DEVELOPMENT OF THE HARMONY ONE PLANT SOLAR PV FACILITY NEAR VIRGINIA, FREE STATE PROVINCE

Avifauna Baseline and Impact Assessment Report

October 2022

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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony One Plant Solar PV facility and associated infrastructure with a contracted capacity of up to 30MW located in the town of Welkom and 14km north west of the town of Virginia, Free State Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the study 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).

Five avifaunal habitat types were identified on the study area and surroundings, ranging from moist mixed and secondary grassland, grassy depressions and inundated quarries to transformed and landscape/manicured areas. The study area was also surrounded by a number of pans and the Witpan Dam, which provided foraging and roosting habitat for a large number of waterbird taxa. Approximately 178 bird species are expected to occur in the wider study area, of which 88 species were observed in the study area (during two surveys). The expected richness included 11 threatened or near threatened species, 14 southern African endemics and 11 near-endemic species. The vulnerable Lanner Falcon (*Falco biarmicus*) was observed on the study site (during a fly-over), while the near threatened Greater flamingo (Ph*oenicopterus roseus*) and Lesser Flamingo (*Phoeniconaias minor*) were observed at the nearby Witpan Dam. Ten southern African endemics and six near-endemic species were confirmed on the study site. In addition, a total of 80 collision-prone bird species have been recorded from the study area (*sensu* atlas data), of which 62 species were waterbird and shorebird taxa, and another 10 species were birds of prey. These also included the near threatened Greater Flamingo (*P. roseus*) and Lesser Flamingo (*P*. *minor*) which were both regular foraging visitors to the nearby Witpan Dam and the many smaller pans in the area. It was evident that the number of potential collision-prone species that could occur in the study area was high

The main impacts associated with the proposed PV solar facility included 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).

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was predicted to be moderate-high to low after mitigation (depending on the type of impact). **However, the risk for waterbirds and shorebirds (including flamingo taxa) colliding with the PV infrastructure remained eminent due to the presence of inundated pans and dams in the study area and a high frequency of passing waterbirds**. **Waterbird interactions with the PV infrastructure was predicted as persistent due to the spatial location of the proposed footprint site (surrounded by water features of which some sustain large numbers of birds).** It was strongly recommended that the proposed mitigation measures and monitoring protocols (e.g. post construction monitoring) be implemented during the construction and operational phase of the project (e.g. the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds).

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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 Savannah Environmental (Pty) Ltd and Freegold Harmony (Pty) Ltd.;
- 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)
31 October 2022

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 20 years of experience in ecological-related assessments and more than 15 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 Project Description

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony One Plant Solar PV facility and associated infrastructure with a contracted capacity of up to 30 MW. The Harmony One Plant Solar PV facility is based near Harmony 1 Gold Plant operations located in the town of Welkom and ~14km north west of the town of Virginia within the Matjhabeng Local Municipality respectively, and within the Lejweleputswa District Municipality, Free State Province.

The solar facility will be located on a 75ha footprint area, which will include the PV arrays, associated infrastructure and grid connection infrastructure (Figure 2). The infrastructure associated PV facility includes:

- Solar PV arrays comprising of bifacial PV modules and mounting structures, using single axis tracking technology. Once installed, it will stand up to 5m above ground level.
- Inverters and transformers, a SCADA room, and maintenance room.
- Cabling between the project components.
- Balance of Plant:
  - Existing spare switchgear panels, upgraded switchgear circuit breakers or additional switchgear panels.
  - EK self-build works as defined in the CEL.
- On-site facility substation to facilitate the connection between the solar PV facilities and Eskom electricity grid. The Size and Capacity of the on-site stations will be 40MW.
- An onsite Medium voltage (MV) switching station forming part of the collector substation.
- Temporary laydown areas.
- Access roads, internal roads and fencing around the development area.
- Up to 132kV Overhead Power Lines (OHPL) with a maximum of 30m height with a 30m servitude width.
- Underground LV cabling will be used on the PV sites.

The PV facility will be located on the following farm portions:

Farm Name	Portion Number
STUIRMANSPAN 92	RE/90
STUURMANSPAN 157	RE/157
MARMAGELI 20	RE/20
WELKOM 80	RE/80

The facility will tie-in to the Brand gold (6.6/132 kV) substation. The grid line will have a connection capacity of up to 132kV. The line connecting the PV facility to the respective substation will be up to 44kV.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the study 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 area;
  - 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).

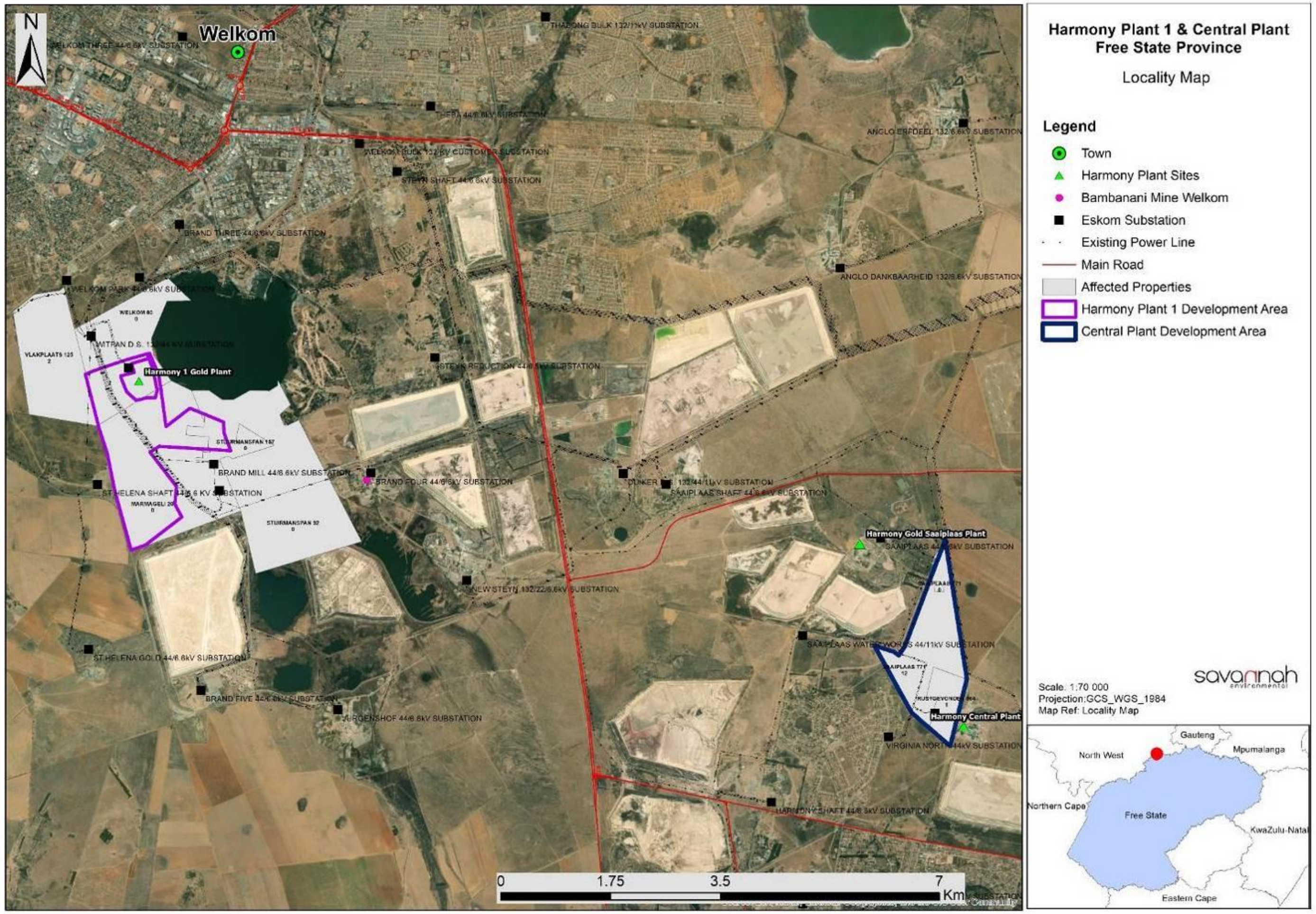


Figure 1: A map illustrating the geographic position of the proposed Harmony One Plant Solar PV facility. The map also shows the proposed location of another PV facility known as Harmony Central Plant Solar PV facility.

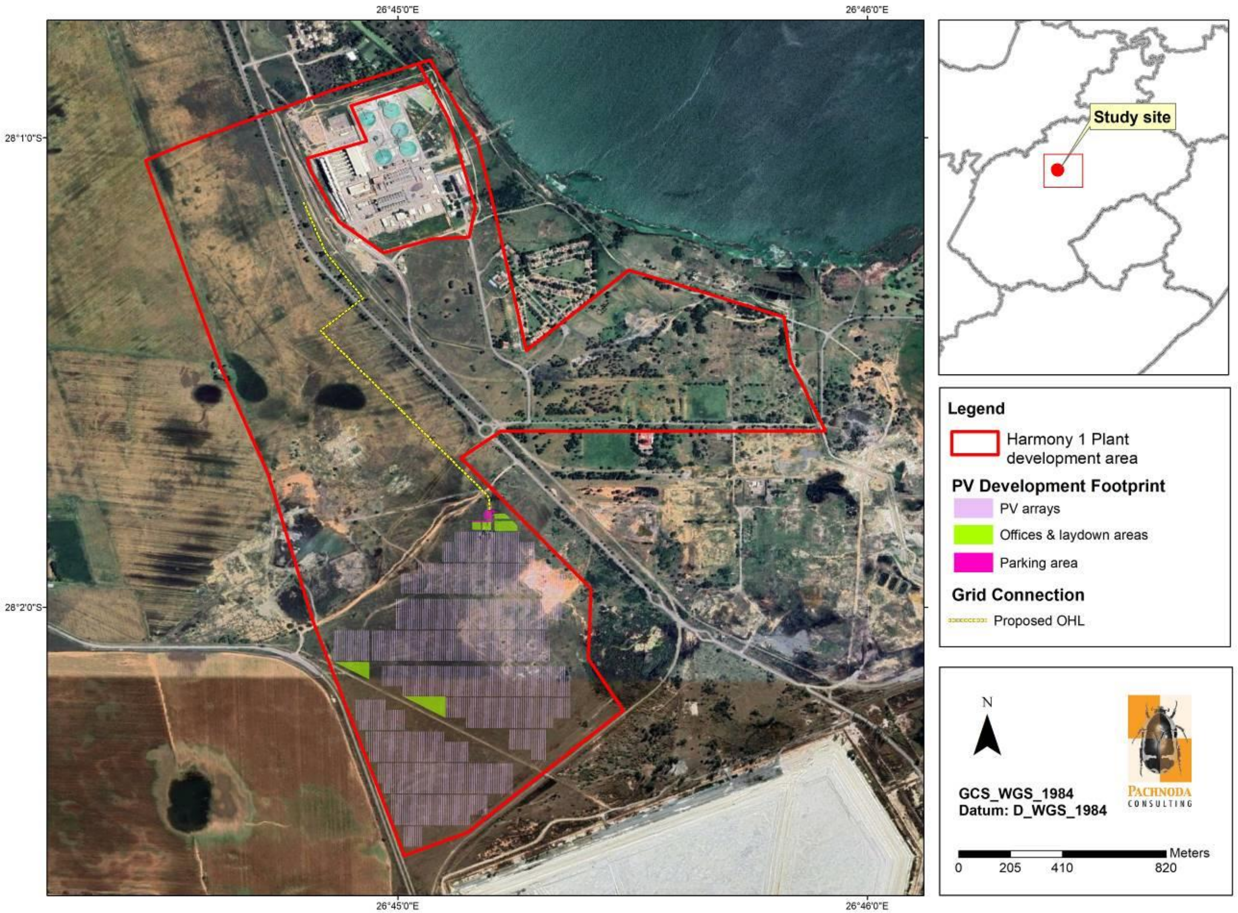


Figure 2: A satellite image illustrating the geographic position of the proposed Harmony One Plant Solar PV facility and proposed development footprint.

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.

2. METHODS & APPROACH

The current report places emphasis on the avifaunal community as a key indicator group on the proposed study area, 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;
- Observations made during two site visits (06 – 09 June 2022 and 11 - 15 July 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) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities of selected bird species that could be present on the study area.
- 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 cells (QDCs) 2826BA (Bloudrif) and 2826BB (Virginia) (Figure 3). The information was then modified according to the prevalent habitat types present on the development area. 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 area. 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 2800_2640 and 2800_2645 (although all eight pentad grids surrounding grid 2800_2640 were also scrutinised) (Figure 4).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World

Bird List v. 12.2), unless otherwise specified (see www.worldbirdnames.org as specified by Gill et al, 2022).

- The best practice guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa were also consulted (Jenkins *et al.,* 2017).

