 (259 nights). The monitoring period therefore spans late autumn, winter, spring, and two-thirds of summer and as such provides a representative sample of annual bat activity patterns and how this changes seasonally. Therefore, this assessment is based on an appropriate dataset with which to understand bat activity and assess risk.

Table 1: Summary of the Bat Acoustic Monitoring Sampling Locations and Effort

Bat Detector	Coordinates	# Sample Nights	Total Bat Passes	Altitude (m)	Nearest Habitat Features
UE1	-26.661737°S 29.654723°E	371	9.052	1,629	10 m west of small stream, 110 m west from woodland patch, grassland vegetation
UE2	-26.691674°S 29.639374°E	322	2,573	1,653	220 m southwest of small stream, 300 m west from woodland patch, grassland vegetation, CBA (Irreplaceable)
UE3	-26.562662°S 29.608323°E	322	2,338	1,691	380 m south of seep wetland, 750 m from farm dam, within grassland but adjacent to cultivated areas
UE4	-26.598876°S 29.612947°E	248	125,227	1,685	within woodland patch, 140 m north of farm dam, 160 m from seep wetland, 400 m north of farm buildings
UE5	-26.507918°S 29.548908°E	280	12,374	1,668	95 m northeast of farm dam, 140 m west of farm dam, grassland vegetation, 260 m east of farmstead, 340 m north of cultivated areas, 300 m west of farm buildings
UE6	-26.501742°S 29.613135°E	270	2,034	1,694	180 m southeast of seep wetland, 670 m south of farm dam, 300 m southeast of cultivate fields, 885 m southwest of farm buildings, grassland vegetation
UE7 (60 m +120 m)	-26.614954°S 29.606512°E	60 m = 321 120 m = 244	60 m = 1,519 120 m = 368	1,697	240 m north of cultivated areas, 245 m west of livestock kraal with trees, 330 m northwest of channeled valley-bottom wetland, grassland vegetation
UE8 (60 m +120 m)	-26.739593°S 29.659108°E	60 m = 230 120 m = 229	60 m = 1,180 120 m = 266	1,665	160 m north of seep wetland, 380 m west of cultivated areas, grassland vegetation

To locate features on site where bats maybe/are roosting, surveys were undertaken which first entailed discussions with landowners to locate any known roosts, or potential roosts with evidence of bats. In addition, buildings at two of the farmsteads within the AoI (Figure 1) were systematically surveyed in August 2021 (winter), September 2021 (spring) and May 2022 (autumn) respectively. The surveys aimed to directly observe roosting bats, locate evidence of roosting bats (e.g., culled insect remains, fur-oil-stained exit and entry points, guano/droppings), and assess the potential for each building to support bats.

Acoustic data retrieved from each bat detector were processed using Kaleidoscope® Pro (Version 5.4.2, Wildlife Acoustics, Inc.). Bats were automatically identified using the embedded "Bats of South Africa Version 5.4.0" reference library and verified by inspecting echolocation files. The number of acoustic files recorded was used as a measure to quantify bat activity, whereby each file was considered one bat pass of the microphone.

5 SPECIALIST FINDINGS

5.1 Ecological Baseline

The Project Area of Influence (PAOI) is situated in the Grassland Biome, and comprises predominantly Soweto Highveld Grassland vegetation (Figure 1) supporting short to medium-high, dense, tufted grassland (Mucina and Rutherford 2006). Eastern Highveld Grassland and Amersfoort Highveld Clay Grassland occur in the north and southeast of PAOI respectively. Both Soweto Highveld Grassland and Eastern Highveld Grassland are classified as Vulnerable while Amersfoort Highveld Clay Grassland is classified as Least Concern (SANBI 2018). The vegetation has limited structural heterogeneity since grasses dominate the landscape, but isolated trees and clumps of trees are also scattered across the PAOI. The landscape consists of slightly to moderately undulating plains with some low hills and wetland depressions and has largely been transformed by cultivation (the primary land use in the PAOI), urban sprawl, mining, and road infrastructure. The PAOI is in a summer rainfall region and has a cool-temperate climate with dry winters, frequent occurrence of frost and large differences in both diurnal and seasonal temperature extremes (Mucina and Rutherford 2006).

Critical Biodiversity Areas (CBA), areas of high biodiversity value that must be maintained in a natural state, are located throughout the PAOI (Figure 1), classified as either "CBA Irreplaceable" and "CBA Optimal". The former category comprises 1) areas required to meet conservation targets and those with irreplaceability values greater than 80 %, 2) areas which represent critical linkages or pinch-points in the landscape that must remain natural, and 3) Critically Endangered ecosystems (MTPA 2014). The latter category comprises areas that are not 'irreplaceable', but they are the most optimal land configuration to meet all biodiversity targets. Ecological Support Areas (ESA), not essential for meeting biodiversity targets but important in supporting the functioning of CBAs and delivering important ecosystem services, are also located throughout the PAOI (Figure 1). While there are no protected areas inside the PAOI, 44 protected areas are located within 100 km.

Based on current taxonomic information and bat occurrence data, 24 species could occur within the AoI (Table 2). The majority have a low likelihood of occurrence and acoustic monitoring has confirmed the presence in the AoI of six species. This includes four species classified as high risk from wind energy development: Natal Long-fingered bat, Cape Serotine, Little Free-tailed bat, and Egyptian Free-tailed bat.

Table 2: Bat Species Potentially Occurring within the Ummbila Emoyeni PAOI

Common Name *Species Name*	Key Habitat Requirements*	Prob. of Occurrence	Conservation Status		WEF Risk[§]
			IUCN[†]	RSA[‡]	
Natal Long-fingered bat *Miniopterus natalensis*	Temperate or subtropical species. Primarily in savannas and grasslands. Roosts in caves, mines, and road culverts. Clutter-edge forager.	**Confirmed (1,828 passes)**	LC/U	LC	High
Cape Serotine *Laephotis capensis*	Arid semi-desert, montane grassland, forests, savanna and shrubland. Roosts in vegetation and human-made structures. Clutter-edge forager.	**Confirmed (65,374 passes)**	LC/S	LC	High
Mauritian tomb bat *Taphozous mauritianus*	Savanna woodland preferring open habitat. Roosts on rock faces, the outer bark of trees or on the outer walls of buildings under the eaves of roofs. Forages in urban areas and over cultivation. Open-air forager.	High	LC/U	LC	High
Little Free-tailed bat *Chaerephon pumilus*	Semi-arid savannah, forested regions, woodland habitats. Roosts in narrow cracks in rock and trees but also in buildings. Open-air forager. Forages in urban areas and over cultivation.	**Confirmed (1,188 passes)**	LC/U	LC	High

Common Name *Species Name*	Key Habitat Requirements*	Prob. of Occurrence	Conservation Status IUCN†	RSA!	WEF Risk$^{\delta}$
Midas Free-tailed bat *Mops midas*	Hot low-lying savanna and woodland. Roosts in narrow cracks in rock and trees but also in buildings. Open-air forager.	Low	LC/D	LC	High
Egyptian Free-tailed bat *Tadarida aegyptiaca*	Desert, semi-arid scrub, savanna, grassland, and agricultural land. Roosts in rocky crevices, caves, vegetation, and human-made structures. Open-air forager.	**Confirmed (18,184 passes)**	LC/U	LC	High
Wahlberg's Epauletted fruit bat *Epomophorus wahlbergi*	Roost in dense foliage of large, leafy trees. Associated with forest and forest-edge habitats but will forage in urban environments.	Low	LC/S	LC	High
African Straw-coloured fruit bat *Eidolon helvum*	Non-breeding migrant in the PAOI.	Low	NT/D	LC	High
Egyptian Rousette *Rousettus aegyptiacus*	Distribution influenced by availability of suitable caves roosts.	Low	LC/S	LC	High
Temminck's Myotis *Myotis tricolor*	Montane forests, rainforests, coastal forests, savannah woodlands, arid thicket, and fynbos. Roosts communally in caves (and mines) and closely associated with mountainous terrain. Migratory. Clutter-edge forager.	Low	LC/U	LC	Medium-High
Welwitsch's Myotis *Myotis welwitschii*	Mainly open woodland and savannah but also high-altitude grassland, tropical dry forest, montane tropical moist forest, savannah and shrublands. Clutter-edge forager.	Low	LC/U	LC	Medium-High
Yellow-bellied house bat *Scotophilus dinganii*	Occurs throughout the Savannah Biome but avoids open habitats such as grasslands and Karoo scrub. Roosts in hollow trees and buildings. Clutter-edge forager.	**Confirmed (321 passes)**	LC/U	LC	Medium-High
Green House bat *Scotophilus viridis*	Savannah woodland species: restricted to low-lying, hot savannahs and avoids open habitats such as grasslands. Roosts in hollow trees and buildings. Clutter-edge forager.	Low	LC/U	LC	Medium-High
Dusky Pipistrelle *Pipistrellus hesperidus*	Woody habitats, such as riparian vegetation and forest patches. Recorded roosting in narrow cracks in rocks and under the loose bark of dead trees. Clutter-edge forager.	Low	LC/U	LC	Medium-High
Rusty Pipistrelle *Pipistrellus rusticus*	Savannah woodland and associated with open water bodies. Roosts in trees and old buildings. Clutter-edge forager.	Low	LC/U	LC	Medium-High
Long-tailed Serotine *Eptesicus hottentotus*	Montane grasslands, marshland and well-wooded riverbanks, mountainous terrain near water. Roosts in caves, mines, and rocky crevices. Clutter-edge forager.	**Confirmed (357 passes)**	LC/U	LC	Medium
Egyptian Slit-faced bat *Nycteris thebaica*	Savannah, desert, arid rocky areas, and riparian strips. Gregarious and roosts in caves but also in mine adits, Aardvark holes, rock crevices, road culverts, roofs, and hollow trees. Clutter forager.	Medium	LC/U	LC	Low
Geoffroy's Horseshoe bat *Rhinolophus clivosus*	Savannah woodland, shrubland, dry, riparian forest, open grasslands, and semi-desert. Roosts in caves, rock crevices, disused mines, hollow baobabs, and buildings. Clutter forager.	Medium	LC/U	LC	Low
Bushveld Horseshoe bat *Rhinolophus simulator*	Occurs in caves within areas of moist savannah, adjacent to rivers and savannah woodland, montane habitats, and coastal mosaics. Commonly associated with riparian forest and along wooded drainage lines. Roosts in caves and mines. Clutter forager.	Medium	LC/D	LC	Low
Blasius's Horseshoe bat *Rhinolophus blasii*	Savannah woodlands and are dependent on the availability of daylight roosting sites such as caves, mines, or boulder piles. Clutter forager.	Low	LC/D	NT	Low
Darling's Horseshoe bat *Rhinolophus darlingi*	Mesic woodland savannahs. Roosts in caves, boulder piles, mines, culverts, large hollow trees and disused buildings. Clutter forager.	Low	LC/U	LC	Low

