DEVELOPMENT OF THE DOORNHOEK PV 2 FACILITY AND ASSOCIATED INFRASTRUCTURE, NORTH WEST PROVINCE

Avifauna Baseline and Impact Assessment Report

April 2022

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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Doornhoek PV (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Doornhoek 2 PV facility and associated infrastructure on Portion 18 of the Farm Doornhoek 372 IP, near Klerksdorp, North West Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the project area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the project area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species).

Baseline avian data was obtained from point count sampling techniques during two independent sampling sessions (December 2021 and March 2022).

Five prominent avifaunal habitat types were identified on the study site, and consisted of open savannoid grassland with bush clump mosaics, short Klerksdorp Thornveld, secondary (regenerating) grassland on old agricultural fields, dense short *Grewia*-*Vachellia* shrubveld and transformed areas consisting of build-up land. The highest number of bird species and bird individuals were observed from dense thornveld/shrubveld habitat. Approximately 223 bird species were expected to occur in the wider study area, of which 118 species were observed in the study site and immediate surroundings. The expected richness included 11 threatened or near threatened species, 16 southern African endemics and 25 were near-endemic species. The endangered Secretarybird (*Sagittarius serpentarius*) was confirmed from open grassland habitat south-west of the study site, with a nest located 2.3km south-west of the study site. Ten southern African endemics and 14 near-endemic species were confirmed on the study site and immediate surroundings.

The main impacts associated with the proposed PV solar facility includes the following:

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction.
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or colliding with the panels (as they are mistaken for waterbodies).
- Collision with associated infrastructure (mainly overhead power lines).

The proposed PV layout did not overlap with a prescribed Secretarybird buffer area (see Figure 15 in main document), whereby an evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). In addition, the study site did not overlap with any major avian flyway, which explains the low occurrence of waterbird

taxa at the study site.

No fatal-flaws were identified during the assessment, although it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

In addition, a total of 56 collision-prone bird species have been recorded from the wider study area (*sensu* atlas data), of which 26 species were birds of prey.

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DECLARATION OF INDEPENDENCE

I, Lukas Niemand (Pachnoda Consulting CC) declare that:

- I act as the independent specialist in this application to Doornhoek PV (Pty) Ltd ("the applicant");
- I will 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 applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
13 April 2022

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 15 years of experience in ecological-related assessments and more than 10 years in the field of bird interactions with electrical and renewable energy infrastructure. He has conducted numerous ecological and avifaunal impact assessments including Eskom Transmission projects, hydro-electric schemes, solar farms and other activities in South Africa and other African countries.

1. INTRODUCTION

1.1 Background

Pachnoda Consulting cc was requested by Doornhoek PV (Pty) Ltd to compile an avifauna impact assessment report for the proposed Doornhoek 2 PV facility (herewith referred to as the "study site") and associated infrastructure with a contracted capacity of up to 50MW located on a site approximately 11km north of the town of Klerksdorp in the North West Province (Figure 1). The development area is situated within the City of Matlosana Local Municipality within the Dr Kenneth Kaunda District Municipality. The site is accessible via an existing district road located adjacent to the east of the development area.

The infrastructure of the facility will consist of the following components (Figure 2):

- PV modules and mounting structures
- Inverters and transformers
- Battery Energy Storage System (BESS)
- Site and internal access roads (up to 8m wide)
- Operation and Maintenance buildings, including a gate house and security building, control centre, offices, warehouses and workshops for storage and maintenance.
- Temporary and permanent laydown area
- Grid connection solution, including the following:
    - 33kV cabling between the project components and the facility substation
    - A 132kV facility substation
    - A 132kV Eskom switching station
    - A Loop-in-Loop out (LILO) overhead 132kV power line between the Eskom switching station and the existing Watershed–Klerksdorp 1 132kV power line.

The proposed Doornhoek 2 PV Facility will cover approximately 80ha in extent.

The project site is located within the Klerksdorp Renewable Energy Development Zones (REDZ), and therefore, a Basic Assessment (BA) process will be undertaken in accordance with GN R114 (as formally gazetted on 16 February 2018). An additional up to 115MW PV facility (referred to as "Doornhoek 1 PV Facility") is concurrently being considered on the same property and is being assessed through a separate Basic Assessment (BA) process.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the project area[1] according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the project area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species; sensu IUCN, 2022; Taylor et al., 2015; Marnewick et al., 2015).

A bird assessment is required as part of the Environmental Impact Assessment process to investigate the impacts of the proposed solar facility on the avian attributes at the study site and its immediate surroundings. The avifaunal attributes at the proposed PV facility will be determined by means of a desktop analysis of GIS based information, third-party datasets and a number of site surveys. It also provides the results from two independent pre-construction surveys as per the best practice guidelines of Jenkins *et al.* (2017).

The terms of reference are to:

- conduct a baseline bird assessment based on available information pertinent to the ecological and avifaunal attributes on the project area and habitat units;
- conduct an assessment of all information on an EIA level in order to present the following results:
    - typify the regional and site-specific avifaunal macro-habitat parameters that will be affected by the proposed project;
    - provide a shortlist of bird species present as well as highlighting dominant species and compositions;
    - provide an indication on the occurrence of threatened, near threatened, endemic and conservation important bird species likely to be affected by the proposed project;
    - provide an indication of sensitive areas or bird habitat types corresponding to the study site;
    - highlight areas of concern or "hotspot" areas;
    - identify and describe impacts that are considered pertinent to the proposed development;
    - highlight gaps of information in terms of the avifaunal environment; and
    - recommend additional surveys and monitoring protocols (*sensu* Jenkins et al., 2017).

[1] The "project area" has a larger footprint than the proposed Doornhoek 2 PV facility and its associated infrastructure (the "study site") and includes the immediate surroundings.

1.3 Scope of Work

The following aspects form part of the Scope of Work:

- A desktop study of bird species expected to occur (e.g. species that could potentially be present), as well as species recorded in the past (e.g. SABAP1);
- A baseline survey of observed bird species according to ad hoc observations and two sampling surveys;
- A list of bird species historically recorded within the relevant quarter degree grid in which the study site occurs (SABAP1);
- Any protected or threatened bird species recorded in the past within the relevant quarter degree grid, their scientific names and colloquial names, and protected status according to IUCN red data lists; and
- The potential of these protected or threatened species to persist within the study area.

The following aspects will be discussed during this avifaunal assessment:

- Collision-prone bird species expected to be present and or observed;
- A list of the dominant bird species;
- A list of observed and expected threatened and near threatened species (according to IUCN red data list);
- Possible migratory or nomadic species;
- Potential important flyways/ congregatory sites and/or foraging sites; and
- Avian impacts associated with the PV solar facility.

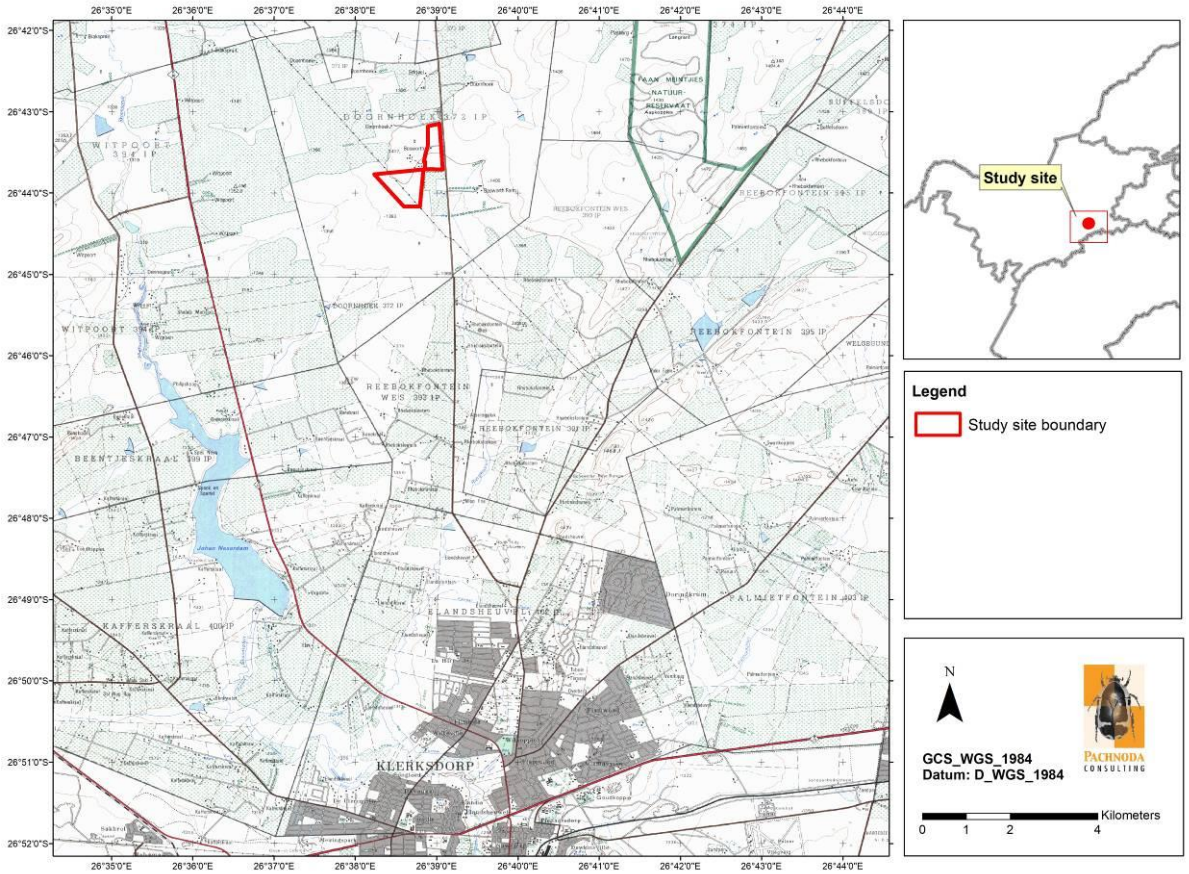

Figure 1: A topo-cadastral image illustrating the geographic position of the Doornhoek 2 PV facility.

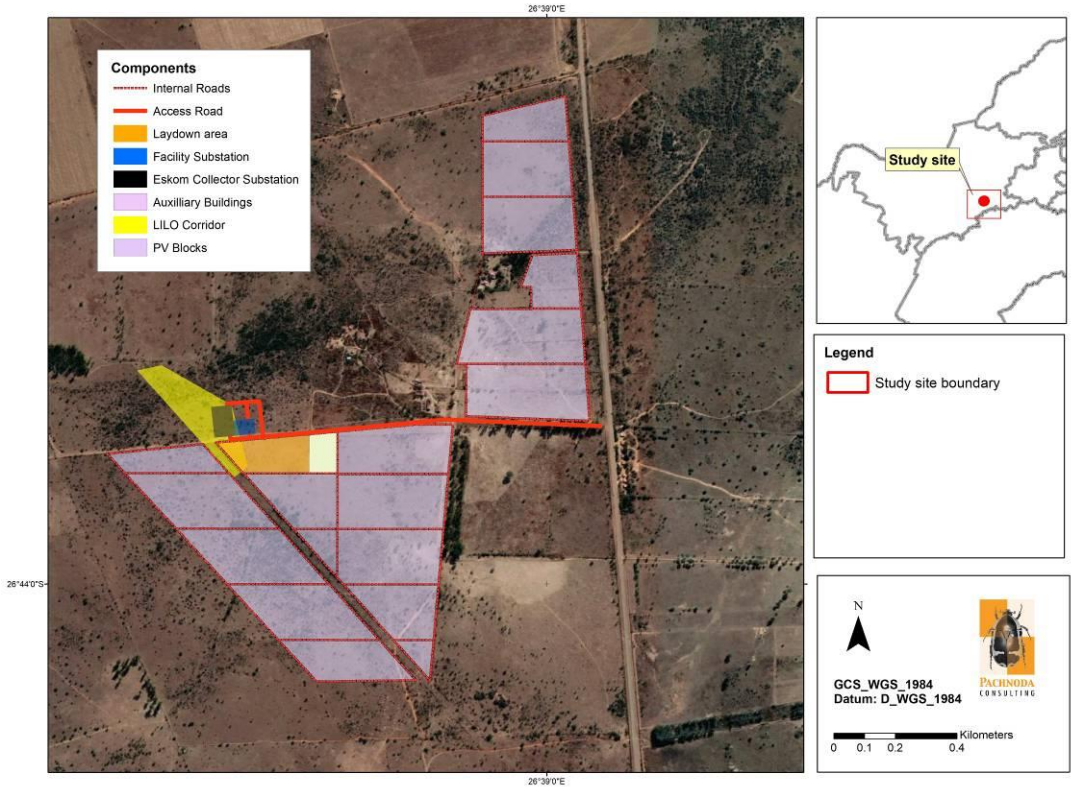

Figure 2: A satellite image illustrating the geographic position of the proposed Doornhoek 2 PV facility and associated infrastructure.

2. METHODS & APPROACH

The current report places emphasis on the avifaunal community as a key indicator group on the proposed study site, thereby aiming to describe the conservation significance of the ecosystems in the area. Therefore, the occurrence of certain bird species and their relative abundances may determine the outcome of the ecological sensitivity of the area and the subsequent proposed layouts of the solar facility infrastructure.

The information provided in this report was principally sourced from the following sources/observations:

- relevant literature – see section below;
- relevant literature – see section below;
- observations made during two site visits (20 - 22 December 2021 and 11 - 12 and 14 March 2022); and
- personal observations from similar habitat types in proximity to the study area.

2.1 Literature survey and Database acquisition

A desktop and literature review of the area under investigation was commissioned to collate as much information as possible prior to the detailed baseline survey. Literature consulted primarily makes use of small-scale datasets that were collected by citizen scientists and are located at various governmental and academic institutions (e.g. Animal Demography Unit & SANBI). These include (although are not limited to) the following:

- Hockey *et al.* (2005), Harrison *et al.* (1997) and Del Hoyo *et al.* (1992-2011) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities (e.g. biome-restricted bird species) of selected bird species that could be present on the study site.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2022) and the regional conservation assessment of Taylor *et al.* (2015).
- Distributional data was sourced from the South African Bird Atlas Project (SABAP1) and verified against Harrison et al. (1997) for species corresponding to the quarter-degree grid cell (QDGC) 2626DA (Rykaartspos) and 2626DC (Klerksdorp). The information was then modified according to the prevalent habitat types present on the study site. The SABAP1 data provides a “snapshot” of the abundance and composition of species recorded within a quarter degree grid cell (QDGC) which was the sampling unit chosen (corresponding to an area of approximately 15 min latitude x 15 min longitude). It should be noted that the atlas data makes use of reporting rates that were calculated from observer cards submitted by the public as well as citizen scientists. It therefore provides an indication of the thoroughness of which the QDGCs were surveyed between 1987 and 1991.
- Additional distributional data was also sourced from the SABAP2 database (http://www.sabap2.birdmap.africa). The information was then modified according to the prevalent habitat types present on the study site. Since bird distributions are dynamic (based on landscape changes such as fragmentation and climate change), SABAP2 was born (and launched in 2007) from SABAP1 with the main difference being that all sampling is done at a finer scale known as pentad grids (5 min latitude x 5 min longitude, equating to 9 pentads within a QDGC). Therefore, the data is more site-specific, recent and more comparable with observations made during the site visit (due to increased standardisation of data collection). The pentad grids relevant to the current project are 2640_2635 (although information from all eight surrounding pentad grid was also scrutinised; Figure 3).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World

Bird List v. 12.1), unless otherwise specified (see www.worldbirdnames.org as specified by Gill et al, 2022.

- All observations obtained during the site visits were submitted to the South African Bird Atlas Project (SABAP2).
- The best practice guidelines for solar facilities by BirdLife South Africa (Jenkins et al., 2017).

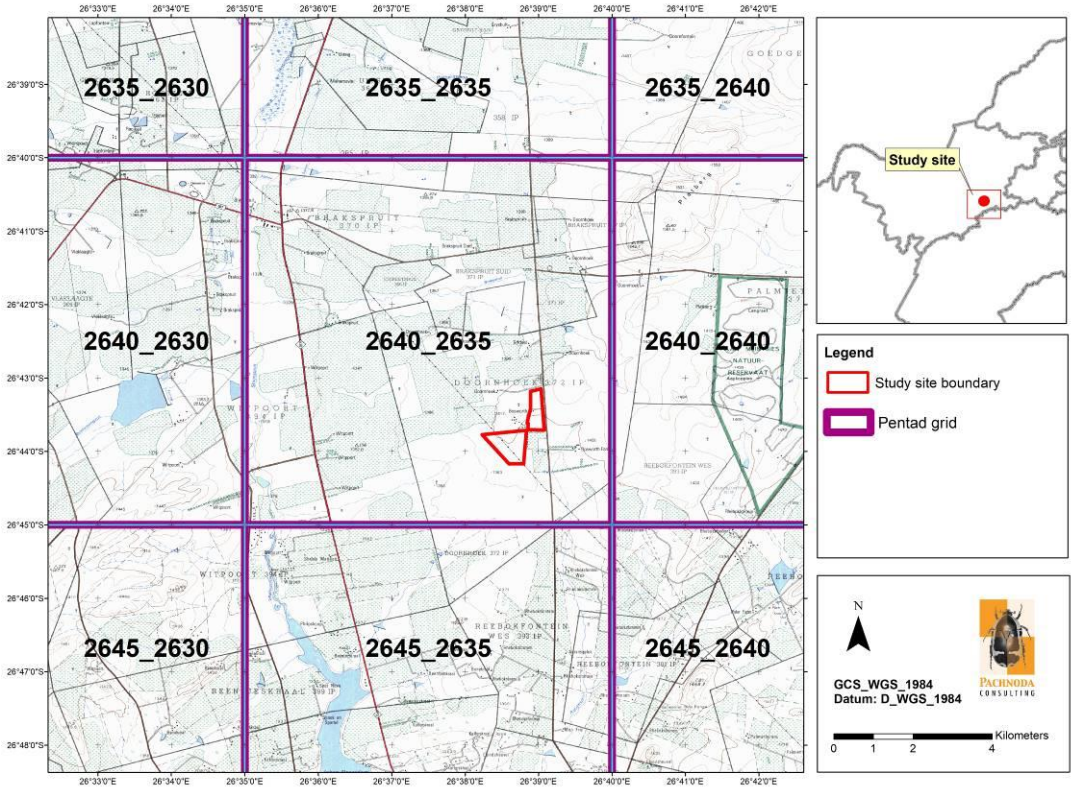

Figure 3: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study site was surveyed during two independent site visits representing an early wet season (December 2021) and a late wet season survey (March 2022).

The baseline avifaunal survey was conducted by means of the following survey techniques:

2.2.1 Point Counts

Bird data was collected by means of 24 point counts (as per Buckland et al. 1993) from the project area (including the immediate surrounding area, where all birds seen and heard from a specific point over a set period of time was recorded. Data from the

point counts has been analysed to determine dominant and indicator bird species (so-called discriminant species), relative densities and to delineate the different bird associations present.

The use of point counts is advantageous since it is the preferred method to use for skulking or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex (e.g. mountainous). It is considered to be a good method to use, and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). The spatial position of each point count is illustrated in Figure 4. The spatial placement of the point counts was determined through a stratified random design which ensures coverage of each habitat type and/or macro-habitat (Sutherland et al., 2004).

Therefore, the sampling approach was adapted so that all the bird species seen within approximately 50m m (mainly bushveld and woodland, n= 11 points) to 100m (mainly open grassland, n= 13 points) from the centre of the point were recorded (resulting in an area of 0.78 ha and 3.14 ha respectively) along with their respective abundance values (a laser rangefinder was used to delineate the area to be surveyed at each point). Each point count lasted approximately 20 - 30 minutes, while the area within the 50-100m radius of homogenous habitat was slowly traversed to ensure that all bird species were detected and or flushed (as proposed by Watson, 2003). To ensure the independence of observations, points were positioned at least 200 m apart. Observations were not truncated, and in order to standardise data collection, the following assumptions were conformed to (according to Buckland *et al.*, 1994):

- All birds on the point must be seen and correctly identified. This assumption is in practice very difficult to meet in the field as some birds in the nearby vicinity may be overlooked due to low visibility or were obscured by vegetation (e.g. graminoid cover). Therefore, it is assumed that the portion of birds seen on the point count represents the total assemblage on the point.
- All birds must be recorded at their initial location. All movements of the birds are random and therefore natural in relation to the movements of the observer. None of the birds moved in response to the presence of the observer, and birds flying past without landing were omitted from the analysis.

- In other words, no bird is recorded more than once.

2.2.2 Random (ad hoc) surveys

To obtain an inventory of bird species present (apart from those observed during the point counts), all bird species observed/detected while moving between point counts were identified and noted. Particular attention was devoted to suitable roosting, foraging and nesting habitat for species of conservation concern (e.g. threatened or near threatened species). In addition, the fly patterns of large non-passerine and birds of prey were recorded, as well as the locality of collision-prone birds.

2.2.3 Analyses

Data generated from the point counts was analysed according to Clarke & Warwick (1994) based on the computed percentage contribution (%) of each species, including the consistency (calculated as the similarity coefficient/standard deviation) of its contribution. Hierarchical Agglomerative Clustering (a cluster analysis-based group-average linkages; Clarke & Warwick 1994) was performed on calculated Bray-Curtis coefficients derived from the data. A cluster analysis is used to assign "species associations" between samples with the aim to objectively delineate groups or assemblages. Therefore, sampling entities that group together (being more similar) are believed to have similar compositions.

The species richness and diversity of each bird association was analysed by means of richness measures (such as the total number of species recorded (S) and Shannon Wiener Index) were calculated to compare the associations with each other.