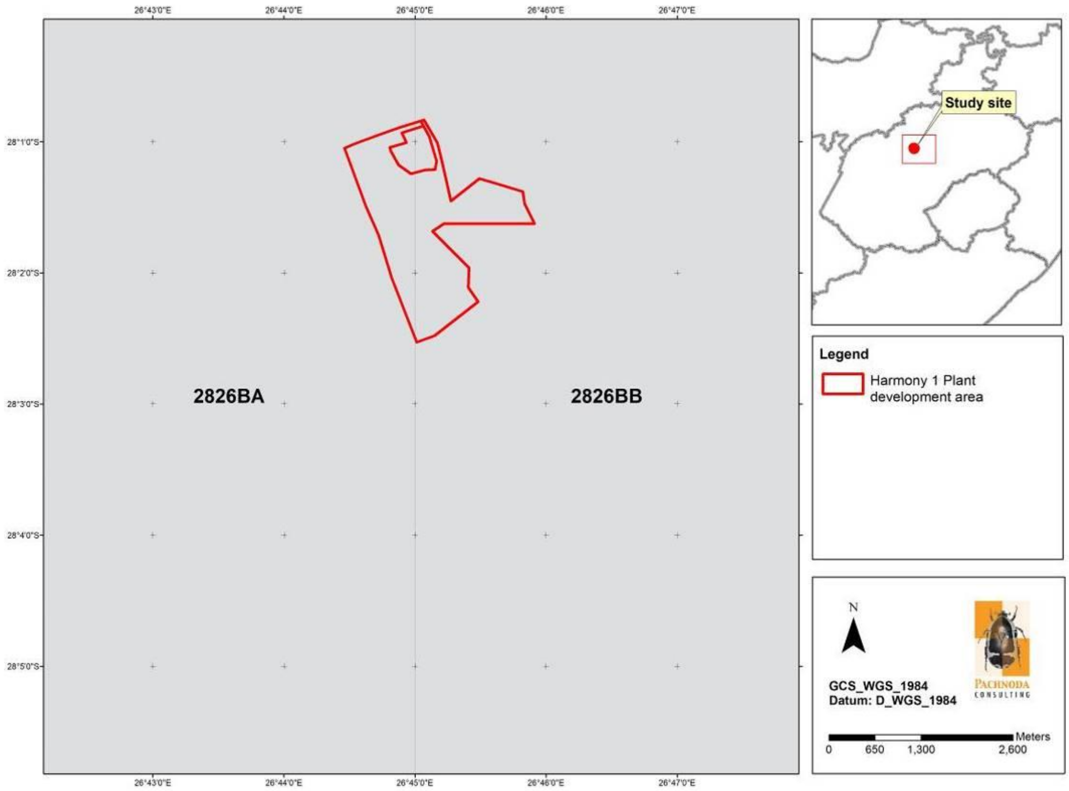


Figure 3: A map illustrating the quarter-degree grid cells that were investigated for this project.

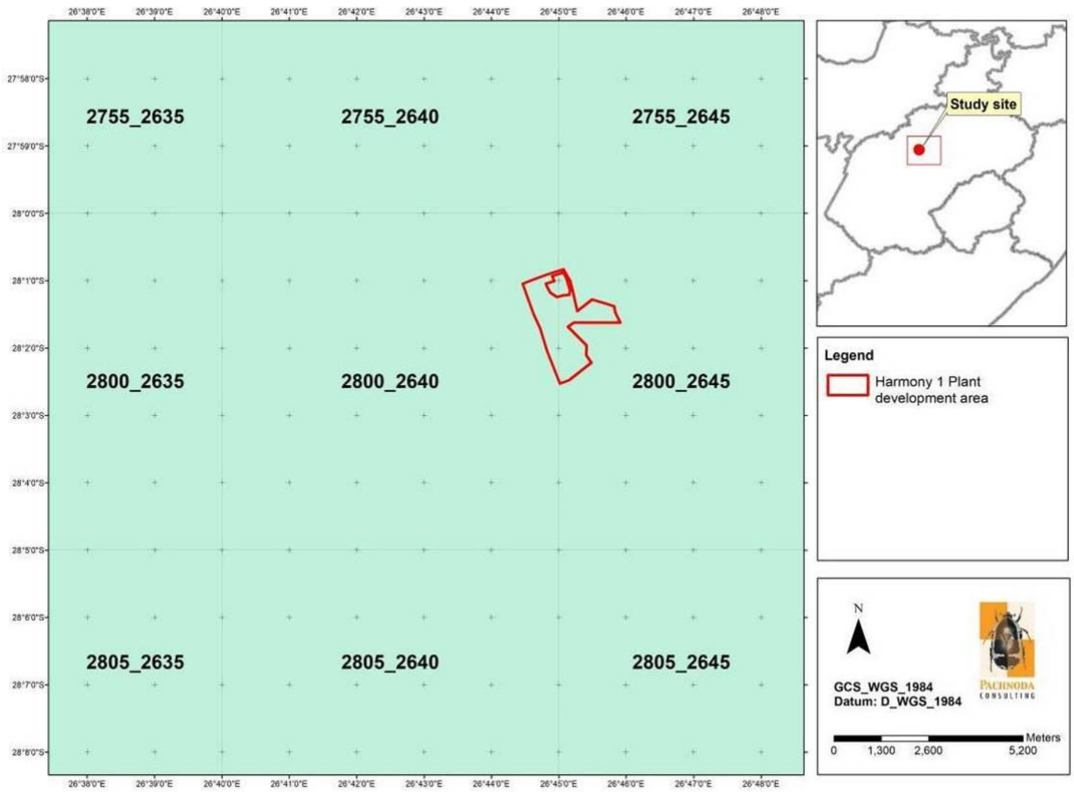


Figure 4: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study area was surveyed during two independent site visits (June and July 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 11 point counts (as per Buckland et al. 1993) from the study area. 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 5. 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 from the centre of the point were recorded (resulting in an area of 0.78 ha) 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 50m 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.

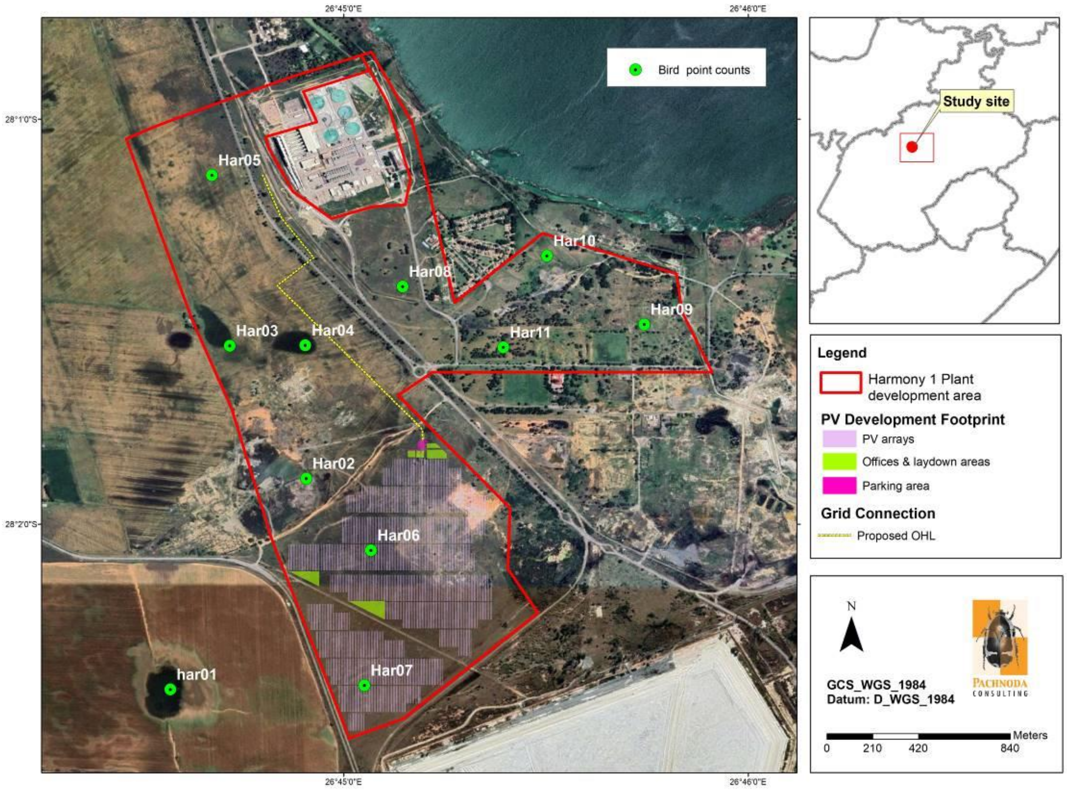


Figure 5: A map illustrating the spatial position of 30 bird point counts located within the study area.

2.2 Sensitivity Analysis

A sensitivity map was compiled based on the outcome of a desktop analysis and baseline surveys.

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 service (e.g. wetlands) or the overall preservation of biodiversity.

2.3.2 Avifaunal Importance

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 provide suitable habitat for a number of threatened or rare species. These areas should preferably be protected;
- *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 species diversity (most species are usually exotic or weeds).

2.3 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.
- A replicative sampling protocol (two sampling surveys) was followed representing the end of the austral wet season and during the peak austral dry season. The austral dry season is not the optimal time of the year to

conduct bird surveys since many of the migratory species (Palearctic and Intra-African migratory species) will be absent. However, these species represent a small percentage of the expected species that could occur on the study site. In addition, many resident species also become less vocal (e.g. cisticolas) during the dry season with the risk that these species may be overlooked. However, replicative surveys detected the majority of these species and the observed list of species for the study area is considered to be a true representation of the expected richness.

- 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 PV facility will be located near Harmony Gold Central Plant operations located ~6km north east of the town of Virginia and ~11km south east of the town of Welkom, Free State Province (Figure 1).

3.2 Regional Vegetation Description

The proposed PV facility corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It comprehends an ecological type known as Vaal-Vet Sandy Grassland (Mucina & Rutherford, 2006) (Figure 6).

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. Although 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.

The Vaal-Vet Sandy Grassland occurs in the Free State and North-West Provinces, where it extends from Lichtenburg and Ventersdorp southwards to Klerksdorp, Leeudoringstad, Bothaville and the Brandfort area north of Bloemfontein. It occurs at an altitude of 1 220-1 560 m and is mainly confined to aeolian and colluvial sand overlying shales and mudstones. The floristic structure of the Vaal-Vet Sandy

Grassland is mainly a low tussocky grassland with many karroid elements. In its untransformed condition, *Themeda triandra* is an important dominant graminoid, while intense grazing and erratic rainfall is responsible for an increase of *Elionurus muticus, Cymbopogon pospischilii* and *Aristida congesta*.

The Vaal-Vet Sandy Grassland is a threatened (**Endangered**) ecosystem with only a few remaining patches of untransformed grassland being statutorily conserved (c. 0.3 % at Bloemhof Dam, Schoonspruit, Sandveld, Faan Meintjies, Wolwespruit and Soetdoring Nature Reserves). In addition, the Vaal-Vet Sandy Grassland is a Critically Endangered Ecosystem (as per Section 52 of National Environmental Management Biodiversity Act, (Act No. 10 of 2004)) and a Critical Biodiversity Area as per the Free State Conservation Plan (DESTEA, 2015). More than 63 % of this grassland type is already transformed by cultivation, and intense livestock grazing.

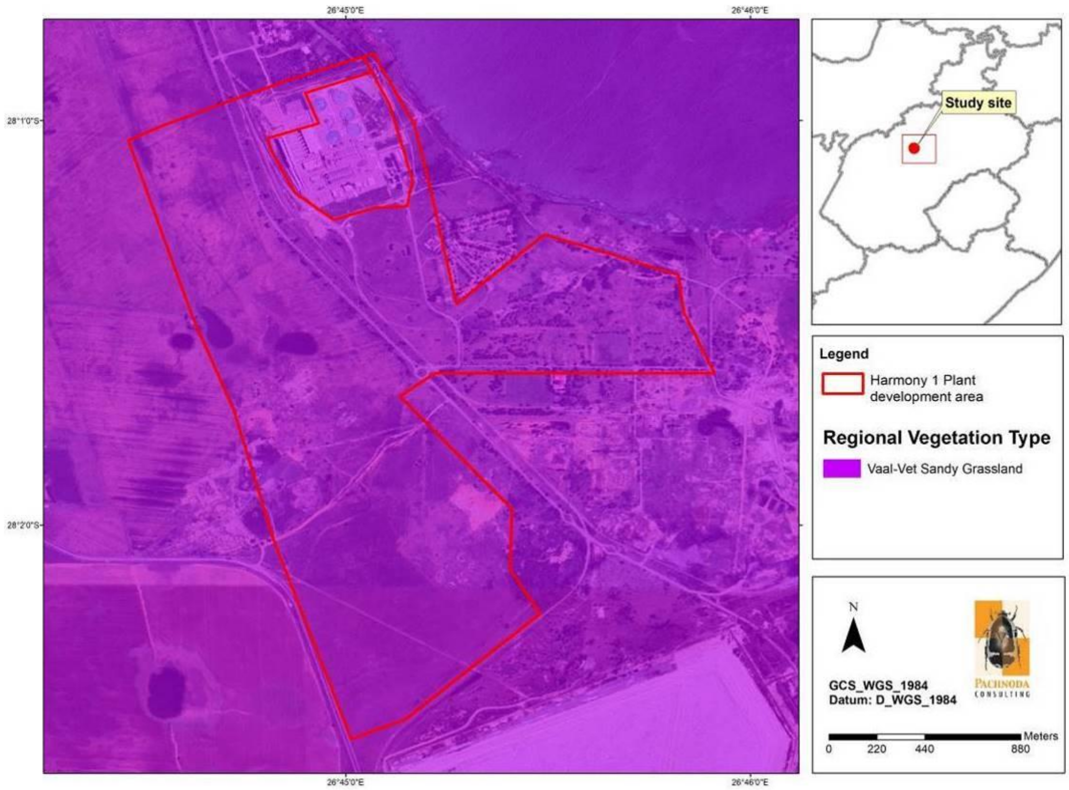


Figure 6: A satellite image illustrating the regional vegetation type corresponding to the study site and immediate surroundings. Vegetation type categories were defined by Mucina & Rutherford (2006; updated 2012).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the study site comprehends the following land cover categories (Figure 7):

Natural areas:

- Grassland;
- Low shrubland; and
- Wetlands;

Transformed areas:

- Mines and quarries; and
- Build-up areas.

From the land cover dataset it is evident that most of the study area is covered by natural grassland and low shrubland. However, quarries and build-up areas is also respectively prevalent on the western and eastern parts of the study site (the latter includes manicured and landscaped habitat consisting of exotic tree species. The majority of the study area (consisting of natural grassland) is primarily vacant with the exception of the eastern section which consists of homesteads and build-up land.