Common Name *Species Name*	Key Habitat Requirements*	Prob. of Occurrence	Conservation Status		WEF Risk[δ]
			IUCN[†]	RSA[!]	
Sundevall's Leaf-nosed bat *Hipposideros caffer*	Savannah, bushveld and/or coastal forests, near to rivers and other water sources. Roosts in caves, sinkholes, rock fissures, hollow trees, mines, and culverts. Clutter forager.	Low	LC/D	LC	Low
Percival's Short-eared Trident bat *Cloeotis percivali*	Savannah and woodland areas. Roosts in caves and mine tunnels. Clutter forager.	Low	LC/U	EN	Low
Botswana Long-eared bat *Laephotis botswanae*	Dry and moist savannah, grassland, and heathland habitats. Often found in the vicinity of rivers or in association with rocky outcrops. No information on roosting sites.	Low	LC/U	LC	Low

*Child et al. (2016), *Monadjem et al. (2020); [!] Child et al. (2016); [†]IUCN (2021); [δ] MacEwan et al. (2020b)

Bat roosting sites in the PAOI are relatively limited and unlikely to support large congregations of bats, with no underground sites (e.g., caves, mines, sinkholes) present. The closest known major bat roost is approximately 75 km north of the PAOI. Although occasional ridges and rocky outcrops are features of the landscape (Mucina and Rutherford 2006), none are present in the PAOI. Bats are likely to roost in buildings associated with farmsteads within and bordering the project especially Cape Serotine and Egyptian Free-tailed Bat (Monadjem et al. 2018). The building inspections on site did not reveal any roosting bats but evidence (e.g., fur-oil-stained exit/entry points) suggests that bats are using these features. Trees growing at these farmsteads and elsewhere on site where they form clumps, could also provide roosting spaces for bats.

Sensitive features in the PAOI at which bat foraging activity may be concentrated include farm buildings (and within built up areas for some species) where they would forage for insects attracted to lighting (Rydell 1992, Jung and Kalko 2010), dams and wetland areas (Sirami et al. 2013), within and along the edge of woodland/tree patches, and over cultivated areas (Bohmann et al. 2011, Noer et al. 2012).

5.2 Summary of Pre-Construction Bat Monitoring

A total of 156,931[1] bat passes were recorded across 371 sample nights, 83 % of which were attributed to Cape serotine. Thirteen (13) percent of total activity was attributed to Egyptian free-tailed bat. The remaining four species accounted for 5 % of all activity.

Approximately 80 % of total activity was recorded at UE4 and 88 % of this activity was attributed to Cape serotine. The magnitude of activity at this location varied by species; median bat passes per night for Cape serotine at UE4 was 27.8, while for Egyptian free-tailed bat this was 0.36 (Figure 2).

Most bat activity (98 %) was recorded by microphones at ground level (10 m) compared to at higher altitudes (60 m or 120 m). Approximately 80 % of activity at 60 m and 120 m was attributed to Egyptian free-tailed bat, with Cape serotine and Little free-tailed bat accounting for ca. 12 % and 7 % respectively. All three species were recorded across both heights. Long-tailed serotine, Yellow-bellied house bat and Natal long-fingered bat were seldomly recorded at height.

[1] This excludes an additional 25,353 bat passes that were unable to be assigned to any particular species by the Wildlife Acoustics library "Bats of South Africa Version 5.4.0", and were thus classified as No ID. These calls were excluded from all analyses but are reported on here to highlight that they may include call fragments from species not confirmed for the site, and hence, the species list for the AoI may not be complete.

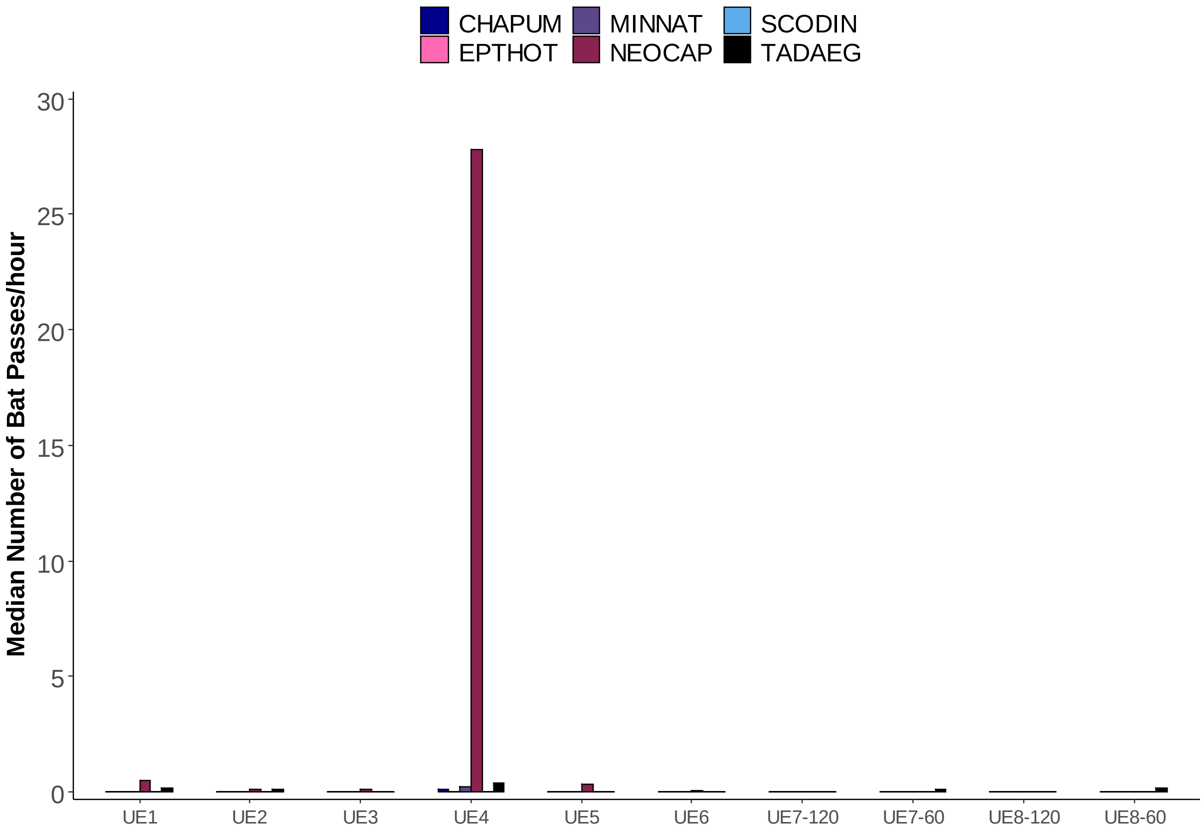

Figure 2: Bar chart showing the medium number of bat passes per night at each monitoring location per species.

A clear spatial pattern in bat activity is evident with notably higher activity recorded at UE4, which is within a stand of Eucalyptus trees, near several large dams, and a series of buildings. The increased activity at this part of the site suggests that bats (especially Cape serotine which had high activity levels here) could be roosting in the trees or buildings near this bat detector, as well as using this part of the site for foraging presumably because the trees, water and possibly lights associated with the buildings would attract insect prey. Similarly, UE5 was also situated near these landscape features (Table 2) and showed elevated activity of Cape serotine and Egyptian free-tailed bats. Bat detectors in areas away from such features and located in more open areas (e.g., UE3 and UE6) had lower activity levels. Spatial risk in the AoI therefore varies with location (including across altitudes) and species (Table 3).

Table 3: Spatial risk profile of the AoI based on median bat passes/night (Risk = High, Medium, Low)

Bat Detector	Cape serotine				Egyptian free-tailed bat			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
UE1	0.5	0.0	0.8	1.7	0.1	0.1	0.6	0.1
UE2	0.1	0.0	0.1	0.8	0.0	0.0	0.1	0.3
UE3	0.1	0.0	0.2	0.3	0.0	0.0	0.2	0.0
UE4	27.6	0.0	23.6	47.8	0.2	0.0	3.0	0.3
UE5	0.0	0.1	3.6	3.9	0.0	0.2	1.3	0.1
UE6	0.0	0.0	0.4	0.5	0.0	0.1	0.3	0.0
UE7-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UE7-60	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1
UE8-120	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
UE8-60	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.3

Bat activity varied seasonally with lowest activity in winter and activity increasing through spring and peaking in summer, although this varied by species. Both Egyptian free-tailed bat and Cape serotine showed bi-modal peaks in activity, with low activity in winter (Figure 3). Egyptian free-tailed bat activity at 10 m peaked between October and December (spring to summer transition) with a median of ~ 0.6 bat passes per night while Cape serotine activity peaked in January (summer) with a median of 2.1 bat passes per night (Figure 3). At 60 m and 120 m, median activity of Cape serotine was 0 for all months while for Egyptian free-tailed bats, activity was highest in December with 0.5 bat passes per night at 120 m. This species was not recorded at height in all months, and activity was highest in December across all heights. Based on the median number of bat passes at height, Egyptian free-tailed bats are expected to be at high risk in December, medium risk between August and February and low risk during winter. Cape serotine, and all other bat species, are expected to be at low collision risk at height across all months.

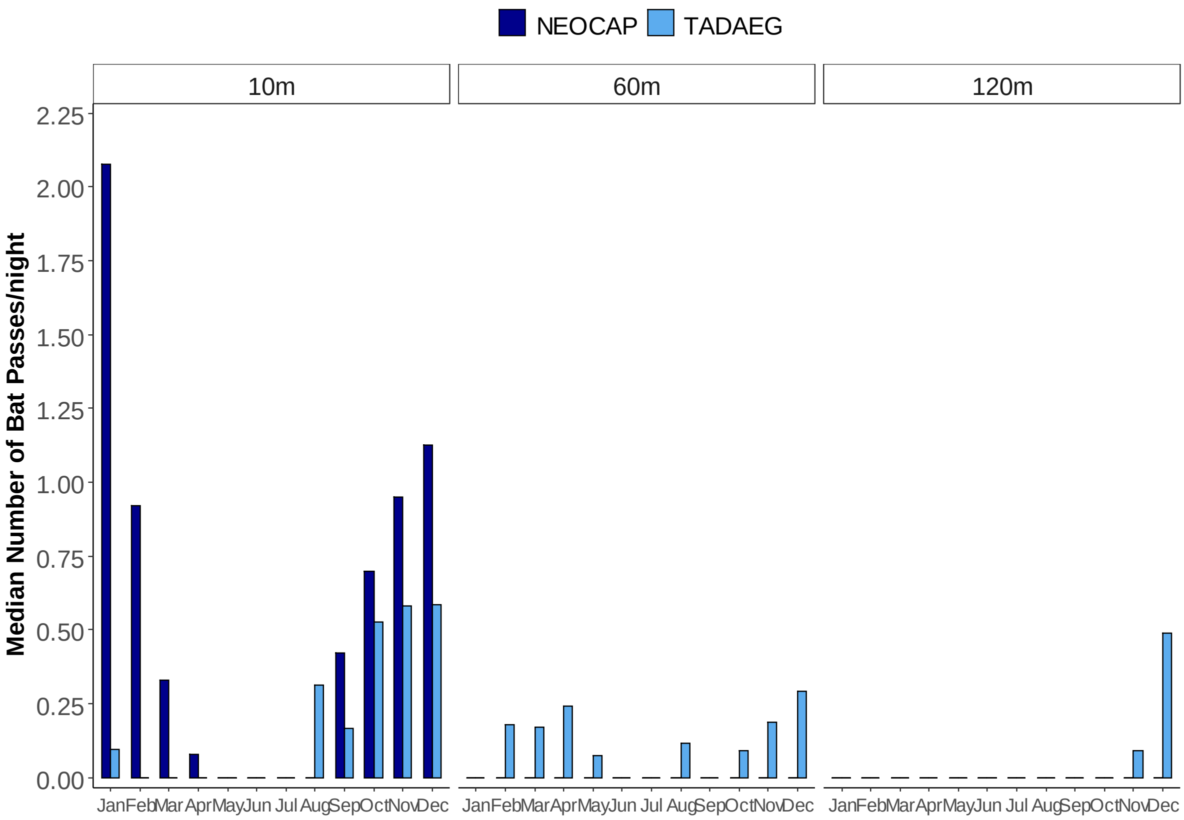

Figure 3: Bar chart showing bat passes/night by month for Cape serotine (NEOCAP) and Egyptian free-tailed bat (TADAEG).