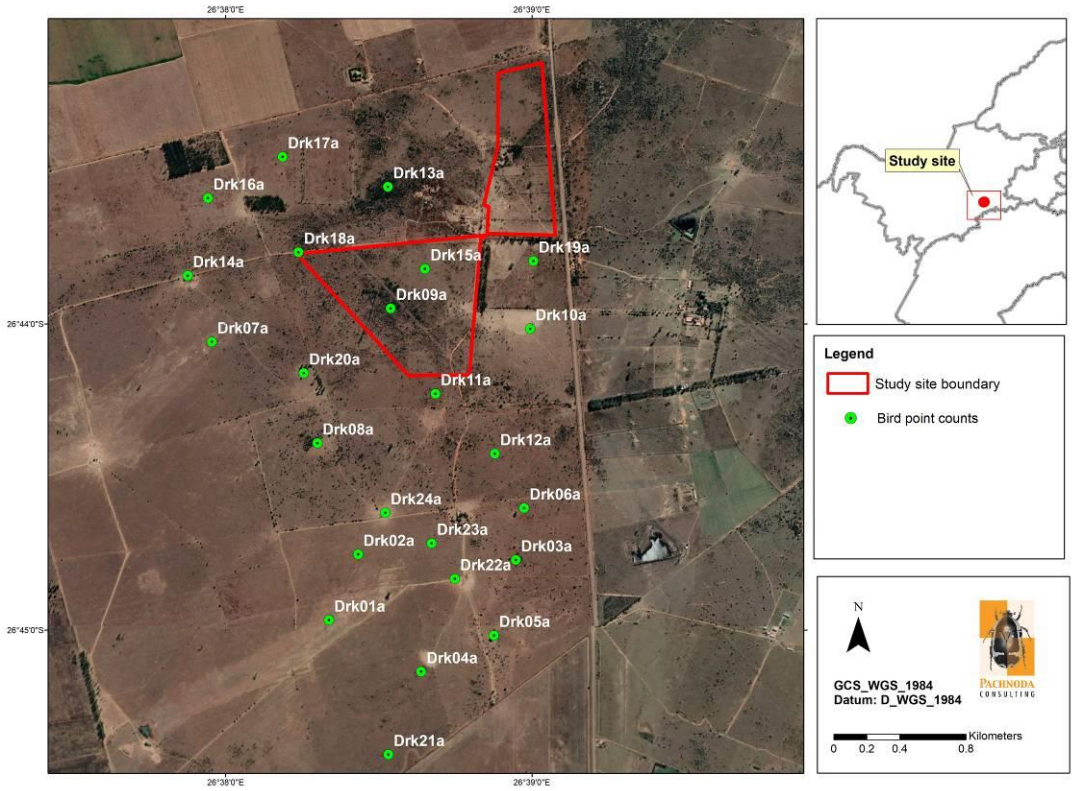

Figure 4: A map illustrating the spatial position of 24 bird point counts located within the project area[2].

2.3 Sensitivity Analysis

A sensitivity map was compiled based on the outcome of the baseline results.

The ecological sensitivity of any piece of land is based on its inherent ecosystem service (e.g. wetlands) and overall preservation of biodiversity.

2.3.1 Ecological Function

Ecological function relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity amongst one another are perceived to be more sensitive and will be those contributing to ecosystem services (e.g. wetlands) or the overall preservation of biodiversity.

2.3.2 Avifaunal Importance

[2] Also refer to Section 2.4 dealing with "Limitations".

Avifaunal importance relates to species diversity, endemism (unique species or unique processes) and the high occurrence of threatened and protected species or ecosystems protected by legislation.

2.3.3 Sensitivity Scale

- *High* – Sensitive ecosystems with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems OR with high species diversity and usually contain high numbers of threatened, endemic or rare bird species. These areas should preferably be protected;
- *Moderately high* - Untransformed or productive habitat units (which can also be artificial) which contain high bird numbers and/or bird richness values. These areas are often fragmented OR azonal, and hence of small surface area that are often surrounded by habitat of moderate or low sensitivity. These habitat units also include potential habitat for threatened species. Development is often considered permissible on these areas if there is enough reason to believe that these areas are widespread in the region and future planned developments are unlikely to result in the widespread loss (>50 %) of similar habitat at a regional scale.
- *Medium* – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems OR ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species; and
- *Low* – Degraded and highly disturbed/transformed systems with little ecological function and are generally very poor in bird species diversity (most species are usually exotic or weeds).

2.4 Limitations

- It is assumed that third party information (obtained from government, academic/research institution, non-governmental organisations) is accurate and true.
- Some of the datasets are out of date and therefore extant distribution ranges may have shifted although these datasets provide insight into historical distribution ranges of relevant species.
- The datasets are mainly small-scale and could not always consider azonal habitat types that may be present on the study area (e.g. artificial livestock watering points). In addition, these datasets encompass surface areas larger than the study area, which could include habitat types and species that are not present on the study site. Therefore the potential to overestimate species

richness is highly likely while it is also possible that certain cryptic or specialist species could have been be overlooked in the past.

- Some of the datasets (e.g. SABAP2) managed by the Animal Demography Unit of the University of Cape Town were recently initiated and therefore incomplete.
- The layout of the proposed facility has changed significantly after the fieldwork was completed, which explains the low amount of point counts corresponding to the physical boundary of the Doornhoek 1 PV Facility. The original proposed boundary (and scope of work) was much larger (especially to the south; c. 630 ha which included three proposed PV solar facilities), which necessitated spatial sampling of bird point counts as indicated in Figure 4. However, even though the point count sample size was statistically reduced on the Doornhoek 1 PV facility, the sampling strategy does provide sufficient coverage of all the major habitat types in the region and also contributed to a much higher detection probability for avifaunal species.
- This company, the consultants and/or specialist investigators do not accept any responsibility for conclusions, suggestions, limitations and recommendations made in good faith, based on the information presented to them, obtained from the surveys or requests made to them at the time of this report.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Locality

The proposed Doornhoek 2 PV facility and associated infrastructure will be located on Portion 18 of the Farm Doornhoek 372 IP. The project site is approximately 11km north of Klerksdorp in the North West Province (Figure 1).

3.2 Regional Vegetation Description

The study site corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It consists of the ecological type known as Klerksdorp Thornveld (Mucina & Rutherford, 2006; updated 2012) (Figure 5).

From an avifaunal perspective it is evident that bird diversity is positively correlated with vegetation structure, and floristic richness is not often regarded to be a significant contributor of patterns in bird abundance and their spatial distributions. Grasslands are generally poor in woody plant species, and subsequently support lower bird richness values, it is often considered as an important habitat for many terrestrial bird species such as larks, pipits, korhaans, cisticolas, widowbirds including large terrestrial birds such as Secretarybirds, cranes and storks. Many of these species are also endemic to South Africa and display particularly narrow

distribution ranges. Due to the restricted spatial occurrence of the Grassland Biome and severe habitat transformation, many of the bird species that are restricted to the grasslands are also threatened or experiencing declining population sizes. Bushveld and woodland habitat consist of higher floristic structure (owing to the presence of tree and shrub species) with a subsequent increase in vertical heterogeneity. The increase in vertical heterogeneity also increase niche space and allow for niche-packing by species which often share the same prey resource. Therefore, bushveld and woodland habitat is often rich in bird species numbers, but often lacks the high endemicity observed in Highveld grassland habitat.

The Klerksdorp Thornveld is a vulnerable ecosystem and is confined to the North West Province where it occurs in two disparate patches in the Wolmaranstad, Ottosdal and Hartbeesfontein region and in the Botsalano Game Park near Mahikeng. It occurs on plains and irregular undulating plains between altitudes of 1 260m and 1 580m. It predominately contains open to dense microphyllous bush clumps with a dry graminoid cover that are dominated by species of the genera *Vachellia* and *Senegalia*.

Currently, only 2.5% of the remaining 70.8% of untransformed Klerksdorp Thornveld is formally protected within the Faan Meintjies Nature Reserve, Mahikeng Game Reserve and the Botsalano Game Reserve. This ecosystem has a high grazing capacity and is hence often overutilised, especially for grazing purposes, which invariably result in the invasion of *Vachellia karoo*. It is characterised by a high habitat and floristic diversity and aesthetic appeal, which renders it as an important conservation entity.

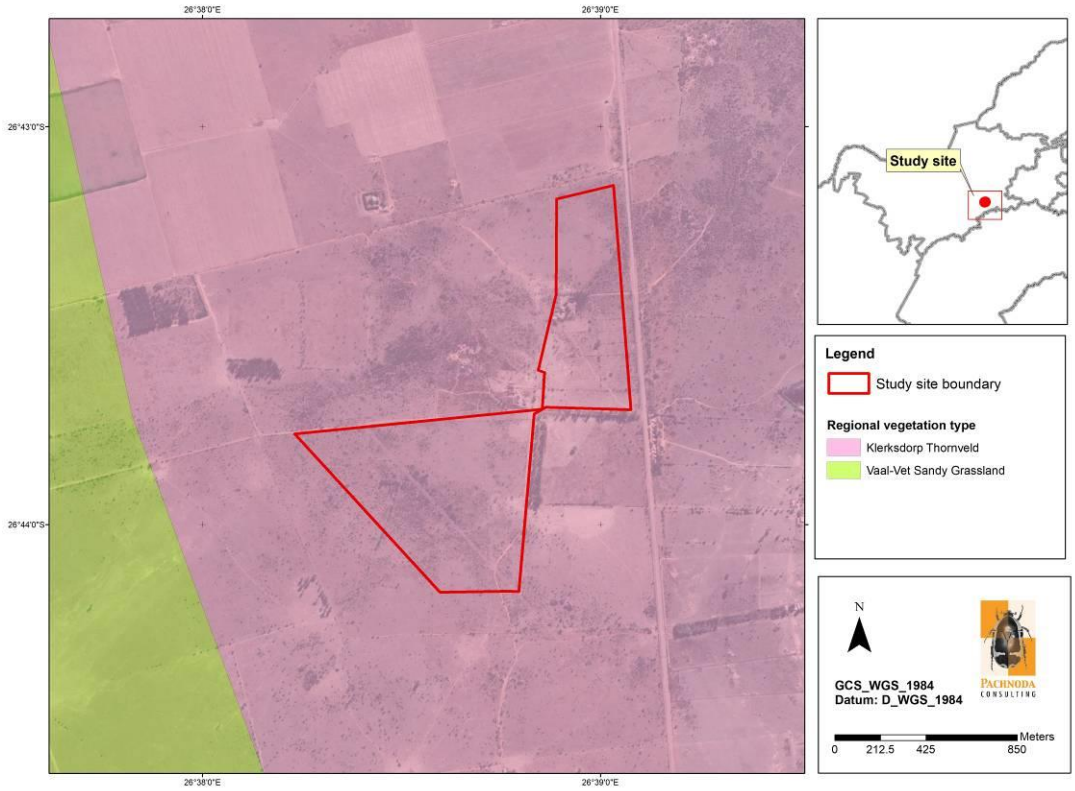

Figure 5: A topographic image illustrating the regional vegetation type corresponding to the study site. Vegetation type categories were identified according to Mucina & Rutherford (2006).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the project area comprehends the following land cover categories (Figure 6):

Natural areas:

- Grassland;
- Low shrubland;
- Thicket/dense bush; and
- Woodland and open bush.

From the land cover dataset it is evident that most of the study site is covered by natural grassland and dense to open savannoid grassland. The study site is primarily used for livestock production and livestock grazing. Existing infrastructure includes a powerline servitude located on the western part of the study site.

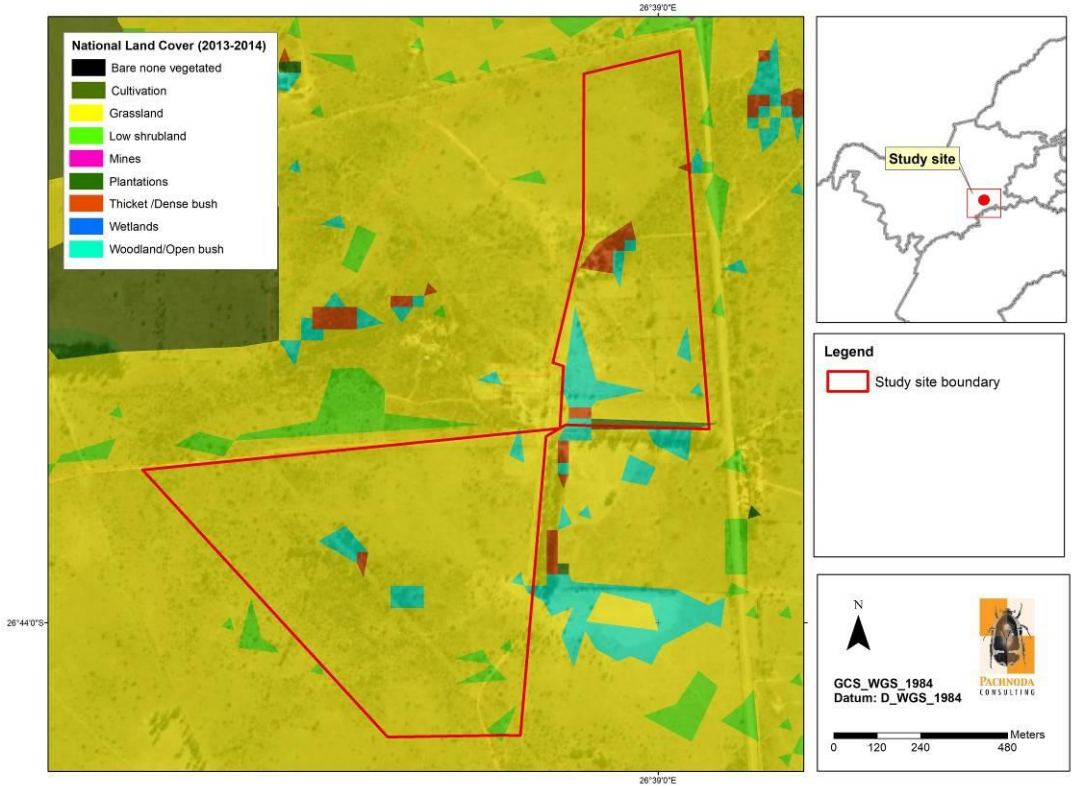

Figure 6: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study area.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study site is located approximately 3.6km west of the Faan Meintjies Nature Reserve (and within 700m of the reserve's 3km buffer area) (Figure 7). This conservation area is a municipal reserve under management of the City of Matlosana Local Municipality.

There are no other formal protected areas or any Important Bird and Biodiversity Areas in close proximity to the study site.

3.5 Annotations on the National Web-Based Environmental Screening Tool

Regulation 16(1)(v) of the Environmental Impact Assessment Regulations, 20145 (EIA Regulations) provides that an applicant for Environmental Authorisation is required to submit a report generated by the Screening Tool as part of its application. On 5 July 2019, the Minister of Environmental Affairs, Forestry and Fisheries published a notice in the Government Gazette giving notice that the use of the Screening Tool is compulsory for all applicants to submit a report generated by the Screening Tool from 90 days of the date of publication of that notice.

The Screening Tool is intended to allow for pre-screening of sensitivities in the landscape to be assessed within the EA process. This assists with implementing the mitigation hierarchy by allowing developers to adjust their proposed development footprint to avoid sensitive areas. The Screening Tool report will indicate the (preliminary) environmental sensitivities that intersect with the proposed development footprint as defined by the applicant as well as the relevant Protocols.

As the Screening Tool contains datasets that are mapped at a national scale, there may be areas where the Screening Tool erroneously assigns, or misses, environmental sensitivities because of mapping resolution and a high paucity of available and accurate data. Broad-scale site investigations will provide for an augmented and site-specific evaluation of the accuracy and 'infilling' of obvious and large-scale inaccuracies. Information extracted from the National Web-based Environmental Screening Tool (Department of Environmental Affairs, 2020), indicated that the study site holds a medium sensitivity with respect to the relative animal species protocol (Figure 8) (report generated 13/04/2022):

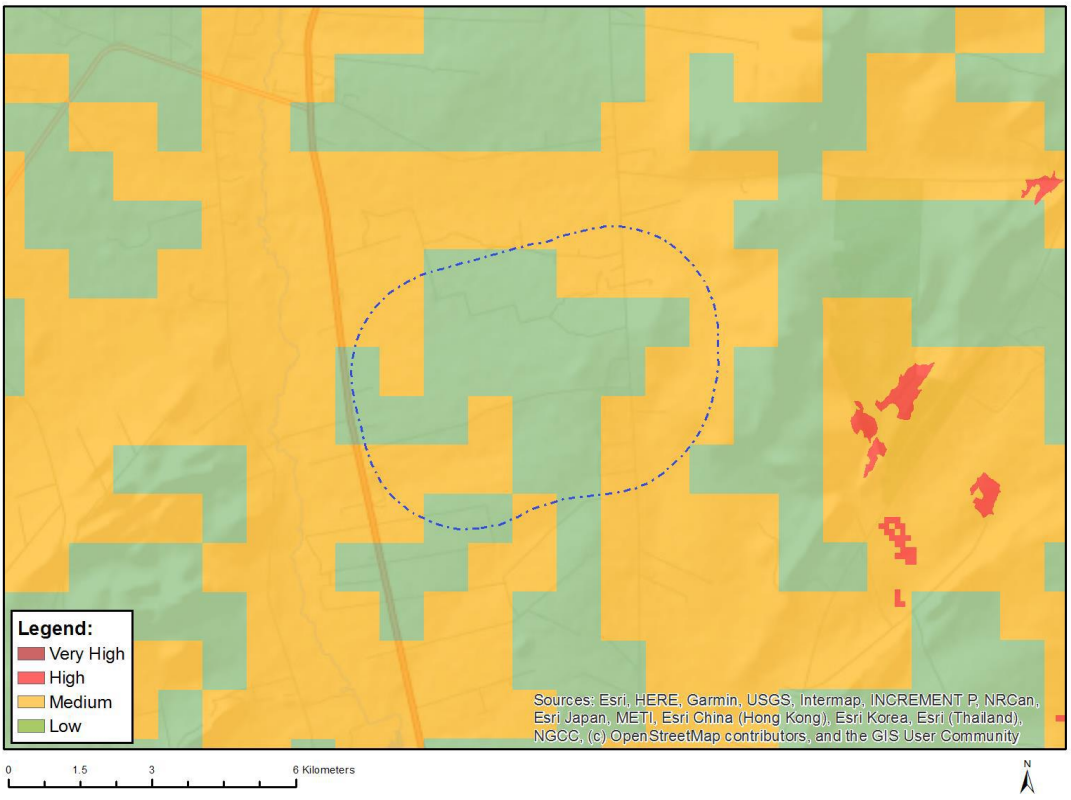

Figure 7: The animal species sensitivity of the study site according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low sensitivity
Medium	Mammalia-*Crocidura maquassiensis*
Medium	Mammalia-*Hydrictis maculicollis*

It is evident from the results of the Screening Tool report that the study area does not contain important habitat for threatened bird species.

The study site holds a low sensitivity with respect to the relative avian theme (Figure 9) (report generated 13/04/2022):

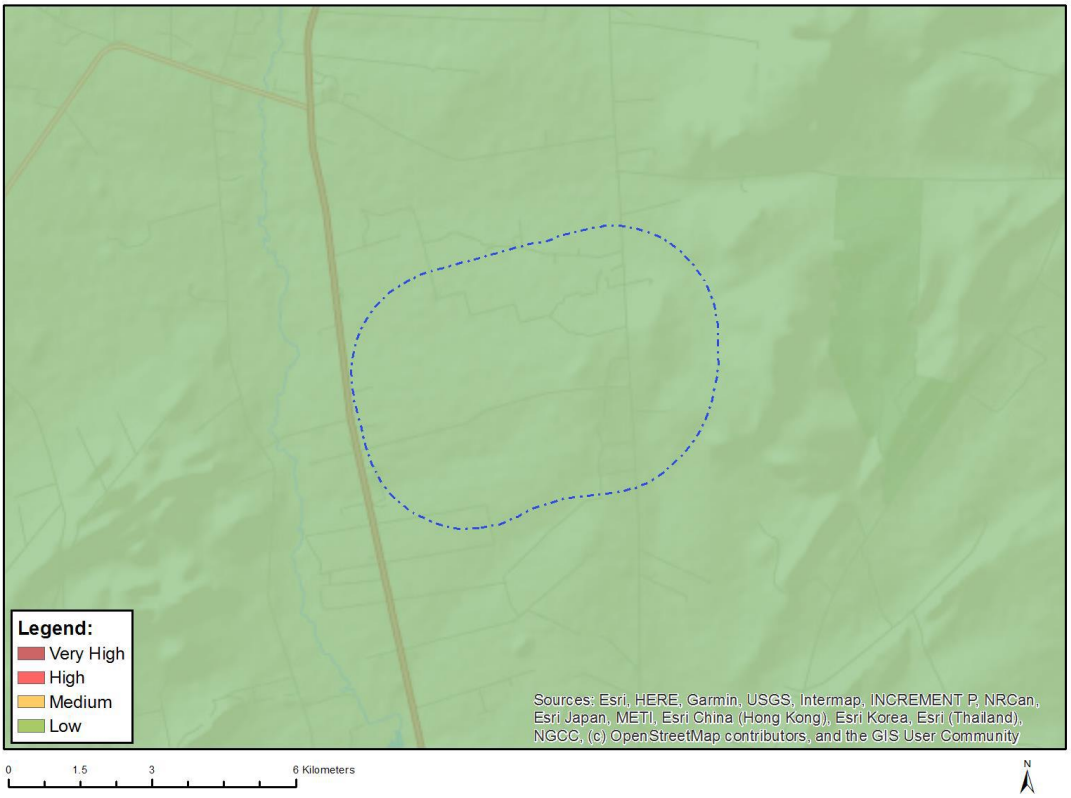

Figure 8: The relative avian sensitivity of the study site according to the Screening Tool.

It is evident from the results of the Screening Tool report that the study area is potentially not an important area for bird species with a high probability to interact with the solar infrastructure and that the site does not potentially overlap with important avian flyways.

