Chiropteran Specialist Report for Phase 3 of the Proposed Soventix-Solar Africa Solar PV Facility, Hanover, Northern Cape.

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For:

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1. Introduction

In 2021, South Africa committed, in alignment with the Paris Agreement, to significantly reduce its reliance on coal generated electricity and to reduce greenhouse gas emissions to 350-420 MtCO2e by 2030 with a goal of reaching net-zero CO_2 emissions by 2050. The European Union, Germany, France, the United Kingdom and the United States of America, pledged $8.5 billion during COP26 (November 2021) to contribute to the upgrading of infrastructure (electrical grid expansion particularly in the Northern Cape and Eastern Cape) to encourage renewable energy (RE) projects and to help develop new sectors (electric vehicles and green hydrogen).

In light of this pledge and financial contribution to renewable energy projects and new sectors, we can expect to see an increase in solar photovoltaic (PV) farms, concentrating solar-thermal power (CSP) and wind energy farms (WEF).

Recent evaluations of reports and available data of the impacts of WEF and solar projects on bats and birds in general have shown that birds are more susceptible to fatal collisions with WEF associated infrastructure than bats (Choi *et al.* 2020; Agudelo *et al.* 2021). However, the number of bat fatalities at wind turbines still raises concern not only due to the risk of bat population numbers decreasing, but also a loss of trophic interactions and ecosystem services provided by bats (Scholz and Voigt, 2022).

South Africa has high solar resource potential, particularly in the Northern Cape (**Image 1**). The cumulative impacts of renewable energy on wildlife, particularly birds and bats are not well understood and creates a sense of haste in quantifying and understanding the impacts as the sector rapidly expands, even at a global scale. Visser *et al.* (2018) showed that in the Northern Cape some bird species used the Jasper solar PV facility to forage, find shade and shelter, drink water from the evaporation ponds and nest on the supports of the solar panels. The alteration in habitat from natural arid savanna to grassland resulted in the reduction of abundance of certain species, although the bird community species composition did not change (Visser *et al.* 2018).

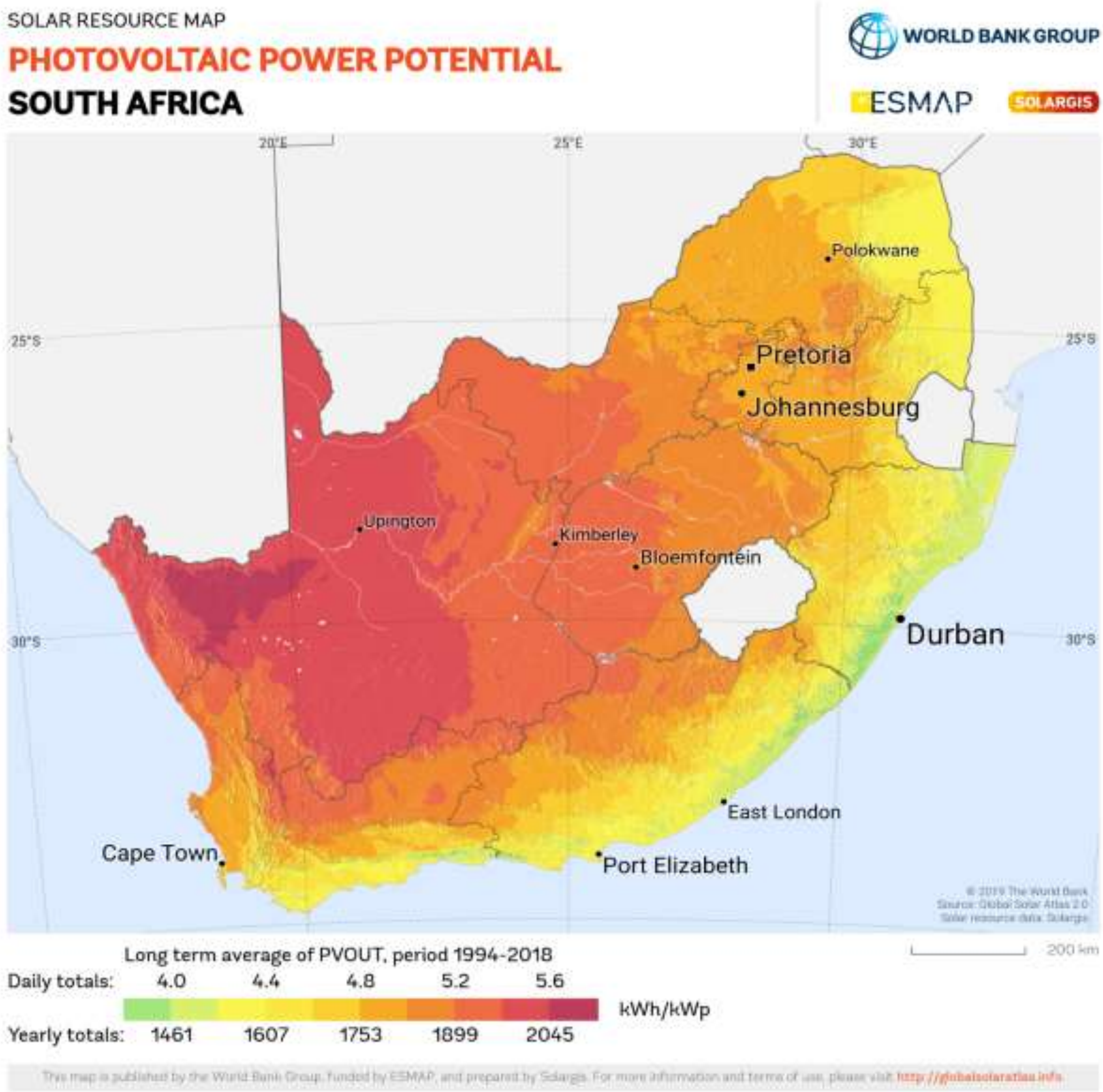


Image 1. The photovoltaic power potential across South Africa highlighting the enormous potential in the Northern Cape. © 2020 The World Bank, Source: Global Solar Atlas 2.0, Solar resource data: Solargis.

Data on bird and bat collisions with solar PV projects is even more scant with a recent publication by Smallwood (2022) predicted annual fatalities of 716 bats using projected fatality rates of bats at solar PV projects (total of 12 220 MW) in 2019. For all utility-scale solar projects (PV, CSP, solar evaporation ponds) in 2020, the mean annual mortality for bats was 11 418 (Smallwood 2022). The general consensus is that more data are needed and that there needs to be a standardisation of methodologies for monitoring and searching for fatalities at RE projects to ensure more accurate data is collected.

The most pertinent impact associated with RE projects is the destruction and or alteration of natural habitats. In general, solar power plants in relation to traditional power plants have lower impacts since they have significantly lower CO_2 emissions (unless situated in a forested region), and occupy less or the same amount of land (Turney and Fthenakis, 2011). In arid or desert regions where solar radiation is intense and biodiversity is lower, it is suggested that solar power projects in general will have the lowest environmental impact (Turney and Fthenakis, 2011).

The construction phase, operational phase (including transmission lines, evaporation dams, tall structures etc.) and solar power plant fencing are three main areas of concern that have a direct impact on natural habitats and associated wildlife on the solar PV project footprint. During the construction phase the natural habitat can be significantly altered if the ground is scraped bare in preparation for the installation of the solar panels. The use of herbicides or frequent mowing keeps the vegetation from growing back or growing tall respectively. In response to the immediate and significant alteration in natural vegetation, food availability for both predators and prey will change, hiding spots and shelter will decrease and predation strategies will alter.

Depending on the management strategy during the operational phase, vegetation is usually kept clear of the solar PV panels and infrastructure, resulting in similar impacts as the above listed impacts during the construction phase. If natural vegetation is maintained below the solar PV panels, the shallow cast by the panels can result in a change in the microclimate beneath the panels thus altering the vegetation composition (Graham *et al.* 2021) and in turn the species composition of prey items such as insects. Montag *et al.* (2016) showed that although management practices encouraged greater insect biodiversity (and bird biodiversity) there was no difference in bat biodiversity, between the control and solar plants but bat activity was higher over the control plots. A possible explanation for this observation may have related to bats being confused by artificially smooth surfaces as echolocation calls are not reflected back to a bat, thus bats may perceive the smooth surfaces as voids and may avoid or even collide with the surface (Montag *et al.* 2016). This aspect requires further investigation. The installed infrastructure such as the solar PV panels, transmission lines, and security fencing, can increase the risk of collision resulting in the injury and or death of wildlife (Smallwood 2022).

Bats are globally threatened due to anthropogenic developments and climate change impacting individual fitness, animal behaviour, community structure and population dynamics (Ancillotto *et al.* 2016; Smith *et al.* 2016). Cumulative impacts on South African bats of climate change, disease, wind turbine induced fatalities, agricultural intensification, and loss of habitat due to anthropogenic activities needs to be studied and understood as bats are critical components of ecosystem functioning with the ecosystem services that they provide (Kunz *et al.* 2011). The consequences due to the loss of these bat provided ecosystem services remains unknown (Kunz *et al.* 2011). Understanding these impacts is important to develop effective management plans to preserving ecosystem functioning and health.

Another aspect to be aware of that would extend beyond the footprint of the solar PV project is the decommissioning of “dead” solar panels once they have reached the average lifespan of 20-30 years. Solar panels are categorised under electrical and electronic products and are classified as hazardous waste (Hazardous Substances Act 15 of 1973) and they contain for example; lead, aluminum, arsenic, cadmium and copper, depending on the type of panel and are not allowed to be disposed of in general landfills. The Extended Producer Responsibility legislation (Gazette No. 44539 of NEM: Waste Act 59 of 2008) should help limit the number of panels that end up in landfills and leach hazardous elements in the environment that are detrimental to biodiversity and human health beyond the footprint of the solar PV project. At the moment, the recycling and extraction of valuable (silver and copper) and toxic elements from solar panels is expensive and a developing industry in South Africa. It is thus imperative that not only the producers of the solar PV panels but also the solar PV project developers are active in ensuring the correct recycling procedures of the solar PV panels.