On a nightly level, bat activity is higher during the first few hours of the night (Figure 4 and, Figure 5). At height, all species apart from Egyptian free-tailed bat have low risk for all seasons and time periods. Based on median bat activity, Egyptian free-tailed bat is at medium risk in summer between 21:00 and 22:00, and low risk during all other time periods.

To investigate temporal activity patterns at ground level, the dataset was split into two. The first dataset consisted of data from all detectors except U4, and the second dataset consisted of data from only U4. Both datasets only included that for Cape serotine and Egyptian free-tailed bat since these two species accunted for most activity. All other species are at low risk for all time periods. Data were separated because the overwhelming majority of bat activtiy was recorded at U4 (Table 2).

For Cape serotine, high risk is expected in summer between 19:00 and 21:00. Medium risk is expected between 18:00 and 21:00 in spring, between 21:00 and 05:00 in summer, and between 17:00 and 18:00 in autumn (Figure 4). For Egyptian free-tailed bat, medim risk is expected between 18:00 and 20:00 in winter, between 20:00 and 00:00 in summer, and between 18:00 and 00:00 in spring (Figure 4).

At U4, Cape serotine is at high risk across the night in spring and summer, as well as between 18:00 and 20:00 in autumn. Medium risk is expected between 19:00 and 20:00 in autumn and betwween 17:00 and 18:00 in winter. For Egyptian free-tailed bat, high risk is expected between 19:00 and 22:00 in spring, and medium risk between 22:00 and 01:00.

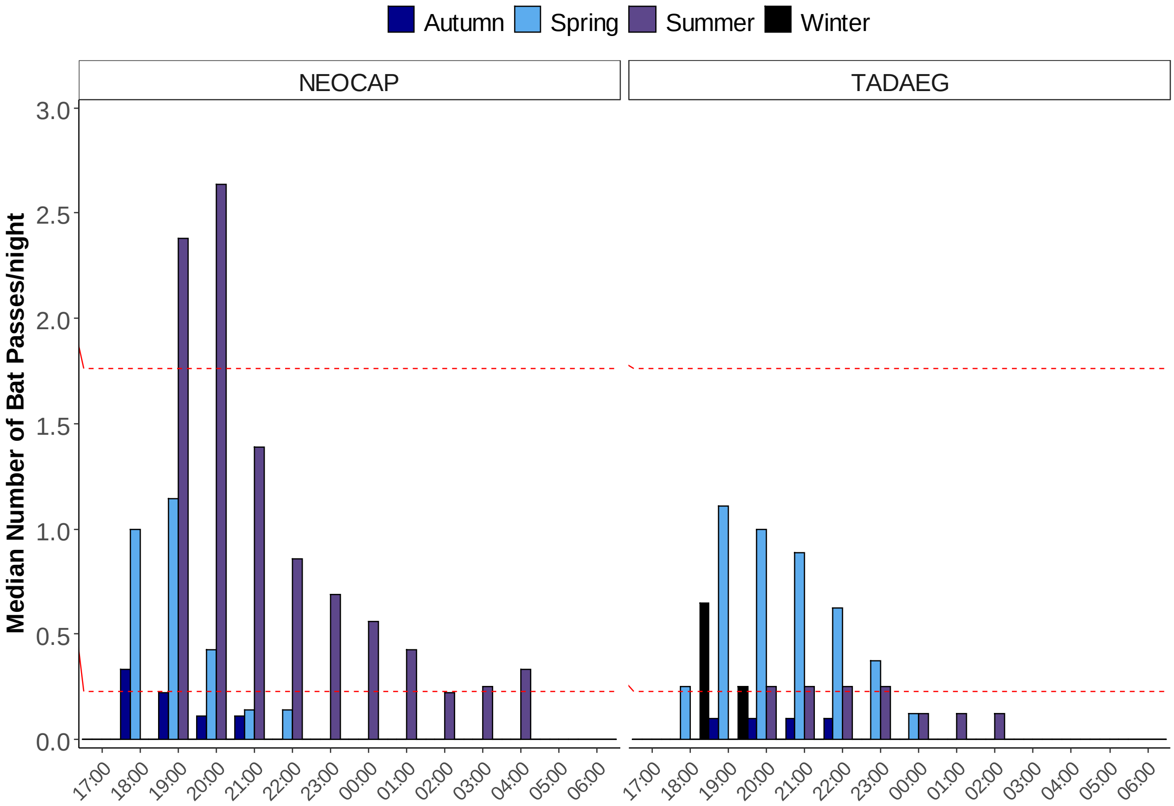

Figure 4: Median number of bat passes per night across nightly time periods for Cape serotine (NEOCAP) and Egyptian free-tailed bat (TADAEG). 17:00 represents bat activity between 17:00 and 18:00 etc. Data from U4 are excluded (see Figure 5). Median bat activity between the two red lines represents Medium risk.

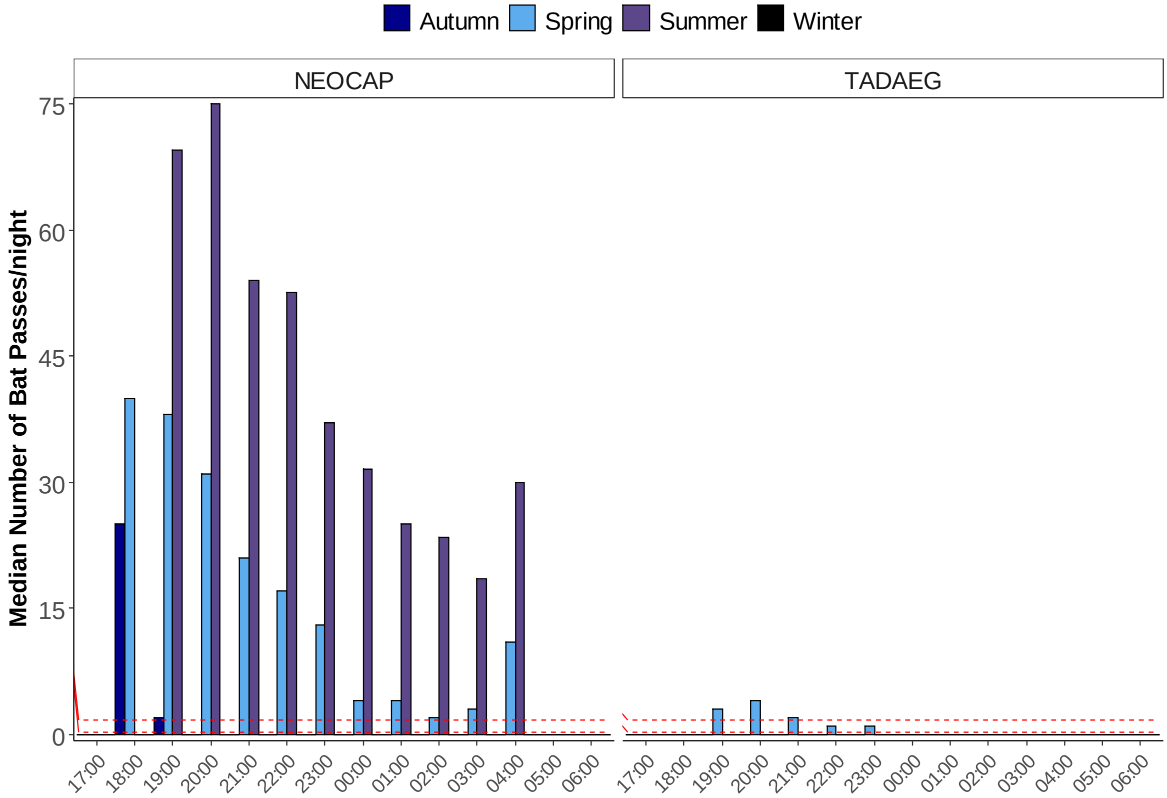

Figure 5: Median number of bat passes per night across nightly time periods for Cape serotine (NEOCAP) and Egyptian free-tailed bat (TADAEG) for U4. 17:00 represents bat activity between 17:00 and 18:00 etc. Median bat activity between the two red lines represents Medium risk.

6 IDENTIFICATION AND ASSESSMENT OF IMPACTS

Impacts to bats that are likely to occur because of the construction, operation and decommissioning of a wind and solar PV energy facility, and grid connection in the AoI are identified and assessed in the following sections. In preparing this impact assessment, the unit of analysis is the local bat community and their associated habitats within the PAOI. As such, impacts are not assessed relative to individual bats. For each impact identified in Section 6, the respective mitigation measures were categorised into those aimed at first avoiding impacts, then minimising impacts, and finally restoring areas impacted.

The primary mechanism to mitigate risks of the project to bats is to avoid impacts. The monitoring data showed that there is higher bat activity in proximity to habitat features such as tree clumps, buildings, dams/wetlands, and rivers/streams. These features are known to promote bat activity (e.g., Rydell 1992, Vaughan 1997, Sirami et al. 2013). Therefore, to avoid impacts, buffers of 200 m have been placed around these features as per best practice (Table 4). These buffered areas are No-Go for infrastructure placement, except for access and internal distribution roads and the OHL for practical reasons, to avoid and minimise impacts to bat habitats (see Figure 6 – Figure 8). Even though the OHL can cross No-Go areas, the pylon position themselves must be placed outside of No-Go areas. Therefore, the maximum possible span should be implemented to avoid the sensitive area while ensuring the technical feasibility of the development. The substations, operation and maintenance buildings, collectors, connectors, construction compounds, laydown areas, and batching plants must also avoid No-Go areas. The location of batching plant 2, the collector stations, the MTS overlaps slightly with No-Go areas and must be microsited and/or optimized.