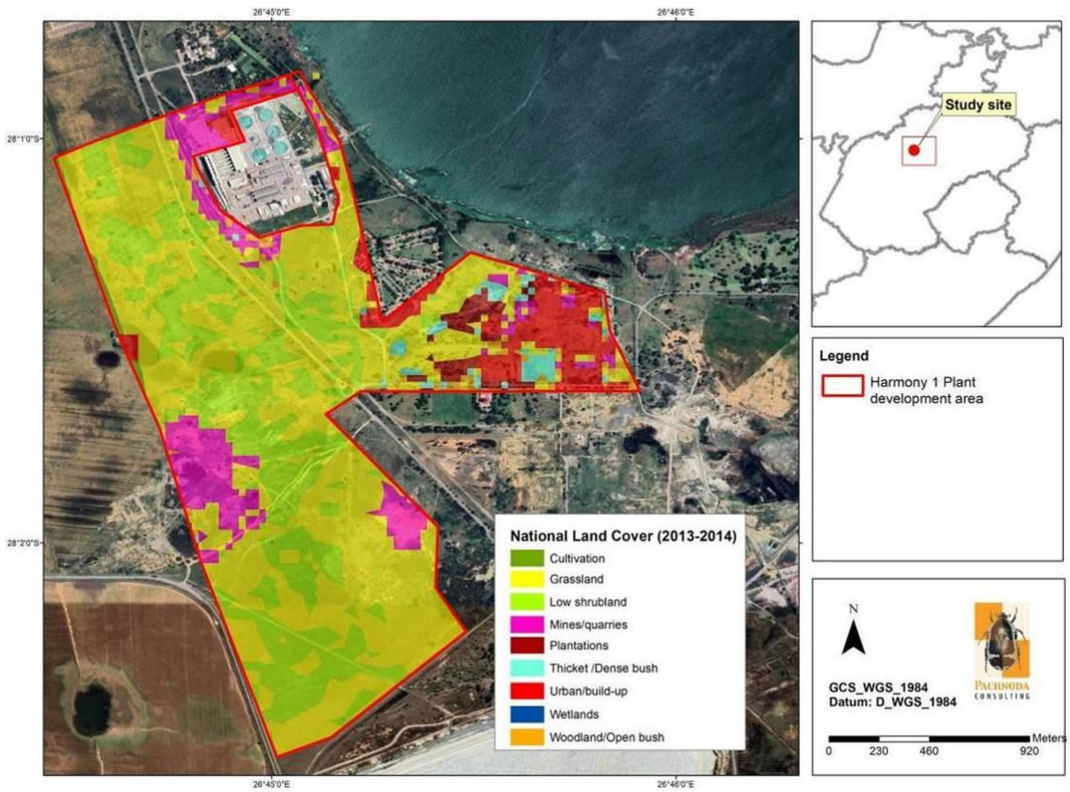


Figure 7: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study site and immediate surroundings.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study area does not coincide with any conservation area or Important Bird and Biodiversity Area (IBA). The nearest conservation area to the proposed study area is the Willem Pretorius Game Reserve, which is located 45 km south-east of the study site. The Willem Pretorius Game Reserve is also a recognised IBA (SA044).

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 area and immediate surroundings hold a **medium** sensitivity with respect to the relative animal species protocol (Figure 8) (report generated 25/04/2022):

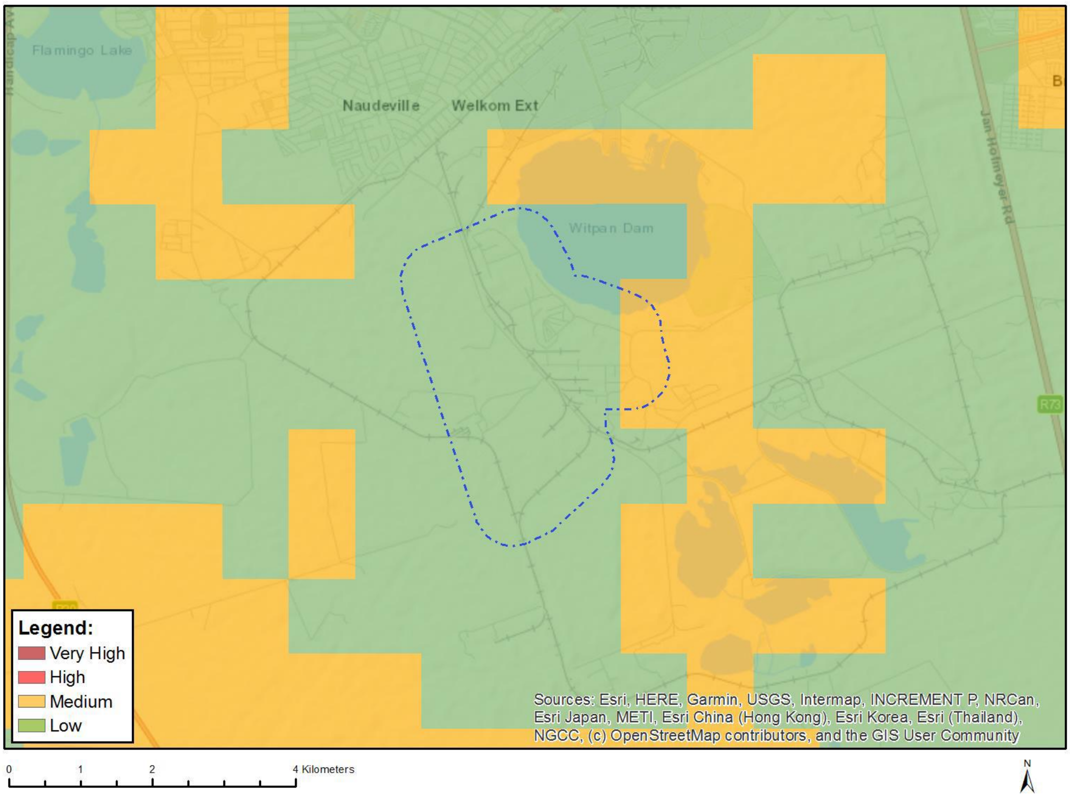


Figure 8: The animal species sensitivity of the study area and immediate surroundings according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low sensitivity
Low	Reptilia-*Smaug giganteus*
Low	Mammalia-*Ourebia ourebi ourebi*

According to the results of the screening tool, a low probability of occurrence is evident for threatened bird species although the eastern section holds a medium sensitivity for a threatened lizard and mammal species.

It is evident that the study area and immediate surroundings correspond to a **low** avian theme sensitivity (see Figure 9).

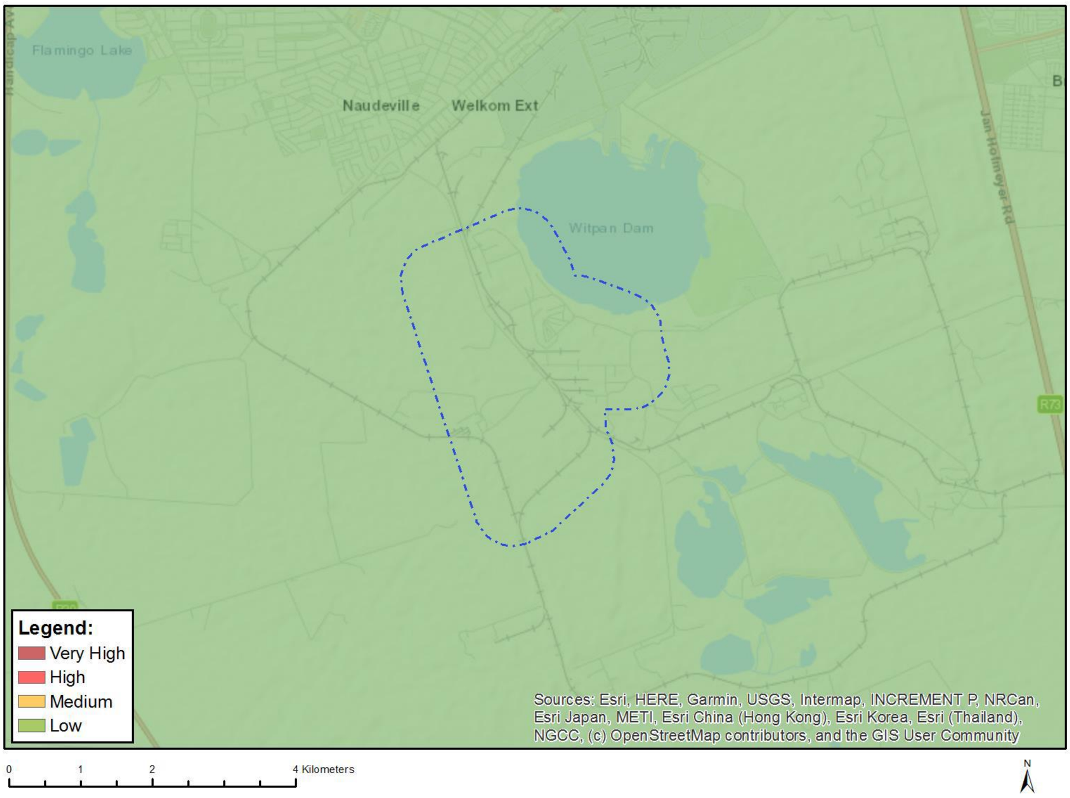


Figure 9: The relative avian sensitivity of the study area and immediate surroundings according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low sensitivity

However, the study area and immediate surroundings hold a **very high** sensitivity with respect to the relative terrestrial biodiversity theme (Figure 10):

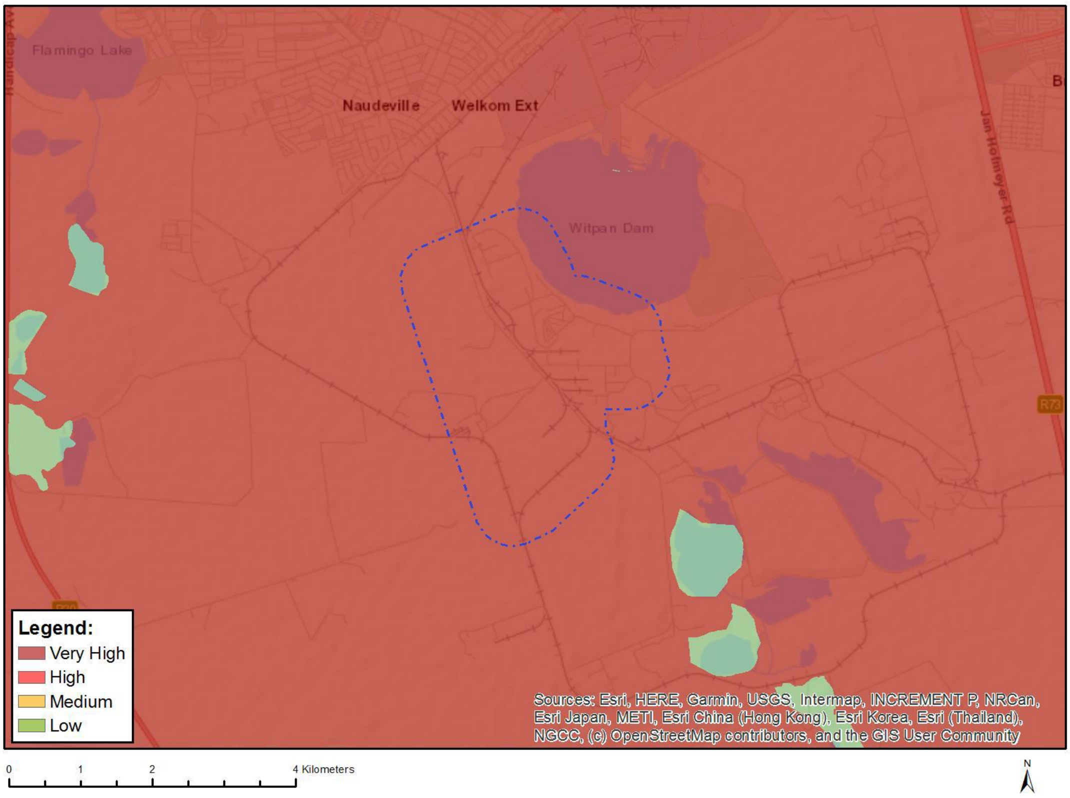


Figure 10: The relative terrestrial biodiversity sensitivity of the study area and immediate surroundings according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Very High	Critical Biodiversity Area 1
Very High	Endangered Ecosystem

It is evident from the results of the Screening Tool report that part of the entire study area coincides with a Critical Biodiversity Area 1 (CBA 1) as per the Free State Biodiversity Plan (DESTEA, 2015). In addition, the study site also coincides with an Endangered ecosystem which is represented by the Vaal-Vet Sandy Grassland.

4. RESULTS AND DISCUSSION

4.1 Avifaunal habitat types

Apart from the regional vegetation type, the local composition and distribution of the vegetation associations on the study area and immediate surroundings are a consequence of a combination of factors simulated by geomorphology, presence of inundated wetland features and past land use practice which have culminated in a number of habitat types that deserve further discussion (Figure 11 and Figure 12):

1. *Secondary grassland:* This unit is prominent on the study area and covers a significant surface area on the western part of the development area which was probably utilised as cultivation in the past. It represents a grassland sere

with a secondary albeit monotonous composition that is dominated by *Cynodon dactylon* and graminoid species of the genus *Eragrostis*. The expected bird composition is represented by widespread cryptic grassland species of which the richness is low. Typical bird species expected to be present include a variety of cisticolas (Cloud Cisticola *Cisticola textrix*, Desert Cisticola *C. aridulus* and Zitting Cisticola *C. juncidis*), Cape Longclaw (*Macronyx capense*), Rufous-naped Lark (*Mirafra africana*) and Long-tailed Widowbird (*Euplectes progne*). It also provides ephemeral foraging habitat for collision-prone species such as the Northern Black Korhaan (*Afrotis afraoides*).