2. Purpose and Objectives

The purpose of this study was to investigate the impact of activities in relation to Phase 3 of the Soventix-Solar Africa solar PV facility in accordance with Appendix 6 of the EIA Regulations 2014.

The following activities in relation to Phase 3 triggered a bat scoping study (SABAA-South African Bat Assessment Association):

- Any disturbance of destruction of natural rocky outcrops and or roost type structures, both natural and anthropogenic,
- Disturbance within 500m of structures, above and below ground, that could be used by bats as roosting sites, natural and or anthropogenic,
- And disturbance or destruction of rivers and wetlands, or within 200m of riparian areas.

The objectives of the study are to:

- Identify all species recorded in the area and describe their association with specific habitat types,
- Identify bats of conservation importance if present and also the potential of their and other species occurrence,
- Identify areas of importance to bats, indicate buffer zones,
- To investigate the potential impacts of the development and cumulative impacts of similar RE projects in a 30km radius of the proposed solar PV facility on bat populations in the area,
- And to provide mitigation measures as part of the Environmental Impact Assessment (EIA) to be put in place to lessen the expected impacts.

In accordance with the Environmental Impact Assessment Regulations of 2014 (GN R982 in GG 38282, 2014) the following General requirements for EAPs and specialists were met;

(1) An EAP and a specialist, appointed in terms of regulation 12(1) or 12(2), must-

(a) be independent;

(b) have expertise in conducting environmental impact assessments or undertaking specialist work as required, including knowledge of the Act, these Regulations and any guidelines that have relevance to the proposed activity;

(c) ensure compliance with these Regulations;

(d) perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the application;

(e) take into account, to the extent possible, the matters referred to in regulation 18 when preparing the application and any report, plan or document relating to the application; and

(f) disclose to the proponent or applicant, registered interested and affected parties and the competent authority all material information in the possession of the EAP and, where applicable, the specialist, that reasonably has or may have the potential of influencing-

(i) any decision to be taken with respect to the application by the competent authority in terms of these Regulations; or

(ii) the objectivity of any report, plan or document to be prepared by the EAP or specialist, in terms of these Regulations for submission to the competent authority; unless access to that information is protected by law, in which case it must be indicated that such protected information exists and is only provided to the competent authority.

(2) In the event where the EAP or specialist does not comply with subregulation (1)(a), the proponent or applicant must, prior to conducting public participation as contemplated in Chapter 6 of these Regulations, appoint another EAP or specialist to externally review all work undertaken by the EAP or specialist, at the applicant's cost. [Subreg. (2) amended by GN 326 of 7 April 2017.]

(3) An EAP or specialist appointed to externally review the work of an EAP or specialist as contemplated in subregulation (2), must comply with subregulation (1)(a). [Subreg. (3) amended by GN 326 of 7 April 2017.]

3. Soventix Solar PV Facility Site Description

3.1. Project Description and Current Land Use

Phase 3 is a proposed 400 MW solar PV facility and associated infrastructure by Soventix SA (Pty) Ltd and Solar Africa on the remaining area of Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C and other properties (**Image 2**). The size of the development footprint is approximately 600 ha (1.5 ha per MW). The development area contains ephemeral drainage lines with the footprint within 100-500m of the water resource.

Phase 3 of the Soventix-Solar Africa solar PV facility and associated infrastructure (30°50’14.37”S; 24°21’22.21’’E) is situated near the town of Hanover, Northern Cape in the Pixely ka Seme District Municipality. Phase 3 and Phase 2 will feed into the authorised sub-station on the PV02 footprint (Phase 1) (DEA Ref: 14/12/16/3/3/2/998) via a connecting overhead powerline (**Image 3**).

Sheep farming is the current land use practice and will continue as an Agrivoltaic system with the combination of the operational solar PV facility and sheep farming.

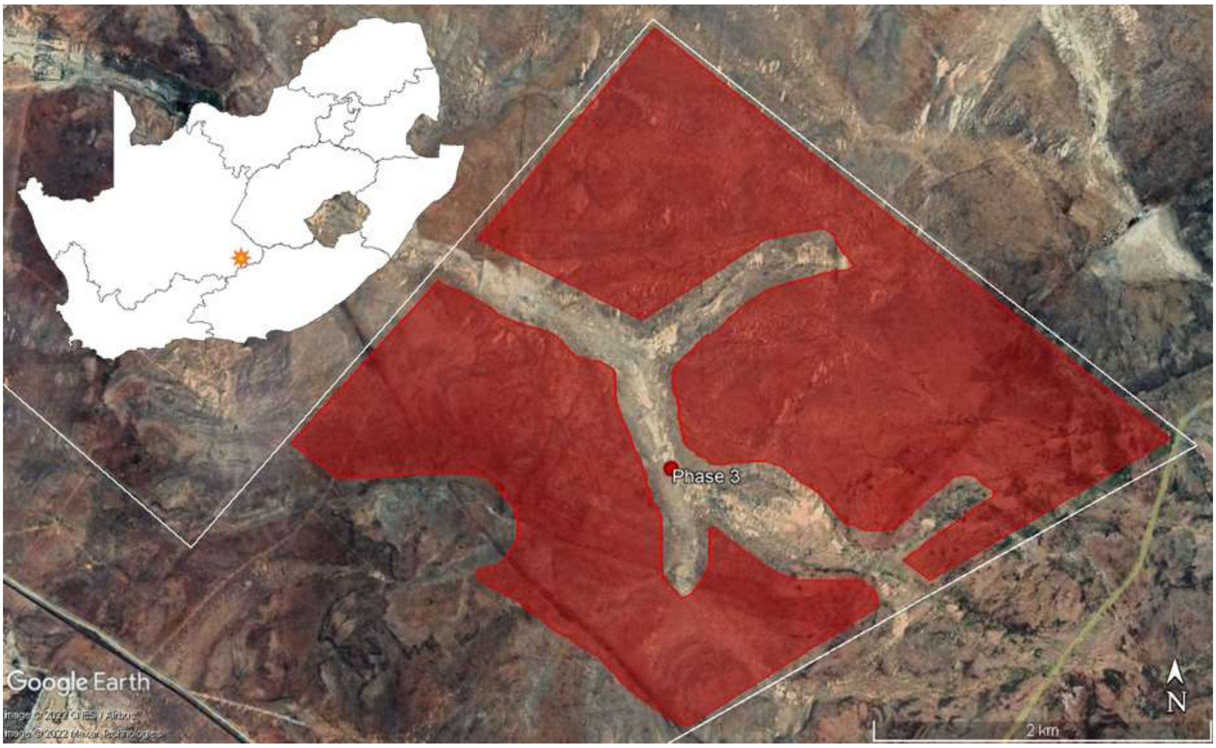


Image 2. The extent of Phase 3 of the proposed Soventix-Solar Africa solar PV facility and associated infrastructure (red) and the boundary of the affected property (white). The map insert of South Africa indicates the approximate location of Phase three within the Northern Cape.

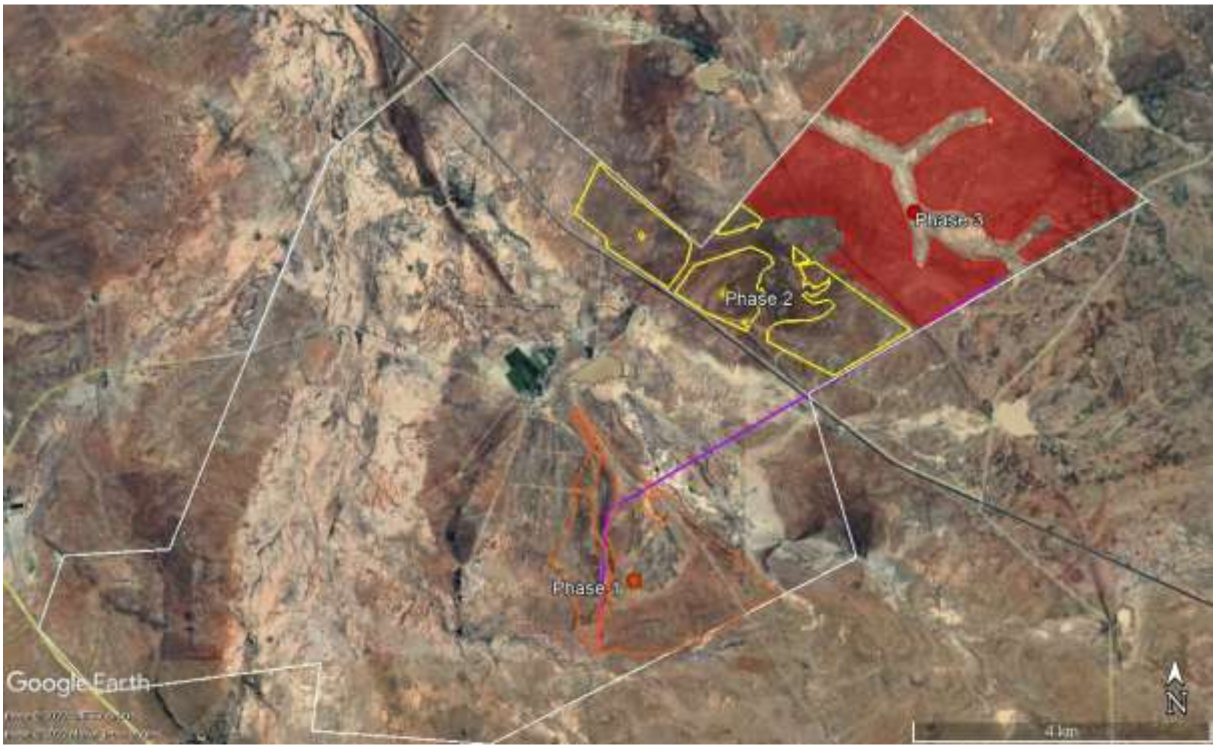


Image 3. The overhead powerline (purple) connecting Phase 3 (filled red) and Phase 2 (yellow) to the authorised sub-station in Phase 1 (orange).