Table 4: Features used to assign spatial risk categories in the AoI for bats (Chiroptera)

Risk Level		
Low	**Medium**	**No-Go**
Heavily modified land	CBA Optimal	Farm Dams
Moderately modified land	ESA Landscape corridor	Wetlands
	ESA Local corridor	Trees
	Other Natural Areas	Buildings
		Rivers/Streams
		Wetlands
		CBA Irreplaceable Areas

To avoid collision impacts, no part of the wind turbines, including the blade tips, shall intrude into the No-Go buffers. The turbine assessed in this report has a rotor diameter of 170 m RD and hub height of 150 m. Thus to ensure the turbine blades do not cross into the bat buffers an additional distance of 42 m must be added to the 200 m No-Go buffers, in line with Mitchell-Jones and Carlin (2014) and based on the following equation:

[Eq. 1]

$$b = \sqrt{(buffer + bl)^2 - (hh - fh)^2}$$

$$b = \sqrt{(200 + 85)^2 - (150 - 0)^2}$$

$$b = 242\ m$$

Where:
Buffer = 200 m
bl: Turbine blade length = 85 m
hh: Hub height = 150 m
fh: Feature height = 0 m

Six turbines in the proposed layout (Figure 6) are currently located within No-Go areas: WTG10, WTG61, WTG82, WTG88, WTG100, and WTG101. These turbines must be relocated into low and medium sensitivity areas. To address this overlap between project infrastructure and areas important for bats, the project has produced an optimised layout which avoids No-Go areas for bats (Figure 6). Therefore, the revised optimized turbine layout avoids all no-go areas and is acceptable.

An additional mitigation measure that is recommended to mitigate collision risk is to maximise the minimum blade sweep. The species principally at risk from the proposed wind farm is Cape serotine since the other five species were recorded less often. High risk was identified for this species at ground level (represented by 10 m). However, high risk for this species at ground level might not result in high risk in the rotor swept zone which is typically higher than 10 m. For example, at 60 m risk to Cape serotine is low (Table 3). This species is typically a clutter-edge species meaning it is adapted to use airspaces near the edge of vegetation, in vegetation gaps, near the ground, and above water (Schnitzler and Kalko 2001). This species does show flexibility in its behaviour and was recorded at 60 m and 120 m, away from these habitat features, albeit at a significantly lower magnitude than at 10 m (Figure 3). Activity is likely to decrease exponentially with height (Wellig et al. 2018) meaning risk would decrease from high at 10 m to low at 60 m. The size of the rotor swept area should account for this because the lower the blades sweep the ground, the higher risk they will present to bats. It is therefore recommended to maximise the minimum blade sweep height. Based on the assessed turbine, the minimum blade sweep is 65 m which is supported since risk to bats at this height is low (Table 3). Future changes to turbine dimensions during the projects development should maintain a minimum blade sweep of 30 m since it is likely bats would be a low to moderate risk at this height.

During operation, bat fatality monitoring must be undertaken to search for bat carcasses beneath wind turbines to measure the residual impact of the WEF on bats for a minimum of two years

(Aronson et al. 2020). Mitigation measures that are known to minimise bat fatality if needed based on the fatality monitoring results include curtailment and/or acoustic deterrents (Arnett et al. 2013, Romano et al. 2019, Weaver et al. 2020). These techniques must be used if post-construction fatality monitoring indicates that species fatality thresholds have been exceeded (MacEwan et al. 2018) to minimise impacts, maintain the impacts to bats within acceptable limits of change and prevent declines in the impacted bat population. The bat fatality thresholds for the project were determined as follows:

(a) Annual fatality threshold per 10 ha = 0.2[2]

(b) Turbine area of influence (ha) = 17,637.70[3]

(c) Annual fatality threshold per LC species = (a) x [(b)/10]

= 353 individuals[4]

Thus, according to the threshold guidance (MacEwan et al. 2018), the bias-adjusted threshold fatality value is 353 individuals per least concern (LC) bat species per annum. Should this be exceeded, curtailment and/or acoustic deterrents must be used to reduce fatality levels to below the threshold. For frugivorous bats, conservation important or rare/range restricted bats, i.e., Species of Special Concern (SSC), the annual fatality threshold is 1 individual. This threshold is relevant to five bat species at the project although these all have a low likelihood occurrence:

(d) Annual fatality threshold per SSC = 1 individual

African Straw-coloured fruit bat
Wahlberg's Epauletted fruit bat
Percival's Short-eared Trident bat
Blasius's Horseshoe bat
Egyptian Rousette

To avoid impacts due to light pollution from the substation and operation and maintenance buildings, and polarized light pollution from solar PV panels, this infrastructure must not be constructed within the No-Go buffers. This will increase the distance between this infrastructure and bat habitats, avoiding the impact as much as possible. Solar PV panels inadvertently attract aquatic insects by the horizontally polarized light they reflect because they appear to be bodies of water (Horváth et al. 2010, Fritz et al. 2020). This can have negative impacts on ecological processes including on bat-insect interactions, especially those feeding on aquatic insects, if critical life-history functions of these insects (e.g., egg deposition) is disrupted. For this reason, Száz et al. (2016) suggest that the strategic development of solar panels away from water bodies may be beneficial. This has been achieved since no solar PV panels will be located in No-Go Areas (Figure 7) and hence the location of the solar PV facility is acceptable in terms of impacts to bats. However, effects from lighting and solar PV panels might still impact bats and insects depending on the intensity. This can be minimised by using motion-sensor lighting, minimising sky-glow by using hoods, and by using low pressure sodium lights at the substation and operation and maintenance buildings.

To align with regional conservation and integrated development planning, the Mpumalanga Biodiversity Sector Plan Handbook (MTPA 2014) was consulted to further define spatial risk in the AoI. The intention here was to align biodiversity conservation policy objectives with renewable energy policy objectives, attempting to minimise trade-offs between conflicting goals (Jackson 2011, Gasparatos et al. 2017). The handbook includes a map of terrestrial areas that are important for conserving biodiversity and ecological processes – Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) respectively. CBA Irreplaceable Areas were categorised as No-Go areas (Figure 6) because the conservation goals for these areas are to maintain them in a natural state with no loss of ecosystems, functionality or species, and with

[2] Based on reference value for Drakensberg Montane Grasslands, Woodlands and Forest in MacEwan et al. (2018).
[3] See Figure 1 for delineated Area of Influence.
[4] This threshold must be compared to the unbiased annual bat fatality estimate generated as part of the post-construction fatality monitoring program.

no flexibility in land-use options (MTPA 2014). To ensure no turbine blades cross into these spaces, they were buffered by 42 m according to [Eq. 1]. The remaining areas were assigned low or medium risk where all infrastructure development should be prioritized. These included modified land, ESA, CBA optimal, and other Natural Areas (Table 4). Although the primary objective of the CBA optimal areas is to maintain these spaces in a natural state with no loss of ecosystems, functionality or species, some flexibility in land-use options is permitted (MTPA 2014). Similarly, in ecological supports areas (ESAs), the objective is to maintain habitats in a natural, or near-natural, state with limited loss of ecosystems or functionality. Hence, these areas were classified as medium risk, permitting the siting of turbines in these spaces. All turbines will be subjected to a post-construction bat fatality monitoring program which will monitor residual impacts at turbines located in CBA optimal and ecological support areas, as well as turbines in low-risk areas. The results of this monitoring will inform management actions where needed to ensure alignment with the MTPA objectives to limit impacts to biodiversity.

6.1 Wind Energy Facility

Wind farms impact bats directly because bats collide with spinning wind turbine blades (Horn et al. 2008), and indirectly through the modification of habitats, including disturbance or destruction of roosting, foraging and commuting spaces and light pollution (Kunz et al. 2007b; Millon et al. 2018).

6.1.1 Construction Phase

Impact: **MODIFICATION OF BAT HABITAT (ROOSTING, FORAGING, COMMUTING)**			
Nature: Vegetation clearing for access roads, turbines and their service areas and other infrastructure, as well as noise and dust generated during the construction phase, will impact bats by removing habitat used for foraging and commuting, through disturbance, and displacement (Kunz et al. 2007b, Millon et al. 2018, Bennun et al. 2021). This impact is likely to have species specific effects; clutter edge species (e.g., Cape serotine) are more likely to be impacted by habitat modification given their greater association with physical habitat features compared to high-flying species (e.g., Egyptian free-tailed bat). Construction of WEF infrastructure could result in destruction (direct impact) of bat roosts (trees, buildings) and disturbance (indirect impact) of bat roosts potentially resulting in roost abandonment. Bat mortality can occur if roosts which contain bats are destroyed. Installation of new infrastructure in the landscape (e.g., buildings, turbines, road culverts) can inadvertently provide new roosting spaces for some bat species, attracting them to areas with wind turbines and potentially increasing the likelihood of collisions.			
	Rating	Motivation	Significance
Prior to Mitigation			
Duration	Short-term (2)	The impact will persist for the duration of the construction period, but displacement could persist for the duration of operation.	Low Negative (24)
Extent	Site (1)	The impact will be limited to the site of development.	
Magnitude	Low (5)	Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat. Roosts are critical for bat life history thus impacts to roosts could impact on ecological processes. However, no major confirmed roosts have been found within the AoI and hence it is unlikely this impact will have a high magnitude.	
Probability	Probable (3)	The responses of bats to habitat modification due to wind turbines is largely understudied but it is reasonable to assume that there will be some level of	

<table>
<tr><td></td><td></td><td>species-specific displacement effect [e.g., Millon et al. (2018)].

Since no confirmed roosts have been located, it is unlikely that this impact will occur.</td><td></td></tr>
<tr><td colspan="4">Mitigation/Enhancement Measures</td></tr>
<tr><td colspan="4">Mitigation:
Avoid:
Limit potential for bats to roost in project infrastructure (e.g., buildings, turbines, road culverts) by ensuring they are properly sealed such that bats cannot gain access.

No construction activities at night.

No placement of infrastructure (except roads) within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams (see No-Go Areas in Figure 6). Relocate WTG10, WTG61, WTG82, WTG88, WTG100, and WTG101. The construction compounds, laydown areas, and batching plants must also avoid No-Go areas.

Minimise:
Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees, and where this is required, these features should be examined for roosting bats. This study assumes that all buildings and trees are potentially roosts and must be buffered by 200 m since numerous species (Table 2) use these features for roosting.

Apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during construction.