2. *Moist mixed grassland:* This unit is located on the southern part of the development area, including the western boundary adjacent to the Witpan Dam shoreline. The graminoid structure and composition is essentially similar to that of the secondary grassland unit, although the graminoid composition appears to be higher and more diverse and it is located on soils with a high moisture content (probably due to seepage from the nearby slimes dams and pans). The bird composition is also similar to that of the secondary grassland although it provides habitat for high numbers of foraging passerine birds, especially when burned (caused by veld fires). Large numbers of foraging granivores and insectivores colonise this grassland sere during the dry season which include prominent species such as Red-billed Quelea (*Quelea quelea*), Pied Starling (*Lamprotornis bicolor*), Red-capped Lark (*Calandrella cinerea*), Southern Red Bishop (*Euplectes orix*) and Long-tailed Widowbird (*E. progne*). The endemic Melodious Lark (*Mirafra cheniana*) is a regular foraging and potential breeding resident (pers. obs.).

3. *Depressions*: This habitat occurs on the western part of the development area, and is represented by a series of small grassy depressions of which the basins are colonised by members of the Cyperaceae, especially species of the genus *Eleocharis, Kyllinga* and *Cyperus*. The edges are often dominated by *Eragrostis gummiflua*. This habitat provides habitat for a unique bird composition represented by many smaller wetland-associated passerine species, although larger non-passerines such as waterfowl were absent since the presence of open water and lentic conditions were uncommon, which will discourage waterfowl and shorebirds from utilising the habitat. Expected typical bird species include Zitting Cisticola (*C. juncidis*), Levaillant's Cisticola (*C. tinniens*) and Quailfinch (*Ortygospiza atricollis*).

4. *Artificial dam and inundated quarries*: These are represented by mined quarries which have become inundated during precipitation events and groundwater infiltration. Although artificial of origin, these often provide ephemeral foraging habitat for widespread waterfowl and shorebird such as Egyptian Goose (*Alopochen aegyptiacus*), Little Grebe (*Tachybaptus ruficollis*), Red-knobbed Coot (*Fulica cristata*) and Three-banded Plover (*Charadrius tricollaris*).

5. *Transformed and landscaped (manicured) areas*: These areas are represented by build-up land and landscaped areas of which the tree cover is predominantly composed of exotic species. These features are invariably also artificial although colonised by a high number of bird species which favours the vertical heterogeneity provided by the tree canopy. However, the bird composition is expected to be represented by a "bushveld" composition which is often present in urban landscaped (manicured) gardens and parks (c. Ring-necked Dove *Streptopelia capicola*, White-browed Sparrow-weaver *Plocepasser mahali*, Red-eyed Dove *S. semitorquata*, Common Myna *Acridotheres tristis*, Crested Barbet *Trachyphonus vaillantii* and Cape Starling *Lamprotornis nitens*).

It is evident from Figure 11 that the proposed development footprint (PV arrays) is covered by approximately 30 % secondary grassland (in the north), 30% mixed moist grassland (south and west) and by 30% transformed grassland (east).

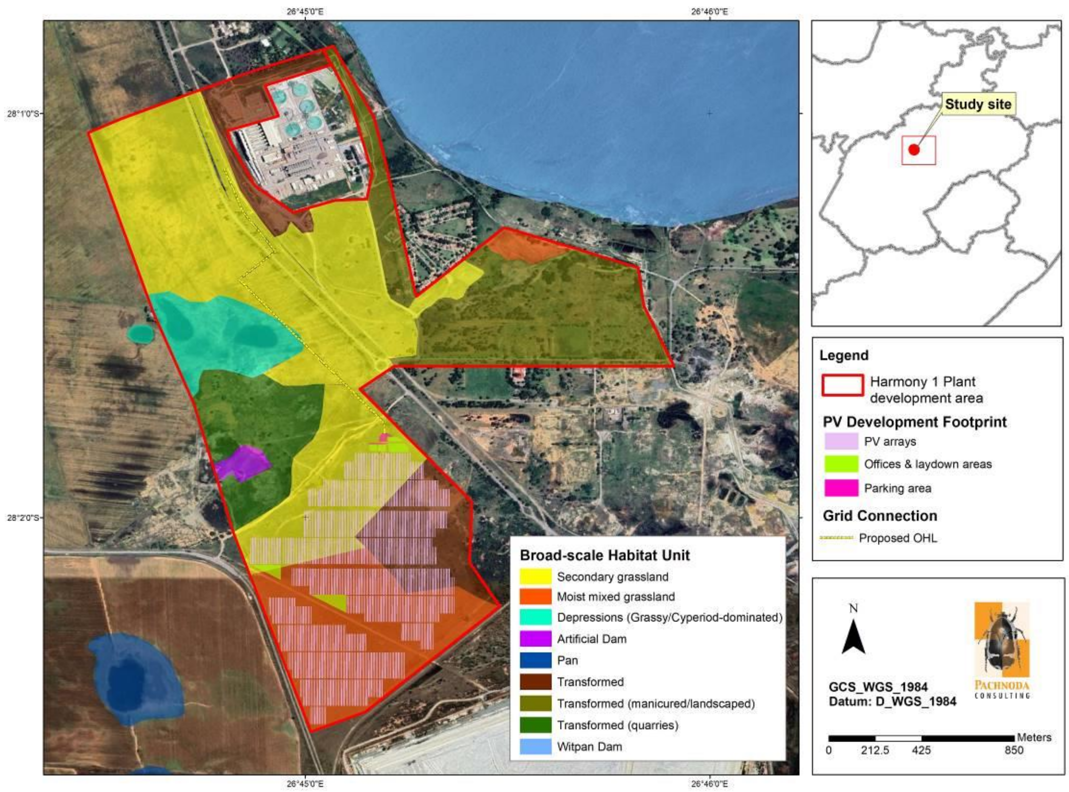
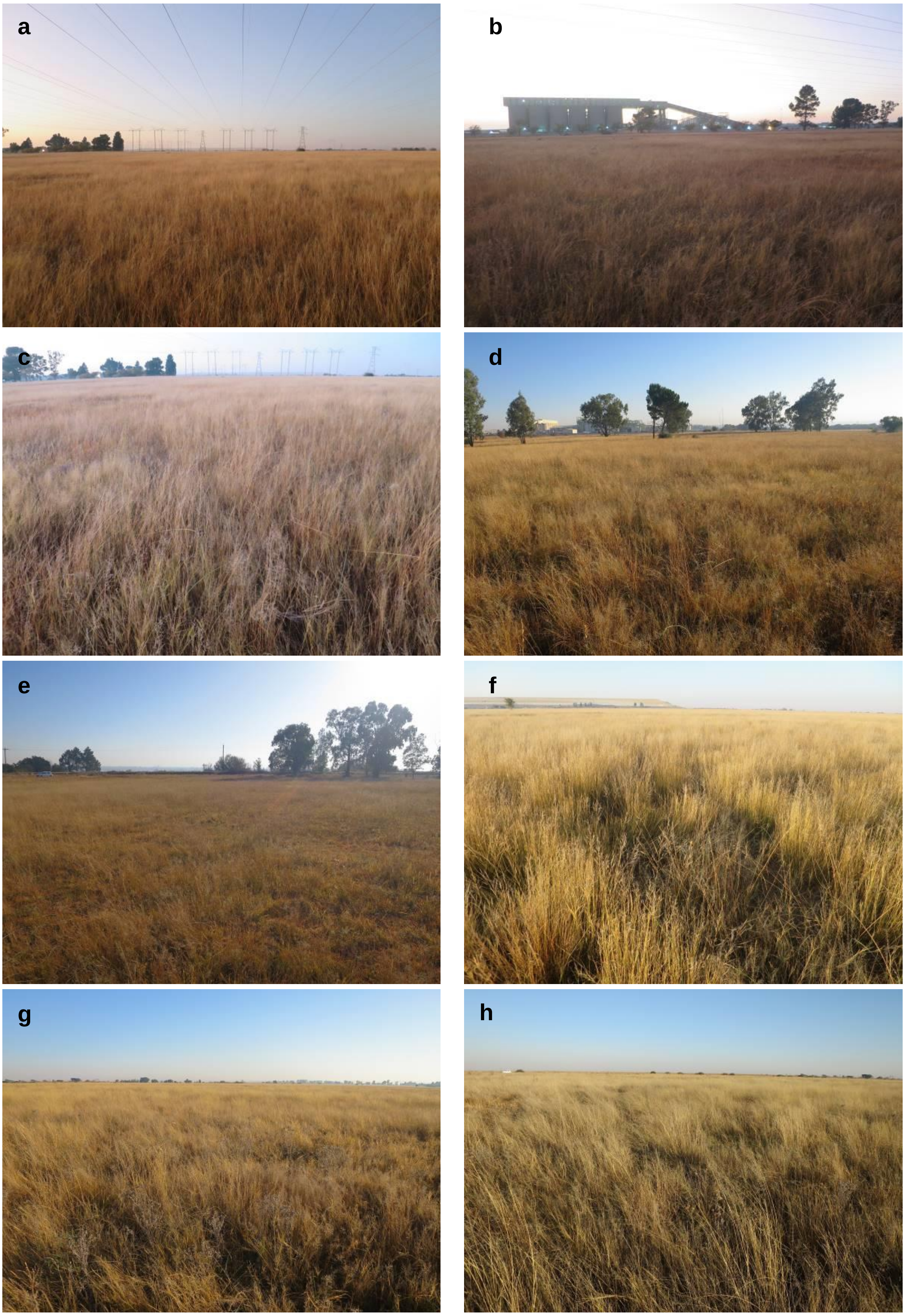


Figure 11: A habitat map illustrating the avifaunal habitat types on the study area and immediate surroundings.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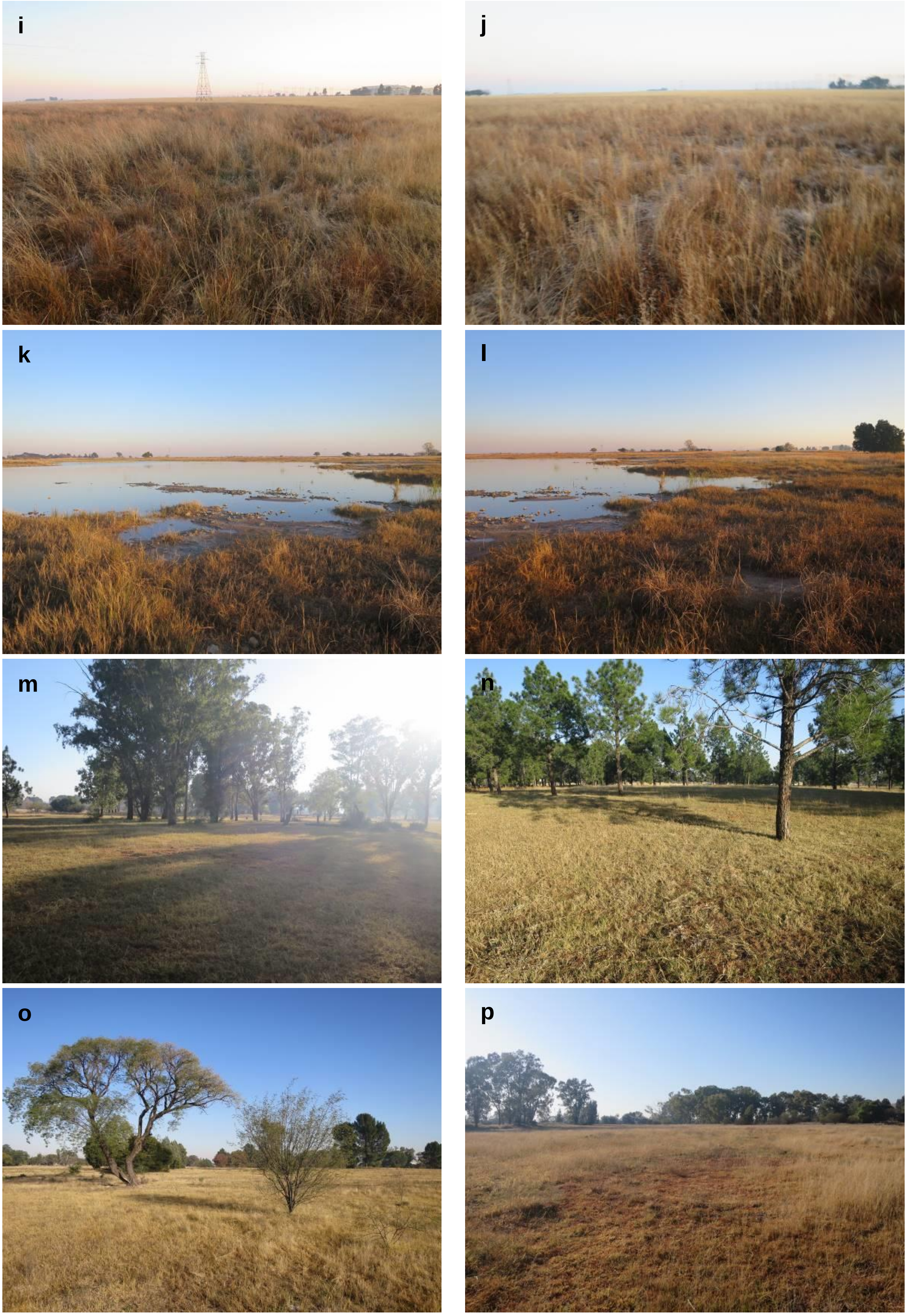
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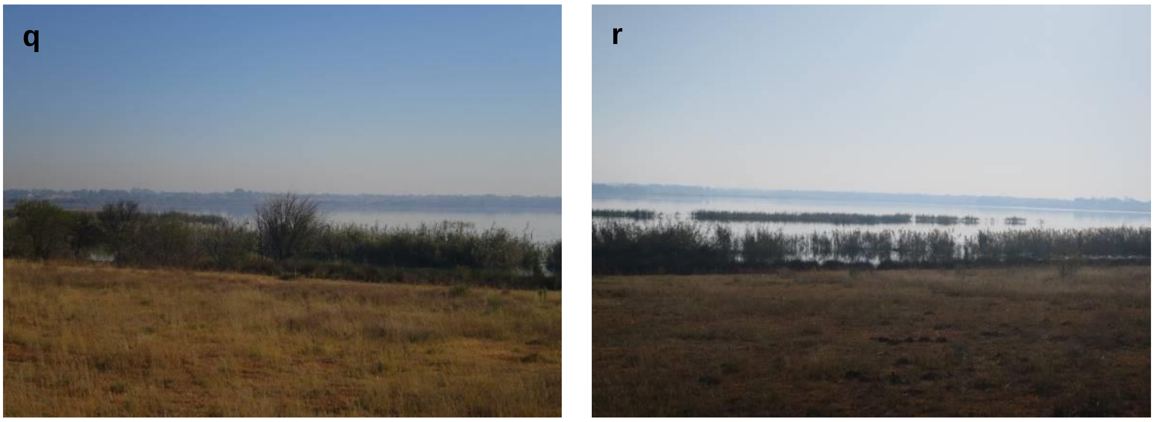

Figure 12: A collage of images illustrating examples of avifaunal habitat types confined to the development area and immediate surroundings: (a - d) secondary grassland, (e – h) mixed moist grassland, (i - j) depressions, (k - l) an artificial dam and inundated quarries, (m – p) transformed and landscaped areas and (q - r) an example of the nearby Witpan Dam.