3.2. Vegetation

The vegetation unit occurring on the proposed Phase 3 footprint is the Eastern Upper Karoo. The Eastern Upper Karoo does not contain any centre of endemism and is not particularly florally diverse. Similarto other arid and semi-arid areas, it is dominated by Poaceae, Asteraceae and

Fabaceae (Mucina and Rutherford, 2011). Dwarf microphyllous shrubs and species of *Aristida* and *Eragrostis* grasses dominate the dry/arid, open and exposed landscape of the Eastern Upper Karoo. Several endemic floral taxa occur in the Eastern Upper Karoo for example *Lycium oxycarpum, Eriocephalus ericoides, Pentzia globose, Helichrysum dregeanum, Aristida diffusa* and *Eragrostis lehmanniana*. The Eastern Upper Karoo is classified as "Least Threatened" with moderate to high soil erosion and the presence of the common and widespread alien plant *Medicago laciniata* (Mucina and Rutherford, 2011).

3.3. Climate

The peak rainfall season is autumn and summer ranging from 180-430mm across the west to east gradient (Mucina and Rutherford, 2011). The minimum winter temperature is approximately -7°C with regular occurrences of frost and the mean maximum summer temperature is 36°C (Mucina and Rutherford, 2011).

3.4. Topography

The Eastern Upper Karoo landscape generally consists of vast flats and gentle sloping plains (Mucina and Rutherford, 2011) that can become saturated during high rainfall seasons (**Image 4**). Rocky ridges, hills and koppies are scattered in the landscape (**Image 5**).

Image 4. The generally flat open dry arid landscape of the Eastern Upper Karoo transformed into a lush, water saturated grassland due to a high rainfall season.

Image 5. A ridge along the eastern border of the footprint breaks the flat monotony of an otherwise flat, grassy landscape.

4. Sample Methods and Data Analysis

4.1 Desktop Study

The desktop study was conducted to identify;

- areas of potential importance to bats such as foraging areas and roosting sites and,
- the species probability of occurrence, and

4.2 Data Collection and Analysis

4.2.1 Acoustic Monitoring

Prevailing weather conditions and veld conditions during the survey time period resulted in a deviation from the original transect protocol used for Phase 1 and Phase 2. Transects could not be conducted as the majority of the footprint was saturated from high rainfall. Instead, three bat detectors (two SM4 mini bat and one SM3 SONGMETER, Wildlife Acoustics, Inc., MA) were placed within the proposed development area for Phase 3 (**Image 6**) in a manner that bat activity representative of the site could be monitored. The bat detectors passively recorded bat echolocation calls for 13 nights (3-15 April 2022) (**Image 7**).

Image 6. The placement of three bat detectors that monitored bat activity for 13 nights across the proposed Phase 3 footprint.

Image 7. A SM4mini bat detector mounted on a wooden pole to passively record bat activity over the proposed Phase 3 footprint.

In addition to the waterlogged landscape, spectacular thunderstorms rolled across the expanse of the footprint, rendering driven transects impractical. It was imperative that the data collection was conducted between late spring and summer (early autumn at the latest), to ensure a representative sample of the bat species assemblage. During summer, bats are most active in South Africa due to warmer temperatures, increased precipitation and the associated increase in insect activity. Since the prevailing weather conditions during the data collection period may have likely impacted bat activity, it is recommended that bat monitoring is conducted during spring and/or summer during pre-construction, construction and post-construction.

All calls recorded by the bat detectors were converted into zero-crossing (ZC) and sound (WAV) files for identification purposes. Kaleidoscope Pro (version 5, Wildlife Acoustics, Inc., WA) and AnalookW (Chris Corben) were used to identify individual bat echolocation calls and bat behaviour. Species were identified based on peak frequency, call duration and bandwidth.

To prevent the overestimation or bias of bat activity due to bat behaviour, all bat passes recorded in a minute of a given species were standardise to an Activity Index (AI) which is one AI of a specific bat species per minute (Miller, 2001).

To determine time periods of main activity (foraging, commuting and/or social), AI of bat species were summed into time categories of 30min.

4.2.2 Statistical Analysis

The statistical program R (version 4.2.0) was used to run descriptive statistics on the data set to explain any observed patterns in the data. To determine if the minimum temperature (Tmin) recorded on site affected bat AI, Spearman's rank correlation test was run. A Kruskal-Wallis test (kruskal.test) was run to determine if there is a difference between activity indexes (AI) at each site.

5. Results

5.1Desktop Study

5.1.1 Areas of potential importance to bats: Water Resources and Roosting Sites

A watercourse was observed via Google Earth Pro to be present centrally in the proposed Phase 3 footprint (**Image 8**) and indicated on maps provided by the EAP. The ephemeral drainage line and the extent of any ephemeral water resource associated with the drainage line, could be an important resource for bats for both drinking and foraging and shaping bat communities particularly in dry landscapes (Razgour *et al.* 2011; Blakey *et al.* 2018).

Image 8. The extent of the watercourse identified on Google Earth, traversing the proposed Phase 3 footprint area that could be of importance to bats for drinking and foraging.

The potential roosting sites identified during the desktop (**Image 9**) study were investigated on foot on 03 April 2022 for signs of bat occupancy (the presence of urine stains on rocks, the characteristic smell of guano particularly that of free-tailed bats, and audible squeaking that bats tend to emit when disturbed in their roost during the day).

Image 9. The location of potential roosting sites on a ridge including a 100m buffer zone from the crest of the ridge (orange) near the eastern border of the Phase 3 footprint in relation to the proposed solar arrays (red).

5.1.2 Probability of species occurrence

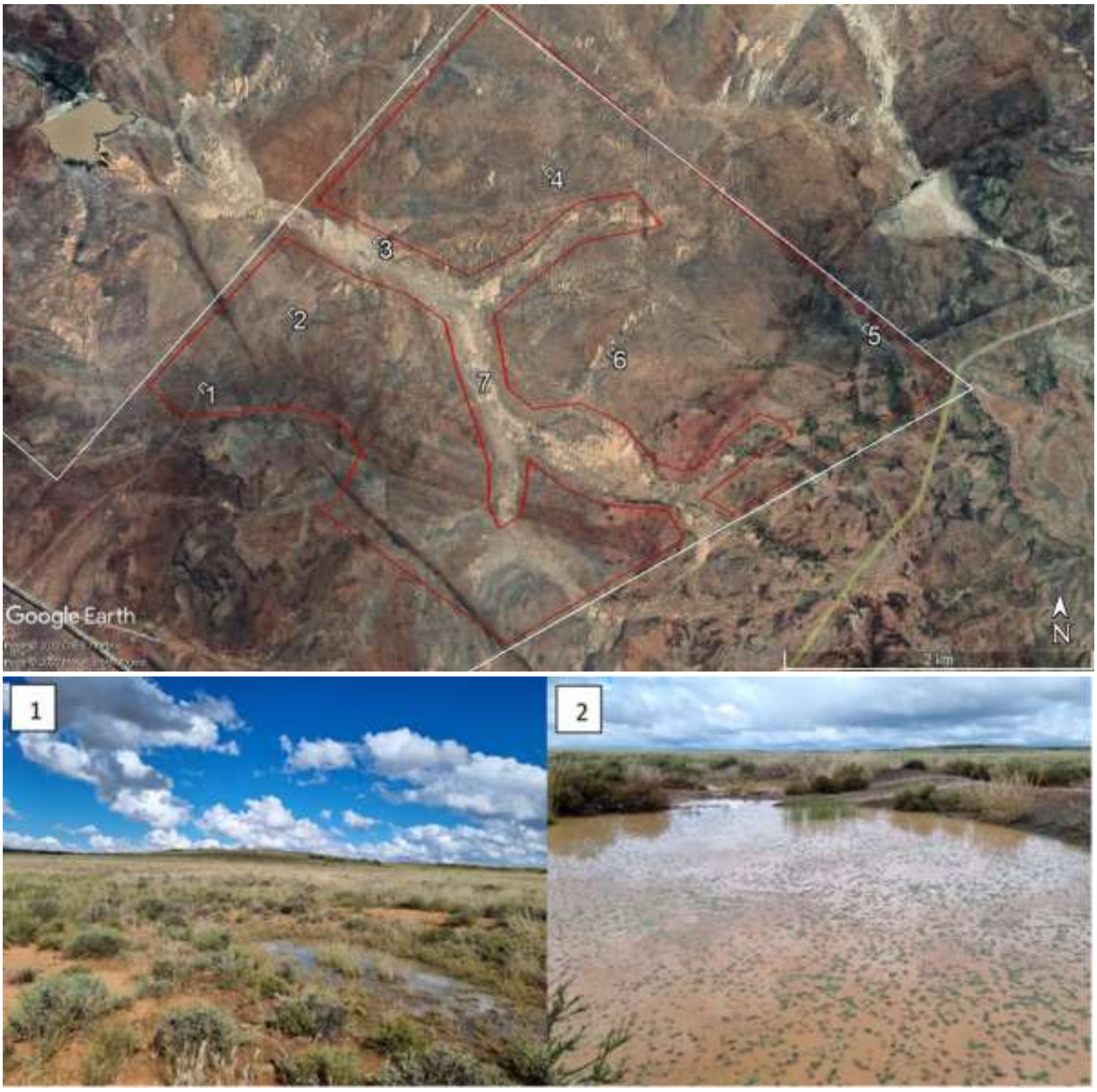
A list of species that may occur on the proposed Soventix solar PV facility was composed with all species considered "Least Concern" on the IUCN Red data list (IUCN 2021-3) and 2016 Red List of Mammals of Southern Africa, Lesotho and Swaziland, with the exception of *Rhinolophus denti* that is classified as Near Threatened on the 2016 Red List of Mammals of Southern Africa, Lesotho and Swaziland. Together with the site visit for Phase 1 and Phase 2, amendments to the probability of occurrence of the listed species over the proposed Phase 3 footprint has been amended where applicable(*).

Table 1. Probability of occurrence of bats species over Phase 3 of the proposed Soventix solar PV facility and associated infrastructure.