Restore:
Rehabilitate all areas disturbed during construction, (including aquatic habitat).</td></tr>
<tr><td colspan="4">Post Mitigation/Enhancement Measures</td></tr>
<tr><td>Duration</td><td>Short-term (2)</td><td>Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.</td><td rowspan="4">Low Negative (12)</td></tr>
<tr><td>Extent</td><td>Site (1)</td><td>Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.</td></tr>
<tr><td>Magnitude</td><td>Low (3)</td><td>The application of the mitigation measures may lower the magnitude of impact but not remove it completely.</td></tr>
<tr><td>Probability</td><td>Improbable (2)</td><td>The application of the mitigation measures may lower the probability of impact but not remove it completely.

Since no confirmed roosts have been located, no buildings will be destroyed, and potential roosting spaces are buffered by 200 m, it is unlikely that this impact will occur.</td></tr>
<tr><td colspan="4">Residual Impact:
After the application of the mitigation measures, the residual impact of habitat modification should be relatively low because the amount of habitat lost will be low compared to remaining habitat for bats in the PAOI. Further, the application of buffers to key bat habitats should limit the impact of habitat loss, displacement and disturbance since some bat species (e.g., Cape serotine) would still be able to access favourable spaces (e.g., commuting along drainage networks which are buffered and hence providing relatively safe passage between turbines).

Despite undertaking roost surveys, no roosting bats were discovered but it is highly likely bats are roosting in buildings within the AoI since other roosting spaces are limited. Hence some residual impact could occur to unidentified roosts.</td></tr>
</table>

6.1.2 Operational Phase

<table>
<tr><th colspan="4">Impact:
BAT FATALITY</th></tr>
<tr><td colspan="4">Nature:
Bat mortality (direct impact) through collisions and/or barotrauma with wind turbine blades is the principal impact of wind energy facilities on bats (Cryan and Barclay 2009, Arnett et al. 2016).</td></tr>
<tr><th></th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Prior to Mitigation</td></tr>
<tr><td>Duration</td><td>Long term (4)</td><td>The impact will persist for the duration of the operation of the wind farm.</td><td rowspan="4">Medium Negative (52)</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>The impact will mainly be limited to the site of development, but bats can be attracted to (Richardson et al. 2021, Guest et al. 2022), or move through, the wind farm from beyond the site.</td></tr>
<tr><td>Magnitude</td><td>Moderate (6)</td><td>Median bat passes per hour ranged from low to high risk, varying spatially and temporally. Given the limitations of acoustic monitoring (Lintott et al. 2016, Voigt et al. 2021) it is reasonable to assume a moderate impact overall.</td></tr>
<tr><td>Probability</td><td>Highly Probable (4)</td><td>Bat fatality has been reported at all wind farms where this has been investigated in South Africa thus it is highly probably bat fatality will occur at the wind farm.</td></tr>
<tr><td colspan="4">Mitigation/Enhancement Measures</td></tr>
<tr><td colspan="4">Mitigation:
<u>Avoid:</u>
No placement of turbines within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams (see No-Go Areas in Figure 6) to reduce spatial overlap between bats and wind turbines. Relocate WTG10, WTG61, WTG82, WTG88, WTG100, and WTG101.

Maintain a minimum blade sweep of 30 m to avoid impacts to lower flying bats such as clutter-edge species (e.g., Cape serotine, Natal long-fingered bat).

<u>Minimise:</u>
- Implement fatality monitoring throughout the operational phase and apply curtailment or deterrents if fatality thresholds are exceeded. A Biodiversity Management Plan (BMP) for bats must be developed which includes the design of a post-construction fatality monitoring program (PCFM) for bats, and an adaptive management response plan that provides an escalating scale of mitigation (e.g., curtailment) should fatality thresholds be exceeded.</td></tr>
<tr><td colspan="4">Post Mitigation/Enhancement Measures</td></tr>
<tr><td>Duration</td><td>Long term (4)</td><td>The impact will persist for the duration of the operation of the wind farm.</td><td rowspan="4">Low Negative (20)</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>The impact will mainly be limited to the site of development, but bats can be attracted to (Richardson et al. 2021, Guest et al. 2022), or move through, the wind farm from beyond the site.</td></tr>
<tr><td>Magnitude</td><td>Low (3)</td><td>Mitigation measures for bats (e.g., curtailment) have consistently been shown to be effective in reducing bat fatality (Adams et al. 2021) hence the magnitude of impacts will be lower through its application.</td></tr>
<tr><td>Probability</td><td>Improbable (2)</td><td>The application of the mitigation measures may lower the probability of impact but not remove it completely.</td></tr>
<tr><td colspan="4">Residual Impact:
The application of mitigation measures, specifically curtailment, can reduce bat fatality but not completely remove the risk. Hence, some residual risk is expected but this is likely to be within acceptable limits of change, particularly through the use of fatality thresholds (MacEwan et al. 2018).</td></tr>
</table>

6.1.3 Decommissioning Phase

Impact: MODIFICATION OF BAT HABITAT			
Nature: Impacts during the decommissioning phase will be indirect and involve disturbance to bats through excessive noise and dust, and damage to vegetation.			
	Rating	Motivation	Significance
Prior to Mitigation			
Duration	Short-term (2)	The impact will persist for the duration of the decommissioning phase.	Low Negative (14)
Extent	Site (1)	The impact will be limited to the site of development.	
Magnitude	Low (4)	Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat. Most decommissioning activities will take place during daylight hours when bats are not active, lessening the impact magnitude.	
Probability	Improbable (2)	Decommissioning activities will probably not impact bats	
Mitigation/Enhancement Measures			
Mitigation: Avoid: No decommissioning activities at night. Minimise: Apply good abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during decommissioning. Restore: Rehabilitate all areas disturbed during throughout the operation of the project (including aquatic habitat).			
Post Mitigation/Enhancement Measures			
Duration	Short-term (2)	Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.	Low Negative (5)
Extent	Site (1)	Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.	
Magnitude	Minor (2)	The application of the mitigation measures will likely result in limited impacts to bats.	
Probability	Very Improbable (1)	Decommissioning activities are very unlikely to impact bats with mitigation.	
Residual Impact: There are unlikely to be major residual impacts because of decommissioning activities on site provided habitat restoration is implemented successfully.			

6.2 Solar PV Facility

Although birds fatally collide with solar PV panels (Visser et al. 2019, Bennun et al. 2021), there is limited evidence that this occurs with bats. Bats may collide with solar panels while attempting to drink from the smooth panel surfaces, which acoustically resemble water (Greif and Siemers 2010). Impacts of solar PV infrastructure to bats are largely indirect and include destruction and modification of habitat, habitat fragmentation, barrier effects, and polarized light pollution (Horváth et al. 2010, Lovich and Ennen 2011, Bennun et al. 2021).

6.2.1 Construction Phase

Impact: MODIFICATION OF BAT HABITAT

<table>
<tr><td colspan="4">Nature:

Solar panels and their supporting infrastructure are thought to have a barrier effect on normal bat foraging behaviour, which can exclude bats from accessing areas of suitable habitat. Vegetation clearing for access roads, solar panels and their service areas and other infrastructure, as well as noise and dust generated during the construction phase, will impact bats by removing habitat used for foraging and commuting, through disturbance, and displacement (Kunz et al. 2007b, Millon et al. 2018, Bennun et al. 2021). This impact is likely to have species specific effects; clutter edge species (e.g., Cape serotine) are more likely to be impacted by habitat modification given their greater association with physical habitat features compared to high-flying species (e.g., Egyptian free-tailed bat).

Construction of PV infrastructure could result in destruction (direct impact) of bat roosts (trees, buildings) and disturbance (indirect impact) of bat roosts potentially resulting in roost abandonment. Bat mortality can occur if roosts which contain bats are destroyed. Installation of new infrastructure in the landscape (e.g., buildings, road culverts) can inadvertently provide new roosting spaces for some bat species, attracting them to areas with wind turbines[5] and potentially increasing the likelihood of collisions.</td></tr>
<tr><th></th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Prior to Mitigation</td></tr>
<tr><td>Duration</td><td>Short-term (2)</td><td>The impact will persist for the duration of the construction period, but displacement could persist for the duration of operation.</td><td rowspan="4">Low Negative (24)</td></tr>
<tr><td>Extent</td><td>Site (1)</td><td>The impact will be limited to the site of development.</td></tr>
<tr><td>Magnitude</td><td>Low (5)</td><td>Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat.

Roosts are critical for bat life history thus impacts to roosts could impact on ecological processes. However, no confirmed roosts have been found within the AoI and hence it is unlikely this impact will have a high magnitude.</td></tr>
<tr><td>Probability</td><td>Probable (3)</td><td>The responses of bats to habitat modification due to solar panels is largely understudied but it is reasonable to assume that there will be some level of species-specific effect (e.g., (Millon et al. 2018).</td></tr>
<tr><td colspan="4">Mitigation/Enhancement Measures</td></tr>
<tr><td colspan="4">Mitigation:
<u>Avoid:</u>
Limit potential for bats to roost in project infrastructure (e.g., buildings, road culverts) by ensuring they are properly sealed such that bats cannot gain access.

No construction activities at night, no placement of infrastructure (except roads) within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams (see No-Go Areas in Figure 7). The construction compounds, laydown areas, and batching plants must also avoid No-Go areas.

<u>Minimise:</u>
Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees, and where this is required, these features should be examined for roosting bats. This study assumes that all buildings and trees are potentially roosts and must be buffered by 200 m since numerous species (Table 2) use these features for roosting.

Apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during construction.

<u>Restore:</u></td></tr>
</table>

[5] Although the solar PV panels do not present a collision risk to bats, should bats search for roosting opportunities associated with this new infrastructure this may bring them into the vicinity of wind turbines since the solar PV and wind energy facilities will be installed within the same AoI.

Rehabilitate all areas disturbed during construction, (including aquatic habitat).			
Post Mitigation/Enhancement Measures			
Duration	Short-term (2)	Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.	Low Negative (12)
Extent	Site (1)	Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.	
Magnitude	Low (3)	The application of the mitigation measures may lower the magnitude of impact but not remove it completely.	
Probability	Improbable (2)	The application of the mitigation measures may lower the probability of impact but not remove it completely. Since no confirmed roosts have been located, no buildings will be destroyed, and potential roosting spaces are buffered by 200 m, it is unlikely that this impact will occur.	
Residual Impact: After the application of the mitigation measures, the residual impact of habitat modification should be relatively low because the amount of habitat lost will be low compared to remaining habitat for bats in the PAOI. Further, the application of buffers to key bat habitats should limit the impact of habitat loss, disturbance, and displacement since some bat species (e.g., Cape serotine) would still be able to access favourable spaces (e.g., commuting along drainage networks which are buffered) and bat can still forage among solar panels. Despite undertaking roost surveys, no roosting bats were discovered but it is highly likely bats are roosting in buildings within the AoI since other roosting spaces are limited. Undiscovered roosts in unbuffered areas may be unknowingly destroyed during construction.			