4.2 Species Richness and Summary statistics

Approximately ~178 bird species are expected to occur on the development area and immediate surroundings (refer to Appendix 1 and Table 1). The expected richness was inferred from the South African Bird Atlas Project (SABAP1 & SABAP2)[1] (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 18 % of the approximate 990[2] species listed for the southern African subregion[3] (and approximately 20 % of the 871 species recorded within South Africa[4]). However, the species richness obtained from the pentad grids 2800_2640 and 2800_2645 corresponding to the study area[5] is lower than the expected number of species with an average of 69.4 species recorded for each full protocol card submitted (for observation of two hours or more; range = 31 - 101 species). The lower richness is explained due to the spatial scale of the pentad grid and habitat variability, whereby the study area is much smaller in surface area and will encompass less habitat variability.

According to field observations (June and July 2022), the total number of species observed on the study area is *ca*. 88 species (see Appendix 1). It shows that the surveys on the study area produced a tally that is within range when compared to the average richness recorded for the corresponding pentad grid and were regarded as

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1 The expected richness statistic was derived from pentad grids 2800_2640 and 2800_2645 totalling 184 bird species and modified according to habitat suitability, personal observations and probability of occurrence (based on 61 submitted cards, 42 being full protocol cards and 19 being ad hoc cards).
2 *sensu* www.zestforbirds.co.za (Hardaker, 2022) including four recently confirmed bird species (vagrants).
3 A geographical area south of the Cunene and Zambezi Rivers (includes Namibia, Botswana, Zimbabwe, southern Mozambique, South Africa, eSwatini and Lesotho).
4 With reference to South Africa (including Lesotho and eSwatini (BirdLife South Africa, 2022).
5 Including observations made during June-July 2022 surveys.

sufficient. On a national scale, the species richness per pentad on the study area is considered to be high (refer to Figure 14).

According to Table 1, the study area is poorly represented by biome-restricted[6] (see Table 2) and local endemic/near-endemic bird species. Approximately 11 threatened or near threatened species is known to be present in the wider study area with only three species recorded on the study are during the surveys. Furthermore, four southern African endemics and 10 near-endemic species were confirmed on the study area and the immediate surroundings (Table 3). However, a large percentage of the species recorded in the study area was represented by waterbirds and shorebird taxa (ca. 37% of the total number of recorded bird species, sensu SABAP2).

The 2022 surveys also detected two bird species that are novel (new) species, which were observed for the first time within pentad grids 2800_2640 and 2800_2645. These species were previously overlooked. These include:

- Melodious Lark (*Mirafra cheniana*) - observed from the secondary and mixed moist grasslands.
- Common Scimitarbill (*Rhinopomastus cyanomelas*) - observed from moist rank grassland bordering a slimes dam; and

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 (study area and surroundings)***	Observed Richness Value (study area)****
Total number of species*	178 (18 %)	88 (50 %)
Number of Red Listed species**	11 (8 %)#	3 (27 %)
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	2 (14%)	0 (0 %)
Number of local endemics (BirdLife SA, 2022)*	3 (8 %)	1 (33 %)
Number of local near-endemics (BirdLife SA, 2022)*	6 (20 %)	4 (67 %)
Number of regional endemics (Hockey *et al.,* 2005)**	14 (13 %)	10 (71 %)
Number of regional near-endemics (Hockey *et al.,* 2005)**	11 (18 %)	6 (54 %)

* only species in the geographic boundaries of South Africa (including Lesotho and eSwatini) 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).

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

**** Percentage values in brackets refer to totals compared against the expected number of species in the project area.
# Includes taxa recorded from pentad grids adjacent to 2655_2645.

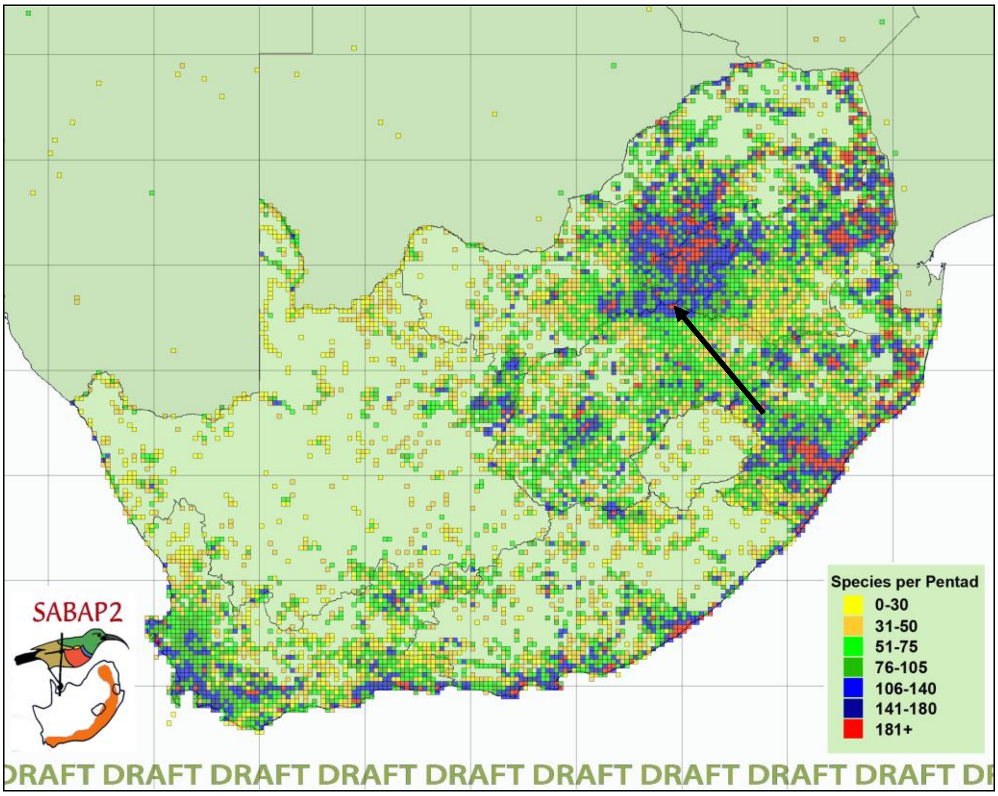


Figure 13: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts over 181 bird species.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) likely to occur on the study area.

Species	Kalahari-Highveld	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena)*	X		Uncommon
White-bellied Sunbird (*Cinnyris talatala*)		X	Uncommon

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

Common Name	Scientific name	Regional Status	Global Status	Observed (Jun & Jul 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
Chestnut-banded Plover	*Charadrius pallidus*	NT				1	1
Curlew Sandpiper	*Calidris ferruginea*		NT			1	
Greater Painted-snipe	*Rostratula benghalensis*	NT					1

Common Name	Scientific name	Regional Status	Global Status	Observed (Jun & Jul 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
Greater Flamingo	*Phoenicopterus roseus*	NT		1	1	11	
Lesser Flamingo	*Phoeniconaias minor*	NT	NT	1	1	1	
Lanner Falcon	*Falco biarmicus*	VU		1	1		
Maccoa Duck	*Oxyura maccoa*	VU	EN		1	1	
Secretarybird	*Sagittarius serpentarius*	EN	EN		1		1
South African Shelduck	*Tadorna cana*	End		1	1	1	
Cape Shoveller	*Anas smithii*	End		1	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			1
Ant-eating Chat	*Myrmecocichla formicivora*	End		1			1
Fiscal Flycatcher	*Melaenornis silens*	End					1
Fairy Flycatcher	*Stenostira scita*	End					1
Cape Longclaw	*Macronyx capensis*	End		1			1
Orange River White-eye	*Zosterops pallidus*	End		1			1
South African Cliff Swallow	*Petrochelidon spilodera*	End					1
Pied Starling	*Lamprotornis bicolor*	End		1			1
Orange River Francolin	*Scleroptila gutturalis*	N-end			1		1
Acacia Pied Barbet	*Tricholaema leucomelas*	N-end		1			1
African Red-eyed Bulbul	*Pycnonotus nigricans*	N-end		1			1
Kalahari Scrub Robin	*Cercotrichas paena*	N-end					1
Chestnut-vented Warbler	*Curruca subcoerulea*	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
Yellow Canary	*Crithagra flaviventris*	N-end					1
Mountain Wheatear	*Oenanthe monticola*	N-end					1
Cloud Cisticola	*Cisticola textrix*	N-end		1			1
Blue Korhaan	*Eupodotis caerulescens*	End	NT		1		1
Abdim's Stork	*Ciconia abdimii*	NT			1		
Yellow-billed Stork	*Mycteria ibis*	EN			1		
	Totals:	**34**	**5**	**19**	**12**	**7**	**26**

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

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the study area and immediate surroundings based on their historical distribution ranges and the presence of suitable habitat. According to Table 3, a total of 11 species could occur on the study area which includes two globally threatened species, three globally near threatened species, two regionally threatened species and four regionally near-threatened species.

It is evident from Table 4 that the highest reporting rates (>10%) were observed for the globally endangered Maccoa Duck (*Oxyura maccoa*), the regionally endangered Yellow-billed Stork (*Mycteria ibis*), the globally near threatened Lesser Flamingo (*Phoeniconaias minor* – see Figure 14) and Curlew Sandpiper (*Calidris ferruginea*) and the regionally near threatened Greater Flamingo (*Phoenicopterus roseus* – see Figure 14). These species are regarded as regular foraging visitors to the nearby pans and the Witpan Dam which occur adjacent to the development area. However, these species are probably absent on the physical development footprint due to the absence of any suitable habitat. *Nevertheless, birds dispersing or commuting between the nearby pans and Witpan Dam will have to fly over the footprint site and could potentially interact (collide) with the PV panels and associated electrical infrastructure*.

The regionally vulnerable Lanner Falcon (*Falco biarmicus*) appears to be resident on the study area, where it as observed hunting pigeons and doves between the Harmony one plant and the onsite substation (Figure 14). This species was previously overlooked since it was last recorded during 2014 in the study area (sensu SABAP2).

The remaining species have low reporting rates (<10%) and are regarded as irregular foraging visitors with low probabilities of occurrence. The low probability of occurrence for these species is due to absence of suitable habitat (mainly foraging habitat) on the study site and the historical displacement of these species owing to increased anthropogenic disturbances (e.g. agriculture, mining activities and pedestrians).