However, the study site holds a very high sensitivity with respect to the relative terrestrial biodiversity theme (Figure 10) (report generated 13/04/2022):

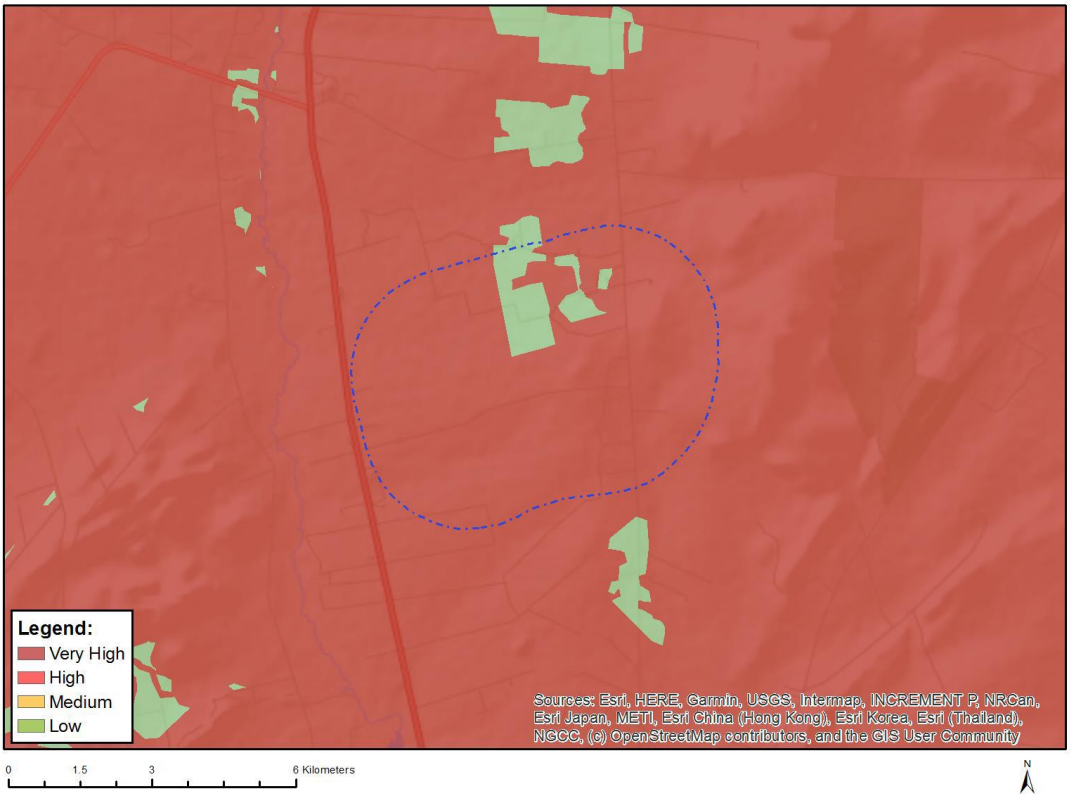

Figure 9: The relative terrestrial biodiversity sensitivity of the study site according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low Sensitivity
Very High	Critical biodiversity area 1
Very High	Ecological support area 1
Very High	Ecological support area 2
Very High	Protected Areas Expansion Strategy
Very High	Endangered ecosystem
Very High	Bosworth Private Nature Reserve

It is evident from the results of the Screening Tool report that the study area coincides with a Critical Biodiversity Area (CBA10 and Ecological Support Areas (ESA 1 & 2) as per the North West Biodiversity Sector Plan (Schaller and Desmet, 2015). It also coincides with an endangered ecosystem (c. Vaal-Vet Sandy Grassland) which requires a detailed terrestrial ecological evaluation as part of the EA process. In addition, the study site is also located in close proximity to the Bosworth Farm rock engravings and areas of archaeological and cultural heritage sites, which pertains to the "Bosworth Private Nature Reserve".

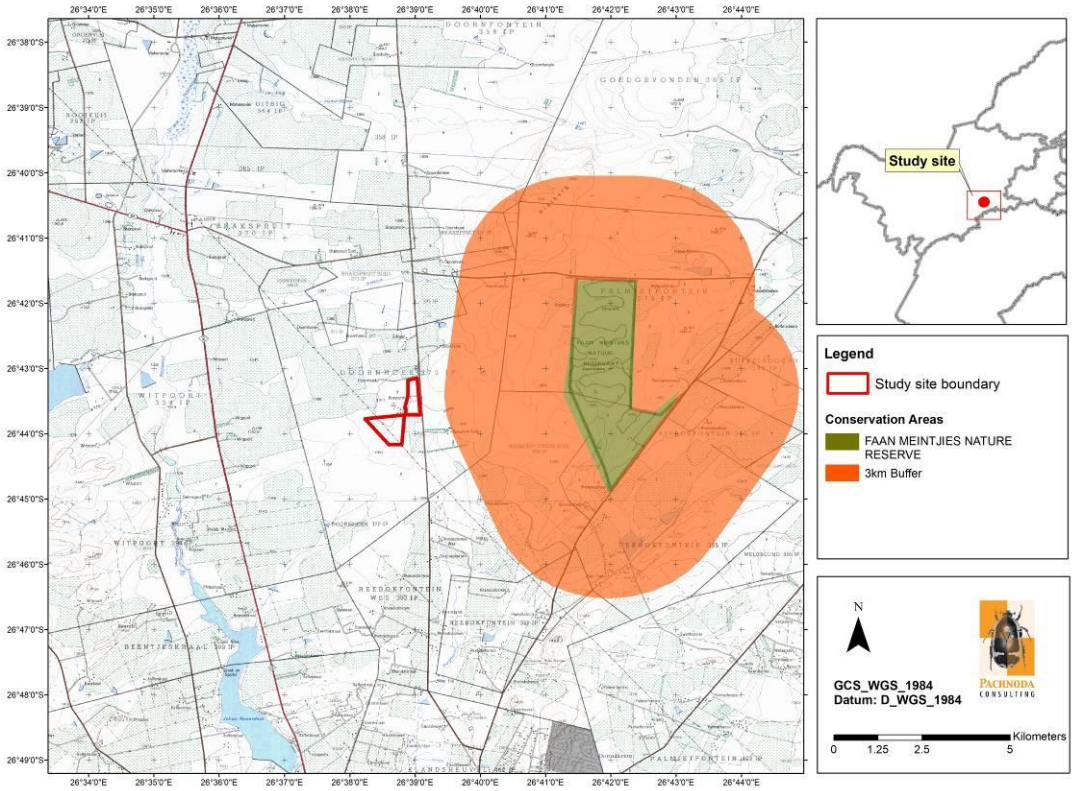

Figure 10: A map illustrating the locality of a conservation area in close proximity to the study site.

4. RESULTS AND DISCUSSION

4.1 Avifaunal habitat types

Apart from the regional vegetation types, the local composition and distribution of the vegetation associations on the study site are a consequence of a combination of factors simulated by topography, historical disturbances and grazing intensity (presence of livestock) which have culminated in a number of habitat types that deserve further discussion (Figure 11 and Figure 12):

1. *Open savannoid grassland with bush clump mosaics:* This unit is scattered on the study site and covers a large surface area on the western and northern section of the proposed PV facility. It is represented by two discrete floristic variations which also provide habitat for two discrete avifaunal associations. The first floristic variation is predominantly represented by untransformed and slightly grazed grassland, depending on grazing intensity, and dominated by "late-successional" graminoids such a *Themeda triandra, Cymbopogon caesius, C. pospischilii, Trachypogon spicatus* and *Diheteropogon amplectens*. It is occupied by a typical grassland bird composition dominated by insectivorous and granivore passerine bird species such as Desert

Cisticola, (*Cisticola aridulus*), Zitting Cisticola (*C. juncidis*), Cloud Cisticola (*C. textrix*), Rufous-naped Lark (*Mirafra africana*), Southern Red Bishop (*Euplectes orix*) and Red-billed Quelea (*Quelea quelea*). Prominent non-passerine species include Orange River Francolin (*Scleroptila gutturalis*), Swainson's Spurfowl (*Pternistis swainsonii*), Northern Black Korhaan (*Afrotis afraoides*), Crowned Lapwing (*Vanellus coronatus*) and Black-winged Kite (*Elanus caeruleus*).

The bush clumps form a prominent mosaic characterised by the dominance of a woody layer of *Searsia lancea, Ziziphus mucronata* and *Vachellia karoo subsp. africana* forms canopy constituents in some areas. The eminent increase in vertical heterogeneity provided by the woody layer is colonised by a "Bushveld" bird association consisting of insectivorous and frugivore passerines such as Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcoerulea*), African Red-eyed Bulbul (*Pycnonotus nigricans*), Red-backed Shrike (*Lanius collurio*)' as well as granivores such as Southern Masked Weaver (*Ploceus velatus*). Non-passerine bird taxa are represented by Ring-necked Dove (*Streptopelia capicola*), Acacia Pied Barbet (*Tricholaema leucomelas*) and Red-faced Mousebird (*Urocolius indicus*).

2. *Short Klerksdorp Thornveld:* This unit is prominent on the western part of the study site and is represented by microphyllous bushveld dominated by *Vachellia karoo* and in some areas it is also represented by tall *Senegalia cf. hereroensis* and *V. erioloba*. Other plant species are similar in floristic composition to the bush clump mosaics (see above). The tall vertical heterogeneity assists with the colonisation of a "Bushveld" bird association consisting of mainly insectivorous passerines. The latter composition is similar to the bird composition predicted for the bush clump mosaic habitat unit. Other noteworthy species include Neddicky (*Cisticola fulvicapilla*), Chestnut-vented Warbler (*Curruca subcoerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Long-billed Crombec (*Sylvietta rufescens*) and Chinspot Batis (*Batis molitor*).

3. *Secondary (regenerating) grassland on old agricultural land/pastures:* This unit is confined to areas that were historically utilised for cultivation and/or on pastures. It is represented by tall secondary grassland consisting of aspect dominants such as *Hyparrhenia hirta* and *Eragrostis curvula*. However, the palatable *Themeda triandra* is locally dominant on some parts of this habitat type. The bird richness is low and mainly represented by small cryptic insectivores and granivores such as Desert Cisticola, (*Cisticola aridulus*), Zitting Cisticola (*C. juncidis*), Black-chested Prinia (*Prinia flavicans*) and Quailfinch (*Ortygospiza atricollis*). It also provides ephemeral foraging habitat for larger terrestrial species such as the Northern Black Korhaan (*Afrotis afraoides*).

4. *Dense short Grewia-Vachellia shrubveld:* This unit is characterised by short dense shrubveld dominated by *Grewia flava, Vachellia karoo* and *V. robusta*. It provides habitat for a "Bushveld" bird association that is similar in composition to the Klerksdorp Thornveld although it supports high numbers of bird species with arid thornveld affinities such as Crimson-breasted Shrike (*Laniarius atrococcineus*), Green-winged Pytilia (*Pytilia melba*), Violet-eared Waxbill (*Granatina granatina*) and Black-faced Waxbill (*Brunhilda erythronotos*).

5. *Transformed areas*: This area is represented by a build-up land (houses). This feature is an unimportant habitat for bird species.

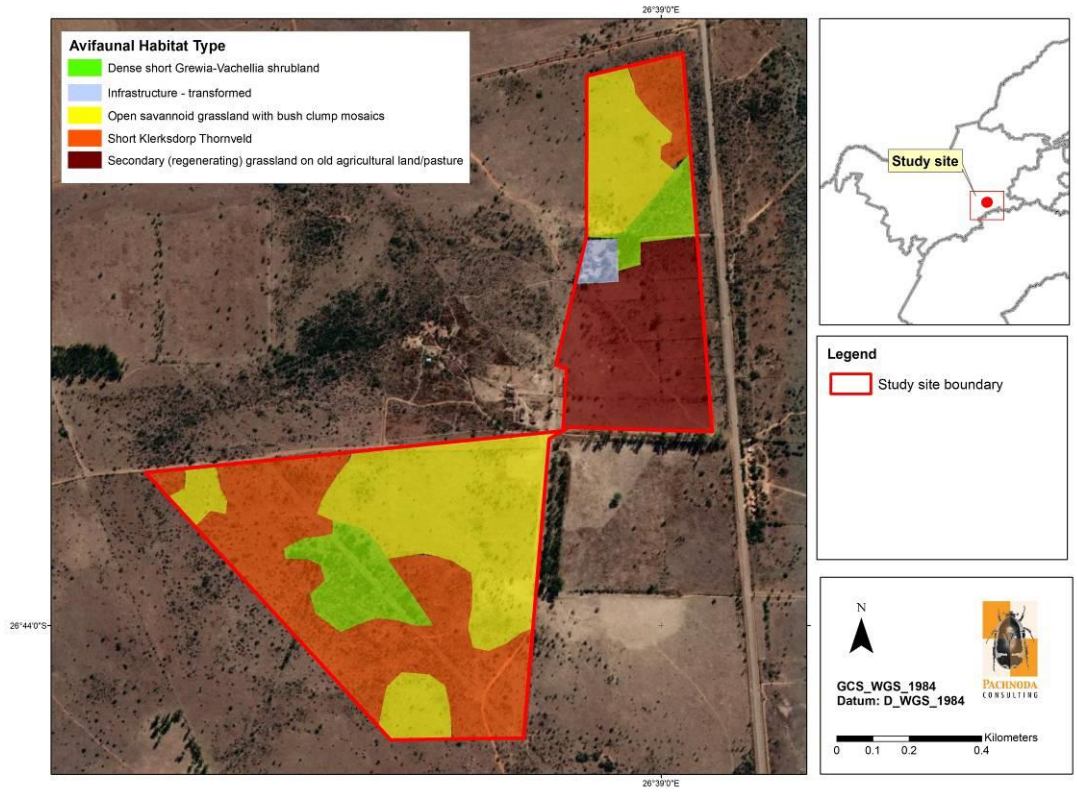

Figure 11: A habitat map illustrating the important avifaunal habitat types on the study site.

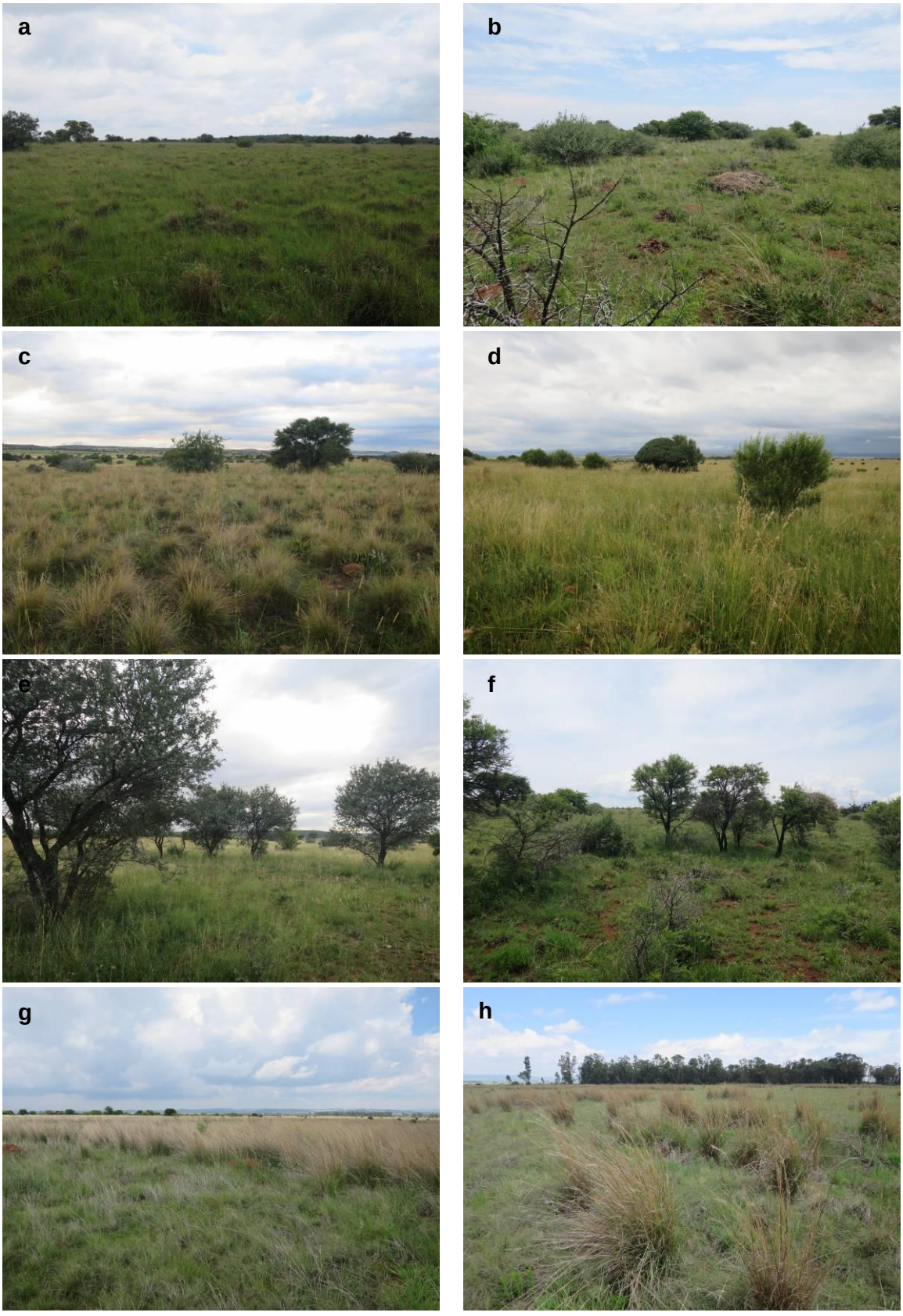
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Figure 12: A collage of images illustrating examples of avifaunal habitat types observed on the study site and the immediate surroundings: (a - d) open savannoid grassland with bush clump mosaics (e - f) short Klerksdorp Thornveld, (g - h) secondary (regenerating) grassland on old agricultural land/pastures and (i - j) dense short *Grewia-Vachellia* shrubland.

4.2 Species Richness and Summary statistics

Approximately 223 bird species are expected to occur in the wider study area (refer to Appendix 1 and Table 1). The expected richness was inferred from the South African Bird Atlas Project (SABAP1 & SABAP2)[3] (Harrison et al., 1997; www.sabap2.birdmap.africa) and the presence of suitable habitat in the study area. The expected richness is also strongly correlated with favourable environmental conditions (e.g. during good rains) and seasonality (e.g. when migratory species are present). This equates to 23 % of the approximate 987[4] species listed for the southern African subregion[5] (and approximately 26 % of the 871 species recorded within South Africa[6]). However, the species richness obtained[7] from the pentad grid 2640_2635 corresponding to the project area was slightly higher than the expected number of species, with 231 species recorded. The latter mainly includes waterbird and shorebird taxa which were predominantly absent from the study site due to the absence of suitable wetland habitat. According to field observations, the total number of species observed on the project area is *ca*. 118 species (see Appendix 1). However, an average number of 60 species is recorded for each full protocol card submitted for the pentad grid corresponding to the study site 2640_2635 (for observations of two hours or more), which show that the surveys produced a higher tally and were regarded as sufficient. On a national scale, the species richness per pentad on the study area is considered to be high (refer to Figure 13).

[3] The expected richness statistic was derived from the pentad grid 2640_2635 (including adjacent grids) totalling 335 bird species (based on 1445 full protocol cards).

4 *sensu* www.zestforbirds.co.za (Hardaker, 2020) including four recently confirmed bird species (vagrants).

5 A geographical area south of the Cunene and Zambezi Rivers (includes Namibia, Botswana, Zimbabwe, southern Mozambique, South Africa, Swaziland and Lesotho).

6 With reference to South Africa (including Lesotho and Swaziland (BirdLife South Africa, 2022).

7 Including observations made during the December 2021 and March 2022 surveys.

According to Table 1, the study site is poorly represented by biome-restricted[8] (see Table 2) and local endemic bird species. It does support *ca*. 41 % of the near - endemic species present in the subregion. Of the 223 bird species expected to occur in the project area, 11 are threatened or near threatened species[9], 16 are southern African endemics and 25 are near-endemic species. In addition, one threatened species (Secretarybird *Sagittarius serpentarius*) was observed on habitat immediately adjacent to the study site (Table 3). Furthermore, 10 southern African endemics and 14 near-endemic species were confirmed on the study site and the immediate surroundings (Table 3).

Prominent wetland features and waterbodies are absent from the study site and surroundings, thereby explaining the low richness of waterfowl, wading birds and shorebird taxa on the study site. However, two small impoundments are located between 2.5 and 2.8 km south-west of the study site, with another small dam located approximately 600 m east of the study site. These impoundments could attract additional waterbird and shorebird species to the study area (apart from those listed in Appendix 1).

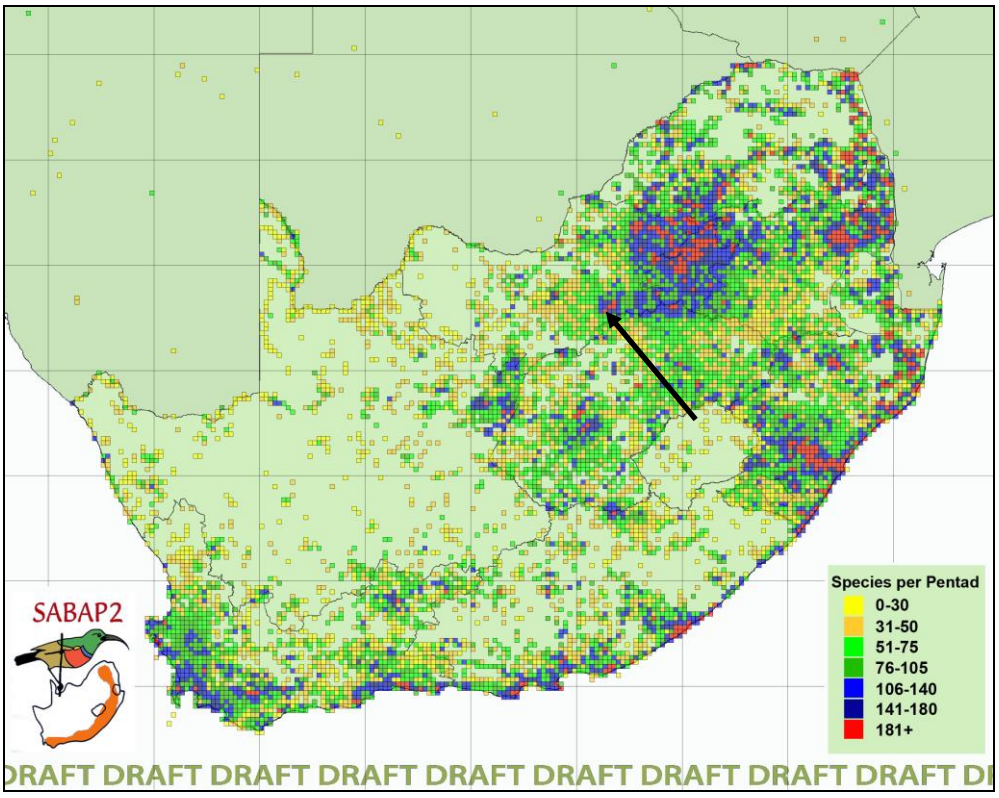

Figure 13: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts over 181 bird species.

[8] A species with a breeding distribution confined to one biome. Many biome-restricted species are also endemic to southern Africa.

[9] Please note that an additional three species were also confirmed from the wider study area, but the probability that these species could occur is very low due to the absence of suitable foraging and/or breeding habitat on the study site.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor *et al*., 2015 and the IUCN, 2022), endemics and biome-restricted species (Marnewick *et al*., 2015) expected (*sensu* SABAP1 and SABAP2) to occur in the study site and immediate surroundings.

Description	Expected Richness Value (project area and surroundings)***	Observed Richness Value (project area)****
Total number of species*	223 (26 %)	118 (53 %)
Number of Red Listed species*	11 (8 %)	1 (9 %)
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	4 (29 %)	3 (75 %)
Number of local endemics (BirdLife SA, 2022)*	2 (5 %)	2 (100 %)
Number of local near-endemics (BirdLife SA, 2022)*	6 (20 %)	4 (67 %)
Number of regional endemics (Hockey *et al.,* 2005)**	16 (15 %)	10 (63 %)
Number of regional near-endemics (Hockey *et al.,* 2005)**	25 (41 %)	14 (56 %)

* only species in the geographic boundaries of South Africa (including Lesotho and Swaziland) were considered.
** only species in the geographic boundaries of southern Africa (including Namibia, Botswana, Zimbabwe and Mozambique south of the Zambezi River) were considered
*** Percentage values in brackets refer to totals compared against the South African avifauna (*sensu* BirdLife SA, 2022).
**** Percentage values in brackets refer to totals compared against the expected number of species in the project area.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) observed on the study site and immediate surroundings.