6.2.2 Operational Phase

Impact: **POLARIZED LIGHT POLLUTION**			
Nature: Solar PV panels cause polarized light pollution, potentially altering bat-insect interactions. Polarized light attracts polarotactic insects (particularly aquatic insects) which may in turn attract bats, bringing them into the vicinity of the project and indirectly increase the risk of collision with wind turbines (since solar panels will be placed in the vicinity of wind turbines).			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	Long term (4)	The impact will persist for the duration of the operation of the solar PV farm.	**Medium Negative (33)**
Extent	Local (2)	The impact will be limited to the site of development, but light effects from solar panels can occur beyond the site.	
Magnitude	Low (5)	Polarized light pollution is an understudied impact, but has been demonstrated to impact ecological processes (Horváth et al. 2009, Horváth et al. 2010)	
Probability	Probable (3)	Given the confirmed presence of bats in the AoI and degree of available aquatic habitat, it is probable this impact could occur.	
Mitigation/Enhancement Measures			
Mitigation: Avoid:			

No placement of solar PV panels within 200 m of aquatic habitat (see No-Go Areas in Figure 7). Minimise: Bennun et al. (2021) recommend placing non-polarising white tape around and/or across panels to minimise reflection which can attract aquatic insects.			
Post Mitigation/Enhancement Measures			
Duration	Long term (4)	Even with mitigation, the impact will persist for the duration of the operation of the wind farm.	Low Negative (18)
Extent	Site (1)	With mitigation, sky glow can possibly be reduced to the site.	
Magnitude	Low (4)	The application of the mitigation measures may lower the magnitude of impact but not remove it completely.	
Probability	Improbable (2)	The application of the mitigation measures may lower the probability of impact but not remove it completely.	
Residual Impact: Residual impacts of ecological light pollution are likely to be low and acceptable since the recommended mitigation measures have been shown to be effective for bats (Stone et al. 2015). However, unintended ecosystem effects could still occur because of the disrupted ecological dynamics.			

6.2.3 Decommissioning Phase

Impact: MODIFICATION OF BAT HABITAT			
Nature: Impacts during the decommissioning phase will be indirect and involve disturbance to bats through excessive noise and dust, and damage to vegetation.			
	Rating	Motivation	Significance
Prior to Mitigation			
Duration	Short-term (2)	The impact will persist for the duration of the decommissioning phase.	Low Negative (12)
Extent	Site (1)	The impact will be limited to the site of development.	
Magnitude	Minor (3)	Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat. Most decommissioning activities will take place during daylight hours when bats are not active, lessening the impact magnitude.	
Probability	Improbable (2)	Decommissioning activities will probably not impact bats	
Mitigation/Enhancement Measures			
Mitigation: Avoid: No decommissioning activities at night. Minimise: Apply good abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during decommissioning. Restore: Rehabilitate all areas disturbed throughout the operation of the facility (including aquatic habitat).			
Post Mitigation/Enhancement Measures			
Duration	Short-term (2)	Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.	Low Negative (5)

Extent	Site (1)	Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.	
Magnitude	Minor (2)	The application of the mitigation measures will likely result in limited impacts to bats.	
Probability	Very Improbable (1)	Decommissioning activities are very unlikely to impact bats with mitigation.	
Residual Impact: There are unlikely to be major residual impacts because of decommissioning activities on site provided habitat restoration is implemented successfully.			

6.3 Grid Connection

The direct impact of grid connection infrastructure is collisions with powerlines. Insectivorous bats are unlikely to collide with powerlines since they can avoid these obstacles using echolocation but fruit bats do collide with powerlines (Tella et al. 2020), although the likelihood of occurrence for fruit bats species in the AoI is low (Table 2). Indirect impacts include loss of habitat to construct substations and OHL pylons, and ecological light pollution (Longcore and Rich 2004).

6.3.1 Construction Phase

Impact: **MODIFICATION OF BAT HABITAT**			
Nature: Vegetation clearing for grid connection infrastructure (access roads, substation buildings, pylons), as well as noise and dust generated during the construction phase, will impact bats by removing habitat used for foraging and commuting, through disturbance, and displacement (Kunz et al. 2007b, Millon et al. 2018, Bennun et al. 2021). This impact is likely to have species specific effects; clutter edge species (e.g., Cape serotine) are more likely to be impacted by habitat modification given their greater association with physical habitat features compared to high-flying species (e.g., Egyptian free-tailed bat). Construction of grid connection infrastructure could result in destruction (direct impact) of bat roosts (trees, buildings) and disturbance (indirect impact) of bat roosts potentially resulting in roost abandonment. Bat mortality can occur if roosts which contain bats are destroyed. Installation of new infrastructure in the landscape (e.g., buildings, road culverts) can inadvertently provide new roosting spaces for some bat species, attracting them to areas with wind turbines[6] and potentially increasing the likelihood of collisions.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	Short-term (2)	The impact will persist for the duration of the construction period, but displacement could persist for the duration of operation.	Low Negative (14)
Extent	Site (1)	The impact will be limited to the site of development.	
Magnitude	Low (4)	Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat. Roosts are critical for bat life history thus impacts to roosts could impact on ecological processes. However, no confirmed roosts have been found within the AoI and hence it is unlikely this impact will have a high magnitude.	

[6] Although the grid connection infrastructure does not present a collision risk to non-fruit bats, should bats search for roosting opportunities associated with this new infrastructure this may bring them into the vicinity of wind turbines.

Probability	Improbable (2)	The application of the mitigation measures may lower the probability of impact but not remove it completely.	
Mitigation/Enhancement Measures			
Mitigation: Avoid: Limit potential for bats to roost in project infrastructure (e.g., buildings, road culverts) by ensuring they are properly sealed such that bats cannot gain access. No construction activities at night, no placement of pylons within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams (see No-Go Areas in Figure 8). The OHL itself is permitted to cross over No-Go Areas for practical routing reasons but pylon positions must avoid No-Go Areas. Therefore the maximum possible span should be implemented to avoid the sensitive area while ensuring the technical feasibility of the development. The construction compounds, laydown areas, and batching plants must also avoid No-Go areas. Minimise: Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees, and where this is required, these features should be examined for roosting bats. This study assumes that all buildings and trees are potentially roosts and must be buffered by 200 m since numerous species (Table 2) use these features for roosting. Apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during construction. Restore: Rehabilitate all areas disturbed during construction, (including aquatic habitat).			
Post Mitigation/Enhancement Measures			
Duration	Short-term (2)	Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.	**Low Negative (6)**
Extent	Site (1)	Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.	
Magnitude	Low (3)	The application of the mitigation measures may lower the magnitude of impact but not remove it completely.	
Probability	Very Improbable (1)	The application of the mitigation measures may lower the probability of impact but not remove it completely. Since no confirmed roosts have been located, no buildings will be destroyed, and potential roosting spaces are buffered by 200 m, it is unlikely that this impact will occur.	
Residual Impact: After the application of the mitigation measures, the residual impact of habitat modification should be relatively low because the amount of habitat lost will be low compared to remaining habitat for bats in the PAOI. Further, the application of buffers to key bat habitats should limit the impact of habitat loss, disturbance, and displacement since some bat species (e.g., Cape serotine) would still be able to access favourable spaces (e.g., commuting along drainage networks which are buffered) and bat can still forage among solar panels. Despite undertaking roost surveys, no roosting bats were discovered but it is highly likely bats are roosting in buildings within the AoI since other roosting spaces are limited. Undiscovered roosts in unbuffered areas may be unknowingly destroyed during construction.			

6.3.2 Operational Phase

Impact:

LIGHT POLLUTION			
Nature: Construction of grid infrastructure will increase ecological light pollution from artificial lighting associated with the substation and other operational and maintenance buildings. Light pollution can alter ecological dynamics (Horváth et al. 2009). Lighting attracts and can cause direct mortality of insects, reducing the prey base for bats, especially bat species that are light-phobic. These species may also be displaced from previous foraging areas due to lighting. Other bat species forage around lights, attracted by higher numbers of insects. This may bring these species into the vicinity of the project and indirectly increase the risk of collision with wind turbines.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	Long term (4)	The impact will persist for the duration of the operation of the wind farm.	**Medium Negative (44)**
Extent	Local (2)	The impact will be limited to the site of development, but sky glow can occur beyond the site depending on the scale and intensity of lighting used.	
Magnitude	Low (5)	Light pollution is an understudied impact, but it is likely that ecological processes may be disturbed. However, given the small scale of lighting that will be used at the project, the magnitude is predicted to be low.	
Probability	Highly Probable (4)	Effects of light pollution have been demonstrated for bats (Rydell 1992, Svensson and Rydell 1998, Stone et al. 2009), thus it is probable that the impact will occur.	
Mitigation/Enhancement Measures			
Mitigation: Avoid: No placement of substations and operational and maintenance buildings within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams (see No-Go Areas in Figure 8). Minimise: Use as little lighting as possible, maximise use of motion-sensor lighting, avoid sky-glow by using hoods, increase spacing between lighting units, and use low pressure sodium lights (Rydell 1992, Stone 2012).			
Post Mitigation/Enhancement Measures			
Duration	Long term (4)	Even with mitigation, the impact will persist for the duration of the operation of the grid infrastructure.	**Low Negative (16)**
Extent	Site (1)	With mitigation, sky glow can possibly be reduced to the site.	
Magnitude	Low (3)	The application of the mitigation measures may lower the magnitude of impact but not remove it completely.	
Probability	Improbable (2)	The application of the mitigation measures may lower the probability of impact but not remove it completely.	
Residual Impact: Residual impacts of ecological light pollution are likely to be low and acceptable since the recommended mitigation measures have been shown to be effective for bats (Stone et al. 2015). However, unintended ecosystem effects could still occur because of the disrupted ecological dynamics.			

6.3.3 Decommissioning Phase

Impact: **MODIFICATION OF BAT HABITAT**
Nature:

Impacts during the decommissioning phase will be indirect and involve disturbance to bats through excessive noise and dust, and damage to vegetation.			
	Rating	Motivation	Significance
Prior to Mitigation			
Duration	Short-term (2)	The impact will persist for the duration of the decommissioning phase.	Low Negative (12)
Extent	Site (1)	The impact will be limited to the site of development.	
Magnitude	Minor (3)	Given the limited habitat modification relative to remaining habitat this impact is likely to only cause a slight impact on processes as bats will find alternative habitat. Most decommissioning activities will take place during daylight hours when bats are not active, lessening the impact magnitude.	
Probability	Improbable (2)	Decommissioning activities will probably not impact bats	
Mitigation/Enhancement Measures			
Mitigation: Avoid: No decommissioning activities at night. Minimise: Apply good abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste) created during decommissioning. Restore: Rehabilitate all areas disturbed during throughout the operation of the grid connection infrastructure (including aquatic habitat).			
Post Mitigation/Enhancement Measures			
Duration	Short-term (2)	Even with mitigation, the impact will still occur for the same duration hence there is no reduction in the quantified effect.	Low Negative (5)
Extent	Site (1)	Even with mitigation, the impact will still occur across the same extent hence there is no reduction in the quantified effect.	
Magnitude	Minor (2)	The application of the mitigation measures will likely result in limited impacts to bats.	
Probability	Very Improbable (1)	Decommissioning activities are very unlikely to impact bats with mitigation.	
Residual Impact: There are unlikely to be major residual impacts because of decommissioning activities on site provided habitat restoration is implemented successfully.			