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**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
Calidris ferruginea (Curlew Sandpiper)	Near-threatened	-	12.82	Generally confined to muddy fringes of inland pans and large impoundments, lagoons and estuaries.	Regular summer non-breeding visitor to the shoreline habitat of nearby pans and large impoundments. Probably absent on the physical footprint site due to the absence of suitable habitat. Birds dispersing between pans could potentially fly over the site and may interact with the PV panels.
Ciconia abdimii (Abdim's Stork)	-	Near-threatened	2.56	A non-breeding summer visitor to open grassland and recently tilled agricultural land.	Probably highly irregular foraging visitor in summer. Highly seasonal and often absent in some years. It has not been recently observed on the study area (it was lass recorded during 2010; *sensu* SABAP2).
Charadrius pallidus (Chestnut-banded Plover)	-	Near-threatened	7.69	Partial to the shoreline of saline pans and also saltworks.	An uncommon visitor to the shoreline habitat of nearby pans. Probably absent on the physical footprint site due to the absence of suitable habitat. Birds dispersing

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					between pans could potentially fly over the site and may interact with the PV panels.
Eupodotis caerulescens (Blue Korhaan)	Near-threatened	(delisted)	2.56	Prefers extensive open short grassland and cultivated land.	Vagrant, probably absent and historically displaced due to anthropogenic activities. It has not been recently observed on the study area (it was last recorded during 2012; *sensu* SABAP2).
Falco biarmicus (Lanner Falcon)	-	Vulnerable	2.56	Varied, but prefers to breed in mountainous areas although also using old disused mine voids.	It appears to be resident on the development area where it was frequently observed hunting pigeons and doves between the main Harmony One plant and the on-site substation (pers. obs.). This individual was probably overlooked since it was previously recorded during 2014 on the study site.
Oxyura maccoa (Maccoa Duck)	Endangered	Vulnerable	58.97	Large saline pans and shallow impoundments.	A regular foraging visitor and possibly also breeding visitor to the pans and impounds adjacent to the study area. Probably absent on the physical footprint site due to the

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					absence of suitable habitat. Birds dispersing between pans could potentially fly over the site and may interact with the PV panels and electrical infrastructure.
Mycteria ibis (Yellow-billed Stork)	-	Endangered	17.95	Wetlands, pans and flooded grassland.	A regular foraging visitor to the pans and impounds adjacent to the study area. Probably absent on the physical footprint site due to the absence of suitable habitat. Birds dispersing between pans could potentially fly over the site and may interact with the PV panels and electrical infrastructure.
Phoeniconaias minor (Lesser Flamingo)	Near-threatened	Near-threatened	64.10	Restricted to large saline pans and other inland water bodies containing cyanobacteria.	A regular foraging visitor to the shallow margins of Witpan Dam (pers. obs.) and probably also the nearby smaller pans. Probably absent on the physical footprint site due to the absence of suitable habitat. Birds dispersing between the pans and dams in the area could potentially fly over the site and may interact with the PV panels and electrical

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					infrastructure.
Phoenicopterus roseus (Greater Flamingo)	-	Near-threatened	69.23	Restricted to large saline pans and other inland water bodies.	A highly regular foraging visitor to the shallow margins of Witpan Dam (pers. obs.) and probably also the nearby smaller pans. Probably absent on the physical footprint site due to the absence of suitable habitat. Birds dispersing between the pans and dams in the area could potentially fly over the site and may interact with the PV panels and electrical infrastructure.
Rostratula benghalensis (Greater Painted-snipe)	-	Near-threatened	2.56	Prefers well-vegetated seasonally inundated depressions and pans, especially in the Savanna Biome.	A highly irregular foraging visitor and probably absent on the study area. It has not been recently observed on the study area (it was last recorded during 2012; *sensu* SABAP2).
Sagittarius serpentarius (Secretarybird)	Endangered	Endangered	2.56	Prefers open grassland or lightly wooded habitat.	A highly irregular foraging visitor and probably absent on the study area. Historically displaced due to anthropogenic activities. It has not been recently observed on the study area (it

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence
					was last recorded during 2009; *sensu* SABAP2).

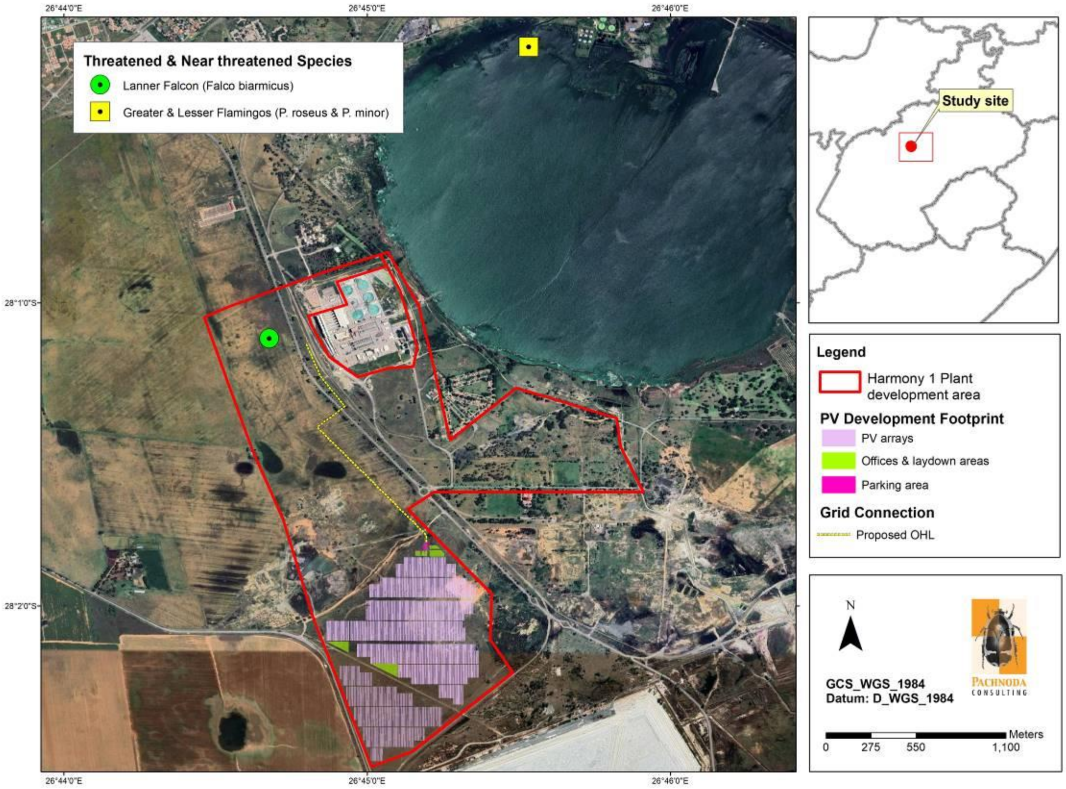


Figure 14: A map illustrating the occurrence of threatened and near threatened bird species observed on the development area and immediate surroundings during the June/July 2022 surveys.

4.4 Bird Assemblage Structure and Composition

4.4.1 Summary of point counts

A total of 54 bird species and an average abundance of 939.5 individuals were recorded from 11 bird points (representing two replicative counts) located on the development area. The data provides an estimate of the bird richness and their numbers on the study area and immediate surroundings obtained during two independent survey sessions. A mean of 12.09 species and 85.41 individuals were recorded per point count. The highest number of species was recorded from point count was 19 species (manly from landscaped and manicured areas) and between 290 and 360 individuals (manly from secondary grassland and pan edges). The high number of individuals are explained by the occurrence of large feeding flocks of Red-billed Quelea (*Quelea quelea*) and congregations of waterfowl (especially large flocks of Spur-winged Goose *Plectropterus gambiensis*) at endorheic pans during the austral dry season. The lowest number of species and individuals was respectively seven species and five individuals (highly moribund secondary grassland).

The mean frequency of occurrence of a bird species in the study area was 22.39 % and the median was 18.18%, while the most common value (mode) was 9.09%. The latter represents those species that were encountered in only one point count. Five species occurred in 50% or more of the point counts (Table 5) with Crowned Lapwing (*Vanellus coronatus*) and Ring-necked Dove (*Streptopelia capicola*) occurring in > 80% of the point counts.

Table 5: Bird species with a frequency of occurrence greater than 50% observed on the study area (according to 11 counts).

Species	Frequency (%)	Species	Frequency (%)
Crowned Lapwing (*Vanellus coronatus*)	72.73	Red-capped Lark (*Calandrella cinerea*)	54.55
Ring-necked Dove (*Streptopelia capicola*)	63.64	Zitting Cisticola (*Cisticola juncidis*)	54.55
African Pipit (*Anthus cinnamomeus*)	54.55		

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 15 and Figure 16 it is evident that the highest bird richness values were observed from transformed and manicured habitat units with intermediate richness values observed from the mixed moist grassland habitat. In addition, high bird numbers (abundance) were observed from moist grassland units and from nearby endorheic pans where waterbirds tend to congregate during the austral dry season (Figure 17). Therefore, the potential displacement of birds due to the loss of habitat during construction is likely to occur at natural habitat which features moist grassland and wetland-features (e.g. pans).

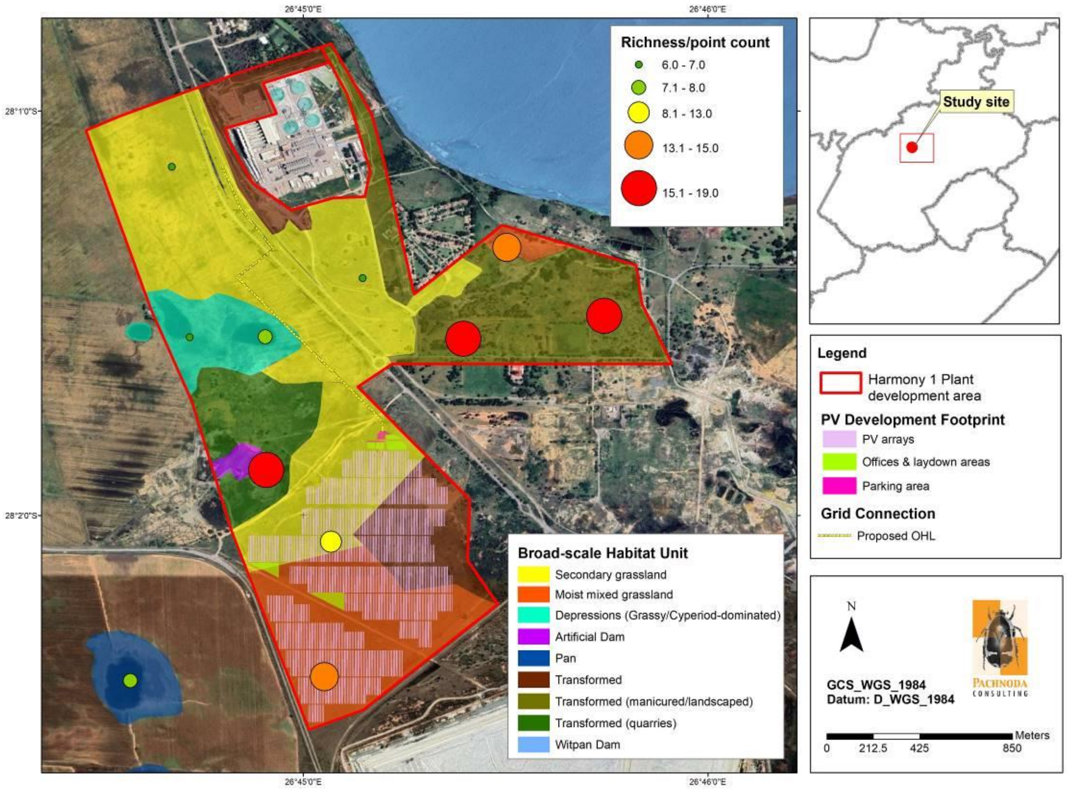


Figure 15: A map of the study area illustrating the spatial distribution of bird richness values (number of species) obtained for each point count.

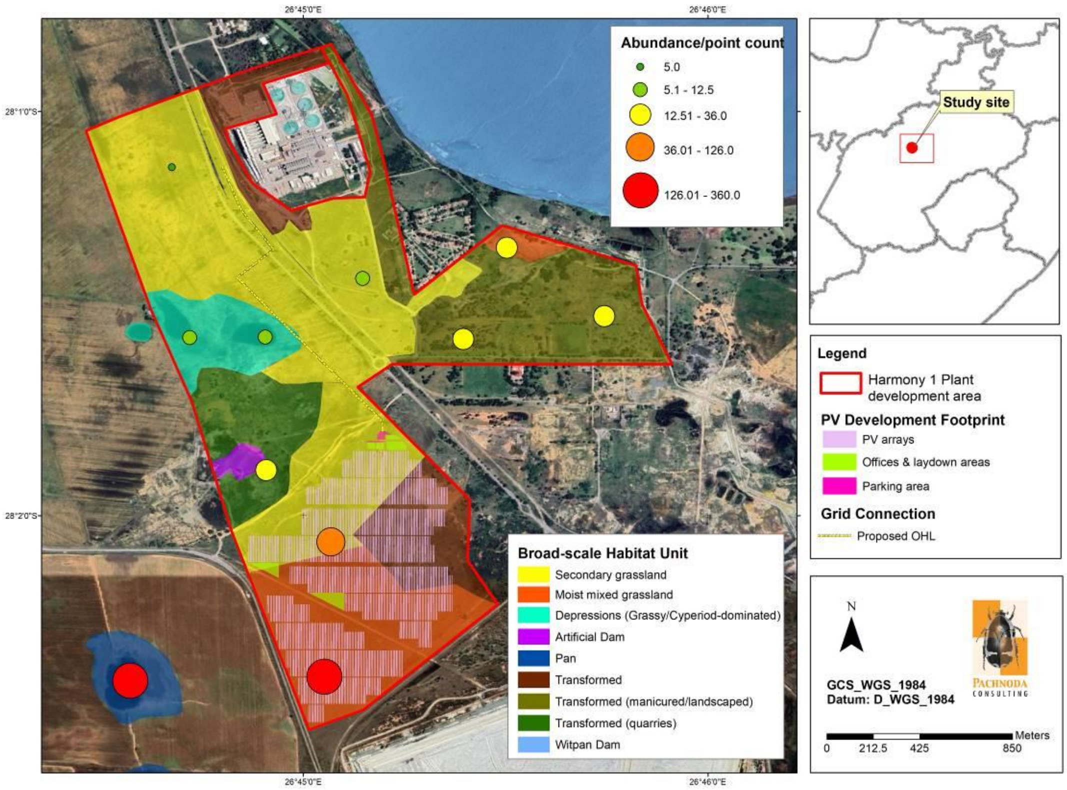


Figure 16: A map of the study area illustrating the distribution of bird abundance values (average number of individuals) obtained for each point count.

4.4.3 Dominance and typical bird species

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 included the Ring-necked Dove (*Streptopelia capicola),* Crowned Lapwing (*Vanellus coronatus*) and White-browed Sparrow-weaver (*Plocepasser mahali*). 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 predominantly represented by terrestrial/ ground -foraging insectivores (insect-eating) and granivores (seed-eating taxa).