Scientific Name	Common Name	Habitat Preference	Foraging Guild	Roost Type	Probability of Occurrence (Low/Medium/High)
Tadarida aegyptiaca	Egyptian Free-tail Bat	Widespread and abundant, found in all habitat types	Open air forager	Rock crevices, caves, exfoliating rock, behind tree bark, ceilings, thatch roofs	High
Laephotis capensis	Cape Serotine	Widespread and abundant	Clutter-edge forager	Roofs of houses, under tree bark, at the base of aloe leaves	High
Eptesicus hottentotus	Long-tailed Serotine	Widespread but sparse	Clutter-edge forager	Caves and rocky outcrops	Medium
Miniopterus natalensis	Natal Long-fingered Bat	Widespread. More common in the south and east than the arid west	Clutter-edge forager	Caves	Medium (*)
Rhinolophus clivosus	Geoffroy's Horseshoe Bat	Variety of habitats including riparian forest, woodland and arid savanna	Clutter forager	Caves, mine adits, culverts, cavities in piles of boulders	Low
Rhinolophus darlingi	Darling's Horseshoe Bat	Variety of habitats including arid savanna	Clutter forager	Caves, mine adits, culverts, cavities in piles of boulders	Low
Rhinolophus denti (Near Threatened)	Dent's Horseshoe Bat	Arid habitats-Restricted to areas with rocky outcrops and caves	Clutter forager	Caves, crevices in rocky outcrops, semi-dark caverns	Low (*)
Nycteris thebaica	Egyptian Slit-faced Bat	Variety of habitats, avoids open grassland	Clutter forager	Road culverts, caves, aardvark burrows, hollow trees	Medium

5.2 Bat Activity, Water Resources and Roosting Sites

The high rainfall experienced during the summer period resulted in vast expanses of the proposed Phase 3 footprint saturated with bountiful ephemeral pans and surface water available for bats to drink from and potentially forage on insects attracted to the water and lush vegetation (**Image 10**).



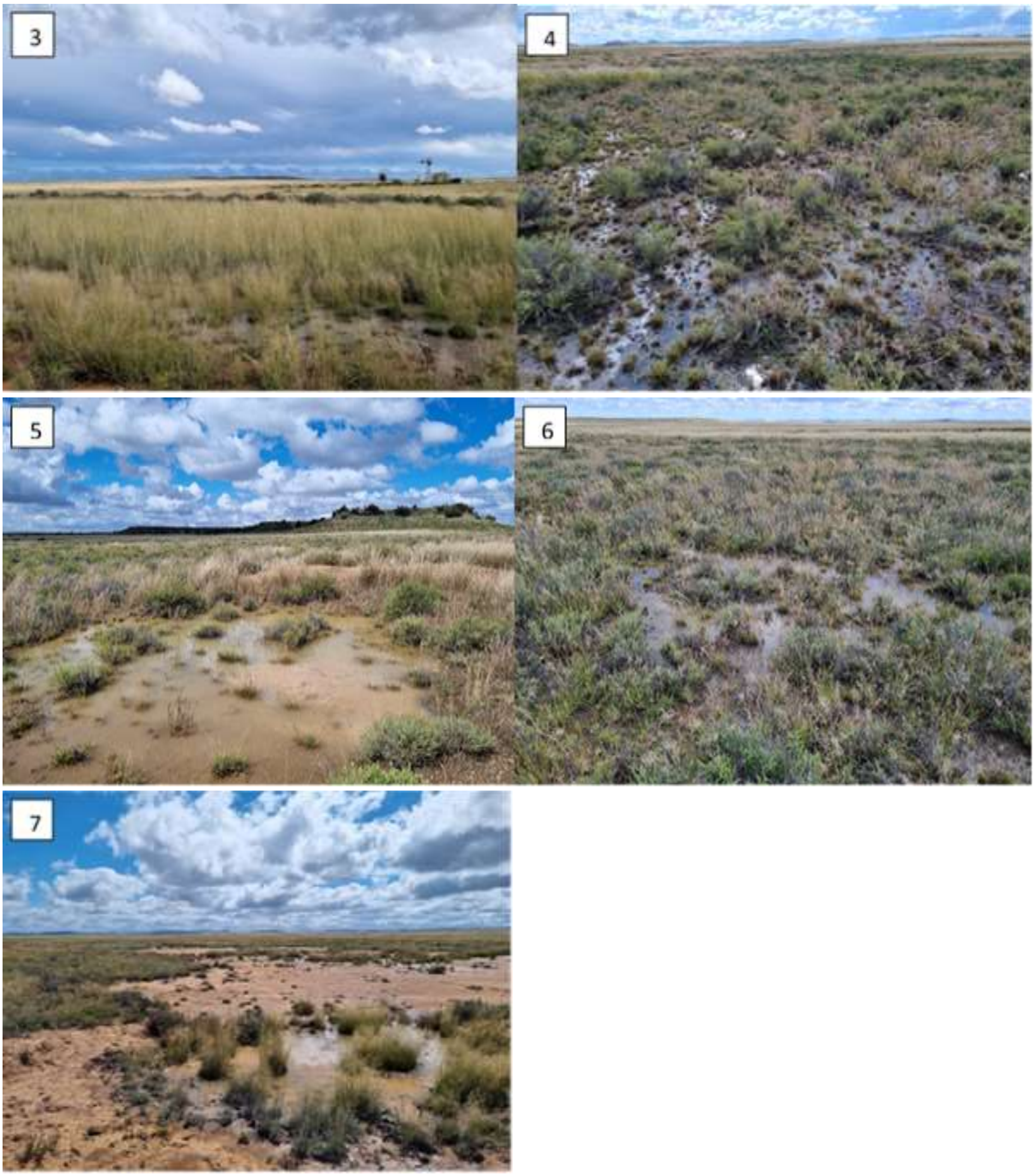


Image 10. Map indicating locations of images taken from across the landscape indicating the extent of the waterlogged landscape that covered the majority of the footprint during the fieldwork period. Associated images are labelled 1-7.

Potential roosting sites on the proposed footprint of Phase 3 were searched for on foot in the ridge (30°50’0.60”S; 24°23’2.34”E) situated on the northeast farm portion (**Image 11**). No roosts were located, however, the ridge should be preserved and buffered with a zone of at least 100m from the parameter of the solar array (Image 9).

Image 11. The ridge located near the eastern border of the Phase 3 footprint where no evidence of bat roosting was found but rock hyrax middens were found.

5.3 Acoustic Monitoring

5.3.1 Species Richness

Three bat species out of a potential eight species were recorded over the proposed Phase 3 footprint namely; *Tadarida aegyptiaca* (Egyptian Free-tailed bat), *Laephotis capensis* (Cape Serotine), and *Miniopterus natalensis* (Natal Long-fingered bat) (**Table 2**). *Laephotis capensis* dominated the activity at each site (**Figure 1**) and accounted for 64.71%, *T. aegyptiaca* accounted for 32.72% of the activity and *M. natalensis* accounted for 2.57%. All three species are widespread and abundant and are classified as “Least Concern” on the IUCN Red Data List (IUCN 2021) and the Red List of Mammals of Southern Africa, Lesotho and Swaziland.

Table 2. Species identified according to echolocation calls, conservation status, distribution, habitat preference, foraging ecology, roost type and profile.

Species Name and Conservation Status	Distribution & Habitat Preference	Foraging Ecology	Roost Type	Profile
Family VESPERTILIONIDAE				
Cape Serotine – *Neoromicia capensis* **Least Concern***	Widespread throughout southern and central Africa. Tolerant of a wide range of habitat types: arid semi-desert, forest, montane grasslands and savanna.	Clutter-edge forager.	Roofs of houses, under bark of trees, at bases of aloes and thatch roofs.	
Family MOLOSSIDAE				
Egyptian Free-tailed bat – *Tadarida aegyptiaca* **Least Concern***	Widespread and abundant throughout southern Africa but restricted distribution in western Botswana and western Namibia. Absent from most of Mozambique and Malawi. Vegetation type appears to have little influence on distribution. Occurs in most habitat types but avoids forests.	Open air forager.	Rock crevices, caves, hollow trees, under bark and under exfoliating rocks. Have been recorded roosting in large colonies in roofs of anthropogenic structures.	
Family MINIOPTERIDAE				
Natal Long-fingered bat - *Miniopterus natalensis* **Least Concern***	Widespread across southern Africa and common in the eastern and southern regions but not abundant in the western arid regions. Generally a temperate or subtropical species.	Clutter-edge forager.	Cave dependent.	

*IUCN Red Data List 2021-3, images © D. Cory-Toussaint

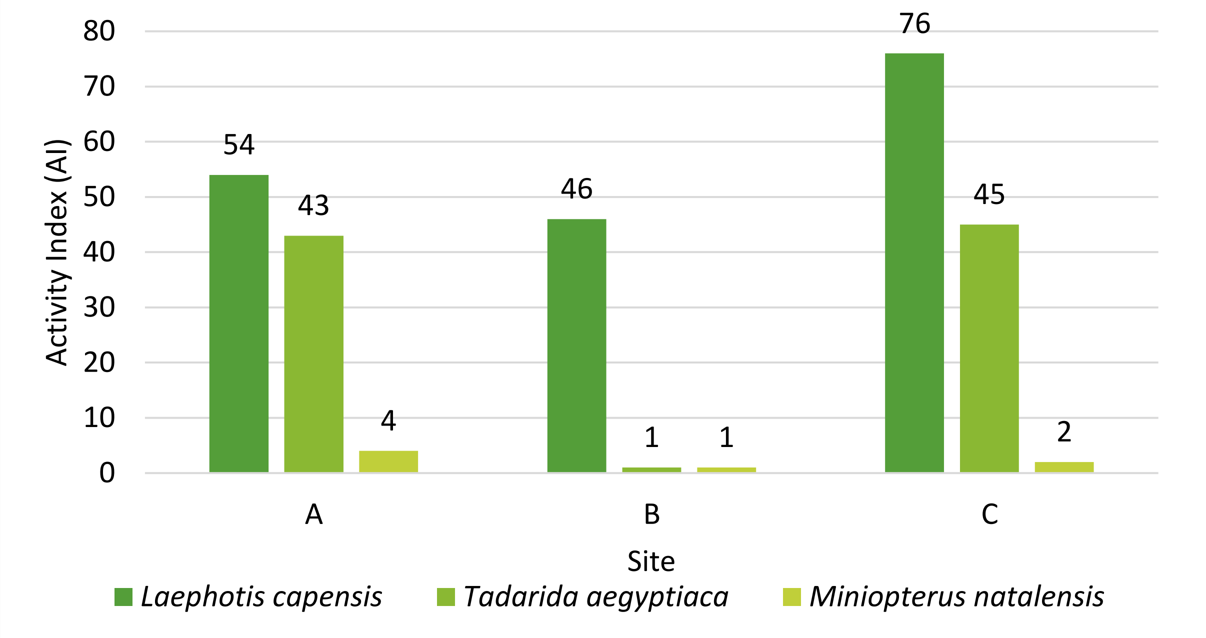


Figure 1. Activity index (AI) of *Laephotis capensis, Tadarida aegyptiaca* and *Miniopterus natalensis* across the three sites. The locations of the bat monitoring sites A, B and C are indicated in Image 6.