6.4 Cumulative Impacts

For the purposes of the cumulative impact assessment (CIA), cumulative impacts are defined as the total impacts resulting from the successive, incremental, and/or combined effects of a project when added to other existing, planned and/or reasonably anticipated future projects, as well as background pressures (IFC 2013). The project considered here is the Ummbila Emoyeni Renewable Energy Facility, consisting of wind turbines, solar PV panels and the infrastructure needed to connect these technologies to the distribution and transmission grid. The goal of this assessment was to evaluate the potential resulting impact to the vulnerability and/or risk to the sustainability of the bat species affected (IFC 2013).

6.4.1 Step 1: VECs and spatial-temporal boundary

Following guidance in IFC (2013), the first step in the CIA was to determine the Valued Environmental Components (VECs), the bat species most likely to be affected by cumulative impacts, and the temporal and geographic scope of the analysis. Of the species recorded in the AoI during the acoustic monitoring, and based on bat distribution records (ACR 2020), Cape serotine (*Laephotis capensis*), Egyptian free-tailed bat (*Tadarida aegyptiaca*) and Natal long-fingered bat (*Miniopterus natalensis*) are most likely to be impacted cumulatively. This is because they are the most widespread bat species in South Africa (Monadjem et al. 2020), classified as high risk species to wind energy impacts (MacEwan et al. 2020b), and the most impacted by operating wind energy facilities in the country (Aronson 2022).

Two nationally threatened species may also be impacted cumulatively; the Near-Threatened Blasius's Horseshoe bat (*Rhinolophus blasii*) and the Endangered Percival's Short-eared Trident bat (*Cloeotis percivali*). However, neither species have been confirmed for the AoI but both are rare and difficult to sample (Child et al. 2016). Nonetheless, the PAOI does not meet the habitat requirements for these species; Savannah woodlands and roosting sites such as caves or mines. Both are considered to be at low risk of collision impacts (MacEwan et al. 2020b). Because they are unlikely to be present on site, and are at low collision risk, this CIA does not consider these two species as VECs. However, because both species are sensitive to habitat disturbance and habitat loss (Child et al. 2016), impacts to them will be managed using the annual fatality threshold for Species of Special Concern (SSC), which is 1 individual annually.

For both wind and solar energy, the temporal time frame over which cumulative impacts are considered was 25 years, the typical lifespan of a renewable energy facility. However, cumulative effects could extend beyond this timeframe since development is phased over time.

The Ecologically Appropriate Area of Analysis (EAAA) for the assessment was determined by considering the ecology of the identified species likely to be affected. The acoustic monitoring confirmed the presence of Natal long-fingered bat in the PAOI, a migratory species which moves seasonally between winter hibernacula and summer maternity cave roosts in South Africa (van der Merwe 1975, Miller-Butterworth et al. 2003). In north-eastern South Africa, where the proposed development is planned, van der Merwe (1975) showed migration between maternity caves in Limpopo and hibernacula caves in Gauteng/North-West undertaken by pregnant females (who later return south with weaned pups), with caves separated by 150 km at least. Males typically undertake shorter movements (> 60 km) between various highveld caves (van der Merwe 1975). This migration increases the potential that these bats will encounter wind turbines, or be displaced by them (Millon et al. 2018), especially if these are placed along migratory routes. Although these movements are typically north-south, Pretorius et al. (2020) suggest that movement could also occur east-west between Gauteng and a maternity cave in Sudwala, Mpumalanga, a distance of approximately 250 km. Although additional research is needed to better understand long and short distance movements of Natal long-fingered bat in South Africa more precisely, given the numerous roost sites (both caves and mines) in Mpumalanga and body of work already demonstrating or suggesting migratory behaviour in the north-east of the country between these sites, it is reasonable that cumulative impacts of wind energy may impact this species at large scales and hence cumulative impacts need to be assessed accordingly. Based on van der Merwe (1975), a 150 km radius around the PAOI was therefore defined as EAAA1 (Figure 9), especially since cumulative impacts should be evaluated across scales potentially affected species are likely to occur (Voigt et al. 2012, Lehnert et al. 2014).

The remaining VECs are not migratory and hence a second, smaller EAAA was used. Data on the spatial ecology of the Egyptian free-tailed bat and Cape serotine, specifically the sizes of their foraging or community ranges, are not available. Data from European free-tailed bat, *Tadarida teniotis*, in Portugal (Marques et al. 2004) and Serotine bat, *Eptesicus serotinus*, in England (Robinson and Stebbings 1997) were used as surrogates. Feeding areas for some *T. teniotis* individuals were over 30 km from their roost while the maximum distance between *E. serotinus* feeding areas was over 41 km. CIA in South African typically consider developments within a radius of 35 km which therefore is potentially in line with the movement ecology of the Egyptian free-tailed bat and Cape serotine. Hence the EAAA2, specific for these two species, was a 35 km radius around the PAOI (Figure 9).

6.4.2 Step 2: Other Activities and External Drivers

The second step in the CIA was to identify other past, existing, or planned activities within EAAA1 and EAAA2 and to assess the external influences and stressors on the three VECs. With reference to the Renewable Energy Application database (Q1, 2022), currently 39 and 3 approved or in process renewable energy projects are located within EAAA1 and EAAA2 respectively (Figure 9). This is likely to be higher since the database only considers logged applications and those in the early development stages are not included. Camissa is aware of at least an additional three such developments planned for Mpumalanga within EAAA1. Given that EAAA1 also includes a Renewable Energy Development Zone (REDZ), it is reasonable to expect further development over the 25-year period considered in this assessment. The REDZ provides policy support for renewables growth and although the Emalahleni REDZ is designated for solar energy (DEFF 2019) which has lower impacts on the VECs, its existence creates an enabling environment for wind energy development as well. As such, at least a moderate level of wind energy development can be expected over the following 25 years in both EAAAs.

There are no documented major past threats to Egyptian free-tailed bat and Cape serotine or current threats to them other than renewable energy (Child et al. 2016). Hence this CIA considers renewable energy the primary impact to these VECs. Natal long-fingered bat is locally threatened in parts of its range by habitat loss resulting from conversion of land to agricultural use, incidental poisoning with insecticides, loss of prey base, and the disturbance of roosting and maternity caves (Child et al. 2016).

6.4.3 Step 3: Baseline Status of VECs

Egyptian free-tailed bat is very widely distributed, locally common and recorded from many protected areas in South Africa however, although the population is stable, the population size is unknown (Child et al. 2016). It is classified as Least Concern nationally and globally. This species is present in the AoI and based on its activity levels, it is at medium risk of collision during autumn, spring, and summer. It is flexible in its habitat requirements and one reason for its wide distribution is its affinity to roost in buildings or other man-made structures (Monadjem et al. 2020).

Cape serotine is also widely distributed in South Africa with a large population and hence is classified as Least Concern nationally and globally. However, it is possible that this species comprises a complex of closely related species (Monadjem et al. 2020). The population trend is stable, but the population size is unknown. Although this species is present in the AoI, and its activity levels suggest high risk of collision, this species was seldomly recorded at 60 m and 120 m. Cape serotine is also flexible in its habitat requirements and its use of buildings and other anthropogenic structures as roosts has possibly led to its numbers increasing.

Natal long-fingered bat is a common and widespread species, classified as Least Concern nationally and globally with a stable national population, but it may be experiencing local declines (Child et al. 2016). The size of the national population is unknown but this species roosts in large colonies; De Hoop Guano cave in the Western Cape hosts approximately 200,000 individuals, and in the Highveld, some caves may contain up to 4000 individuals (Child et al. 2016). Activity levels of this species in the AoI were relatively low and this species was seldomly recorded at height (60 m and 120 m).

6.4.4 Step 4: Assess Cumulative Impacts on VECs

The key potential impacts and risks that could affect the long-term sustainability and/or viability of the Egyptian free-tailed bat and Cape serotine in EAAA2 are collisions with wind turbines. This may lead to local extinctions and fragmentation of the national population since bats have low reproductive rates (Barclay and Harder 2003). For Natal long-fingered bat, key risks include collisions with wind turbines blades, but also displacement along migratory routes due to wind turbines (Millon et al. 2018), and impacts to roosting sites within EAAA1, which may also lead to local or regional extinctions and population fragmentation. This species shows strong philopatry which means that should a colony be lost or destroyed, it may not be repopulated from other areas, potentially leading to local extinction (Miller-Butterworth et al. 2003).

6.4.5 Step 5: Assess Significance of Predicted Cumulative Impacts

Rodhouse et al. (2019), Davy et al.(2020) and Frick et al. (2017) have all shown that in North America, Least Concern bats may be experiencing impacts due to wind farms that could result in changes to their conservation status. This may be a future scenario for widespread, common Least Concern bats species in South Africa. As such, the significance of cumulative impacts is assessed as High, especially for Natal long-fingered bat as it is possible that the project will result in an unacceptable loss to local bat populations.

	Overall impact of the proposed project considered in isolation	Cumulative impact of the project and other projects in the area
Extent	Site (1)	Regional (5)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	High (9)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (33)**	**High (72)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes (see Section 7)	Yes (see Section 7)
Confidence in findings: Medium		

6.4.6 Step 6: Management of Cumulative Impacts

Management interventions for bats at operating wind farms in South Africa are benchmarked against fatality thresholds. These thresholds attempt to manage impacts to bats by considering potential population level effects, with the threshold values set below the rate at which populations may decline due to anthropogenic pressures (MacEwan et al. 2018). Thresholds have been set for this project and these should be determined for all other future wind energy developments. In theory, should each individual development apply thresholds and appropriate mitigation measures if these are exceeded, the EAAA1 and EAAA2 VEC populations may not decline.

The mitigation measures proposed in this report include buffering key habitats used by bats, use of appropriate lighting technology, minimising polarized light pollution and using curtailment and/or acoustic deterrents should be applied to all future projects so that there is a collective management responsibility (IFC 2013). This is especially key for Natal long-fingered bats which migrate through EAAA1.