Table 6: Typical (high frequency of occurrence) bird species on the study area.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Ring-necked Dove (*Streptopelia capicola*)	1.81	0.57	15.44	Granivore: ground gleaner
Crowned Lapwing (*Vanellus coronatus*)	1.14	0.41	13.18	Insectivore: ground gleaner

White-browed Sparrow-weaver (*Plocepasser mahali*)	3.14	0.38	11.74	Granivore: ground gleaner
Red-capped Lark (*Calandrella cinerea*)	1.57	0.37	8.74	Granivore:/insectivore ground gleaner
Zitting Cisticola (*Cisticola juncidis*)	0.33	0.24	7.64	Insectivore: upper canopy foliage gleaner
African Pipit (*Anthus cinnamomeus*)	0.76	0.31	6.38	Insectivore: ground gleaner
Laughing Dove (*Spilopelia senegalensis*)	0.57	0.32	5.53	Granivore: ground gleaner
Southern Masked Weaver (*Ploceus velatus*)	0.67	0.27	3.84	Granivore: upper to lower to ground gleaner
Cloud Cisticola (*Cisticola textrix*)	0.24	0.22	3.39	Insectivore: upper canopy foliage gleaner
Quailfinch (*Ortygospiza atricollis*)	0.81	0.16	3.08	Granivore: ground gleaner

4.4.4 Diversity and species richness

The highest number of bird species on the study area was observed from pans and areas with surface water, followed by the bird association on landscaped areas (Table 7). The lowest number of bird species was recorded from the moist grassland units.

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

Bird Association	Number of species	Number of Individuals	Shannon Wiener Index H'(log$_e$)
Depressions/dams/pans	25	134.00	1.74
Moist grassland	20	19.50	2.48
Secondary grassland	21	108.50	0.97
Landscaped/manicured areas	23	32.25	2.67

4.5 Passerine bird densities

Thirty-five passerine bird species were recorded from 10 point counts[7] on the development area. The development area accommodates approximately 11.54 species.ha^{-1} (Appendix 2). The average density per hectare is 66.79 birds.ha^{-1} and ranges between 5.13 birds.ha^{-1} to 369.87 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

A consistent movement of waterbirds species were (especially the South African Shelduck *Tadorna cana,* Spurwinged Goose *Plectropterus gambiensis* and Egyptian Goose *Alopochen aegyptiacus*) were detected which could potentially collide with the

[7] One of the point counts corresponded to a pan, which were only occupied by non-passerine species and was omitted from the density estimate analysis.

PV infrastructure when visiting nearby water features in the area (Figure 17). These species were regularly observed (especially in the early mornings) flying across the development area as well as the proposed footprint area in a northerly direction from the slimes dams and nearby pans towards Witpan Dam. In addition, with many individuals were also observed perching on the existing pylon structures and at the small pan located west of the development area, where large congregations of waterfowl were observed. Most of these individuals tend to take advantage of the wet conditions created by the foot slopes of the tailing facilities and shallow inundated pans/dams.

The home ranges of approximately one pair of Northern Black Korhaan (*Afrotis afraoides*) correspond to the development area (Figure 17). These individuals could become displaced from the study area during the construction phase of the PV arrays.

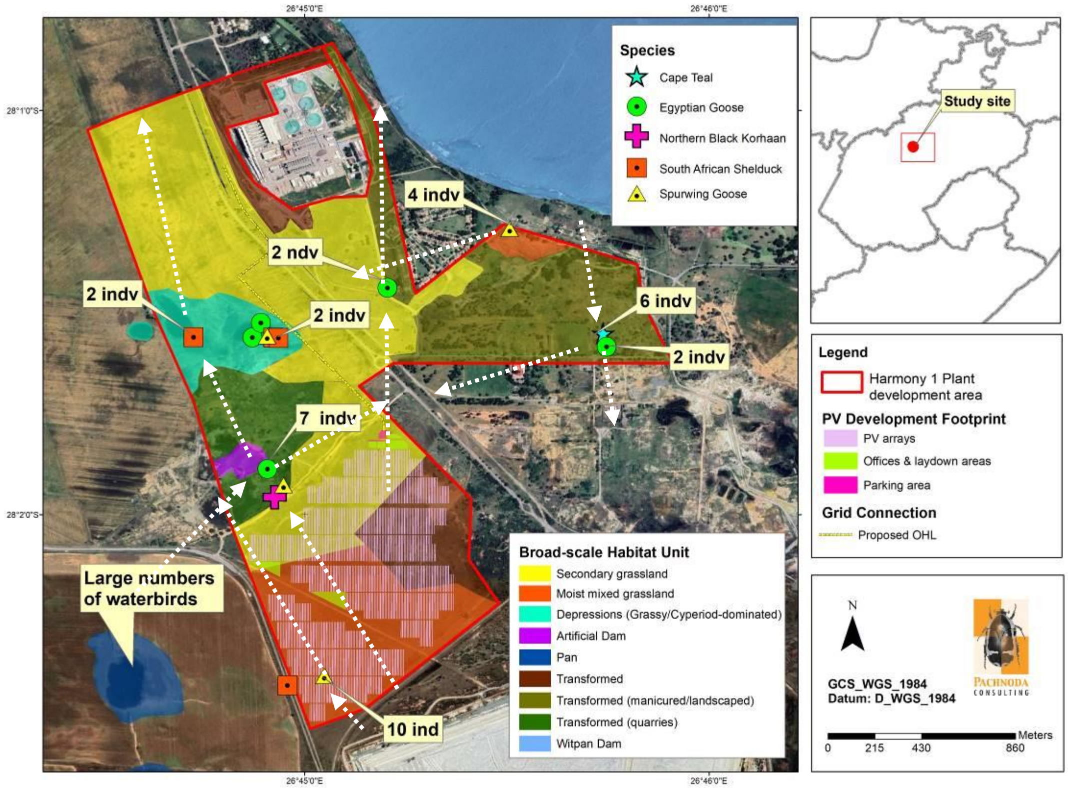


Figure 17: A map of the study area illustrating the occurrence and movements of collision prone birds. Birds without annotations refer to single individuals, and birds without flight directions (arrows) were perched.

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 18):

Areas of high sensitivity

It includes the grassy depressions, all adjacent pans and the proposed buffer zones.

The grassy depressions have the potential to attract passerine bird species with high affinities for wetland-associated habitat units. It thereby contributed towards the local avian richness in supporting bird species that are otherwise absent from the surrounding terrestrial "dryland" grassland units.

More importantly, the nearby pans and the Witpan Dam support large congregations of waterfowl and shorebirds taxa, including globally and regionally threatened and near threatened species (e.g. flamingo taxa). These pans are also important from a functional and dynamic perspective at the landscape level since it forms part of an "inter-connected" system or "stepping stones" within the regional catchment, meaning that environmental conditions at these pans (e.g. water levels, salinity, food availability, availability of shoreline habitat) are constantly changing. Therefore, none of the pans within catchment are similar to each, thereby providing a continuous supply of resources for waterbirds which tend to commute on a daily basis over the study site and along the edges of the slimes dams (which are often inundated). The placement of electrical infrastructure and PV panels in close proximity to these areas as well as on areas where the frequency of fly-overs by waterbirds are high could increase potential avian collisions with the infrastructure. Nevertheless, the inundated quarries are of artificial origin and could be removed.

Areas of medium sensitivity

It includes the moist mixed grassland and the artificial impoundment/quarry. The grassland provide potential suitable foraging habitat for a high number of bird species and bird individuals when compared to the other units. However, reporting rates for threatened and near threatened bird species are anticipated to be relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural. In addition, the inundated quarry attracts small numbers of waterfowl and shorebirds which feed and roost along the margins, especially Spur-winged Goose (*Plectropterus gambiensis*), Egyptian Goose (*Alopochen aegyptiacus*), South African Shelduck (*Tadorna cana*) and Three-banded Plover (*Charadrius tricollaris*).

Areas of low sensitivity

These habitat units are represented by transformed types and include the secondary grasslands, a build-up land and landscaped/manicured areas.

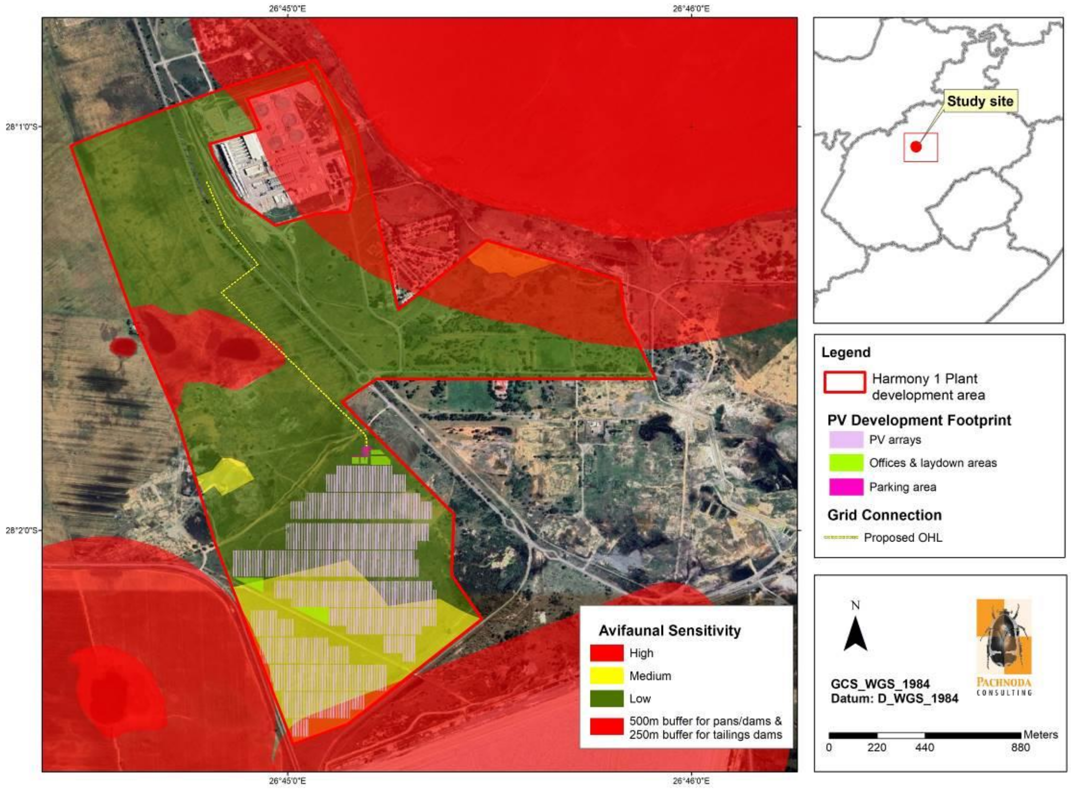


Figure 18: A map illustrating the preliminary avifaunal sensitivity of the area based on habitat types supporting bird taxa of conservation concern and important ecological function.

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.

4.8.2 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 Harmony One Plant Solar PV Facility

Table 8 provides a summary of the impacts anticipated and quantification thereof.

4.9.1 Loss of habitat and displacement of birds

Approximately 75 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 11.54 species.ha^{-1} and 66.79 birds.ha^{-1} will become displaced should the activity occur (as per Jenkins et al., 2017). Displacement will mainly affect regional endemic passerine and smaller non-passerine species inhabiting the open secondary and moist grassland of medium to low avifaunal sensitivity. , At least one pairs of Northern Black Korhaan could become displaced during the construction phase.

- Melodious Lark (*Mirafra cheniana*);
- Cloud Cisticola (*Cisticola textrix*); and to a lesser extend also
- Kalahari Scrub Robin (*Cercotrichas paena*);
- Northern Black Korhaan (*Afrotis afraoides*).

4.9.2 Creation of "new" avian habitat and bird pollution

It is possible that the PV 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*);
- Speckled Pigeon (*Columba guinea*); and potentially also
- Egyptian Goose (*Alopochen aegyptiacus*).

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 same applies to the locally abundant Egyptian Goose (*Alopochen aegyptiacus*) which may roost on the infrastructure. The impact is manageable and will result in a low significance.

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

The presence of pans, inundated quarries and the Witpan Dam in close proximity to the footprint area increase the risk of waterbirds and shorebird taxa interacting with the PV panels. A number of species were observed with a high frequency of occurrence which traversed the development area in on a daily basis (bird dispersing between the pans) which could interact with the PV panels.

The installation of appropriate bird deterrent devices such as a combination of rotating flashers/reflectors, including diverters which emit light during nigh time are essential to increase the visibility of the infrastructure for birds such as flamingos which tend to disperse during the night. Post-construction monitoring to quantify mortalities will be important during the early operational phase in order to determine "hotspot" areas (e.g. areas where bird collisions or mortalities are recorded) which may require additional mitigation measures.

Desktop results and site observations show that the following species could interact with the panel infrastructure:

- South African Shelduck (*Tadorna cana*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Yellow-billed Duck (*Anas undulata*);
- White-faced Duck (*Dendrocygna viduata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- Cape Teal (*Anas capensis*);
- Cape Shoveller (*Anas smithii*);
- Glossy Ibis (*Plegadis falcinellus*);
- Black-winged Stilt (*Himantopus himantopus*);
- Three-banded Plover (*Charadrius tricollaris*); and potentially also
- Greater Flamingo (*Phoenicopterus roseus*);
- Lesser Flamingo (*Phoeniconaias minor*);
- Maccoa Duck (*Oxyura maccoa*);
- White-breasted Cormorant (*Phalacrocorax lucidus*)
- Reed Cormorant (*Microcarbo africanus*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and potentially also
- Little Grebe (*Tachybaptus ruficollis*);
- Black-headed Heron (*Ardea melanocephala*);
- Red-knobbed Coot (*Fulica cristata*);
- Grey Heron (*Ardea cinerea*);
- Little Egret (*Egretta garzetta*);
- Great Egret (*Ardea alba*);
- African Darter (*Anhinga rufa*);
- Common Moorhen (*Gallinula chloropus*) and
- African Swamphen (*Porphyrio madagascariensis*).

4.9.4 Interaction with overhead powerlines and reticulation

A 132kV overhead powerline is proposed to tie-in to the Brand gold (6.6/132 kV) substation. However, the proposed grid corridor will be placed alongside existing overhead powerlines which will greatly increase the visibility of the lines, and thereby reduce the potential for collision-prone bird species to interact with the powerlines. Impacts with powerlines 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.