5.3.2 Bat activity over Phase 3 of the proposed Soventix solar PV facility and associated infrastructure, Hanover.

Total bat AI recorded by the three bat detectors over the proposed footprint for Phase 3 was very low with a total activity index (AI) of 272. Foraging activity was low with an AI of 35 and the remainder of the AI commuting/searching (n = 237).

The low AI recorded over the site was negatively correlated, although weakly, to the prevailing minimum temperatures (T_{min}) (Spearman's rank correlation: $P<0.05$, coefficient=-0.27) (**Figure 2**). AI across the proposed development footprint of Phase 3 was fairly even with no significant difference in AI between the three sites (Kruskal-Wallis: $P>0.05$).

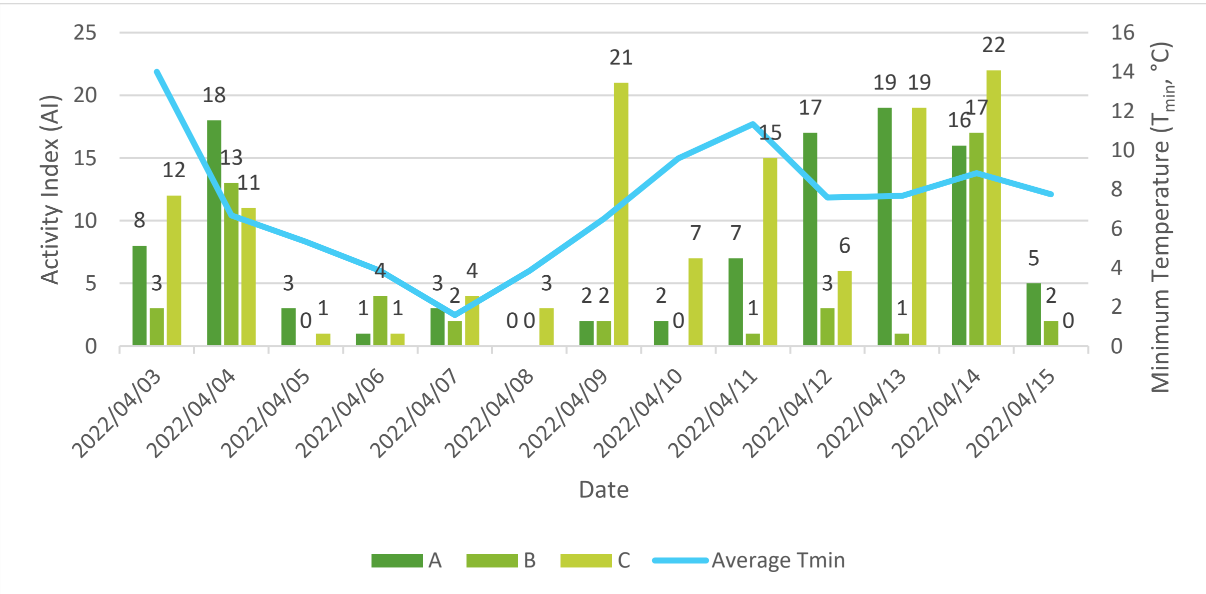


Figure 2. Activity index (AI) across the three sites in relation to the average minimum temperature (T_{min}).

6. Potential Impacts and Mitigation Measures

It is important that the project developers are cautious and sensitive to species occurring within a given development footprint in relation to potential cumulative impacts of anthropogenic activities and other solar PV facilities in the vicinity of the proposed Soventix solar PV facility and associated infrastructure. Fine scale and cumulative environmental impacts (regional and global) relating to the installation and operation of solar PV facilities have not been extensively addressed in scientific literature. The Linde Solar Farm (Simacel 155 Pty Ltd), Du Plessis Solar PV4, Mulilo Solar PV De Aar, South African Mainstream Renewable Power De Aar PV (De Aar Solar Power Pty Ltd) and Solar Capital De Aar (Solar Capital Pty Ltd) that lie 36km, 37km, 39km, 37km and 35km respectively from the proposed Soventix Solar Farm. The impacts of bats over these solar farms have not been assessed and addressed. Cumulatively, there may be a high potential for loss of species diversity, decrease in ecosystem functionality and service provision, and the cessation of processes within the landscape that can be permanent, lead to further land degradation and ultimately a collapse in the livelihood of natural fauna, flora and human inhabitants.

The conservation of the Nama-Karoo is largely dependent on the land use and conservation practices of privately owned land as the vast majority of vertebrate and invertebrate species are nomadic and move with the fluctuating availability of resources associated with the unpredictable nature of rainfall events. With the widespread water availability in the landscape due to the high volume of rainfall, I did not expect that bats would have congregated over specific water resources on the proposed Phase 3 footprint to reveal areas of importance thus potential impacts and mitigation measures are discussed considering the above average rainfall (as seen in the landscape during the April 2022 data collection period) and average rainfall that usually falls in the region.

The significance of the impacts of the planning & design phase, the construction phase and the decommissioning phase were determined by rating the impacts for each phase according to the following criteria:

- The **aspect** relates to the characteristic of a given activity that interacts with the environment that can cause an environmental impact. The impact can be either beneficial or adverse and can have a direct and decisive impact on the environment. The aspect can contribute partially or indirectly to a larger environmental change.
- The **extent** of the impact is rated;
    - High (4) if it extends beyond the boundaries of the site (Provincial, National, or International);
    - Moderate (3) if the impact is local (within the farm boundaries) to Regional (affects the neighbours);
    - Low (2) if the impact is contained within the boundary of the site or;
    - No impact (1) if no area is affected.
- The **intensity or magnitude** of the impact is rated;

    - High (4) if the functioning of the environmental processes will cease, if there is a complete change in species occurrence and species assemblages, or the disturbance of pristine areas;
    - Moderate (3) if the altered environmental processes will continue, if there are moderate changes in species occurrence and species assemblages or if areas of potential conservation and resource use by the species are disturbed
    - Low (2) if the natural processes are affected but not modified, if there are minor changes in species occurrence and species assemblages and if already degraded areas are disturbed;
    - No impact (1) if natural processes are not affected.
- The **duration** of the impact is rated;
    - High (4) if the impact is long term and permanent (>2years);
    - Moderate (3) if the impact is medium term and the lifespan of the impact is temporary and restricted to the operational phase (>1<2 years);
    - Low (2) if the impact is immediate and once-off with the lifespan of the impact restricted to the construction phase or to a season (<1 year).
- The **mitigation potential** will be rated;
    - High (4) if the potential to mitigate the impact and achieve the objectives is high;
    - Moderate (3) if the potential to mitigate the impact and achieve the objectives is moderate;
    - Low (2) if there is potential to mitigate the impact and a risk remains of the objectives not being met;
    - If there is no mechanism for mitigation and achieving the objects, the impact will be rated 1.
- The **acceptability** of the impact will be rated;
    - High (4) if the impact is unacceptable and the project or design must be abandoned;
    - Moderate (3) if the impact is manageable with expensive regulatory controls and the project proponent’s commitments;
    - Low (2) if there is some risk to the environment but can be easily prevented using simple controls or mitigation measures;
    - No impact (1) if the impacts are acceptable with no risk to the environment.
- The **probability of the impact occurring** will be reported as;
    - Definite (D – 4) if the impact has a high probability of occurring (>95%) if there is substantial supportive data or even if preventative measures are put in place;
    - Probable (P – 3) if there is a risk of the impact occurring (5-95%);
    - Improbable (I – 2) if the impact is unlikely to occur (<5%);

    - No impact (N – 1) if the impact will not occur (0%).
- The **status** if the impact occurs is categorised as;
    - Negative if there is a net loss of the resource, thus an adverse effect;
    - Neutral, if there is no net loss or gain;
    - Positive if there is a net gain of the resource if the impact occurs, thus a beneficial effect of the impact.
- The **potential to mitigate** is determined by the sum of the extent, magnitude and duration of the impact multiplied by the potential to mitigate as is classified as;
    - High if the significance value is between 30-40, thus there is a high potential to mitigate and achieve the project objectives;
    - Moderate if the significance value is between 20-29, thus there is a moderate potential to mitigate and achieve the project objectives;
    - Low if the significance value is between 0-19, thus indicating that there is a potential to mitigate, however, there is a risk that the project objectives are not met.

Areas of significance for bats such as foraging and socialising areas, landscape features used for commuting/navigation and roosting sites must be considered during the planning, layout and design of the solar arrays.

The potential impacts during planning and design, construction and operation, and decommissioning (including rehabilitation) are detailed below in **Table 3a-b** and mitigation measures are discussed below taking cumulative impacts of the surrounding developments into consideration.

Table 3a: Potential Impacts during the Planning & Design Phase.

Phase	Aspect		Mitigation Action	Extent	Magnitude	Duration	Mitigatory Potential	Significance	Acceptability	Probability of Impact Occurring	Status	Mitigation potential (to meet objectives)
Compliance												
Planning & Design	Decrease in species composition, activity and abundance.	Phase 3	Without	2	2	4	4	32	4	P-3	Negative	H
			With	2	1	1	4	16	2	I-2	Positive	

Table 3b: Potential Impacts during Construction and Operational Phases.