Species	Kalahari-Highveld	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena)*	X		Common
Barred Wren-warbler (*Calamonastes fasciolatus*)	X		Uncommon to Rare
White-throated Robin-chat (*Cossypha humeralis*)		X	Common
White-bellied Sunbird (*Cinnyris talatala*)		X	Common

Table 3: Important bird species occurring in the broader study area which could collide and/ or become displaced by the proposed PV infrastructure.

Common Name	Scientific name	Regional Status	Global Status	Observed (Dec 2021. & March. 2022)	Collision with power lines	Displacement (disturbance & loss of habitat)
White-backed Vulture	*Gyps africanus*	CR	CR		1	
Cape Vulture	*Gyps coprotheres*	EN, End	VU		1	
Secretarybird	*Sagittarius serpentarius*	EN	EN	1	1	1
Martial Eagle	*Polemaetus bellicosus*	EN	EN		1	

Common Name	Scientific name	Regional	Global	Observed	Collision	Displacement
South African Shelduck	*Tadorna cana*	End			1	1
Cape Shoveler	*Anas smithii*	End			1	1
Northern Black Korhaan	*Afrotis afraoides*	End		1	1	1
White-backed Mousebird	*Colius colius*	End		1		1
Melodious Lark	*Mirafra cheniana*	End		1		1
Karoo Thrush	*Turdus smithi*	End				1
Ant-eating Chat	*Myrmecocichla formicivora*	End		1		1
White-throated Robin-chat	*Cossypha humeralis*	End		1		1
Fiscal Flycatcher	*Sigelus silens*	End		1		1
Fairy Flycatcher	*Stenostira scita*	End				1
Cape Longclaw	*Macronyx capensis*	End		1		1
Pied Starling	*Lamprotornis bicolor*	End		1		1
Cape White-eye	*Zosterops virens*	End		1		1
South African Cliff Swallow	*Petrochelidon spilodera*	End		1		1
Pale Chanting Goshawk	*Melierax canorus*	N-end			1	1
Orange River Francolin	*Scleroptila gutturalis*	N-end		1	1	1
Namaqua Sandgrouse	*Pterocles namaqua*	N-end			1	1
Acacia Pied Barbet	*Tricholaema leucomelas*	N-end		1		1
Eastern Clapper Lark	*Mirafra fasciolata*	N-end		1		1
Pink-billed Lark	*Spizocorys conirostris*	N-end				1
Grey-backed Sparrow-lark	*Eremopterix verticalis*	N-end				1
Ashy Tit	*Parus cinerascens*	N-end		1		1
Cape Penduline-tit	*Anthoscopus minutus*	N-end				1
African Red-eyed Bulbul	*Pycnonotus nigricans*	N-end		1		1
Kalahari Scrub Robin	*Cercotrichas paena*	N-end		1		1
Chestnut-vented Warbler	*Curruca subcoerulea*	N-end		1		1
Barred Wren-Warbler	*Calamonastes fasciolatus*	N-end				1
Marico flycatcher	*Bradornis mariquensis*	N-end				1
Pririt Batis	*Batis pririt*	N-end				1
Crimson-breasted Shrike	*Laniarius atrococcineus*	N-end		1		1
Bokmakierie	*Telophorus zeylonus*	N-end		1		1
Cape Sparrow	*Passer melanurus*	N-end		1		1
Scaly-feathered Weaver	*Sporopipes squamifrons*	N-end		1		1
Red-headed Finch	*Amadina erythrocephala*	N-end				1
Shaft-tailed Whydah	*Vidua regia*	N-end		1		1
Yellow Canary	*Crithagra flaviventris*	N-end		1		1
Lark-like Bunting	*Emberiza impetuani*	N-end				1
Cloud Cisticola	*Cisticola textrix*	N-end		1		1
Red-footed Falcon	*Falco vespertinus*	NT	VU		1	
Blue Crane	*Anthropoides paradiseus*	NT, End	VU		1	1
Abdim's Stork	*Ciconia abdimii*	NT			1	
Pallid Harrier	*Circus macrourus*	NT	NT		1	1
Black-winged Pratincole	*Glareola normdanni*	NT	NT		1	1
Black Stork	*Ciconia nigra*	VU			1	1
Falcon, Lanner	*Falco biarmicus*	VU			1	
	Totals:	**49**	**8**	**25**	**17**	**43**

Threatened and near threatened species are indicated in red

CR - Critically endangered, EN - endangered, VU - vulnerable, NT - near threatened

End - southern African endemic

N-end - southern African near-endemic

Prior to further analyses where species richness values are considered, it is imperative to determine if all bird species present were sufficiently sampled. Species accumulation curves (SAC) provide a means to examine data and sampling efficacy. For this project the species accumulation curves (SAC) for the point count data were generated using the software program Estimates S (version 9) with 100 randomizations (as recommended in Colwell, 2013). Curves were generated for the full data set (all point counts). Sampling sufficiency was determined by establishing whether a point had been reached where a line representing one new sample adding one new species was tangent to the curve (Brewer & McCann, 1982). The Michaelis-Menten equation (Soberôn & Llorente 1993) was fitted to the predicted number of species using Estimates S (Raaijmakers, 1987). A satisfactory level of sampling was achieved if 90 % of the bird species were detected, and hence predicted by the model (Moreno & Halffter, 2000).

The species accumulation curve (SAC) reached an asymptote at approximately 21 point counts (Figure 14). The sampling captured approximately 75% of the number of species predicted by the Michaelis-Menten model at 14 point counts. Approximately 85% of the species was captured by 24 counts. Therefore, sampling effort was considered sufficient and recorded most of the species present on the project area during the respective survey sessions.

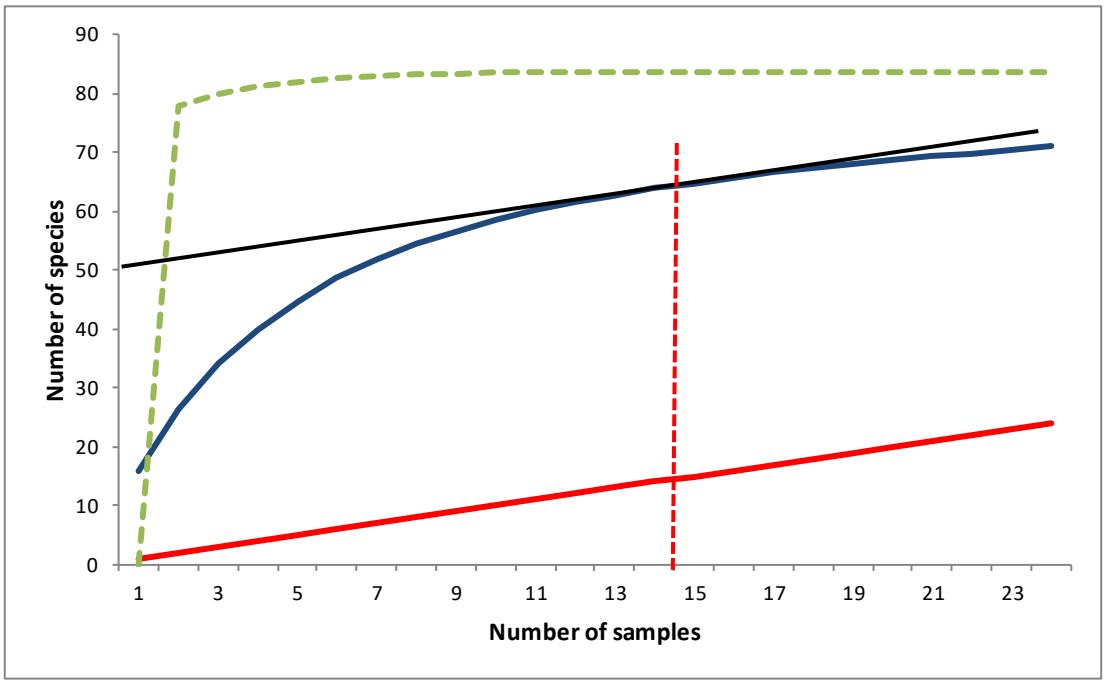

Figure 14: The species accumulation curve (SAC) (red line) for bird points sampled during the December 2021 and March 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 14 counts (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the study site based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of 11 species have been recorded in the wider study area (sensu SABAP1 & SABAP2) which include six globally threatened species, two globally near threatened species, two regionally threatened species and one regionally near-threatened species[10].

The globally endangered Secretarybird (*Sagittarius serpentarius*) was the only threatened species observed from suitable habitat adjacent to the study site. It is regarded as a resident on the study site of which a breeding pair was present (see section below). In addition, the globally critically endangered White-backed Vulture (*Gyps africanus*) has a high likelihood of occurrence pending the presence of suitable food (livestock carcasses).

The regionally vulnerable Lanner Falcon (*Falco biarmicus*) and regionally near threatened Abdim's Stork (*Ciconia abdimii*) show reporting rates between 1.2 % and 1.5 %. These species have a moderate probability of occurrence and are regarded as occasional foraging visitors to the area.

The remaining species are regarded as irregular foraging visitors with low probabilities of occurrence due to the absence of suitable habitat on the study site itself. It is possible that the low reporting rates for some of the species (e.g. Red-footed Falcon *Falco vespertinus*) reflect difficulties in identifications made by citizen scientists (e.g. birdwatchers), and for this reason some of these species could occur in higher numbers due to being overlooked. As an example, Red-footed Falcons (*F. vespertinus*) often occur in flocks of the similar-looking Amur Falcon (*F. amurensis*), which, based on reporting rates, appear to be a common summer visitor to the area. Therefore, it is highly possible that Red-footed Falcons were previously overlooked or misidentified.

Table 4: Bird species of conservation concern that could utilise the study site based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2022)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
Anthropoides paradiseus (Blue Crane)	Vulnerable	Near threatened	1.44	Prefers open grasslands. Also forages in	Highly irregular foraging visitor (although historically

[10] Please note that an additional three species were also confirmed from the wider study area (see Table 4), but the probability that these species could occur on the study site itself is very low due to the absence of suitable foraging and/or breeding habitat.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
				wetlands, pastures and agricultural land.	considered to be a regular visitor to the area - pers. comm., Mr. N Oxford). It was last observed on 04 April 2019 from a pentad grid adjacent to the study site.
Aquila verreauxii (Verreaux's' Eagle)	-	Vulnerable	0.27	Mountainous areas or areas with prominent outcrops with a high prey base (e.g. hyrax)	Regarded as a highly irregular foraging visitor on the study site - most probably absent due to the absence of suitable habitat.
Ciconia nigra (Black Stork)	-	Vulnerable	0.07	Breeds on steep cliffs within mountain ranges; forages on ephemeral wetlands.	Probably a highly irregular foraging visitor to the small impoundments adjacent to the study area (probably absent from the study site itself). It was last observed on 06 August 2016 from a pentad grid adjacent to the study site.
Ciconia abdimii (Abdim's Stork)	-	Near threatened	1.58	Open stunted grassland, fallow land and agricultural fields.	An uncommon or occasional summer foraging visitor to areas consisting of open grassland or arable land. It has not been observed on the study area since 2007 (c. pentad grid 2640_2635).
Circus macrourus (Pallid Harrier)	Near threatened	Near threatened	0.27	Dry and moist open grassland, especially in the vicinity of wetland systems	Regarded as an irregular summer foraging visitor. It has not been observed on the study area since 2007 (c. pentad grid 2640_2635).

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
Falco vespertinus (Red-footed Falcon)	Vulnerable	Near threatened	0.21	Varied, prefers to hunt open arid grassland and savannoid woodland, often in company with Amur Falcons (*F. amurensis*).	A rare summer foraging visitor to the area. Only known from a single observation during 14 March 2021 (probably overlooked).
Falco biarmicus (Lanner Falcon)	-	Vulnerable	1.24	Varied, but prefers to breed in mountainous areas.	An occasional foraging visitor to the study area. It has not been observed on the study area since 2007 (c. pentad grid 2640_2635).
Glareola nordmanni (Black-winged Pratincole)	Near threatened	Near threatened	0.76 (0.95 for pentad grid 2640_2635)	Varied, but forages over open short grassland, pastures and agricultural lands (especially when being tilled)	An irregular foraging visitor to the study area. Only known from a single observation during 10 December 2016 corresponding to the study site (c. pentad grid 2640_2635).
Gyps coprotheres (Cape Vulture)	Vulnerable	Endangered	0.06	Mainly confined to mountain ranges, especially near breeding site. Ventures far afield in search of food.	A highly irregular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses). It was last observed on 25 June 2020 from a pentad grid adjacent to the study site.
Gyps africanus (White-backed Vulture)	Critically Endangered	Critically Endangered	0.34 (2.86 for pentad grid 2640_2635)	Breed on tall, flat-topped trees. Mainly restricted to large rural or game farming areas.	A fairly regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses). It was last observed on 26 March 2022 on the study area (c. pentad grid 2640_2635).
Polemaetus	Endangered	Endangered	0.07	Varied, from	A highly irregular

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
bellicosus (Martial Eagle)				open karroid shrub to lowland savanna.	foraging visitor. It has not been observed on the study area since 2007 (c. pentad grid 2640_2635).
Mycteria ibis (Yellow-billed Stork)	-	Endangered	5.08 (0.95 for pentad grid 2640_2635)	Wetlands, pans and flooded grassland.	Probably a highly irregular foraging visitor to the small impoundments adjacent to the study area (probably absent from the study site itself). It was last observed on 26 January 2008 on the study area (c. pentad grid 2640_2635), although it is considered to be a regular foraging visitor to shoreline habitat along the nearby Klerksdorp Dam.
Oxyura maccoa (Maccoa Duck)	Endangered	Vulnerable	0.48	Large saline pans and shallow impoundments.	Probably absent from the study site, although regarded as an irregular visitor to the small impoundments adjacent to the study site. Regarded as a regular visitor to the nearby Klerksdorp Dam.
Sagittarius serpentarius (Secretarybird)	Endangered	Endangered	0.69 (0.95 for pentad grid 2640_2635)	Prefers open grassland or lightly wooded habitat.	**A breeding (resident) pair occurs on open grassland habitat immediately south of the study site. A nest is located 2.3 km south-west of the study site.**

4.3.1 Notes on the occurrence of Secretarybird (Sagittarius serpentarius)

The regional conservation status of this species was upgraded to Vulnerable since recent evidence suggests that it has experienced rapid declines across its entire range due to habitat loss, anthropogenic disturbances, and intensive grazing (Taylor, 2015). However, its global conservation status was uplisted in 2020 from Vulnerable to Endangered since large declines have been recently reported throughout its range, which include Botswana, eSwatini and South Africa (Birdlife International, 2020). Secretarybirds are widespread in Africa south of the Sahara, but have declined over most of their geographic distribution range due to the loss of suitable habitat caused by inappropriate grazing regimes (resulting in the expansion of woody vegetation), cultivation and urbinazation. The expansion of woody vegetation often result in a reduction of suitable foraging habitat and foraging efficacy (Birdlife International, 2020). In addition, it is also highly susceptible to collision with electrical cables of powerlines, with over 94 powerline fatalities recorded over the past 20 years in South Africa. Based on reporting rates, they appear to be more regularly observed in large conservation and rural areas, and this explains why reporting rates are relatively low on areas that are not statutorily conserved. Secretarybirds prefer open areas, in particular open savanna and grassland, but tend to avoid areas of dense bush or very rocky areas.

Nevertheless, many large terrestrial bird species, including Secretarybirds, show widespread declines in numbers, primarily due to large-scale loss of habitat, especially the loss of large patches of grassland. It is postulated that this steady decline of suitable habitat has “forced” this species to utilise other “sub-optimal” areas, many being closely associated with human settlements, where it is often confronted or threatened by human activities.

A resident/breeding pair of Secretarybirds occurs in close proximity to the study site where it occupies the open grassland valleys immediately south-west of the study site (approximately 613.8 ha of proximal habitat) (refer Figure 15 and Figure 16). It was observed during both surveys, suggesting that the pair resides on the study area. In addition. a nest structure is also located approximately 2.3 km south-west of the study site. To minimise impacts associated with the construction and operation of the PV facility which may displace Secretarybirds from the area, it is recommended that a 2 km buffer be allocated to the nest locality (pers comm., Dr Melissa Whitecross, BirdLife South Africa). The buffer area was derived from the dispersal dynamics of juvenile Secretarybirds (Whitecross et al., 2019), which showed that juvenile Secretarybirds have a mean home range size of 1.21 ± 0.34 km^2 and spend at least an average of 91.30 ± 8.80 days at their natal nesting grounds, although this distance increases exponentially as they mature. More importantly, High natal philopatry occurs in Secretarybirds, with most of the individuals when reaching maturity return to their natal grounds (Whitecross et al., 2019). It emphasises the importance of preserving nesting sites along with suitable foraging habitat.

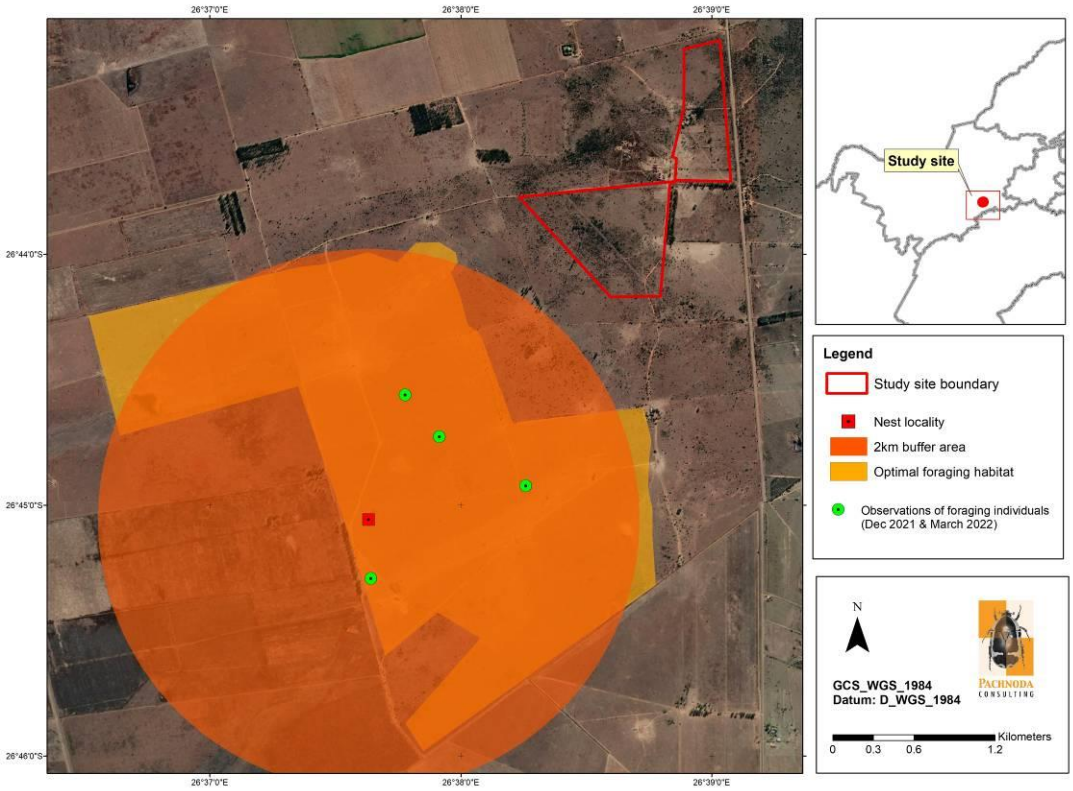

Figure 15: A map illustrating the occurrence of a residing pair of Secretarybirds (*Sagittarius serpentarius*) in close proximity to the study site. The map also displays the locality of a nest structure and the distribution of optimal foraging habitat in the area.

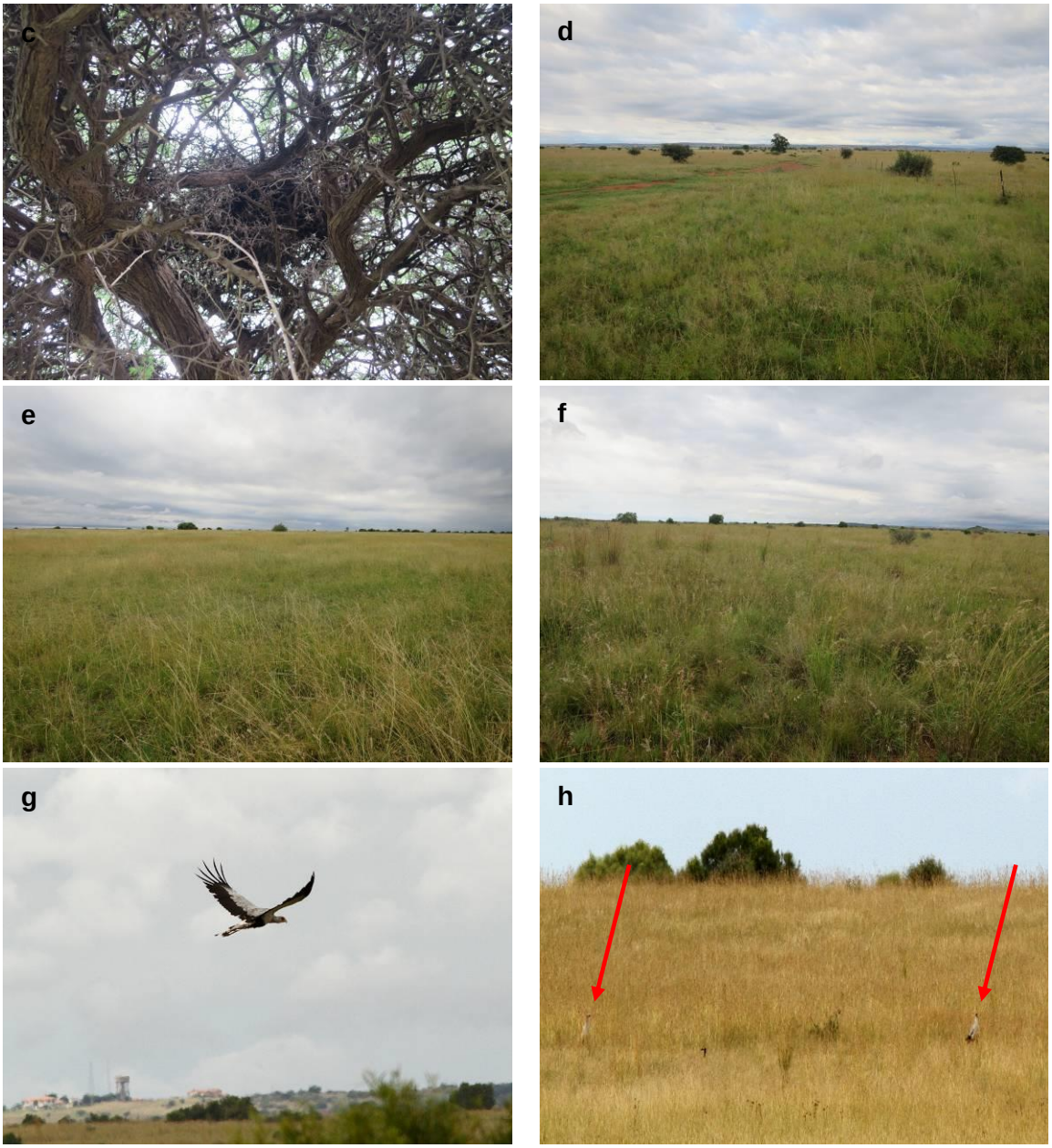

Figure 16: A collage of images illustrating the occurrence of the endangered Secretarybird (*Sagittarius serpentarius*) immediately south-west of the study site: (a - c) a nest situated on *Vachellia erioloba* trees (only visible from above and below), (d - f) open the graminoid structure indicating optimal foraging habitat and (g - h) individual birds observed foraging in the area .