7 ENVIRONMENTAL MANAGEMENT PROGRAMME

7.1 Wind Energy Facility

Objective	Avoid and minimise modification of bat habitats
Project component/s	All project infrastructure
Potential Impact	Vegetation clearing for project infrastructure, as well as noise, dust and pollution generated during construction activities, will impact bats by removing habitat used for foraging and commuting, through disturbance, and displacement. Construction of WEF infrastructure could result in destruction and/or disturbance to bat roosts, and inadvertently provide new roosting spaces for some bat species in risky locations.
Activity/risk source	All construction activities and associated activities (e.g., driving)
Mitigation: Target/Objective	1. Avoid potential for bats to roost in project infrastructure (e.g., buildings, turbines, road culverts) 2. Minimise disturbance to bats

	3. Minimise habitat loss	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. Ensure all project infrastructure (e.g., buildings, turbines, road culverts) is properly sealed such that bats cannot gain access. 2. No construction activities at night, apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste). 3. No placement of infrastructure (except roads) within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams. Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees. Rehabilitate all areas disturbed during construction, (including aquatic habitat).	Project Developer/Contractor	During design and planning phase and throughout construction phase
Performance Indicator	- No bat roosts are destroyed - No bats colonise new project infrastructure for roosting - No infrastructure in No-Go areas (except roads) - All areas disturbed during construction are rehabilitated	
Monitoring	- An appointed ECO must inspect all new project infrastructure, in conjunction with or via training from a bat ecologist, to ensure bats cannot gain access. - ECO to ensure compliance with good construction abatement control practices. - ECO must ensure no infrastructure is placed in No-Go areas (see Figure 2). - If a bat roost is encountered during construction, the ECO must consult a bat ecologist to determine appropriate actions. - ECO to ensure all disturbed areas are rehabilitated.	

Objective	**Avoid and minimise bat fatality**	
Project component/s	Wind Turbines	
Potential Impact	Bat mortality through collisions with wind turbine blades.	
Activity/risk source	Operating Wind Turbines	
Mitigation: Target/Objective	1. Avoid bat fatalities through turbine layout design and turbine dimensions 2. Minimise bat fatalities using curtailment and deterrents during operation	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. No placement of turbines within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams to reduce spatial overlap between bats and wind turbines. 2. Maintain a minimum blade sweep of 30 m to avoid impacts to lower flying bats such as clutter-edge species (e.g., Cape serotine, Natal long-fingered bat). 3. Implement fatality monitoring throughout the operational phase and apply curtailment or deterrents if fatality thresholds are exceeded. Annual fatality threshold per Least Concern species = 353 individuals. Annual fatality threshold per Species of Special Concern = 1 individual for each of [African Straw-coloured fruit bat, Wahlberg's Epauletted fruit bat, Percival's Short-eared Trident bat, Blasius's Horseshoe bat, Egyptian Rousette].	Project Developer/Operator	BMP developed prior to operation. BMP active throughout operation phase.
Performance Indicator	- ≤ 353 individuals per Least Concern species killed annually - ≤ 1 individual per Species of Special Concern killed annually	

Monitoring	- ECO must ensure no turbines are placed in No-Go areas, including the blade tips (see Figure 6). - ECO must ensure the dimensions of the final selected turbine adhere to requirements (A minimum blade sweep of 30 m). - A Biodiversity Management Plan (BMP) for bats must be developed which includes the design of a post-construction fatality monitoring program (PCFM) for bats, and an adaptive management response plan that provides an escalating scale of mitigation should fatality thresholds be exceeded. - ECO to ensure adherence to BMP and any mitigation measures implemented.

7.2 Solar PV Facility

Objective	Avoid and minimise modification of bat habitats	
Project component/s	All project infrastructure	
Potential Impact	Solar panels and their supporting infrastructure may have a barrier effect on bats. Vegetation clearing for project infrastructure, as well as noise, dust and pollution generated during the construction phase, will impact bats by removing habitat, through disturbance, and displacement. Construction of Solar PV infrastructure could result in destruction and/or disturbance to bat roosts, and inadvertently provide new roosting spaces for some bat species in risky locations.	
Activity/risk source	All construction activities and associated activities (e.g., driving)	
Mitigation: Target/Objective	1. Avoid potential for bats to roost in project infrastructure (e.g., buildings, road culverts) 2. Minimise disturbance to bats 3. Minimise habitat loss	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. Ensure all project infrastructure (e.g., buildings, road culverts) is properly sealed such that bats cannot gain access. 2. No construction activities at night, apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste). 3. No placement of infrastructure (except roads) within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams. Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees. Rehabilitate all areas disturbed during construction, (including aquatic habitat).	Project Developer/Contractor	During design and planning phase and throughout construction phase
Performance Indicator	- No bat roosts are destroyed - No bats colonise new project infrastructure for roosting - No infrastructure in No-Go areas (except roads) - All areas disturbed during construction are rehabilitated	
Monitoring	- ECO must inspect all new project infrastructure, in conjunction with or via training from a bat ecologist, to ensure bats cannot gain access. - ECO to ensure compliance with good construction abatement control practices. - ECO must ensure no infrastructure is placed in No-Go areas (see Figure 7). - If a bat roost is encountered during construction, the ECO must consult a bat ecologist to determine appropriate actions. - ECO to ensure all disturbed areas are rehabilitated.	

Objective	Avoid and minimise polarized light pollution
Project component/s	Solar PV panels
Potential Impact	Solar PV panels cause polarized light pollution, potentially altering bat-insect interactions
Activity/risk source	Installation of solar PV panels

Mitigation: Target/Objective	1. Avoid polarized light pollution through spatial planning of the facility 2. Minimise polarized light pollution by minimising reflection from solar PV panels	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. No placement of solar PV panels within 200 m of aquatic habitat. 2. Place non-polarising white tape around and/or across solar panels to minimise reflection which can attract aquatic insects.	Project Developer/Operator	During design and planning phase and throughout operation phase
Performance Indicator	- No solar PV panels within 200 m of aquatic habitat. - White tape placed around and/or across solar panels.	
Monitoring	- ECO must ensure no solar PV panels are within 200 m of aquatic habitat (see Figure 7). - ECO must ensure that white tape is placed around and/or across solar panels, as well as ensuring maintenance of tape during operation.	

7.3 Grid Connection

Objective	Avoid and minimise modification of bat habitats	
Project component/s	All project infrastructure	
Potential Impact	Vegetation clearing for grid connection infrastructure, as well as noise, dust and pollution generated during construction activities, will impact bats by removing habitat used for foraging and commuting, through disturbance, and displacement. Construction of grid connection infrastructure could result in destruction and/or disturbance to bat roosts, and inadvertently provide new roosting spaces for some bat species in risky locations.	
Activity/risk source	All construction activities and associated activities (e.g., driving)	
Mitigation: Target/Objective	1. Avoid potential for bats to roost in project infrastructure (e.g., buildings, road culverts) 2. Minimise disturbance to bats 3. Minimise habitat loss	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. Ensure all project infrastructure (e.g., buildings, road culverts) is properly sealed such that bats cannot gain access. 2. No construction activities at night, apply good construction abatement control practices to reduce emissions and pollutants (e.g., noise, erosion, waste). 3. No placement of infrastructure (except roads and the OHL) within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams. Minimise clearing of vegetation, minimise disturbance and destruction of farm buildings on site, minimise removal of trees. OHL pylons must avoid No-Go areas therefore the maximum possible span should be implemented to avoid the sensitive area while ensuring the technical feasibility of the development. Rehabilitate all areas disturbed during construction, (including aquatic habitat).	Project Developer/Contractor	During design and planning phase and throughout construction phase
Performance Indicator	- No bat roosts are destroyed - No bats colonise new project infrastructure for roosting - No infrastructure in No-Go areas (except roads and the OHL) - All areas disturbed during construction are rehabilitated	
Monitoring	- ECO must inspect all new project infrastructure, in conjunction with or via training from a bat ecologist, to ensure bats cannot gain access. - ECO to ensure compliance with good construction abatement control practices. - ECO must ensure no infrastructure is placed in No-Go areas (see Figure 8). - If a bat roost is encountered during construction, the ECO must consult a bat ecologist to determine appropriate actions.	

	- ECO to ensure all disturbed areas are rehabilitated.

Objective	Avoid and minimise light pollution	
Project component/s	Project Lighting	
Potential Impact	Light pollution can alter ecological dynamics	
Activity/risk source	Emission of light from project lighting	
Mitigation: Target/Objective	1. Avoid light pollution through spatial planning of the facility 2. Minimise light pollution by using appropriate lighting technology	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1. No placement of substations and operational and maintenance buildings within 200 m of key habitat features specifically including tree clumps, buildings, dams/wetlands, and rivers/streams. 2. Use as little lighting as possible, maximise use of motion-sensor lighting, avoid sky-glow by using hoods, increase spacing between lighting units, and use low pressure sodium lights.	Project Developer/Operator	During design and planning phase and throughout operation phase
Performance Indicator	- No buildings in No-Go areas - Use of appropriate lighting technology	
Monitoring	- ECO must ensure no buildings are in No-Go areas (see Figure 8). - ECO must ensure lighting technology meets requirements	

8 CONCLUSION

The overall predicted impact of the project to the VECs is moderate but risk varies both spatially and temporally. On a nightly level, bat activity is higher during the first few hours of the night. At height, all species apart from Egyptian free-tailed bat have low risk for all seasons and time periods. Based on median bat activity, Egyptian free-tailed bat is at medium risk in summer between 21:00 and 22:00, and low risk during all other time periods. However, Cape serotine activity was high during certain periods, mainly at ground level. Since bats can be attracted to wind turbines (Guest et al. 2022), impacts to this species may be high especially in the lower portions of the rotor swept zone. The assessed turbines have a minimum blade sweep of 65 m which is acceptable since risk to bats at this height is low. Future changes to turbine dimensions during the projects development should maintain a minimum blade sweep of 30 m since it is likely bats would be a low to moderate risk at this height. This assumes adherance to all mitigation meausres proposed in this report.

Six turbines in the proposed layout are currently located within No-Go areas: WTG10, WTG61, WTG82, WTG88, WTG100, and WTG101. These turbines must be relocated into low and medium sensitivity areas. This has already been achieved through the development of an optimised layout (Figure 6) which is acceptable since no turbines in this layout are in No-Go areas. The layout of the solar energy facility, specifically the solar panels themselves, is acceptable since these avoid bat No-Go areas (Figure 7). The location of the associated infrastructure must also avoids No-Go areas therefore the location of batching plant 2, the collector stations, and the MTS must be microsited and/or optimized.

The major impact of this specific project would be its contribution to cumulative impacts on VECs in the North-East of South Africa. Depending on the rate of renewable energy expansion in this part of the country, the three VECs may experience local population declines. Apart from the application of buffers and moving infrastructure out of No-Go areas, curtailment and/or the use of acoustic deterrents may be needed. During operation, bat fatality monitoring must be undertaken to search for bat carcasses beneath wind turbines to measure the residual impact of the WEF on bats for a minimum of two years (Aronson et al. 2020). Curtailment and/or acoustic deterrents must be used if post-construction fatality monitoring indicates that species fatality thresholds have been exceeded (MacEwan et al. 2018) to minimise impacts, maintain the impacts to bats within acceptable limits of change and prevent declines in the impacted bat population. Provided these mitigation measures are adhered to, the project assessed can be approved.

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Appendix 1: Figures

Appendix 2: Specialist CV

Appendix 3: Specialist Declaration of Interest