Phase	Aspect		Mitigation Action	Extent	Magnitude	Duration	Mitigatory Potential	Significance	Acceptability	Probability of Impact Occurring	Status	Mitigation potential (to meet objectives)
Compliance												
Construction & Operational Phase	Disturbance to or destruction of roosting sites.	Phase 3	Without	1	1	1	4	12	2	I-2	Neutral	L
			With	1	1	1	4	12	2	I-2	Neutral	
	Construction of PV altering commuting routes within the landscape.	Phase 3	Without	3	3	3	3	27	2	P-3	Negative	H
			With	2	2	2	3	18	2	I-2	Neutral	
	Disturbance/alteration of important areas of bat activity associated with vegetation clearing and	Phase 3	Without	2	3	4	4	36	4	P-3	Negative	H
			With	2	2	2	4	24	2	I-2	Neutral	

	ephemeral water resource disruption.											
	Changes in bat community and abundance of bat species due to habitat degradation.	Phase 3	Without	2	2	3	3	21	2	I-2	Neutral	M
			With	2	2	3	3	21	2	I-2	Neutral	
	Bat foraging patterns affected by habitat changes beneath the solar panels.	Phase 3	Without	3	4	4	3	33	3	P-3	Negative	H
			With	2	2	3	3	21	2	I-2	Neutral	
	Light pollution may alter species composition, foraging patterns and predation rate.	Phase 3	Without	3	3	3	4	36	3	P-3	Positive	H
			With	2	2	3	4	28	2	P-3	Neutral	
	Possible fatalities incurred from infrastructure associated with the solar PV facility including all infrastructure: Solar PV panels, fencing, transmission lines, buildings.	Phase 3	Without	3	3	4	3	30	3	P-3	Negative	M
			With	3	2	3	3	24	3	I-2	Neutral	
	Overall Cumulative Impact of regional solar PV facilities including Phase 3	Cumulative	Without	3	3	4	3	30	4	P-3	Neutral	M
			With	2	2	3	4	28	2	I-2	Neutral	

a. **Disturbance to roosting sites and commuting routes during construction activities,**

- Bats are known to use a variety of roost types from rock cavities, exfoliating rock, tree foliage, under tree bark, tree cavities, aardvark burrows, natural and man-made caves and numerous man-made structures (Jones *et al* 2009, Voight *et al.* 2016, Monadjem *et al.* 2020) however, during the active search for roosts in the rocky outcrop along the eastern boundary, no roosting sites were located.
- Linear structures in the landscape such as vegetation edges and rocky outcrops/ridges, are known to be used by some bats as landmarks to navigate across the landscape (Yovel and Ulanvosky 2017, Ávila-Flores *et al.* 2019).

It is recommended that the ridge near the eastern border is avoided for the development of the solar PV facility and associated infrastructure (**Image 9**). It would be preferable for a 100m buffer zone (from the crest of the ridge) to be extended around the rocky outcrop to limit any potential impact on possible roosting sites and commuting routes.

b. **The removal of vegetation and disruption of the ephemeral water resources resulting in the degradation of habitat resulting in the disturbance of important areas of bat activity,**

- Changes in landscape and habitat conversion can affect bat populations and assemblages on a local and regional scale (Jones *et al*. 2009; Jones *et al*. 2013; Jung and Kalko, 2011).
- Large scale removal of natural vegetation for the installation and operation of solar PV facilities can alter preferred habitats, cause a change in prey availability and thus a change in bat activity in the landscape.
- Seasonal water bodies (for example ephemeral pans) are important as surface water is a scarce resource in arid and semi-arid regions that is important for the survival of many animals (Korine *et al.* 2016; Loumassine *et al.* 2020). These pans are key drinking and foraging resources for bats and must be protected. Open water in arid and semi-arid environments (such as in the Nama-Karoo) may be an important resource influencing survival, resource use, distribution and activity of insectivorous bats.

It is recommended that;

- As much of the natural established vegetation is conserved.
- Where possible, use pre-existing roads during construction. Driving through natural vegetation and drainage lines must be discouraged where construction activities are not taking place.
- Disturbed areas are seeded after construction with seeds of the naturally occurring plant species to protect topsoil and encourage invertebrate species richness.
- The use of domestic livestock (preferably sheep as goats tend to be unselective and may be more destructive to vegetation than sheep) should be used to control the high of vegetation instead of herbicides. Careful management of the

grazing and browsing activity must be monitored as 1) grazing during and shortly after a drought can cause palatable plant species to die off, 2) heavy grazing pressure in summer will favour the growth of karoid shrubs, and 3) high grazing pressure during winter will favour the growth of perennial grasses (Mucina and Rutherford, 2011) both of which can affect insect abundance which in turn may affect bats.

- The topsoil and natural seed bank are protected. Ensure that the vegetation in the solar plant farm footprint is not overgrazed as this will significantly alter plant canopies can lead to the reduction in leaf litter from the plants which is important for seed retention (Jones and Esler, 2004) and will expose the soil to erosion by both wind and water. With the loss of precious topsoil, the restoration of these areas will be difficult.
- The ephemeral drainage line running centrally through the proposed footprint is not altered/developed as this feature would be an important seasonal resource for bats.

c. Light pollution during construction and operational phase.

- Although the solar PV facility will not be lit up during the night time period, selected infrastructure will have to be illuminated. These comparatively small illuminated areas can still impact the surrounding ecological functioning (including biological systems) of the adjacent landscape through spill over lighting and sky glow.
- Artificial lighting is well known to disrupt the flow of information to organisms, provides misleading clues (Rowse *et al.* 2016) and can cause interspecific competition for food resources by extending diurnal species foraging activity into the night-time period (Longcore and Rich, 2004). As such, the spill-over of artificial lighting beyond the proposed solar PV facility and associated infrastructure into dark, natural spaces must be prevented.
- Over fine and large scales, bats can be impacted by all types of conventional lighting (Stone *et al.* 2009; Rowse *et al.* 2016).
- Known impacts of artificial lighting on bats are; delayed emergence and reduced number of individuals from roosts, changes in navigation and commuting behaviour, foraging behaviour alterations, the creation of “barriers” limiting the connectivity of habitats in the landscape and the effective dispersal of species (isolating habitat patches and populations from immigration), and decreased growth rates of young bats if adult bats incur higher energetic losses and experience decreased foraging time if they have to forage further afield from maternity roosts (Stone *et al.* 2009; Boldogh *et al.* 2007; Lewanzik and Voigt, 2014; Gaston and Bennie, 2014; Minnaar *et al.* 2014; Stone *et al.* 2015; Voigt *et al.* 2020).
- Artificial lighting appears to benefits some bat species (light-tolerant) through increasing their foraging efficiency by identifying and exploiting insects

swarming around lights (Lewanzik and Voigt 2014, Rowse *et al.* 2016). Typical bat species that make use of the foraging opportunities under lights are often open-air and clutter-edge forager bat species with echolocation calls adapted for open and semi-open habitats created around artificial lighting (Rowse *et al.* 2016), thus there is an expectation that *L. capensis* and *T. aegyptiaca* may benefit from artificial lighting. *Laephotis capensis* has been shown to forage around lights (Minnaar *et al.* 2014).

- Light intolerant bat species are often slow flying and highly manoeuvrable, adapted for foraging in cluttered environments such as Rhinolophids and Nycterids (Schoeman, 2015; Lewanzik and Voigt, 2014). One reason for these species avoiding lit areas is that their echolocation call structure is not well suited for foraging in the open habitat associated with artificial lighting (Rowse *et al.* 2016). A second reason for certain bat species to avoid artificially lit areas is the sensitivity of bat eyes to light. As light intensity increases, bat's visual sensitivity decreases (Fure, 2006).
- Lighting, particularly in arid regions can have significant impacts on arid bat communities where bats may reduce drinking activity due to artificial lighting (Russo *et al.* 2018).
- Based on Gaston *et al.* (2012), a combination of mitigation strategies could effectively reduce the impact of ecological light pollution. These mitigation options have been suggested below.

Thus, it is highly recommended that:

- The number and position of lights required are limited and installed in areas where it is absolutely necessary,
- A light shield/lamp shade should be used to focus the beam downwards onto the ground to prevent sky glow as well as to prevent light from trespassing beyond the development area into the surrounding naturally dark areas,
- The intensity of the lighting is lowered (dim the lights). Alternatively, in conjunction with substantially dimming the lights, motion sensors could be installed that upon triggering, will increase the light intensity should a trespasser enter the site,
- The spectrum of light chosen has longer wavelengths to reduce the attractiveness of light to insects and in turn, will not cause increased predation pressure and competition around light sources by bats,
- If possible, the duration of the lighting period should be limited and lights switched on shortly after the peak night-time emergence of clutter-edge forager bats ~60min after sunset (Thomas and Jacobs, 2013).

d. Habitat changes beneath the solar panels.

- The change in the microclimate between and beneath the solar panels may provide different ecological conditions which may encourage or provide suitable conditions for botanical diversity (Montag *et al.* 2016). Botanical diversity influences invertebrate diversity as plants provide forage, suitable habitat and structure for reproduction (Montag *et al.* 2016), and thus in turn may positively influence and possibly increase bat foraging activity.

It is recommended that indigenous plant seed mix is planted between and below the solar panels to encourage suitable prey availability for bats.

e. Potential collisions with solar PV facility infrastructure: Solar PV panels and security fencing

- The risk of direct collisions of bats with solar PV panels is unknown and the perception of smooth surfaces by bats is not well studied. If bats perceive smooth surfaces as voids (Montag *et al.* 2016), solar PV panels left in a resting position perpendicular or more than 45 degrees in relation to the ground could pose a collision risk. However, this risk is negated for the proposed Phase 3 since single-axis tracker that allows the panels to be stowed horizontally at night to reduce wind-load and if bats are "confused" by the smooth surface or perceive it as a potential drinking source may approach the surface at a slower speed and not collide with it.
- A 1.8m high galvanised diamond razor mesh security fence will be installed around each of the four solar PV areas. The risk of the security fence in relation to bat collisions and bat injury/mortality is largely unknown. The fatality predictions reported on Smallwood (2022) took into account associated infrastructure including security fencing.