4.4 Bird Assemblage Structure and Composition

4.4.1 Summary of point counts

A total of 71 bird species and an average abundance of 665.5 individuals were recorded from 24 bird points (representing two replicative counts) located on the project area. The data provides an estimate of the bird richness and their numbers on

the study site and immediate surroundings obtained during two independent survey sessions. A mean of 15.83 species and 27.7 individuals were recorded per point count. The highest number of species and individuals recorded from a point count was between 26 - 28 species (from dense bushveld on outcrops and from dense *Grewia-Vachellia* shrubland) and 126 individuals (from artificial watering points). The lowest number of species and individuals was respectively five species and seven individuals (from secondary grassland). The mean frequency of occurrence of a bird species in the study area was 22.30 % and the median was 16.67%, while the most common value (mode) was 4.17%. The latter represents those species that were encountered in only one point count. Five species occurred in 50 % or more of the counts (Table 5), while two species (c. Desert Cisticola *Cisticola aridulus* and black-chested Prinia *Prinia flavicans*) occurred in >80% of all the counts (Table 5).

Table 5: Bird species with a frequency of occurrence greater than 50% observed on the study site and immediate surroundings (according to 24 counts).

Species	Frequency (%)	Species	Frequency (%)
Desert Cisticola (*Cisticola arudulus*)	87.50	Zitting Cisticola (*Cisticola juncidis*)	58.33
Black-chested Prinia (*Prinia flavicans*)	83.33	Red-faced Mousebird (*Urocolius indicus*)	54.17
Rufous-naped Lark (*Mirafra africana*)	66.67		

4.4.2 Summary of richness and average abundance (per point count)

Displacement of birds by the proposed infrastructure is one of the impacts that is anticipated to occur. By mapping the spatial distribution of the number of species and average abundance values obtained from each point count, it is possible to predict where displacement of birds will be more intensive. According to Figure 17 and Figure 18 it is evident that moderate to high bird numbers (as well as a moderate - high number of bird species) occurs on habitat with dense woody structure (e.g. on outcrops, Klerksdorp Thornveld and *Grewia-Vachellia* shrubveld) and at artificial watering points. Most of these habitat types are located along the perimeter of the study site, although a large patch of *Grewia-Vachellia* shrubveld occurs on the western section of the study site. In addition, low bird numbers (and low bird richness) was observed from secondary grassland habitat. This means that the potential displacement of birds due to the loss of habitat during construction is likely to occur at dense bushveld habitat.

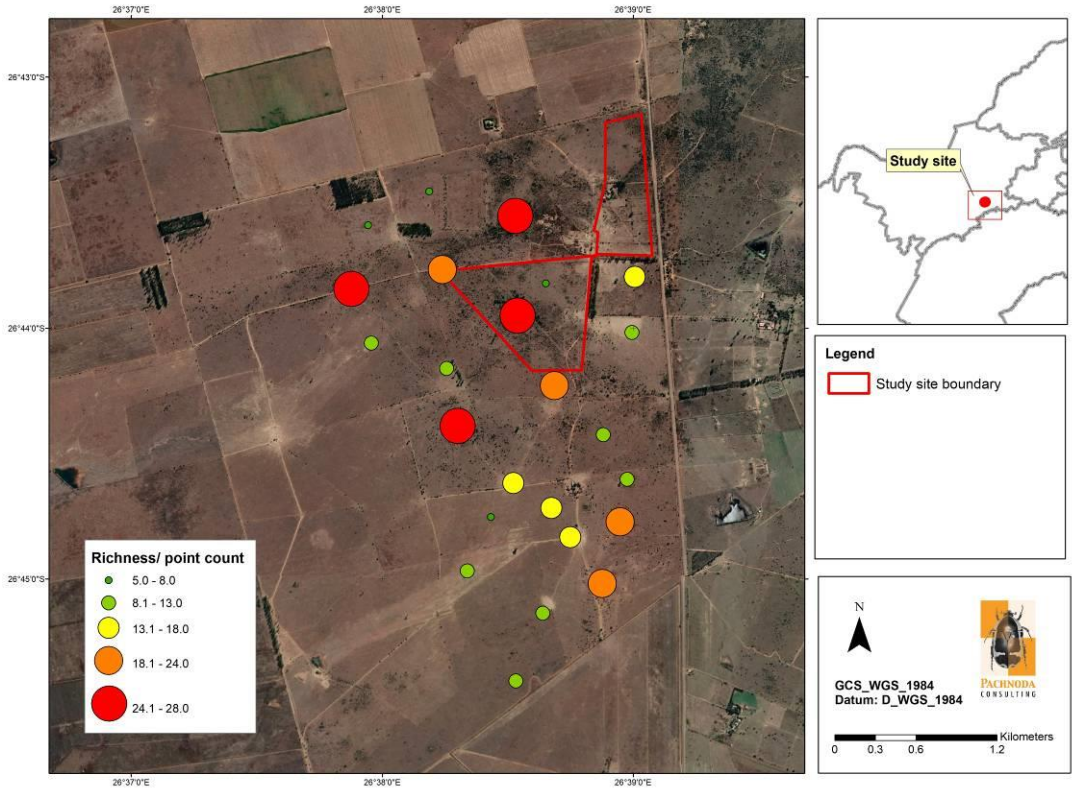

Figure 17: A map of the study area illustrating the spatial distribution of bird richness values (number of species) obtained for each point count.

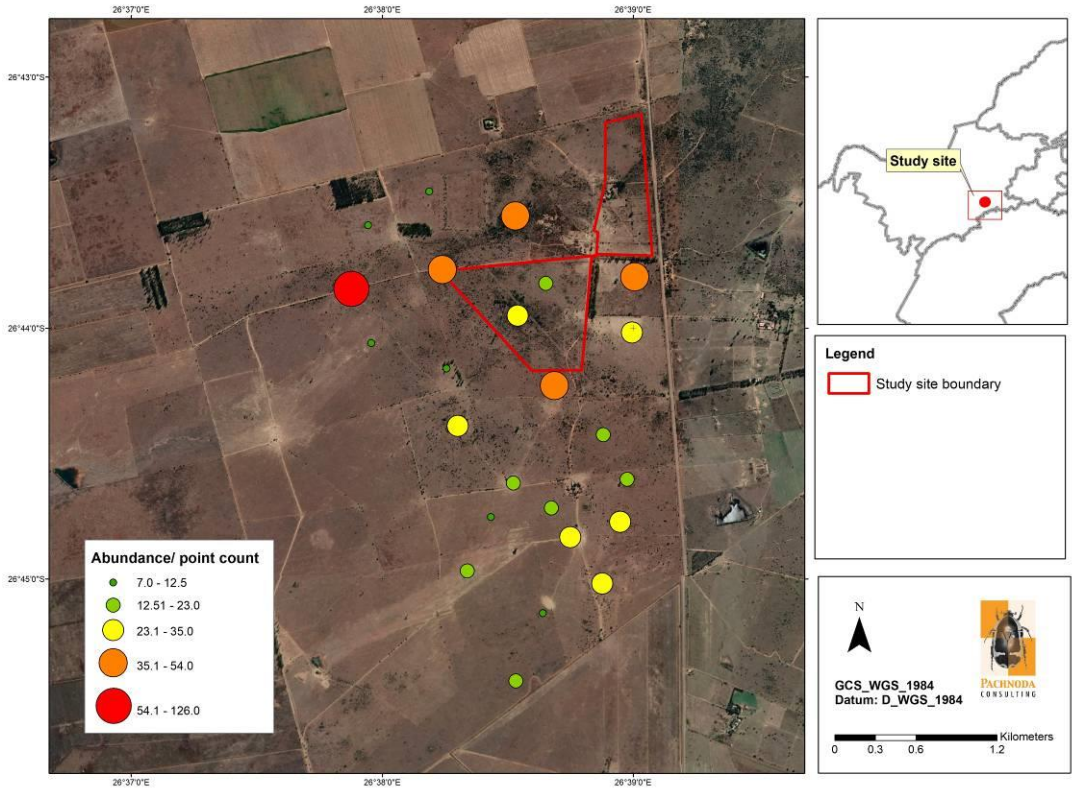

Figure 18: A map of the study area illustrating the distribution of bird abundance values (average number of individuals) obtained for each point count.

4.4.3 Dominance and typical bird species

T The dominant (typical) species on the study area are presented in Table 6. Only those species that cumulatively contributed to more than 90% to the overall similarity between the point counts are presented.

The three most typical bird species on the study area include the Desert Cisticola (*Cisticola aridulus*), Black-chested Prinia (*Prinia flavicans*) and Rufous-naped Lark (*Mirafra africana*). These species are considered widespread species in the broader study area and occur in most of the habitat types that area present. It is also evident from Table 6 that the typical bird assemblage is represented by cryptic (dull coloured) insectivores (insect-eating) and by granivores (seed-eating taxa), but also includes other less common but functionally important guilds which include frugivores (fruit-eaters).

Table 6: Typical bird species on the study area.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Desert Cisticola (*Cisticola aridulus*)	1.06	1.33	17.25	Insectivore: upper canopy foliage gleaner
Black-chested Prinia (*Prinia flavicans*)	1.63	1.31	14.92	Insectivore: upper canopy foliage gleaner
Rufous-naped Lark (*Mirafra africana*)	0.69	0.78	9.80	Granivore & insectivore: ground gleaner
Zitting Cisticola (*Cisticola juncidis*)	0.56	0.67	7.80	Insectivore: upper canopy foliage gleaner
Red-faced Mousebird (*Urocolius indicus*)	1.15	0.60	4.67	Frugivore: upper canopy gleaner
Chestnut-vented Warbler (*Curruca subcaerulea*)	0.88	0.49	3.45	Insectivore: upper canopy foliage gleaner
Red-billed Quelea (*Quelea quelea*)	5.94	0.36	3.22	Granivore: upper to lower canopy gleaner
Southern Masked Weaver (*Ploceus velatus)*	0.52	0.48	2.92	Granivore: upper to lower canopy gleaner

4.4.4 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 24 point counts on the project area differentiate between four discrete bird associations (Global R= 0.5, p=0.001; Figure 19), with statistically significant differences due to floristic structure and canopy cover (e.g. dense bushveld vs. open grassland habitat). These include (1) an association on short dense bushveld, (2) an association pertaining to open tall thornveld ("parkland"), (3) an association confined to secondary and/or shortly grazed grassland and (4) an association confined to untransformed grassland.

The habitat fidelity between species is illustrated in Figure 19 by plotting the relative abundance values of Chestnut-vented Warbler (*Curruca subcaerulea*). It shows that the Chestnut-vented Warbler (a "bushveld" species) is widely distributed within the grassland with bush clump mosaics and within the bushveld units, thereby implying that "grassland' and "bushveld" compositions also integrate with each other.

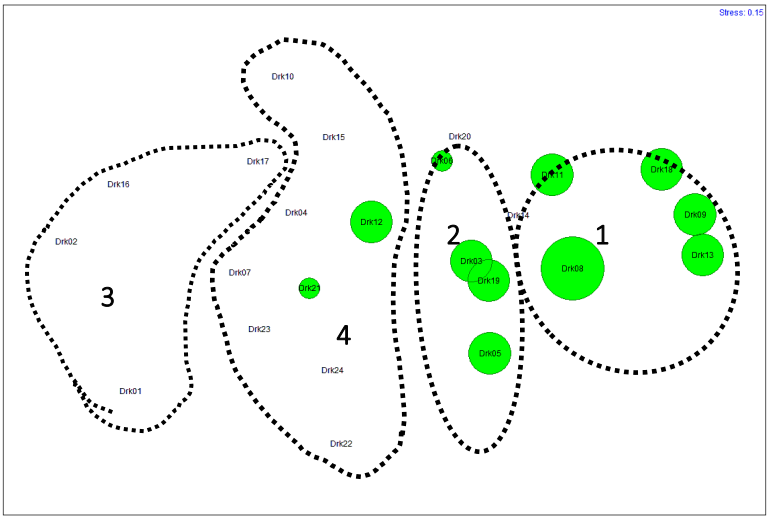

Figure 19: A two-dimensional non-metric multidimensional scaling ordination (stress=0.15) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 24 point counts on the project area. It differentiates between four bird associations: (1) an association on short dense bushveld/shrubland, an (2) association pertaining to open tall thornveld ("parkland"), (3) an association confined to secondary and/or shortly grazed grassland and (4) an association confined to untransformed grassland. The green circles represent the relative abundances of Chestnut-vented Warbler (*Curruca subcaerulea*).

The following bird associations are relevant to the study site and immediate surroundings:

1. Association on short dense bushveld/shrubveld

This is the dominant "bushveld" bird composition on the study area. It is confined to the dense *Grewia-Vachellia* shrubland habitat, dense bushveld on outcrops and Klerksdorp Thornveld.

Dominant species: The Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcaerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Neddicky (*Cisticola fulvicapilla*), Acacia Pied Barbet (*Tricholaema leucomelas*), Red-faced Mousebird (*Urocolius indicus*) and African Red-eyed Bulbul (*Pycnonotus nigricans*) are dominant, while Red-billed Quelea (*Quelea quelea*) is present in high numbers.

Indicator species[11]: Black-crowned Tchagra (*Tchagra senegalus*), Fiscal Flycatcher (*Melaenornis silens*), Chinspot Batis (*Batis molitor*), Rattling Cisticola (*Cisticola cheniana*), Common Scimitarbill (*Rhinopomastus cyanomelas*), White-throated

[11] Indicator species refers to a species with high numbers that is restricted to a particular habitat.

Robin-chat (*Cossypha humeralis*), Crimson-breasted Shrike (*Laniarius atrococcineus*) and Crested Barbet (*Trachyphonus vaillantii*).

2. Association on open tall thornveld ("parkland")

This association is confined to the tall microphyllous woodland which contains aspect dominants such as *Vachellia erioloba* and *Senegalia cf. hereroensis*. It includes the artificial livestock watering points, since these often contain large canopy constituents.

Dominant species: The Desert Cisticola (*Cisticola aridulus*), Southern Masked Weaver (*Ploceus velatus*), Swainson's Spurfowl (*Pternistis swainsonii*), Rufous-naped Lark (*Mirafra africana*), Chestnut-vented Warbler (*Curruca subcaerulea*), White-browed Sparrow-weaver (*Plocepasser mahali*) and Red-backed Shrike (*Lanius collurio*) are dominant, while Red-faced Mousebird (*Urocolius indicus*), Black-chested Prinia (*Prinia flavicans*) and Helmeted Guineafowl (*Numida meleagris*) are also present in high numbers.

Indicator species: White-browed Sparrow-weaver (*Plocepasser mahali*), Speckled Pigeon (*Columba guinea*), Hadeda Ibis (*Bostrychia hagedash*) and Crowned Lapwing (*Vanellus coronatus*).

3. Association on secondary (regenerating) and shortly grazed grassland

This association is confined to the secondary (regenerating) grassland on old agricultural land, and includes shortly grazed grassland which occurs south of the study site.

Dominant species: The Rufous-naped Lark (*Mirafra africana*), Zitting Cisticola (*Cisticola juncidis*), Cape Longclaw (*Macronyx capensis*) and Quailfinch (*Ortygospiza atricollis*) are dominant, while the Desert Cisticola (*Cisticola aridulus*) is present in high numbers.

Indicator species: Quailfinch (*Ortygospiza atricollis*) and Cloud Cisticola (*Cisticola textrix*).

4. Association on untransformed grassland

This association is confined to the open grassland with scattered bush clump mosaics. The bird composition contains both "grassland" and "bushveld" bird species.

Dominant species: The Desert Cisticola (*Cisticola aridulus*), Black-chested Prinia (*Prinia flavicans*), Rufous-naped Lark (*Mirafra africana*) and Zitting Cisticola (*Cisticola juncidis*) are ubiquitous, while Eastern Clapper Lark (*M. fasciolata*), Spike-heeled Lark (*Chersomanes albofasciata*), Northern Black Korhaan (*Afrotis afraoides*),

Southern Red Bishop (*Euplectes orix*) and African Pipit (*Anthus cinnamomeus*) are prominent in the grassland matrix. The Lesser Grey Shrike (*Lanius minor*), African Red-eyed Bulbul (*Pycnonotus nigricans*) and the Pied Crow (*Corvus albus*) are dominant in the bush clumps.

Indicator species: Lesser Grey Shrike (*Lanius minor*), Southern Red Bishop (*Euplectes orix*), Spike-heeled Lark (*Chersomanes albofasciata*), Cape Starling (*Lamprotornis nitens*) and Cape Sparrow (*Passer melanurus*).

The highest number of bird species on the project area was observed from dense short bushveld/shrubveld, followed by the bird association on tall thornveld (Table 7). The lowest number of bird species was recorded from secondary grassland. High numbers of birds were observed from the tall thornveld at artificial watering holes.

Table 7: A summary of the observed species richness and number of bird individuals confined to the bird associations on the project area.

Bird Association	Number of species	Number of Individuals	Shannon Wiener Index H'(log_e)
Dense short bushveld/shrubveld	49	39.7	3.33
Open tall thornveld	44	46.8	2.69
Secondary (regenerating) and short grazed grassland	17	10.4	6.84
Untransformed grassland with bush clump mosaics	43	19.2	3.24

4.5 Passerine bird densities

Fifty passerine bird species were recorded from 24 point counts on the study site and immediate surroundings. The study site and immediate surroundings comprise of approximately 10.90 species.ha^{-1} (Appendix 2). The average density per hectare is 19.14 birds.ha^{-1} and ranges between 2.39 birds.ha^{-1} to 118.59 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

Deterministic daily dispersal of birds (Figure 20 and Figure 21) was not observed apart from a high frequency of foraging Pied Crows (*Corvus albus*) (Figure 21). Nevertheless, the home ranges of approximately 17 to 20 pairs of Northern Black Korhaans correspond to the project area (Figure 20). At least one pair could occupy the grassland on the extreme north-eastern part of the study site.

The flight routes of the birds were random and haphazard and no predicted/deterministic pattern could be established. Therefore, these species utilise searching as a means to find potential food during foraging excursions. However, a pair was observed nesting on a pylon in the north of the project area.

The absence of any water bodies, dams and drainage lines on the study site explains the general absence of waterbirds passing in the area. However, a number of small impoundments occur within the study area (between 2.5 and 2.8 km south-west of

the study site, with another small dam located approximately 600 m east of the study site) which increases the probability for certain waterbirds and shorebirds to fly over the study site during dispersal (dispersing between the nearby Schoonspruit system, Klerksdorp Dam and the smaller farm dams in the region). Typical bird species likely to disperse across the site will include widespread species such as Yellow-billed Duck (*Anas undulata*), Red-billed Teal (*A. erythrorhyncha*), White-faced Whistling Duck (*Dendrocygna viduata*), Reed Cormorant (*Microcarbo africanus*), Little Grebe (*Tachybaptus ruficollis*), Egyptian Goose (*Alopochen aegyptiacus*) and Red-knobbed Coot (*Fulica cristata*).

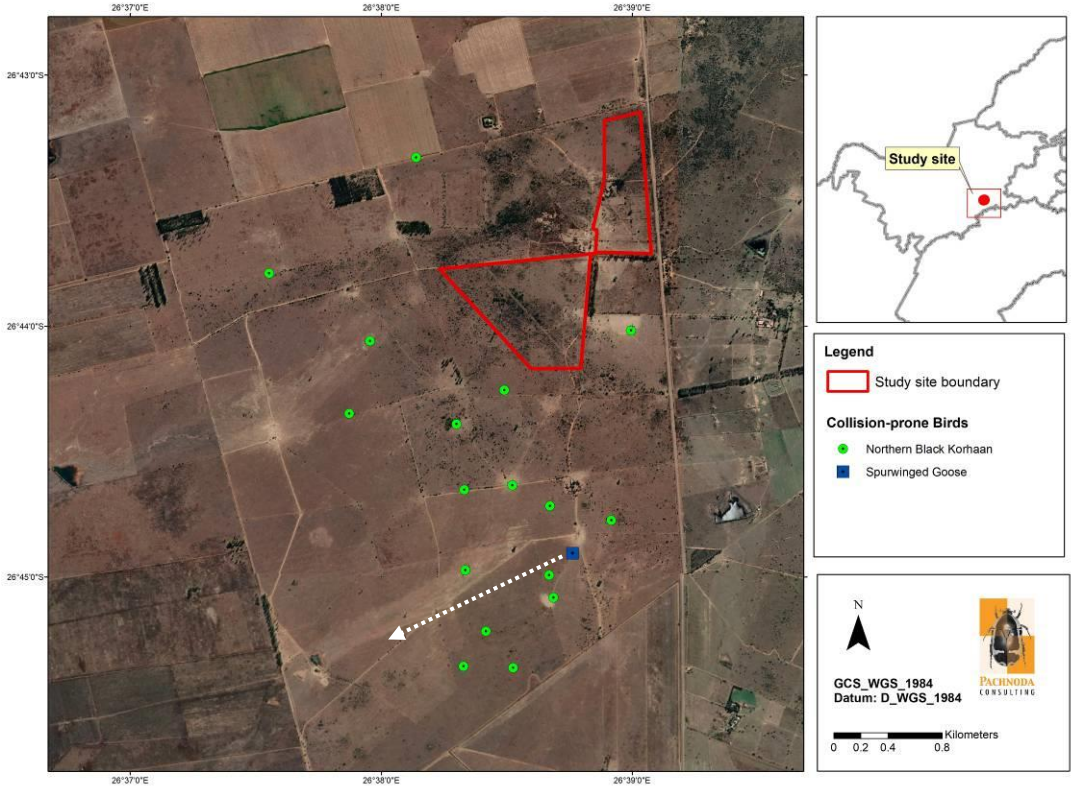

Figure 20: A map of the study site illustrating the occurrence and movements of large terrestrial collision-prone birds.