It is recommended that follow up monitoring (during construction and operation) of the solar PV facility and associated infrastructure including mortality searches along the fence line is conducted to determine if the security fences pose a threat to bats.

f. Cumulative impacts of nearby solar PV facilities on regional bat populations

- Considering that in general bats are sensitive to changes in habitat that drives species composition, activity and abundance (Fahr and Kalko, 2011; Montag *et al.* 2016; Olimpi and Philpott, 2018), the cumulative impact of the alteration of habitat over a greater area may cause a shift in the abundance of bat species to favour open-air forages such as *T. aegyptiaca* if the alteration in habitat is unfavourable for clutter-edge and clutter forager species such as *L. capensis* and *Rhinolophus* species.
- If bat roosting sites were not considered in the assessments of the nearby solar PV facilities, bats could be displaced and may impact on occupied roosting sites and or encourage bats to use anthropogenic structures as alternative roosting sites which could lead to human-wildlife conflict.
- Ephemeral water resources are critical for bats in arid and semi-arid environments for foraging and drinking (Salinas-Ramos *et al.* 2019). If the main seasonal water resources/drainage lines were not protected in the other facilities, inter- and intra-specific competition could occur at neighbouring existing ephemeral water resources.

- Navigation and/or commuting routes could be negatively impacted or altered if landscape features such as ridges are developed or removed for the solar PV facilities.

The impact of Phase 3 can be kept minimal by implementing the mitigation strategies discussed above to ensure the protection of ephemeral water resources, roosting sites, navigational landscape features and maintaining natural vegetation to preserve the existing bat communities and populations.

8. Post-construction Monitoring

Annual monitoring during preconstruction, construction and during the operational phase will provide much needed insight into the changes in bat activity, species composition and ecology over the affected property. One year preconstruction, one year construction of continuous bat and two years post-construction of continuous bat monitoring using passive bioacoustic recording systems in line with the South African Good Practice Guidelines for Surveying Bats at WEF's (Sowler and Stoffberg, 2014) and SAGPG for Operational Monitoring (Aronson *et al.* 2014) should be followed. Should it be found that the construction phase extends beyond a year, the monitoring period can be reduced to the spring/summer months. During the first two years of operation, it is expected that any changes in bat activity and perceived impacts will be most evident. Searches for bat fatalities at solar PV panels, near infrastructure and security fencing must be conducted. Post-construction monitoring can be altered accordingly based on the data collected during the construction phases. By following these guidelines, data sets can be gathered that are comparable with other large-scale renewable energy projects that impact bats, and consolidated to understand the extent of the impacts of these projects and define effective mitigation strategies.

8. Limitations and Assumptions

Prevailing weather and landscape conditions did not allow for the same methodology to be employed as the bat specialist study for Phase 1 and 2. Prevailing weather conditions also impacted bat activity, thus even though nearly two weeks of data was collected, the bat activity across the site is most likely under-represented. The study was also conducted late in the generally accepted bat season and as such, may also account for the low activity and low number of species recorded across the site.

The "whispering" Common slit-faced bat *Nycteris thebaica* is not easily detected and recorded by bat detectors, thus the species presence across the site could not be verified acoustically.

It is assumed that during the peak summer period (mid-summer months), bat activity will be significantly higher than reported in the current report and during this time, additional species may be recorded.

By avoiding bat sensitive areas such as the centrally located ephemeral drainage line and the rocky ridge, that the impact on the local bat community could be moderate to low.

9. General Conclusion

Based on the data collected during the bat baseline survey and available literature, in my opinion, there is little reason for the development of Phase 3 of the proposed Soventix solar PV facility and associated infrastructure not to be approved provided mitigation measures are put in place during the development, operation and decommissioning of the Soventix solar PV facility and associated infrastructure. The rehabilitation and management of the operational solar PV facility and associated infrastructure will be a critical activity as this will have a direct impact on biodiversity and ecosystem functioning further afield than within the boundary of the solar PV facility. The areas demarcated for the development of Phase 1 and 2 have already taken into consideration sensitive habitats and thus the mitigation measures recommended for Phase 1 and Phase 2 including the designated no go areas, will keep sensitive habitats/areas intact and provide corridors through the development areas to neighbouring undeveloped areas that bats could commute and forage through.

Although no specialist bat species were recorded during the study, cumulative impacts of renewable energy facilities in the area may have detrimental impacts on the bat communities in the region. Cumulative deterioration to the landscape and the loss of habitat due to vegetation clearing and roost disturbance/destruction may cause a shift in the species composition and abundance within the bat community to a bias towards more hardy species such as the Egyptian free-tailed bat, *T. aegyptiaca*.

Bat activity and trends in population numbers are of particular interest to determine the cumulative long-term effects of solar PV facilities. It is suggested that a passive recording monitoring system be put in place for one year pre-construction/during construction and thereafter bat activity during construction be monitored during the spring/summer seasons. Two years post construction bat monitoring is advised. A specialist should maintain these systems and determine the impacts of solar PV facility on bat populations in relation to landscape changes in both the physical changes with the installation of the solar PV panels, the resulting change in vegetation structure underneath the solar PV panels and the management strategy of the operational facility. The resulting data from long-term studies/monitoring programs, will assist scientists to determine the effects and impacts of solar PV facilities on South African bat species and thus their conservation.

The views expressed in this report are cautious with an emphasis on conserving the natural vegetation, seasonal resources (such as the ephemeral drainage line), rocky outcrops and ecosystem functionality to enhance the conservation of all bat species that occur in the area and not only the Cape Serotine bat (*L. capensis*), the Egyptian free-tailed bat (*T. aegyptiaca*) and the Natal long-fingered bat (*M.* natalensis) that were recorded during the specialist study.

10. Credentials of the Author

Dr. Dawn Cory-Toussaint has had an interest in bats from a young age and has been involved with the Gauteng and Northern Regions Bat Interest Group since 2004 which developed her interest in Chiropterans further. She completed her doctorate in 2021 investigating the potential of bat species as bioindicators for areas currently transformed by opencast diamond mining in Limpopo. Her honours and Masters studies were focused on heterothermy in bats. Dawn's bat related publications are provided.

Cory-Toussaint D. and Taylor, P. J. 2022. Anthropogenic light, noise, and vegetation cover differentially impact different foraging guilds of bat on an opencast mine in South Africa. *Frontiers in Ecology and Evolution.* https://doi.org/10.3389/fevo.2022.752665.

Cory-Toussaint, D., Taylor, P. J. and Barnhoorn, I. E. J. 2021. Non-invasive sampling of bats reflects their potential as ecological indicators of elemental exposure in a diamond mining area, northern Limpopo Province, South Africa. *Environmental Science and Pollution research.* https://doi.org/10.1007/s11356-021-16466-x.

Cory Toussaint, D., Brigham, R. M., & McKechnie, A. E. 2013. Thermoregulation in free-ranging *Nycteris thebaica* (Nycteridae) during winter: No evidence of torpor. *Mammalian Biology* **78**: 365–368. https://doi.org/10.1016/j.mambio.2012.10.001.

Cory Toussaint, D., & McKechnie A. E. 2012. Interspecific variation in thermoregulation among three sympatric bats inhabiting a hot, semi-arid environment. *Journal of Comparative Physiology B.* **182**: 1129-1140. https://doi.org/10.1007/s00360-012-0683-6.

Cory Toussaint, D., McKechnie, A. E., & van der Merwe, M. 2010. Heterothermy in free-ranging male Egyptian free-tailed bats (*Tadarida aegyptiaca*) in a subtropical climate. *Mammalian Biology* **75**: 466–470. https://doi.org/10.1016/j.mambio.2009.06.001.

Taylor, P. J. Strydom, E., Richards, L., Markotter, L., Cory Toussaint, D., Kearney, T., Cotterill, F. P. D., A. Howard, A., S.A M. Weier, Keith, M., Neef G., Mamba M. L., Magagula, S., and Monadjem A. *In Press*. Highlighting the Angolan Highlands as a diversity hotspot: new collections and new species from south-central Africa resolve the taxonomy of African pipistrelle-like bats. *Zoological Journal of the Linnean Society* Accepted - in Revision.

Taylor, P. J., Nelufule, M., Parker, D. M., Cory Toussaint, D. and Weier, S. M. 2020. The Limpopo River exerts a powerful but spatially limited effect on bat communities in a semi-arid region of South Africa. *Act Chiropterologica* **22**: 75-86. https://doi.org/10.3161/15081109ACC2020.22.1.007.

Dawn Cory Toussaint has been involved in bat surveys for North West Nature Conservation, biodiversity projects and assisting in the study of reproduction in *Tadarida aegyptiaca* (University of Pretoria).

From August 2013-August 2014 she held a position as a Junior Environmental Consultant for Animalia: Zoological and Ecological Consultation CC. as a bat specialist for pre-construction surveys of Wind Energy Farms across the country.

During 2016 she conducted the bat specialist study for Phases 1 & 2 of the proposed Soventix Solar Photovoltaic Plant, a baseline assessment of the bats species on the proposed Spitsvale opencast mining project, Steelpoort, Limpopo Province and compiled a bat species list for the Booysendal Mine, Limpopo Province.

In December 2017, she conducted the bat specialist study for the proposed Modderfontein Solar Photovoltaic Plant, Ekurhuleni, Gauteng, South Africa.

Dawn, together with Fenton "Woody" Cotterill, was part of the National Geographic expedition team in Angola for the Okavango Wilderness Project during November 2019 and their responsibility was small mammal sampling (predominantly bats).

During May and June 2021, Dawn investigated the impact of mining operations on the bat communities further field from the Venetia Diamond Mine.

During April 2022 she compiled the bat specialist study report for the proposed Venetia Solar Photovoltaic Plant, Venetia Diamond Mine, Limpopo.

Dawn is a recent member (member #0052) of the South African Bat Assessment Association.

11. References

Agudelo, M. S., Mabee, T. J., Palmer, R. and Anderson, R. 2021. Post-construction bird and bat fatality monitoring studies at wind energy projects in Latin America: a summary and review. *Heliyon* **7**: e07251. https://doi.org/10.1016/j.heliyon.2021.e07251.