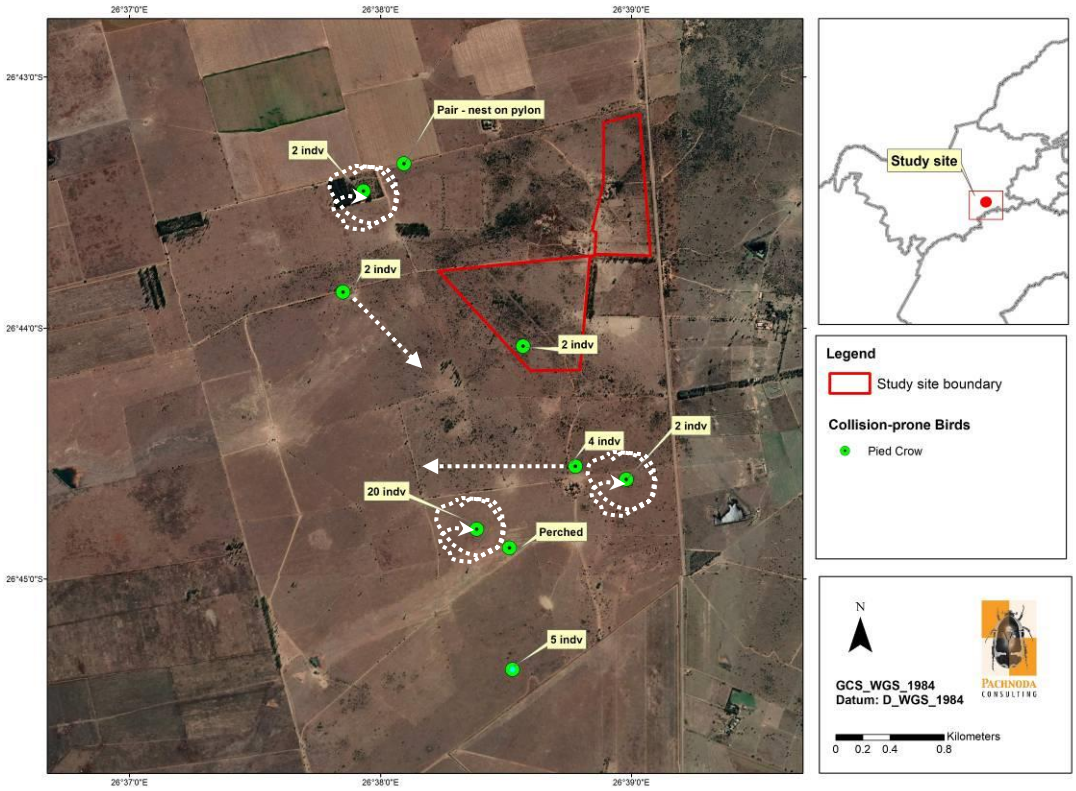

Figure 21: A map of the study site illustrating the occurrence and movements of collision prone birds: Pied Crow.

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising potential sensitive elements based on the following arguments (Figure 22):

Areas of medium sensitivity

Medium sensitivity habitat units include natural habitat represented by extensive open savannoid grassland and the bushveld/shrubveld units. The open savannoid grassland and bush clump mosaics, as well as the Klerksdorp Thornveld are widespread in the region with large surface areas prevalent in the region. Although these habitat units are widespread at a landscape scale, they provide suitable habitat for some collision-prone bird species, including the Northern Black Korhaan (*Afrotis afraoides*) that could become displaced from the area during construction of the facility. However, reporting rates for threatened and near threatened bird species on the study site are relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural.

Areas of medium-low sensitivity

These habitat units include secondary grassland units corresponding to historically disturbed or transformed habitat due to past agricultural practice. This habitat provides ephemeral foraging habitat for certain terrestrial bird species (e.g. Northern Black Korhaan *Afrotis afraoides*) that could become displaced from the area during construction of the facility.

Areas of low sensitivity

These habitat units are represented by artificial habitat types and include built-up land. It represents transformed habitat, thereby contributing little towards the local biodiversity.

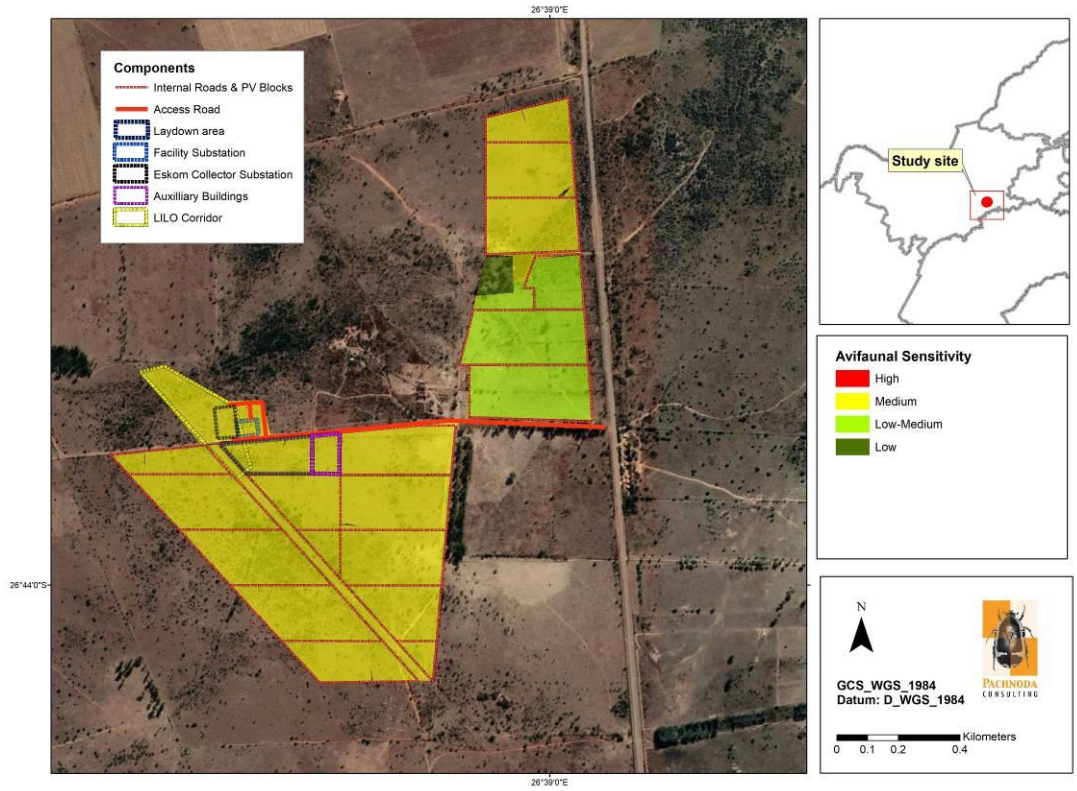

Figure 22: A map illustrating the avifaunal sensitivity of the study site based on the ecological condition of habitat types and the occurrence of collision prone bird species.

4.8 Overview of Avian Impacts at Solar Facilities

4.8.1 Background to solar facilities and their impact on birds

Birds are mobile, and are therefore also more readily affected by solar facilities than other taxonomic groups (e.g. mammals). In fact, birds are also vulnerable to impacts caused by other types of energy facilities such as overhead power lines and wind farms. Little information is available on the impacts of solar energy facilities on birds although Gunerhan *et al.* (2009), McCrary *et al.* (1986), Tsoutsos *et al.* (2005) and the recent investigation reports on bird fatalities in the USA by Kagen *et al*. (2014) and Walston *et al*. (2016) provide discussions thereof. These studies have shown that avian fatalities vary greatly between the geographic positions of the solar facilities and also depend on the type of solar facility. In addition, very few of the large solar facilities in operation undertake systematic monitoring of avian fatalities, which explains the lack of detailed information of avian impacts. According to these studies conducted at both Concentrated Solar Power (CSP) and PV facilities, avian incidental fatalities range from 14 to over 180 birds which were summarised over a survey period conducted during one to three years. According to the Walston *et al.* (2016) assessment, the average annual mortality rate for known utility-scale solar facilities (the annual number of estimated bird deaths per megawatt of electrical capacity) is 2.7, and 9.9 for known and unknown fatalities (which include carcasses found on the project site of which the death is not known). McCrary *et al.* (1986) found an average rate of mortality of 1.9-2.2 birds per week affecting 0.6-0.7% of the local bird population. However, most of the avian fatalities at these solar facilities are also probably underestimated since 10-30% of dead birds are removed by scavengers before being noted. From these analyses and assessments it was evident that:

- Medium levels of bird fatalities occur at PV sites when compared to CSP sites (due to solar flux-based mortalities associated with CSP sites).
- Approximately 81 % of all avian mortalities were caused by collisions, including collisions with electrical distribution lines.
- Most of the mortalities were small passerines (especially swallows).
- Fatalities at these solar facilities also include waterbirds (e.g. grebes, herons and gulls) which were probably attracted by the apparent "lake effect" caused by the reflective surface of the PV panels.
- Approximately 10-11 % of the fatalities consists of waterbirds, but could be as high as 49 % at certain facilities.
- It is unclear if the "lake effect" caused by the panels (at PV facilities) or mirrors (at CSP facilities) are the main cause of birds colliding or interacting with the infrastructure (since both waterbirds and other passerines are colliding with the infrastructure).
- Most of the fatalities are of resident birds as opposed to migratory species.

In a review report by Harrison *et al.* (2016), an attempt was made to provide evidence of the impacts caused by solar PV facilities alone (not combined with CSP facilities) on birds in the UK. These authors reviewed approximately 420 scientific documents, including 37 so-called "grey" literature from non-government and government organisations for any evidence relating to the ecological impacts of solar PV facilities. Their main findings were as follows:

- The majority of the documents were not relevant and peer-reviewed documents of experimental scientific evidence on avian fatalities were non-existent.
- Results based on carcass searches suggest that the bird collision risk at PV developments are low, although these studies did not take collision by overhead power lines into account.
- Many of the documents recommended that PV developments in close proximity to protected areas should be avoided.
- The PV panels reflect polarised light, which can attract polarotactic insects with potential impact to their reproductive biology. In addition, the polarising effect of the PV panels may also induce drinking behaviour in some birds, which may mistake the panels for water.
- They conclude that impact assessment reports should consider taxon-specific requirements of birds and their guilds.

4.9.2 Impacts of PV solar facilities on birds

The magnitude and significance of impacts to birds caused by solar facilities will depend on the following factors:

- The geographic locality of the planned solar facility;
- The size or surface extent of the solar facility;
- The type of solar facility (according to the technologies applied, e.g. PV or CSP); and
- The occurrence of collision-prone bird species (which are often closely related to the locality of the solar facility).

Any planned solar facility corresponding to an area with many threatened, range-restricted or collision-prone species will have a higher impact on these birds. In addition, any planned solar facility located in close proximity to important flyways, wetland systems or roosting/nesting sites used by the aforementioned species will have a higher impact.

The main impacts associated with PV solar facilities include (Jenkins *et al*., 2017):

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction;
- Disturbances caused to birds during construction and operation;

- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or waterbirds colliding with the panels (as they are mistaken for waterbodies);
- Collision with associated infrastructure (mainly overhead power lines and reticulation); and
- Attracting novel species to the area (owing to the artificial provision of new habitat such as perches and shade) which could compete with the residing bird population.

4.9 Impacts associated with the Doornhoek 2 PV Facility

Table 8 provides a summary of the impacts anticipated and quantification thereof (see Appendix 3 for methods used during the assessment of impacts).

4.9.1 Loss of habitat and displacement of birds

Approximately 84 ha will be cleared of vegetation and habitat to accommodate the panel arrays and associated infrastructure. Clearing of vegetation will inevitably result in the loss of habitat and displacement of bird species. From the results, approximately 10.90 species.ha^{-1} and 19.14 birds.ha^{-1} will become displaced should the activity occur across all the habitat types on the study site (as per Jenkins et al., 2017). Displacement will mainly affect passerine and smaller non-passerine species inhabiting the open savannoid grasslands, bush clump mosaics and bushveld units.

The following bird species are most likely to be impacted by the loss of habitat due to their habitat requirements, endemism and conservation status (although not limited to) due to the proposed development:

- Northern Black Korhaan (*Afrotis afraoides*);
- White-browed Scrub-robin (*Cossypha humeralis*);
- Ashy Tit (*Melaniparus cinerascens*);
- Kalahari Scrub Robin (*Cercotrichas paena*);
- Orange River Francolin (*Scleroptila gutturalis*) and potentially also small to medium birds of prey such as:
- Black-winged Kite (*Elanus caeruleus*)
- Lesser Kestrel (*Falco naumanni*) and
- Gabar Goshawk (*Micronisus gabar*).

When considering the number of displaced bird species and their widespread occurrence in the region, the predicted impact due to the overall displacement and habitat loss is moderate without mitigation measures. However, the possibility exists that the endangered Secretarybird (*Sagittarius serpentarius*) could become displaced should construction activities overspill onto suitable foraging habitat (see Figure 15).

4.9.2 Creation of "new" avian habitat and bird pollution

It is possible that the infrastructure (during operation) could attract bird species which may occupy the site or interact with the local bird assemblages in the wider region. These include alien and cosmopolitan species, as well as aggressive omnivorous passerines which could displace other bird species from the area:

- House Sparrow (*Passer domesticus*);
- Common Myna (*Acridotheres tristis*);
- Pied Crow (*Corvus albus*); and
- Speckled Pigeon (*Columba guinea*).

The infrastructure may attract large numbers of roosting columbid taxa, especially Speckled Pigeons (*Columba guinea*), which may result in avian "pollution" through excreta, thereby fouling the panel surfaces. The impact is manageable and will result in a low significance.

4.9.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The study site does not overlap with any major flyway and is located approximately 5 km east of the Schoonspruit system and 6.5 km north-east of the Klerksdorp Dam which both represent major avian flyways or water bodies in the region. The nearest wetland systems are between 2.5 and 2.8 km south-west of the study site, with another small dam located approximately 600 m east of the study site, which explain the low occurrence of waterbird taxa at the study site. These impoundments are often utilised by waterbirds which could accidentally mistake the reflective panels for waterbodies, thereby resulting in bird collisions with the panel surfaces. At this stage the impact is considered to be low depending subsequent monitoring (e.g. pre-construction monitoring) during the peak wet season when most of the wetland features in the region are inundated. This makes predictions regarding the occurrence of waterbird species and their numbers (e.g. density) in the area inconceivable.

However, desktop results and site observations show that the following species could interact with the panel infrastructure:

- Yellow-billed Duck (*Anas undulata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- South African Shelduck (*Tadorna cana*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Little Grebe (*Tachybaptus ruficollis*);
- Reed Cormorant (*Microcarbo africanus*);
- Black-headed Heron (*Ardea melanocephala*);
- Red-knobbed Coot (*Fulica cristata*) and probably also

- Grey Heron (*Ardea cinerea*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and
- White-faced Duck (*Dendrocygna viduata*).

Of these species, the Spur-winged Goose, Egyptian Goose, Red-knobbed Coot, Little Grebe, Yellow-billed Duck, Reed Cormorant and Black-headed Heron were confirmed from small farm dams located within the immediate surroundings.

In the absence of sufficient information on the occurrence of waterbird taxa in the area, as well as the lack of data on bird mortalities caused by collisions, the precautionary principle was applied which results in an impact of moderate significance (in the absence of any mitigation measures).

4.9.4 Interaction with overhead power lines and reticulation

A short loop-in-loop out (LILO) corridor is proposed which feeds directly from the Eskom switching station to the existing Watershed–Klerksdorp 1 123kV powerline. The LILO corridor is not expected to exceed 300m in length. Birds are impacted in three ways by means of overhead power lines. It is however a common rule that large and heavy-bodied terrestrial bird species are more at risk of being affected in a negative way when interacting with power lines. These include the following:

- *Electrocution*

Electrocution happens when a bird bridges the gap between the live components or a combination of a live and earth component of a power line, thereby creating a short circuit. This happens when a bird, mainly a species with a fairly large wingspan attempts to perch on a tower or attempts to fly-off a tower. Many of these species include vultures (of the genera *Gyps* and *Torgos*) as well as other large birds of prey such as the Martial Eagle (*Polemaetus bellicosus*) (Ledger & Annegarn, 1981; Kruger, 1999; Van Rooyen, 2000). These species will attempt to roost and even breed on the tower structures if available nesting platforms are a scarce commodity in the area. Other types of electrocutions happen by means of so-called “bird-streamers”. This happens when a bird, especially when taking off, excretes and thereby causes a short-circuit through the fluidity excreta (Van Rooyen & Taylor, 1999).

Large transmission lines (from 220 kV to 765 kV) are seldom a risk of electrocution, although smaller distribution lines (88 – 132kV) pose a higher risk. However, for this project, the design of the pylon is an important consideration in preventing bird electrocutions. However, electrocution is proportional to the spatial position of carcasses, and will probably only occur when a carcass is located underneath or in close proximity to an overhead distribution power line.

- *Collision*

Collisions with earth wires have probably accounted for most bird-power line interactions in South Africa. In general, the earth wires are much thinner in diameter when compared to the live components, and therefore less visible to approaching birds. Many of the species likely to be affected include heavy, large-bodied terrestrial species such as bustards, korhaans and a variety of waterbirds that are not very agile or manoeuvrable once airborne. These species, especially those with the habit of flying with outstretched necks (e.g. most species of storks) find it difficult to make a sudden change in direction while flying – resulting in the bird flying into the earth wires.

Areas where bird collisions are likely to be high could be ameliorated by marking the lines with appropriate bird deterrent devices such as “bird diverters” and “flappers” to increase the visibility of the lines.

- *Physical disturbances and habitat destruction caused during construction and maintenance*

Construction activities go hand in hand with high ambient noise levels. Although construction is considered temporary, many species will vacate the area during the construction phase and will become temporarily displaced.

Table 8: The quantification of impacts associated with the proposed PV facility and its infrastructure.

1. Nature: Losses of natural habitat and displacement of birds through physical transformation, modifications, removals and land clearance. This impact is mainly restricted to the construction phase and is permanent.		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (6)	Moderate (6)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**Medium (52)**	**Medium (52)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: It is difficult to mitigate against the loss of habitat since clearing of vegetation (or habitat) will be required for the infrastructure associated with the project. Both the PV facility and associated infrastructure occur predominantly on habitat types of medium and low-medium sensitivity. The best practicable mitigation will be to consolidate infrastructure to areas where existing impacts occur.		

Residual:
It is anticipated that during rehabilitation (after removal of the panels) that the vegetation will revert to secondary grassland and shrubland resulting in a potential decrease in bird species richness with low evenness values at a local scale. The residual impact of the PV facility will be medium.

2. Nature:
The creation of novel or new avian habitat for commensal bird species or superior competitive species. This is expected to occur during the operation phase of the facility.

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Footprint (1)	Footprint (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Low (18)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, with experimentation	Yes

Mitigation:
Apply bird deterrent devices and remove nest structures constructed on infrastructure associated with the PV facility under the guidance of the ECO.

Residual:
Secondary displacement by completive bird species such as crows and increased fecundity rate for commensal bird species that are adapted to anthropogenic activities. The impact is regarded as low.

3. Nature:
Avian collision impacts related to the PV facility during the operation phase (collision with the PV panels).

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Medium (30)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these could become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent

Mitigation:
Apply bird deterrent devices to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels. If pre-construction and post-construction monitoring predicts and/or confirms any bird mortalities, an option is to employ video cameras at selected areas to document bird mortalities and to

conduct direct observations and carcass searches on a regular and systematic basis.
Residual: Direct mortality is possible and may still occur irrespective of applied mitigation measures. Regular and systematic monitoring is proposed to assess the efficacy of applied mitigation and further research and testing is suggested to improve mitigation measures (e.g. bird deterrent devices). The residual impact is regarded as low.

4. Nature:
Avian collision impacts related to overhead power lines during operation.

LILO Corridor (only)	Without mitigation	With mitigation
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (21)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of large terrestrial bird and certain bird of prey species	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:
Apply bird deterrent devices to the power lines and make use of "bird-friendly" pylon structures (if pylons are used). Avoid the placement of any cattle feedlots, kraals and watering points in close proximity to any overhead electrical infrastructure in order to avoid attracting birds of prey or scavenger species such as vultures to the study site. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to conduct direct observations and carcass searches on a regular and systematic basis.

Residual:
Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.

5. Nature:
Avian electrocution related to the new distribution lines during operation.

LILO Corridor	Without mitigation	With mitigation
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (21)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of large terrestrial bird and certain bird of prey species	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent

Mitigation:
Avoid the placement of any cattle feedlots, kraals and watering points in close proximity to any overhead electrical infrastructure in order to avoid attracting birds of prey or scavenger species such as vultures to the study site. Grazing of cattle at or in close proximity to distribution lines should be monitored and preferably be avoided (to

minimise potential livestock carcasses near distribution lines). Make use of bird-friendly pylons and bird guards as recommended by EWT.
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.

4.9.5 Collision-prone bird species

A total of 56 collision-prone bird species have been recorded in the wider study area, of which 26 species are birds of prey (Table 9). Those species with SABAP2 reporting rates higher than 20% are regarded to be regular species in the area.

Table 9: Collision-prone bird species and Red listed species (in red) expected to be present on the study site and immediate surroundings inferred from the South African Atlas Project (SABAP2).

Common Name	Scientific Name	Conservation Status	SABAP2 Reporting Rate
Abdim's Stork	*Ciconia abdimii*	NT (regional)	1.58
African Fish Eagle	*Haliaeetus vocifer*		9.54
African Harrier-Hawk	*Polyboroides typus*		0.41
African Hawk-eagle	*Aquila spilogaster*		0.21
African Sacred Ibis	*Threskiornis aethiopicus*		36.31
Amur Falcon	*Falco amurensis*		6.11
Black Sparrowhawk	*Accipiter melanoleucus*		3.77
Black Stork	*Ciconia nigra*		0.07
Black-chested Snake Eagle	*Circaetus pectoralis*		0.41
Black-headed Heron	*Ardea melanocephala*		25.19
Black-winged Kite	*Elanus caeruleus*		44.61
Black-winged Pratincole	*Glareola nordmanni*	NT (global)	0.76
Blue Crane	*Grus paradisea*	NT (regional)	1.44
Brown Snake Eagle	*Circaetus cinereus*		0.21
Cape Shoveler	*Spatula smithii*		18.53
Cape Vulture	*Gyps coprotheres*	EN (regional), VU (global)	0.07
Common (=Steppe) Buzzard	*Buteo buteo vulpinus*		5.35
Coqui Francolin	*Peliperdix coqui*		0.14
Egyptian Goose	*Alopochen aegyptiaca*		52.57
Gabar Goshawk	*Micronisus gabar*		5.70
Greater Kestrel	*Falco rupicoloides*		3.09
Grey Heron	*Ardea cinerea*		34.59
Hadada Ibis	*Bostrychia hagedash*		84.76
Hamerkop	*Scopus umbretta*		7.96
Helmeted Guineafowl	*Numida meleagris*		86.00
Lanner Falcon	*Falco biarmicus*	VU (regional)	1.24
Lesser Kestrel	*Falco naumanni*		6.52
Little Grebe	*Tachybaptus ruficollis*		42.83

Marsh Owl	*Asio capensis*		3.84
Martial Eagle	*Polemaetus bellicosus*	EN (regional)	0.07
Namaqua Sandgrouse	*Pterocles namaqua*		0.41
Natal Spurfowl	*Pternistis natalensis*		8.03
Northern Black Korhaan	*Afrotis afraoides*		73.44
Orange River Francolin	*Scleroptila gutturalis*		13.66
Ovambo Sparrowhawk	*Accipiter ovampensis*		1.24
Pale Chanting Goshawk	*Melierax canorus*		2.40
Pallid Harrier	*Circus macrourus*	NT (global)	0.27
Pied Crow	*Corvus albus*		55.39
Purple Heron	*Ardea purpurea*		4.53
Red-billed Teal	*Anas erythrorhyncha*		25.88
Red-footed Falcon	*Falco vespertinus*	VU (global)	0.21
Reed Cormorant	*Microcarbo africanus*		45.78
Rock Kestrel	*Falco rupicolus*		0.27
Secretarybird	*Sagittarius serpentarius*	EN (regional)	0.69
South African Shelduck	*Tadorna cana*		17.91
Spotted Eagle-Owl	*Bubo africanus*		5.49
Spur-winged Goose	*Plectropterus gambensis*		18.33
Swainson's Spurfowl	*Pternistis swainsonii*		86.34
Western Barn Owl	*Tyto alba*		4.05
Western Cattle Egret	*Bubulcus ibis*		70.08
White Stork	*Ciconia ciconia*		0.34
White-backed Vulture	*Gyps africanus*	CR (regional)	0.34
White-faced Whistling Duck	*Dendrocygna viduata*		12.08
Wood Sandpiper	*Tringa glareola*		7.69
Yellow-billed Duck	*Anas undulata*		49.83
Yellow-billed Kite	*Milvus aegyptius*		0.48

4.10 Recommended avifaunal mitigation

4.10.1 Loss of habitat and displacement bird taxa (including threatened and near threatened birds)

It is difficult to mitigate against the loss of habitat when fixed infrastructure is applied. However, proper site selection of the facility is key to reducing the predicted impacts.

The following mitigation measures are proposed:

- Concentrate all surface infrastructure on habitat of medium to low avifaunal sensitivity. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.
- Where possible, existing access roads should be used and the construction of new roads should be kept to a minimum.

- Prevent an overspill of construction activities into areas that are not part of the proposed construction site - development should not interfere with the proposed Secretarybird buffer area (see Figure 15);
- Use indigenous plant species native to the study site during landscaping and rehabilitation.
- All internal electrical reticulation should be placed underground, while the alignment of the power line and substation should be placed parallel to existing lines.

4.10.2 Creation of "new" avian habitat and bird pollution

The following mitigation measures are proposed:

- Apply bird deterrent devices at selective areas (for example at the corners and middle part of the facility) to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed under the guidance of the ECO.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.

4.10.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The following mitigation measures are proposed:

- Implement at an additional bird survey (pre-construction surveys - see section dealing with monitoring and EMP) during the peak wet season to obtain quantified data on the occurrence or flyways of waterbird taxa. The data will enable informed decisions regarding the use of deterrent devices.
- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility) to discourage birds from colonising/colliding with the infrastructure. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. An option is to employ video cameras at selected areas to document bird mortalities.
- Apply systematic reflective/dynamic markers to the boundary fence to increase the visibility of the fence for approaching birds (e.g. korhaan taxa) and to avoid potential bird collisions with the fence structure.

- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.

4.10.4 Power line interaction: collision and electrocution with power lines

The following mitigation measures are proposed:

- All internal electrical infrastructure and cabling should be placed underground.
- It is advised that all infrastructure be fenced to prevent cattle from accessing into the facility. Avoid the placement of cattle feedlots, kraals and watering points in close proximity to overhead electrical infrastructure. A safe distance of at least 100 m from any overhead powerline is recommended. It is advised that grazing cattle at or in close proximity to distribution lines *(c*. 100 m) be monitored (to avoid the risk of livestock carcasses near distribution lines, which may attract vultures and other scavenging birds and the increased the risk of collision or electrocution by overhead lines). In the event that a carcass is located, it should immediately be removed from the area.
- EWT should be consulted on an appropriate pylon design to be used for the project (if pylons are to be used). In general, the proposed pylon design must incorporate the following design parameters:
    - The clearances between the live components should be as wide as possible within the design limitations/capabilities of the power line.
    - The height of the tower should allow for unrestricted movement of terrestrial birds between successive pylons.
    - The live components should be "bundled" to increase the visibility for approaching birds.
    - "Bird streamers" should be eliminated by discouraging birds from perching above the conductors. In addition, conductors should be strung below the pole to avoid bridging the air gap by perching birds of prey.

It is therefore recommended that the pylon design incorporates "features as illustrated in Figure 23[12].

From Figure 23 it is clear that perching by birds is discouraged by the addition of diagonal crossbars or by doing away with the crossbars that holds the conductors in place. Bird "streamers" are also eliminated by fitting the poles with bird guards/spikes above the conductors. However, safe perching is facilitated by the fitment of a horizontal bar on top of the pole structure without the risk of electrocution (due to the perpendicular orientation of the bar relative to the conductors).

[12] Please note that these are examples of recommended pylon designs. These are taken from steel monopole pylons.


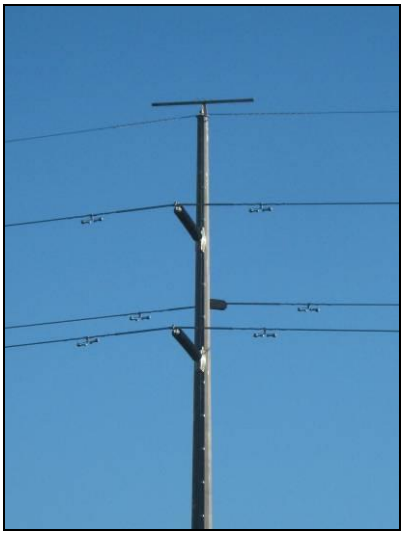

Figure 23: Two bird-friendly tower designs to be considered for the current project.

- All new and planned power lines should be fitted with bird flight diverters (see Figure 24). It is also highly recommended that the existing Watershed–Klerksdorp 1 123kV powerline be retrofitted with bird flight diverters owing to the occurrence of Secretarybirds on the study area.

Figure 24: Examples of bird flight diverters to be used on the power lines: Double loop bird flight diverter (left) and Viper live bird flapper (right).

4.12.5 General mitigation measures

- All construction sites/areas must be demarcated on site layout plans (preferably), and no construction personnel or vehicles may leave the demarcated area except those authorised to do so. Those areas surrounding the construction sites that are not part of the demarcated development area should be considered as “no-go” areas for employees, machinery or even visitors.

- All road networks must be planned with care to minimise dissection or fragmentation of important avifaunal habitat type. Where possible, the use of existing roads is encouraged.
- Open fires is strictly prohibited and only allowed at designated areas.
- Killing or poaching of any bird species should be avoided by means of awareness programs presented to the labour force. The labour force should be made aware of the conservation issues pertaining to the bird taxa occurring on the study site. Any person found deliberately harassing any bird species in any way should face disciplinary measures, following the possible dismissal from the site.
- Checks must be carried out at regular intervals to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of eroded areas should be undertaken.

4.11 Suggested monitoring and Environmental Management Plan

Information on collision trauma (bird mortalities) and the displacement of birds caused by PV solar facilities is insufficient. Therefore, as per the guidelines of Jenkins *et al.* (2017) it is highly recommended that additional pre- and post construction monitoring be implemented to augment existing data:

- At least one additional pre-construction survey is recommended, consisting of a minimum of 2-3 days which is necessary to inform the final EMPr during operation. The survey should coincide with the peak wet season when most of the drainage lines and wetland features in the wider study region are inundated. This will enable the observer to obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels.
- A post-construction survey during operation (with a minimum of 2 x 3 day surveys during a six month period (including the peak wet season)). The surveys aim to obtain mortality data from birds colliding with the panels to advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. The surveys should be conducted in a regular and systematic manner by means of direct observations and carcass searches. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.
- The post-construction monitoring (during operation) should also quantify mortalities caused by the power line network (including the existing network). The information could then be used to inform the electrical infrastructure mortality incident register. Monitoring should run parallel with the post-construction monitoring sessions .Additional mitigation measures should be

tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 1: Minimise potential collision trauma with infrastructure and augmenting existing information on bird interactions with solar infrastructure

Project Component/s	» PV panel arrays
Potential Impact	» Collision trauma caused by photovoltaic panels (the "lake-effect")
Activity/Risk Source	» Operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	Responsibility	Timeframe
1. Apply bird deterrent devices to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed.	ECO & OM	Operation (on-going)
2. Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.	ECO & OM	Operation (on-going)
3. Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
4. Implement pre-construction monitoring protocols (as per Jenkins et al., 2017).	ECO & EM	Prior to construction - At least 1 survey of 1-2 days (during wet season)
5. Implement post-construction monitoring and carcass surveys (as per Jenkins et al., 2017)	OM & CER	Post- construction - At least 2 surveys, each 3 days during a 6 month period
6. Compile management programme to assess efficacy of mitigation and on-going research/trials	EM & OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	1. Implement at least one pre-construction survey consisting of a minimum of

	2-3 days. 2. Surveys should coincide with the peak wet season when most of the drainage lines and wetland features in the wider study region are inundated. 3. Obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels. 4. Monitor terrestrial birds at the fixed point counts by using the exact protocol applied during this report. 5. Implement post-construction survey during operation with a minimum of 2 x 3 day surveys during a six month period (including the peak wet season). 6. Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. 7. Conduct post-construction monitoring in a systematic manner by means of direct observations (an option is the use of installed video cameras at selected areas) and carcass searches. 8. Implement management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 2: Minimise collisions and electrocution associated with power lines

Project Component/s	» Overhead power lines
Potential Impact	» Collision and electrocution caused by power lines
Activity/Risk Source	» Overhead power lines
Mitigation: Target/Objective	» Reduced bird mortalities due to collision/electrocution

Mitigation: Action/Control	Responsibility	Timeframe
1. Apply bird deterrent devices to all new and existing power line.	ECO & CER	Construction
2. Implement post-construction monitoring and carcass surveys (including existing lines) - to run parallel with PV post-construction monitoring.	OM OM	Operation - to run parallel with post-construction monitoring
3. Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT.		Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	1. Implement post-construction monitoring to quantify bird mortalities caused by the power line network. All searches should be done on foot. 2. Compile a management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

4.12 Analysis of proposed alternatives & an opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Doornhoek PV (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Doornhoek 2 PV facility and associated infrastructure on Portion 18 of the Farm Doornhoek 372 IP, near Klerksdorp, North West Province.

Five prominent avifaunal habitat types were identified on the study site, and consisted of open savannoid grassland with bush clump mosaics, short Klerksdorp Thornveld, secondary (regenerating) grassland on old agricultural fields, dense short *Grewia-Vachellia* shrubveld and transformed areas consisting of build-up land. The highest number of bird species and bird individuals were observed from dense thornveld/shrubveld habitat. Approximately 223 bird species were expected to occur in the wider study area, of which 118 species were observed in the study site and immediate surroundings. The expected richness included 11 threatened or near threatened species, 16 southern African endemics and 25 were near-endemic species. The endangered Secretarybird (*Sagittarius serpentarius*) was confirmed from open grassland habitat south-west of the study site, with a nest located 2.3km south-west of the study site. Ten southern African endemics and 14 near-endemic species were confirmed on the study site and immediate surroundings.

The proposed PV layout did not overlap with a prescribed Secretarybird buffer area (see Figure 15), whereby an evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). In addition, the study site did not overlap with any major avian flyway, which explains the low occurrence of waterbird taxa at the study site.

No fatal-flaws were identified during the assessment, although it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

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Appendix 1: A shortlist of bird species expected to be present on the study site and immediate surroundings. The list provides an indication of the species occurrence according to SABAP2 reporting rates. The list was derived (and modified) from species observed in pentad grid 2640_2635 and the eight surrounding grids. The reporting rates include submissions made during the December 2021 and March 2022 surveys.

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
78	Abdim's Stork	*Ciconia abdimii*		1.58	23	1.42	3
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	80.85	1178	13.21	28
149	African Fish Eagle	*Haliaeetus vocifer*		9.54	139	2.36	5
171	African Harrier-Hawk	*Polyboroides typus*		0.41	6	0.00	0
141	African Hawk-eagle	*Aquila spilogaster*		0.21	3	0.00	0
418	African Hoopoe	*Upupa africana*	1	51.00	743	3.77	8
387	African Palm Swift	*Cypsiurus parvus*	1	50.45	735	8.02	17
682	African Paradise Flycatcher	*Terpsiphone viridis*		11.46	167	1.42	3
692	African Pipit	*Anthus cinnamomeus*	1	42.48	619	5.66	12
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	93.21	1358	17.45	37
81	African Sacred Ibis	*Threskiornis aethiopicus*		36.31	529	2.83	6
576	African Stonechat	*Saxicola torquatus*		62.11	905	7.08	15
247	African Wattled Lapwing	*Vanellus senegallus*		4.19	61	0.00	0
772	Amethyst Sunbird	*Chalcomitra amethystina*		12.70	185	3.30	7
119	Amur Falcon	*Falco amurensis*	1	6.11	89	1.89	4
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	42.69	622	11.32	24
514	Ashy Tit	*Melaniparus cinerascens*	1	17.36	253	1.42	3
510	Banded Martin	*Riparia cincta*	1	6.93	101	1.89	4
493	Barn Swallow	*Hirundo rustica*	1	31.98	466	7.55	16

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
614	Barred Wren-Warbler	*Calamonastes fasciolatus*		1.65	24	0.94	2
622	Bar-throated Apalis	*Apalis thoracica*	1	6.04	88	0.47	1
159	Black Sparrowhawk	*Accipiter melanoleucus*		3.77	55	1.42	3
79	Black Stork	*Ciconia nigra*		0.07	1	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	93.34	1360	10.85	23
146	Black-chested Snake Eagle	*Circaetus pectoralis*		0.41	6	0.00	0
431	Black-collared Barbet	*Lybius torquatus*	1	61.02	889	7.55	16
841	Black-faced Waxbill	*Brunhilda erythronotos*	1	10.84	158	0.00	0
55	Black-headed Heron	*Ardea melanocephala*	1	25.19	367	2.83	6
521	Black-headed Oriole	*Oriolus larvatus*		0.41	6	0.00	0
245	Blacksmith Lapwing	*Vanellus armatus*	1	85.72	1249	11.32	24
860	Black-throated Canary	*Crithagra atrogularis*	1	80.99	1180	7.55	16
130	Black-winged Kite	*Elanus caeruleus*	1	44.61	650	8.96	19
282	Black-winged Pratincole	*Glareola nordmanni*		0.76	11	0.00	0
216	Blue Crane	*Grus paradisea*		1.44	21	0.00	0
839	Blue Waxbill	*Uraeginthus angolensis*	1	53.33	777	6.13	13
722	Bokmakierie	*Telophorus zeylonus*	1	29.86	435	3.77	8
823	Bronze Mannikin	*Spermestes cucullata*		2.81	41	1.42	3
145	Brown Snake Eagle	*Circaetus cinereus*		0.21	3	0.00	0
443	Brown-backed Honeybird	*Prodotiscus regulus*		2.40	35	0.00	0
714	Brown-crowned Tchagra	*Tchagra australis*	1	51.48	750	4.72	10
402	Brown-hooded Kingfisher	*Halcyon albiventris*		18.39	268	3.77	8
731	Brubru	*Nilaus afer*	1	31.85	464	0.47	1
695	Buffy Pipit	*Anthus vaalensis*		2.13	31	0.00	0

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
4131	Burchell's Coucal	*Centropus burchellii*		18.46	269	3.77	8
703	Cape Longclaw	*Macronyx capensis*	1	44.06	642	4.72	10
531	Cape Penduline Tit	*Anthoscopus minutus*		2.26	33	0.94	2
581	Cape Robin-Chat	*Cossypha caffra*	1	72.48	1056	5.66	12
94	Cape Shoveler	*Spatula smithii*		18.53	270	0.47	1
786	Cape Sparrow	*Passer melanurus*	1	84.97	1238	12.74	27
737	Cape Starling	*Lamprotornis nitens*	1	62.53	911	8.49	18
316	Ring-necked Dove	*Streptopelia capicola*	1	46.60	679	5.66	12
106	Cape Vulture	*Gyps coprotheres*		0.07	1	0.00	0
686	Cape Wagtail	*Motacilla capensis*	1	48.04	700	3.77	8
1172	Cape White-eye	*Zosterops virens*	1	12.42	181	2.83	6
568	Capped Wheatear	*Oenanthe pileata*		2.61	38	0.47	1
450	Cardinal Woodpecker	*Dendropicos fuscescens*		14.83	216	0.47	1
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*		1.65	24	0.00	0
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	87.44	1274	10.85	23
673	Chinspot Batis	*Batis molitor*	1	25.81	376	1.89	4
872	Cinnamon-breasted Bunting	*Emberiza tahapisi*	1	30.34	442	3.77	8
631	Cloud Cisticola	*Cisticola textrix*	1	16.82	245	2.36	5
154	Common (=Steppe) Buzzard	*Buteo buteo vulpinus*		5.35	78	2.83	6
196	Common Buttonquail	*Turnix sylvaticus*	1	0.21	3	0.47	1
507	Common House Martin	*Delichon urbicum*		0.55	8	0.47	1
734	Common Myna	*Acridotheres tristis*	1	79.55	1159	12.26	26
189	Common Quail	*Coturnix coturnix*		0.48	7	0.00	0
421	Common Scimitarbill	*Rhinopomastus cyanomelas*	1	32.12	468	4.25	9

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
378	Common Swift	*Apus apus*		0.48	7	0.00	0
843	Common Waxbill	*Estrilda astrild*	1	9.40	137	0.47	1
594	Common Whitethroat	*Curruca communis*	1	6.66	97	0.94	2
173	Coqui Francolin	*Peliperdix coqui*	1	0.14	2	0.47	1
439	Crested Barbet	*Trachyphonus vaillantii*	1	85.66	1248	11.32	24
711	Crimson-breasted Shrike	*Laniarius atrococcineus*	1	19.15	279	0.94	2
242	Crowned Lapwing	*Vanellus coronatus*	1	89.91	1310	14.62	31
854	Cuckoo Finch	*Anomalospiza imberbis*		0.34	5	0.00	0
545	Dark-capped Bulbul	*Pycnonotus tricolor*		0.34	5	0.00	0
630	Desert Cisticola	*Cisticola aridulus*	1	45.92	669	3.30	7
352	Diederik Cuckoo	*Chrysococcyx caprius*	1	43.93	640	4.25	9
278	Double-banded Courser	*Rhinoptilus africanus*	1	1.78	26	0.47	1
849	Dusky Indigobird	*Vidua funerea*		0.89	13	1.42	3
1183	Eastern Clapper Lark	*Mirafra fasciolata*	1	26.29	383	3.30	7
89	Egyptian Goose	*Alopochen aegyptiaca*	1	52.57	766	5.19	11
404	European Bee-eater	*Merops apiaster*	1	36.86	537	5.66	12
371	European Nightjar	*Caprimulgus europaeus*		0.27	4	0.94	2
678	Fairy Flycatcher	*Stenostira scita*		2.95	43	0.00	0
570	Familiar Chat	*Oenanthe familiaris*	1	23.82	347	3.30	7
373	Fiery-necked Nightjar	*Caprimulgus pectoralis*		0.69	10	0.00	0
665	Fiscal Flycatcher	*Melaenornis silens*	1	55.25	805	4.25	9
517	Fork-tailed Drongo	*Dicrurus adsimilis*		0.76	11	0.47	1
162	Gabar Goshawk	*Micronisus gabar*	1	5.70	83	2.83	6
595	Garden Warbler	*Sylvia borin*		1.65	24	3.30	7

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
874	Golden-breasted Bunting	*Emberiza flaviventris*		0.48	7	0.00	0
447	Golden-tailed Woodpecker	*Campethera abingoni*	1	4.26	62	0.47	1
346	Great Spotted Cuckoo	*Clamator glandarius*		0.48	7	0.00	0
440	Greater Honeyguide	*Indicator indicator*		4.74	69	1.42	3
122	Greater Kestrel	*Falco rupicoloides*		3.09	45	3.30	7
502	Greater Striped Swallow	*Cecropis cucullata*	1	58.20	848	8.96	19
419	Green Wood Hoopoe	*Phoeniculus purpureus*	1	21.89	319	3.30	7
830	Green-winged Pytilia	*Pytilia melba*	1	28.48	415	1.42	3
339	Grey Go-away-bird	*Crinifer concolor*		1.85	27	1.42	3
54	Grey Heron	*Ardea cinerea*		34.59	504	3.30	7
485	Grey-backed Sparrow-Lark	*Eremopterix verticalis*		0.34	5	0.00	0
557	Groundscraper Thrush	*Turdus litsitsirupa*		0.69	10	0.00	0
84	Hadada Ibis	*Bostrychia hagedash*	1	84.76	1235	10.85	23
72	Hamerkop	*Scopus umbretta*		7.96	116	0.94	2
192	Helmeted Guineafowl	*Numida meleagris*	1	86.00	1253	18.40	39
384	Horus Swift	*Apus horus*	1	0.27	4	0.00	0
784	House Sparrow	*Passer domesticus*	1	70.01	1020	6.60	14
596	Icterine Warbler	*Hippolais icterina*		1.85	27	0.47	1
348	Jacobin Cuckoo	*Clamator jacobinus*	1	2.40	35	0.47	1
835	Jameson's Firefinch	*Lagonosticta rhodopareia*		13.59	198	0.47	1
586	Kalahari Scrub Robin	*Cercotrichas paena*	1	70.42	1026	4.72	10
1104	Karoo Thrush	*Turdus smithi*		58.75	856	6.13	13
351	Klaas's Cuckoo	*Chrysococcyx klaas*		4.05	59	1.42	3
114	Lanner Falcon	*Falco biarmicus*		1.24	18	0.47	1