Ancillotto, L., Santini, L., Ranc, N., Maiorano, L. and Russo, D. 2016. Extraordinary range expansion in a common bat: the potential roles of climate change and urbanisation. *Sci Nat* DOI: 10:1007/s00114-016-1334-7.

Aronson, J., Richardson, E. K., MacEwan, K., Jacobs, D., Marais, W., Aiken, S., Taylor, P., Sowler, S. and Hein, C. 2014. South African good practice guidelines for operational monitoring for bats at wind energy facilities.

Ávila-Flores, R., Bolaina-Badal, A. L., Gallegos-Ruiz, A. and Sánchez-Gómez, W. S. 2019. Use of linear features by the common vampire bat (*Desmodus rotundus*) in a tropical cattle-ranching landscape. *Therya* **10**: 229-234. https://doi.org/10.12933/therya-19-890.

Blakey, R. V., Law, B. S., Straka, T. M., Kingsford, R. T. and Milne, D. J. 2018. Importance of wetlands to bats on a dry continent: a review and meta-analysis. *Hystrix* **29**: 41-52. https://doi.org/0.4404/hystrix–00037-2017.

Boldogh, A., Dobrosi, D. and Samu, P. 2007. The effects of the illumination of buildings on house-dwelling bats and its conservation consequences. *Acta Chiropterologica* **9**: 527-534.

Choi, D. Y., Wittig, T. W. and Kluever, B. M. 2020. An evaluation of bird and bat mortality at wind turbines in the Northeastern Unites States. *PLoS ONE* **15**: e0238034. https://doi.org/10.1371/journal.pone.0238034.

Fahr, J. and Kalko, K. V. 2011. Biome transitions as centres of diversity: habitat heterogeneity and diversity patterns of West African Bat assemblages across spatial scales. *Ecography* **34**: 177-195. https://doi.org/10.1111/j1.600-0587.2010.05510x.

IUCN 2021. The IUCN Red List of Threatened Species. Version 2021-3. http://www.iucnredlist.org.

Gaston, K. J., Davies, T. W., Bennie, J. and Hopkins, J. 2012. Reducing the ecological consequences of night-time light pollution: options and developments. *Journal of Applied Ecology* **49**: 1256-1266. https://doi.org/10.1111/j.1365-2664.2012.02212.x.

Gaston, K. J., and Bennie, J. 2014. Demographic effects of artificial nighttime lighting on animal populations. *Environmental Review* **22**: 323–330**.** https:**//**doi.org/10.1139/er-2014-0005.

Jones, G., Jacobs, D. S., Kunz, T. H., Willig, M. R. and Racey, P. 2009. Carpe noctem: the importance of bats as bioindicators. *Endangered Species Research* 8: 93-115.

Jones, K. E., Russ, J. A., Bashta, A., Bilhari, Z., Catto, C., Csosz, I., Gorbachev, A., Gyorfi, P., Hughes, A., Ivashkiv, I., Koryagina, N., Kurali, A., Langton, S., Collen, A., Margiean, G., Pandourski, I., Parsons, S., Prokofev, I., Szodoray-Paradi, A., Szodoray-Paradi, F., Tilova, E., Walters, C. L., Weatherill, A. and Zavarzin, O. 2013. Indicator Bat Program:

A System for the Global Acoustic Monitoring of Bats. *Biodiversity Monitoring and Conservation: Bridging the Gap between Global Commitment and Local Action, 1st Edition.* John & Wiley Sons, Ltd. Chapter 10.

Jones, F. E. and Esler, K. J. 2004. Relationship between soil-stored seed banks and degradation in Eastern Nama Karoo rangelands (South Africa). *Biodiversity & Conservation* 13: 2027-2053.

Jung, K. and Kalko, E. K. V. 2011. Adaptability and vulnerability of high flying Neotropical aerial insectivorous bats to urbanisation. *Diversity and Distributions* 1-13.

Korine, C., Adams, R., Russa, D., Fisher-Phelps, M. and Jacobs, D. 2016. Chapter 8 – Bats and water: Anthropogenic alterations threaten global bat populations. *Bats in the Anthropocene: Conservation of Bats in a Changing World,* DOI 10.1007/978-3-319-25220-9_8.

Kunz, T. H., de Torrez, E. B., Bauer, D., Lobova, T. and Fleming, T. H. 2011. Ecosystem services provided by bats. *Annals of the New York Academy of Sciences* **1223**: 1–38. https://doi.org/10.1111/j.1749-6632.2011.06004.x.

Lewanzik, D., and Voigt, C. C. 2014. Artificial light puts ecosystem services of frugivorous bats at risk. *Journal of Applied Ecology* **51**: 388–394. https://doi.org/10.1111/1365-2664.12206.

Longcore, T. and Rich, C. 2004. Ecological light pollution. *Frontiers in ecology and Environment* **2**: 191–198. https://doi.org/10.1890/1540–9295(2004)002[0191:ELP]2.0.CO;2.

Loumassine, H. E., Bonnot, N., Allegrini, B., Bendjeddou, M. L., Bounaceur, F. and Aulagnier, S. 2020. How arid environments affect spatial and temporal activity of bats. *Journal of Arid Environments* **180**: 104206. https://doi.org/10.1016/j.jaridenv.2020.104206.

Miller, B. W. 2001. A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring. *Acta Chiropterologica* 3: 93–105.

Minnaar, C., Boyles, J. G., Minnaar, I. A., Sole, C. L. and McKechnie, A. E. 2014. Stacking the odds: Light pollution may shift the balance in an ancient predator-prey arms race. *Applied Ecology* **52**: 522-531. https://doi.org/10.1111/1365-2664.12381.

Montag, H., Parker, G. and Clarkson, T. 2016. The effects of solar farms on local biodiversity: A comparative study. Clarkson and Woods and Wychwood Biodiversity.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. and Schoeman, M.C. 2020. Bats of Southern and Central Africa: A Biogeographic and Taxonomic Synthesis, Second Edition. University of Witwatersrand Press, Johannesburg.

Mucina, L. and Rutherford, M. C. 2011. The Vegetation of South Africa, Lesotho and Swaziland- *Strelitzia 19,* South African National Biodiversity Institute, Pretoria.

Olimpi, E. M. and Philpott, S. M. 2018. Agroecological farming practices promote bats. *Agriculture, Ecosystems and Environment* **265**: 282-291. https://doi.org/10.1016/j.agee.2018.06.008.

Razgour, O., Korine, C. and Saltz, D. 2011. Does interspecific competition drive patterns of habitat use in desert bat communities? *Oecologia* **167**: 493-502. https://doi.org/10.1007/s00442-011-1995-z.

Rowse, E. G., Lewanzik, D., Stone, E. L., Harris, S. and Jones, G. 2016. Chapter 7: Dark Matters: The effects of artificial lighting on bats, in Bats in the Anthropocene: Conservation of Bats in a Changing World, eds. Voigt, C. C. and Kingston, T. https://doi.org/10.1007/978-3-319-25220-9_7.

Russo, D., Ancillotto, L., Cistrone, L., Libralato, N., Domer, A., Cohen, S. and Korine, C. 2018. Effects of artificial illumination on drinking bats: a field test in forest and desert habitats. *Animal Conservation* **22**: 124-133. https://doi.org/10.1111/acv.12443.

Salinos-Ramos, V. B., Ancillotto, L., Bosso, L., Sanchez-Cordero, V. and Russo, D. 2019. Interspecific competition in bats: state of knowledge and research challenges. *Mammal Review* https://doi.org/10.1111/mam.12180.

Scholz, C. and Voigt, C. C. 2022. Diet analysis of bats killed at wind turbines suggests large-scale losses of trophic interactions. *Conservation Science and Practice* https://doi.org/10.1111/csp2.12744.

South African Red List of Mammals 2016. http://www.ewt.org.za/reddata.

Sowler, S. and Stoffberg, S. 2014. South African good practice guidelines for surveying bats in wind farm developments. *Endangered Wildlife Trust.*

Smallwood, S. K. 2022. Utility-scale solar impacts to volant wildlife. *The Journal of Wildlife Management* **86**: e22216. https://doi.org/10.1002/jwmg.22216.

Smith, A., Schoeman, M. C., Keith, M., Erasmus, B. E., Monadjem, A., Moilanen, A. and Di Minin, E. 2016. Synergetic effects of climate and land-use change on representation of African bats in priority conservation areas. *Ecological Indicators* **69**: 276-283. https://doi.org/10.1016/j.ecolind.2016.04.039.

Stone, E. L., Jones, G. and Harris, S. 2009. Street lighting disturbs commuting bats. *Current Biology* **19**: 1123–1127. https://doi.org/10.1016/j.cub.2009.05.058.

Stone, E. L., Harris, S. and Jones, G. 2015. Impacts of artificial lighting on bats: a review of challenges. *Mammalian Biology*, DOI 10.1016/j.mambio.2015.02.004.

Thomas, A. J. and Jacobs, D. S. 2013. Factors influencing the emergence times of sympatric insectivorous bat species. *Acta Chiropterologica* **15**: 121-132. https://doi.org/102.3161/150811013X667920.

Turney, D. and Fthenakis, V. 2011. Environmental impacts from the installation and operation of large-scale solar power plants. *Renewable and Sustainable Energy Reviews* 15: 3261-3270.

Visser, E., Perold, V., Ralston-Paton, S., Cardenal, A. c. and Ryan, P. G. 2018. Assessing the impacts of a utility-scale photovoltaic solar energy facility on birds in the Northern Cape, South Africa. *Renewable Energy* https://doi.org/10.1016/j.renene.2018.08.106.

Voigt, C. C., Scholl, J. M., Bauer, J., Teige, T., Yovel, Y., Kramer-Schadt, S. and Gras, P. 2020. Movement responses of common noctule bats to the illuminated urban landscape. *Landscape Ecology* **35**: 189-201. https://doi.org/10.1007/s10980-019-00942-4.

Yovel, Y. and Ulanvosky, N., 2017. Bat Navigation. *Learning and Memory: A Comprehensive Reference, 2nd ed.; Byrne, JH, Ed*, pp.333-345.

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13. Declaration of Independence

Appendix 1.

14. Compliance to Appendix 6 of GNR 982 (EIA 2014 regulations)

Appendix 2.