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
871	Lark-like Bunting	*Emberiza impetuani*		0.55	8	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	96.29	1403	20.28	43
706	Lesser Grey Shrike	*Lanius minor*	1	6.25	91	0.94	2
442	Lesser Honeyguide	*Indicator minor*		5.42	79	0.94	2
125	Lesser Kestrel	*Falco naumanni*	1	6.52	95	2.36	5
646	Levaillant's Cisticola	*Cisticola tinniens*		50.93	742	3.30	7
410	Little Bee-eater	*Merops pusillus*		11.60	169	1.89	4
6	Little Grebe	*Tachybaptus ruficollis*	1	42.83	624	5.66	12
385	Little Swift	*Apus affinis*	1	25.53	372	4.25	9
621	Long-billed Crombec	*Sylvietta rufescens*	1	9.81	143	0.47	1
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		16.88	246	3.30	7
818	Long-tailed Widowbird	*Euplectes progne*	1	42.55	620	10.38	22
397	Malachite Kingfisher	*Corythornis cristatus*	1	13.52	197	0.94	2
661	Marico Flycatcher	*Melaenornis mariquensis*		0.96	14	0.47	1
361	Marsh Owl	*Asio capensis*		3.84	56	2.36	5
607	Marsh Warbler	*Acrocephalus palustris*		4.19	61	0.00	0
142	Martial Eagle	*Polemaetus bellicosus*		0.07	1	0.00	0
456	Melodious Lark	*Mirafra cheniana*	1	0.96	14	0.94	2
318	Namaqua Dove	*Oena capensis*	1	29.51	430	4.72	10
307	Namaqua Sandgrouse	*Pterocles namaqua*		0.41	6	0.00	0
183	Natal Spurfowl	*Pternistis natalensis*		8.03	117	1.89	4
637	Neddicky	*Cisticola fulvicapilla*	1	68.02	991	9.91	21
1035	Northern Black Korhaan	*Afrotis afraoides*	1	73.44	1070	11.32	24
179	Orange River Francolin	*Scleroptila gutturalis*	1	13.66	199	1.42	3

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
838	Orange-breasted Waxbill	*Amandava subflava*		1.99	29	0.00	0
157	Ovambo Sparrowhawk	*Accipiter ovampensis*		1.24	18	0.00	0
165	Pale Chanting Goshawk	*Melierax canorus*		2.40	35	0.47	1
168	Pallid Harrier	*Circus macrourus*		0.27	4	0.00	0
498	Pearl-breasted Swallow	*Hirundo dimidiata*		0.89	13	0.00	0
522	Pied Crow	*Corvus albus*	1	55.39	807	14.62	31
746	Pied Starling	*Lamprotornis bicolor*	1	4.60	67	0.94	2
490	Pink-billed Lark	*Spizocorys conirostris*		0.62	9	0.47	1
846	Pin-tailed Whydah	*Vidua macroura*	1	35.96	524	7.55	16
694	Plain-backed Pipit	*Anthus leucophrys*		2.06	30	0.00	0
674	Pririt Batis	*Batis pririt*		26.15	381	2.83	6
57	Purple Heron	*Ardea purpurea*		4.53	66	1.42	3
850	Purple Indigobird	*Vidua purpurascens*		1.30	19	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	33.77	492	3.30	7
642	Rattling Cisticola	*Cisticola chiniana*	1	49.07	715	2.36	5
708	Red-backed Shrike	*Lanius collurio*	1	24.43	356	4.25	9
837	Red-billed Firefinch	*Lagonosticta senegala*	1	17.84	260	3.30	7
805	Red-billed Quelea	*Quelea quelea*	1	57.45	837	9.91	21
97	Red-billed Teal	*Anas erythrorhyncha*		25.88	377	4.25	9
501	Red-breasted Swallow	*Cecropis semirufa*		23.75	346	2.36	5
488	Red-capped Lark	*Calandrella cinerea*	1	6.45	94	0.94	2
343	Red-chested Cuckoo	*Cuculus solitarius*		7.82	114	1.89	4
813	Red-collared Widowbird	*Euplectes ardens*		9.33	136	1.42	3
314	Red-eyed Dove	*Streptopelia semitorquata*	1	84.01	1224	12.26	26

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
392	Red-faced Mousebird	*Urocolius indicus*	1	85.79	1250	12.26	26
120	Red-footed Falcon	*Falco vespertinus*		0.21	3	0.00	0
820	Red-headed Finch	*Amadina erythrocephala*		28.00	408	3.30	7
212	Red-knobbed Coot	*Fulica cristata*	1	52.85	770	6.13	13
453	Red-throated Wryneck	*Jynx ruficollis*		4.05	59	0.00	0
50	Reed Cormorant	*Microcarbo africanus*	1	45.78	667	1.89	4
940	Rock Dove	*Columba livia*		25.60	373	4.25	9
123	Rock Kestrel	*Falco rupicolus*		0.27	4	0.00	0
372	Rufous-cheeked Nightjar	*Caprimulgus rufigena*		1.44	21	1.89	4
458	Rufous-naped Lark	*Mirafra africana*	1	61.84	901	10.38	22
460	Sabota Lark	*Calendulauda sabota*	1	21.28	310	0.47	1
789	Scaly-feathered Weaver	*Sporopipes squamifrons*	1	44.96	655	4.25	9
105	Secretarybird	*Sagittarius serpentarius*	1	0.69	10	0.94	2
847	Shaft-tailed Whydah	*Vidua regia*	1	14.00	204	2.36	5
504	South African Cliff Swallow	*Petrochelidon spilodera*	1	48.66	709	9.91	21
90	South African Shelduck	*Tadorna cana*		17.91	261	1.89	4
707	Southern Fiscal	*Lanius collaris*	1	78.24	1140	11.32	24
4142	Southern Grey-headed Sparrow	*Passer diffusus*	1	65.48	954	7.55	16
803	Southern Masked Weaver	*Ploceus velatus*	1	95.54	1392	17.92	38
808	Southern Red Bishop	*Euplectes orix*	1	74.67	1088	15.57	33
390	Speckled Mousebird	*Colius striatus*	1	25.74	375	2.36	5
311	Speckled Pigeon	*Columba guinea*	1	73.99	1078	9.91	21
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	8.79	128	1.42	3
368	Spotted Eagle-Owl	*Bubo africanus*	1	5.49	80	6.13	13

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
654	Spotted Flycatcher	*Muscicapa striata*	1	18.39	268	1.42	3
275	Spotted Thick-knee	*Burhinus capensis*	1	19.35	282	2.36	5
88	Spur-winged Goose	*Plectropterus gambensis*	1	18.33	267	0.94	2
867	Streaky-headed Seedeater	*Crithagra gularis*		1.44	21	0.47	1
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	86.34	1258	13.68	29
411	Swallow-tailed Bee-eater	*Merops hirundineus*		0.76	11	0.00	0
649	Tawny-flanked Prinia	*Prinia subflava*		3.29	48	0.47	1
277	Temminck's Courser	*Cursorius temminckii*	1	0.21	3	0.00	0
238	Three-banded Plover	*Charadrius tricollaris*		22.65	330	1.89	4
851	Village Indigobird	*Vidua chalybeata*		8.79	128	0.00	0
736	Violet-backed Starling	*Cinnyricinclus leucogaster*		0.14	2	0.00	0
840	Violet-eared Waxbill	*Granatina granatina*	1	17.50	255	0.47	1
735	Wattled Starling	*Creatophora cinerea*	1	31.78	463	3.30	7
359	Western Barn Owl	*Tyto alba*		4.05	59	6.13	13
61	Western Cattle Egret	*Bubulcus ibis*	1	70.08	1021	14.15	30
80	White Stork	*Ciconia ciconia*		0.34	5	0.00	0
391	White-backed Mousebird	*Colius colius*	1	50.51	736	5.19	11
107	White-backed Vulture	*Gyps africanus*		0.34	5	0.47	1
763	White-bellied Sunbird	*Cinnyris talatala*	1	33.97	495	4.25	9
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	95.40	1390	18.40	39
588	White-browed Scrub Robin	*Cercotrichas leucophrys*		5.35	78	0.47	1
100	White-faced Whistling Duck	*Dendrocygna viduata*		12.08	176	0.94	2
409	White-fronted Bee-eater	*Merops bullockoides*		2.61	38	0.00	0
383	White-rumped Swift	*Apus caffer*	1	39.33	573	6.13	13

#	Common Name	Scientific Name	Observed (Dec 2021 & March 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
582	White-throated Robin-Chat	*Cossypha humeralis*	1	7.28	106	0.00	0
495	White-throated Swallow	*Hirundo albigularis*		29.79	434	2.36	5
814	White-winged Widowbird	*Euplectes albonotatus*		19.70	287	2.83	6
599	Willow Warbler	*Phylloscopus trochilus*	1	10.71	156	0.94	2
264	Wood Sandpiper	*Tringa glareola*		7.69	112	0.94	2
866	Yellow Canary	*Crithagra flaviventris*	1	51.41	749	3.77	8
600	Yellow-bellied Eremomela	*Eremomela icteropygialis*		3.98	58	0.94	2
96	Yellow-billed Duck	*Anas undulata*	1	49.83	726	7.08	15
129	Yellow-billed Kite	*Milvus aegyptius*		0.48	7	0.47	1
812	Yellow-crowned Bishop	*Euplectes afer*		15.65	228	1.89	4
859	Yellow-fronted Canary	*Crithagra mozambica*		3.16	46	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*	1	22.17	323	4.25	9

Appendix 2: Preliminary density estimates of birds recorded from the study site and immediate surroundings during two independent surveys conducted during December 2021 and March 2022.

Species	Drk13	Drk17	Drk16	Drk18	Drk14	Drk07	Drk20	Drk15	Drk09	Drk11	Drk10	Drk19
African Pipit	0	0	0	0	0	0.5	0	0	0	0	3.5	0
African Red-eyed Bulbul	2	0	0	2	0	0.5	0	1	1.5	1	0	0
Ant-eating Chat	0	0	0	0	0	0	0	0	0	0	0	0
Ashy Tit	0	0	0	0	0	0	0	0	1.5	0	0	0
Bar-throated Apalis	1	0	0	0	0	0	0	0	0	0	0	0
Black-chested Prinia	2	2	0	3	2	1	2	2	2	3	1	2
Black-faced Waxbill	0	0	0	0	0	0	0	0	0.5	0	0	0
Black-throated Canary	0	0	0	0	2.5	0	0	0	1	0	0	1
Blue Waxbill	0	0	0	0	0	0	0	0	0	0	0	2
Brown-crowned Tchagra	1.5	0	0	2	0	0	0	0	0.5	1	0	0
Cape Longclaw	0	0	0.5	0	0	1.5	0	0	0	0	0	0
Cape Robin-chat	0.5	0	0	0	0	0	0	0	0	0	0	0
Cape Sparrow	0	0	0	0	1	0	0	0	0	0	0	0
Cape Starling	0	0	0	0	1	0	0	0	0	0	0	0
Cape White-eye	2	0	0	0	0	0	0	0	0	0	0	0
Chestnut-vented Warbler	2	0	0	2	0	0	0	0	2	2	0	2
Chinspot Batis	1	0	0	1	0	0	0	0	1	1	0	0
Cloud Cisticola	0	0	0	0	0	0.5	0	0	0	0	0	0
Common Whitethroat	0	0	0	0	0	0	0	0	1.5	0	0	0
Crimson-breasted Shrike	0	0	0	2	0	0	0	0	1	0	0	0
Desert Cisticola	0	2	2	0	0.5	1	0.5	2	0	1	2	1
Eastern Clapper Lark	0	0	0	0	0	0	0	0	0	0	0	0

Species	Drk13	Drk17	Drk16	Drk18	Drk14	Drk07	Drk20	Drk15	Drk09	Drk11	Drk10	Drk19
Fiscal Flycatcher	0	0	0	1.5	0	0	0	0	1	1	0	0
Green-winged Pytilia	1	0	0	0	0	0	0	0	0.5	1	0	0
Kalahari Scrub-robin	2	0	0	2	1	0	0	0	1.5	1.5	0	0
Lesser Grey Shrike	0	0	0	0	0	0.5	0	0	0	0	0	0
Long-billed Crombec	0	0	0	0	0	0	0	0	0.5	1	0	0
Long-tailed Widowbird	0	0	0	0	0	0	0	0	0	0	0	0
Neddicky	2	0	0	2	1.5	0	1	0	2.5	1.5	0	1
Quailfinch	0	1.5	1.5	0	0	0	0	0	0	0	0	0
Rattling Cisticola	1	0	0	2	0	0	0	0	0.5	1	0	0
Red-backed Shrike	0	0	0	0	0.5	0	0	0	1	3	0	0
Red-billed Firefinch	2	0	0	0	0	0	0	0	0	0	0	0
Red-billed Quelea	2	0	0	21	75	0	0	15	0	10	7.5	0
Rufous-naped Lark	0	2	1.5	0	0.5	2	0.5	1.5	0	1.5	0	0
Sabota Lark	0	0	0	0.5	0.5	0	0.5	0	1.5	0.5	0	0
Scaly-feathered Weaver	0	0	0	1	0	0	0	0	0	0	0	0
Southern Fiscal	0	0.5	0	0	0.5	0.5	0	0	0	0	0	0
Southern Grey-headed Sparrow	0	0	0	0	0.5	0	1	0	0.5	0	0	0
Southern Masked Weaver	2	0	0	2	2	0	1	0	0	1.5	0	1
Southern Red Bishop	0	0	0	0	1	0	0	0	0	0	0	1.5
Spike-heeled Lark	0	0	0	0	0	0	0	0	0	0	1	0
Spotted Flycatcher	0	0	0	0	0	0	0	0.5	0	0	0	0.5
Violet-eared Waxbill	1	0	0	1	0	0	0	0	1.5	0	0	0
White-bellied Sunbird	1	0	0	0	0	0	0	0	0	0	0	0
White-browed Sparrow-weaver	0	0	0	0	1.5	0	0	0	0	0	1	2
White-throated Robin-chat	1.5	0	0	0	0	0	0	0	0.5	0	0	0

Species	Drk13	Drk17	Drk16	Drk18	Drk14	Drk07	Drk20	Drk15	Drk09	Drk11	Drk10	Drk19
Willow Warbler	1.5	0	0	0.5	0.5	0	0	0.5	1	0	0	1.5
Yellow Canary	2.5	0	0	1	0.5	0	0.5	0	1.5	1	0	0
Zitting Cisticola	0	1.5	1.5	0	0	1	0	0.5	0	0	1	1
Number of individuals	31.5	9.5	7	46.5	92.5	9	7	23	26.5	33.5	17	16.5
Number of species	20	6	5	17	18	10	8	8	23	18	7	12
Number of birds/ha	**40.38**	**3.03**	**2.23**	**59.62**	**118.59**	**2.87**	**8.97**	**7.32**	**33.97**	**42.95**	**5.41**	**5.25**
Number of species/ha	**25.64**	**1.91**	**1.59**	**21.79**	**23.08**	**3.18**	**10.26**	**2.55**	**29.49**	**23.08**	**2.23**	**3.82**
Average number of birds/ha	**19.14**											
Average number of species/ha	**10.90**											

Species	Drk12	Drk06	Drk03	Drk23	Drk22	Drk05	Drk04	Drk21	Drk01	Drk02	Drk24	Drk08	Mean Birds/ha
African Pipit	0	0	0	0	0.5	0	0	0	1	1.5	1	0	**0.14**
African Red-eyed Bulbul	0.5	0	1	0	0.5	1	0	0	0	0	0	0.5	**0.56**
Ant-eating Chat	0	0	0	1.5	2.5	0	0	2	0	2.5	0	0	**0.10**
Ashy Tit	0	0	0	0	0	0	0	0	0	0	0	0	**0.09**
Bar-throated Apalis	0	0	0	0	0	0	0	0	0	0	0	0	**0.06**
Black-chested Prinia	2	2	2	1	0	2	2	2	0	0	2	2	**1.58**
Black-faced Waxbill	0	0	0	0	0	0	0	0	0	0	0	0	**0.03**
Black-throated Canary	0	0	0	0	0	0	0	0	0	0	1	0.5	**0.30**
Blue Waxbill	0	0	0	0	0	0	0	0	0	0	0	0	**0.02**
Brown-crowned Tchagra	0.5	0	0	0	0	0	0	0	0	0	0	1	**0.36**
Cape Longclaw	0	0	0	1.5	0	0	0	0	0.5	1	0	0	**0.06**
Cape Robin-chat	0	0	0	0	0	0	0	0	0	0	0	0	**0.03**
Cape Sparrow	0	0	0	0	1	0	0	0	0	0	1	0	**0.13**

Species	Drk12	Drk06	Drk03	Drk23	Drk22	Drk05	Drk04	Drk21	Drk01	Drk02	Drk24	Drk08	Mean Birds/ha
Cape Starling	0	0	0	0	4	1	2	0	0	0	1	2	**0.46**
Cape White-eye	0	0	0	0	0	1	0	0	0	0	0	0	**0.17**
Chestnut-vented Warbler	2	1	2	0	0	2	0	1	0	0	0	3	**0.95**
Chinspot Batis	0	0	0	0	0	0	0	0	0	0	0	0	**0.23**
Cloud Cisticola	0	0	0	0	0	0	0	0	1	0	0	0	**0.02**
Common Whitethroat	0	0	0	0	0	0	0	0	0	0	0	0	**0.09**
Crimson-breasted Shrike	0	0	0	0	0	0	0	0	0	0	0	0	**0.17**
Desert Cisticola	1	1	0.5	1	1	0.5	1.5	1.5	1.5	2	1	0.5	**0.58**
Eastern Clapper Lark	0	0	0	0.5	1.5	0	0.5	1.5	1	0	0	0	**0.08**
Fiscal Flycatcher	0	0	0	0	0	0	0	0	0	0	0	1	**0.26**
Green-winged Pytilia	0	0	0.5	0	0	0	0	0	0	0	0	1	**0.23**
Kalahari Scrub-robin	0	0	0.5	0	1	0.5	0	0.5	0	0	0	2	**0.66**
Lesser Grey Shrike	0.5	0.5	1	1.5	1.5	0	0	0	0	0	1.5	1.5	**0.29**
Long-billed Crombec	0	0	0	0	0	1	0	0	0	0	0	0	**0.15**
Long-tailed Widowbird	0	0	0	0	0	1	1	0	1	0	0	0	**0.13**
Neddicky	0	0	1	0	0	0.5	0	0	0	0	0	1	**0.77**
Quailfinch	0	0	1.5	0	0	0	0	0	0	0	0	0	**0.12**
Rattling Cisticola	0	0	0	0	0	0	0	0	0	0	0	0	**0.26**
Red-backed Shrike	1.5	1	1	0	0	1	1.5	0.5	0	0	0	0	**0.50**
Red-billed Firefinch	0	0	0	0	0	0	0	0	0	0	0	0	**0.12**
Red-billed Quelea	0	5.5	0	0	0	0	1.5	0	0	0	0	5	**7.02**
Rufous-naped Lark	1.5	1	0.5	1	0	0.5	0.5	1	0	0.5	0.5	0	**0.41**
Sabota Lark	0	0.5	0	0	0	0	0	0	0	0	0	1.5	**0.30**
Scaly-feathered Weaver	0	0	0	2	0	0	0	0	0	0	0	0.5	**0.11**
Southern Fiscal	0	0	0	0	0	0.5	0	0	0	0	0	0	**0.07**
Southern Grey-headed Sparrow	0	0	1	0	0.5	0	0	0	1	0	0	0	**0.19**

Species	Drk12	Drk06	Drk03	Drk23	Drk22	Drk05	Drk04	Drk21	Drk01	Drk02	Drk24	Drk08	Mean Birds/ha
Southern Masked Weaver	0	0.5	0.5	1	0	0	0	0	0	0	0.5	0.5	**0.61**
Southern Red Bishop	2	0	0.5	0.5	0.5	0	1	0	0	0	0	0	**0.20**
Spike-heeled Lark	1	0	0	0	0.5	0	0	1	0	0	0	0	**0.04**
Spotted Flycatcher	0	0	0.5	0	0	1	0	0	0	0	0	0.5	**0.13**
Violet-eared Waxbill	0	0	0	0	0	0.5	0	0	0	0	0	0	**0.23**
White-bellied Sunbird	0	0	0	0	0	0	0	0	0	0	0	0	**0.06**
White-browed Sparrow-weaver	0	0	0	2	0	2	0	0	0	0	0	0	**0.27**
White-throated Robin-chat	0	0	0	0	0	0	0	0	0	0	0	1	**0.17**
Willow Warbler	0	0.5	0	0	0	0	0	0	0	0	0	0.5	**0.26**
Yellow Canary	0	0	0	0	0	0	0	0	0	0	0	0	**0.41**
Zitting Cisticola	0.5	0	0	1	0.5	1	1	1	1	0	1	0	**0.30**
Number of individuals	13	13.5	14	14.5	15.5	17	12.5	12	8	7.5	10.5	25.5	
Number of species	11	10	15	12	13	17	10	10	8	5	10	19	
Number of birds/ha	**4.14**	**4.30**	**17.95**	**4.62**	**4.94**	**21.79**	**16.03**	**3.82**	**2.55**	**2.39**	**13.46**	**32.69**	
Number of species/ha	**3.50**	**3.18**	**19.23**	**3.82**	**4.14**	**21.79**	**12.82**	**3.18**	**2.55**	**1.59**	**12.82**	**24.36**	
Average number of birds/ha	**19.14**												
Average number of species/ha	**10.90**												

Appendix 3: Assessment of Impacts

Direct, indirect and cumulative impacts of the issues identified through the scoping study, as well as all other issues identified in the EIA phase must be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration**, wherein it will be indicated whether:
    - the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
    - the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
    - medium-term(5–15 years) – assigned a score of 3;
    - long term(> 15 years) - assigned a score of 4; or
    - permanent - assigned a score of 5;
- The **consequences (magnitude)**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- the status, which will be described as either positive, negative or neutral.
- the degree to which the impact can be reversed.
- the degree to which the impact may cause irreplaceable loss of resources.
- the degree to which the impact can be mitigated.

The significance is calculated by combining the criteria in the following formula:
S=(E+D+M)P

S = Significance weighting
E = Extent

D = Duration
M =Magnitude
P = Probability

The significance weightings for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated), and
- 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).