- *Collision*

Collisions with earth wires have probably accounted for most bird-powerline 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. For the current project it is proposed that the overhead powerlines (including existing lines) also considers the fitment of dynamic devices such as the "Viper live bird flapper" and nocturnal LED solar-charged bird diverters owing to the potential nocturnal flyovers by flamingo taxa.

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

It is anticipated that part of the powerline line servitude will be cleared of vegetation. In addition, construction activities go hand in hand with high ambient noise levels. Although construction is considered temporary, some 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	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Definite (5)	Probable (3)
Significance	**Medium (50)**	**Low (24)**
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 low to medium sensitivity. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerline) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines).		
Residual: Decreased bird species richness, low evenness values and subsequent loss of avian diversity on a local scale. The impact will also result in increased fragmentation of habitat.		

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 competitive 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	Site and immediate surroundings (4)	Site and immediate surroundings (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Medium (6)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**High (64)**	**Medium-High (56)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of waterfowl and certain shorebird taxa species.	Yes, potential loss of waterfowl and certain shorebird taxa species.
Can impacts be mitigated?	Yes, with experimentation	Yes, with experimentation
Mitigation: It is difficult to mitigate against the potential for waterbird species to collide with the PV infrastructure owing to the spatial location of the footprint area (being located in close proximity to a number of wetland features). Apply bird deterrent devices such as rotating flashers/reflectors to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels - these should be placed at panels nearest (facing) to pans and other water features. Bird deterrent devices should also include light-emitting devices to increase the visibility of the PV infrastructure for waterbird species that migrate at night (e.g. flamingo species). Security/CCTV cameras may be installed to quantify mortalities (cameras are also installed along the perimeter fence for security measures and may also prove to be effective to quantify mortalities). Buffer pans/depressions by at least 500m (arrays should be positioned at least 500m away from pans) and tailing facilities by at least 250m (many waterbirds disperse along the inundated edges of these facilities). If 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 moderate.		

4. Nature: Avian collision impacts related to the overhead power line during operation.		
Grid Corridor	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)

Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of collision-prone waterbird 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. 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. Collisions will be reduced if the corridor is placed alongside existing powerlines.		
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 line during operation.		
Grid Corridor	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of collision-prone waterbird species.	Yes (to some extent), owing to the potential loss of collision-prone waterbird species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Avoid the placement of overhead electrical infrastructure in close proximity to wetland features and tailings facilities. 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 80 collision-prone bird species have been recorded from the study area, of which 62 species are waterbirds and 10 species are birds of prey (Table 9). According to Table 9, it is evident that the number of potential collision-prone species that could occur in the study area is high (c. 45% of the total number of bird species recorded 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	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
Abdim's Stork	*Ciconia abdimii*	2.56	1	6.25	1
African Darter	*Anhinga rufa*	41.03	16	6.25	1
African Fish Eagle	*Haliaeetus vocifer*	15.38	6	0.00	0
African Rail	*Rallus caerulescens*	7.69	3	0.00	0
African Sacred Ibis	*Threskiornis aethiopicus*	43.59	17	0.00	0
African Snipe	*Gallinago nigripennis*	33.33	13	6.25	1
African Spoonbill	*Platalea alba*	33.33	13	0.00	0
African Swamphen	*Porphyrio madagascariensis*	79.49	31	6.25	1
Amur Falcon	*Falco amurensis*	2.56	1	0.00	0
Black Crake	*Zapornia flavirostra*	20.51	8	0.00	0
Black Heron	*Egretta ardesiaca*	25.64	10	6.25	1
Black Sparrowhawk	*Accipiter melanoleucus*	5.13	2	0.00	0
Black-crowned Night Heron	*Nycticorax nycticorax*	10.26	4	0.00	0
Black-headed Heron	*Ardea melanocephala*	38.46	15	0.00	0
Black-necked Grebe	*Podiceps nigricollis*	71.79	28	0.00	0
Black-winged Kite	*Elanus caeruleus*	53.85	21	12.50	2
Black-winged Stilt	*Himantopus himantopus*	84.62	33	18.75	3
Blue Korhaan	*Eupodotis caerulescens*	2.56	1	6.25	1
Blue-billed Teal	*Spatula hottentota*	74.36	29	6.25	1
Cape Shoveler	*Spatula smithii*	79.49	31	12.50	2
Cape Teal	*Anas capensis*	79.49	31	12.50	2
Chestnut-banded Plover	*Charadrius pallidus*	7.69	3	0.00	0
Common Buzzard	*Buteo buteo*	7.69	3	6.25	1
Common Greenshank	*Tringa nebularia*	28.21	11	0.00	0
Common Moorhen	*Gallinula chloropus*	87.18	34	0.00	0
Common Ringed Plover	*Charadrius hiaticula*	12.82	5	0.00	0
Common Sandpiper	*Actitis hypoleucos*	25.64	10	6.25	1
Curlew Sandpiper	*Calidris ferruginea*	12.82	5	0.00	0
Egyptian Goose	*Alopochen aegyptiaca*	79.49	31	18.75	3
Fulvous Whistling Duck	*Dendrocygna bicolor*	25.64	10	0.00	0
Giant Kingfisher	*Megaceryle maxima*	5.13	2	0.00	0
Glossy Ibis	*Plegadis falcinellus*	79.49	31	12.50	2
Goliath Heron	*Ardea goliath*	53.85	21	6.25	1
Great Crested Grebe	*Podiceps cristatus*	28.21	11	0.00	0
Great Egret	*Ardea alba*	2.56	1	0.00	0
Greater Flamingo	*Phoenicopterus roseus*	69.23	27	37.50	6
Greater Painted-snipe	*Rostratula benghalensis*	2.56	1	0.00	0
Grey Heron	*Ardea cinerea*	33.33	13	12.50	2

Common Name	Scientific Name	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
Grey Plover	*Pluvialis squatarola*	2.56	1	0.00	0
Grey-headed Gull	*Chroicocephalus cirrocephalus*	69.23	27	6.25	1
Helmeted Guineafowl	*Numida meleagris*	76.92	30	6.25	1
Intermediate Egret	*Ardea intermedia*	20.51	8	0.00	0
Kelp Gull	*Larus dominicanus*	2.56	1	0.00	0
Kittlitz's Plover	*Charadrius pecuarius*	25.64	10	6.25	1
Lanner Falcon	*Falco biarmicus*	2.56	1	0.00	0
Lesser Flamingo	*Phoeniconaias minor*	64.10	25	25.00	4
Lesser Kestrel	*Falco naumanni*	7.69	3	0.00	0
Little Bittern	*Ixobrychus minutus*	5.13	2	0.00	0
Little Egret	*Egretta garzetta*	33.33	13	0.00	0
Little Grebe	*Tachybaptus ruficollis*	79.49	31	12.50	2
Maccoa Duck	*Oxyura maccoa*	58.97	23	12.50	2
Marsh Owl	*Asio capensis*	2.56	1	0.00	0
Marsh Sandpiper	*Tringa stagnatilis*	23.08	9	0.00	0
Northern Black Korhaan	*Afrotis afraoides*	82.05	32	12.50	2
Orange River Francolin	*Scleroptila gutturalis*	15.38	6	0.00	0
Pied Avocet	*Recurvirostra avosetta*	66.67	26	6.25	1
Pied Kingfisher	*Ceryle rudis*	10.26	4	6.25	1
Purple Heron	*Ardea purpurea*	41.03	16	0.00	0
Red-billed Teal	*Anas erythrorhyncha*	82.05	32	0.00	0
Red-knobbed Coot	*Fulica cristata*	92.31	36	25.00	4
Reed Cormorant	*Microcarbo africanus*	79.49	31	6.25	1
Ruff	*Calidris pugnax*	64.10	25	6.25	1
Secretarybird	*Sagittarius serpentarius*	2.56	1	0.00	0
South African Shelduck	*Tadorna cana*	61.54	24	6.25	1
Southern Pochard	*Netta erythrophthalma*	66.67	26	12.50	2
Speckled Pigeon	*Columba guinea*	92.31	36	6.25	1
Spotted Eagle-Owl	*Bubo africanus*	23.08	9	0.00	0
Spur-winged Goose	*Plectropterus gambensis*	71.79	28	12.50	2
Squacco Heron	*Ardeola ralloides*	64.10	25	6.25	1
Swainson's Spurfowl	*Pternistis swainsonii*	74.36	29	18.75	3
Three-banded Plover	*Charadrius tricollaris*	84.62	33	6.25	1
Western Cattle Egret	*Bubulcus ibis*	79.49	31	18.75	3
Whiskered Tern	*Chlidonias hybrida*	48.72	19	0.00	0
White-backed Duck	*Thalassornis leuconotus*	12.82	5	0.00	0
White-breasted Cormorant	*Phalacrocorax lucidus*	48.72	19	6.25	1
White-faced Whistling Duck	*Dendrocygna viduata*	84.62	33	6.25	1
White-winged Tern	*Chlidonias leucopterus*	35.90	14	12.50	2
Wood Sandpiper	*Tringa glareola*	23.08	9	0.00	0
Yellow-billed Duck	*Anas undulata*	82.05	32	6.25	1

Common Name	Scientific Name	SABAP2 Reporting Rate			
		Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
Yellow-billed Stork	*Mycteria ibis*	17.95	7	0.00	0

4.10 Cumulative Impacts

Cumulative impacts are defined as impacts that result from additional or incremental activities caused by past or present actions together with the current project. Therefore, cumulative impacts are those that will affect the general avifaunal community on the study area due to other planned solar farm projects and electrical infrastructure in the region.

Another PV facility (Harmony Central Plant Solar PV facility) of 14MW is planned approximately 10km south-east of the proposed Harmony Central Plant Solar PV facility.

The cumulative impacts are likely to increase the displacement and loss of habitat. In addition while the grid connection (via overhead powerlines) of these facilities could potentially contribute towards bird strikes with powerlines and avian mortalities due to collision in the region.

A summary of the cumulative impacts is provided in Table 10.

Table 10: A summary of the cumulative impacts.

1. Nature: Regional losses of natural habitat and subsequent displacement of birds.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (33)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	No	
Confidence in findings: High.		
Mitigation: It is difficult to mitigate against the loss of habitat without considering alternative sites. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerline) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines) and to concentrate infrastructure on land with		

a low biodiversity conservation value.		
2. Nature: Avian collision impacts related to the PV facility during the operational phase (collision with the PV panels).		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Site and immediate surroundings (4)	Site and immediate surroundings (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	Medium (6)	High (8)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**Medium-High (56)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Low.		
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. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to employ video cameras to document any bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis. Apply appropriate buffer zones to water features and wetlands.		
3. Nature: Avian collision impacts related to the powerline reticulation and new distribution lines during operation.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: High.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. **Allow for construction of new powerlines parallel to existing lines**. 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. As a priority, all new power lines should be marked with bird diverters.		

4. Nature: Avian electrocution related to the powerline reticulation and new distribution lines during operation.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of waterbird taxa.	Yes (to some extent), owing to the potential loss of waterbird taxa and potential threatened and near threatened waterbird taxa
Can impacts be mitigated?	Yes, to some extent	
Confidence in findings: Moderate.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. As a priority, all new power lines should be marked with bird diverters. Make use of bird-friendly pylons and bird guards. **Position electrical infrastructure in close proximity to existing infrastructure**.		

4.11 Recommended avifaunal mitigation

4.11.1 Loss of habitat and displacement bird taxa

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.
- Use indigenous plant species native to the study area 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 powerlines lines.

4.11.2 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.

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

The following mitigation measures are proposed:

- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility as well as arrays facing in the direction of pans and other water features) to discourage birds from colonising/colliding with the infrastructure. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, flashers, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. The devices should also include light-emitting devices to increase the visibility of the PV infrastructure for waterbird species that migrate at night (e.g. flamingo species). An option is to employ video cameras at selected areas to document bird mortalities.
- Buffer pans by at least 500m (arrays should be positioned at least 500m away from pans /dams/depressions). Many waterbirds were also observed dispersing along the inundated edges of the tailings facilities when commuting between pans – it is recommended that tailings facilities be buffered by at least 200-250m.
- 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.

4.11.4 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.
- Position the proposed grid connection alongside existing powerline servitudes.
- 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 19[8].

From Figure 19 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).

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

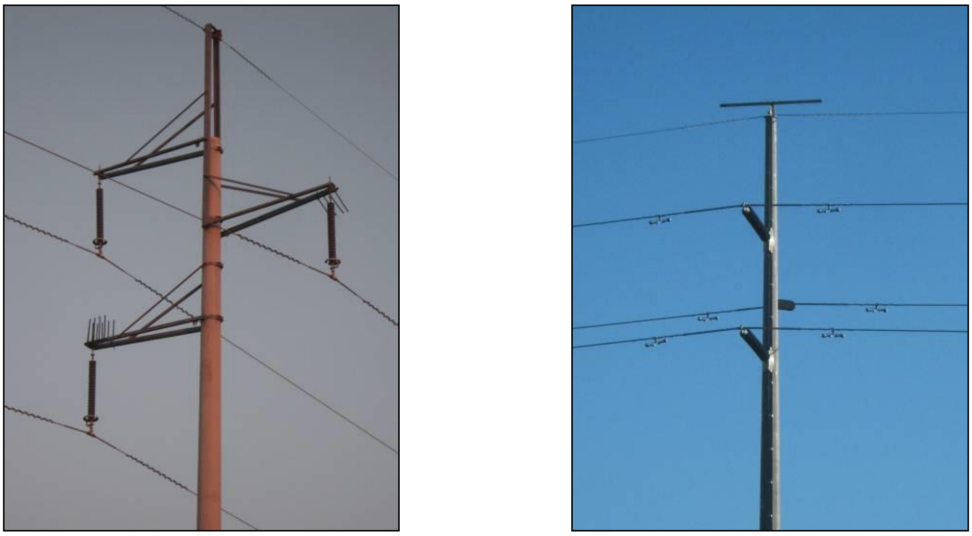
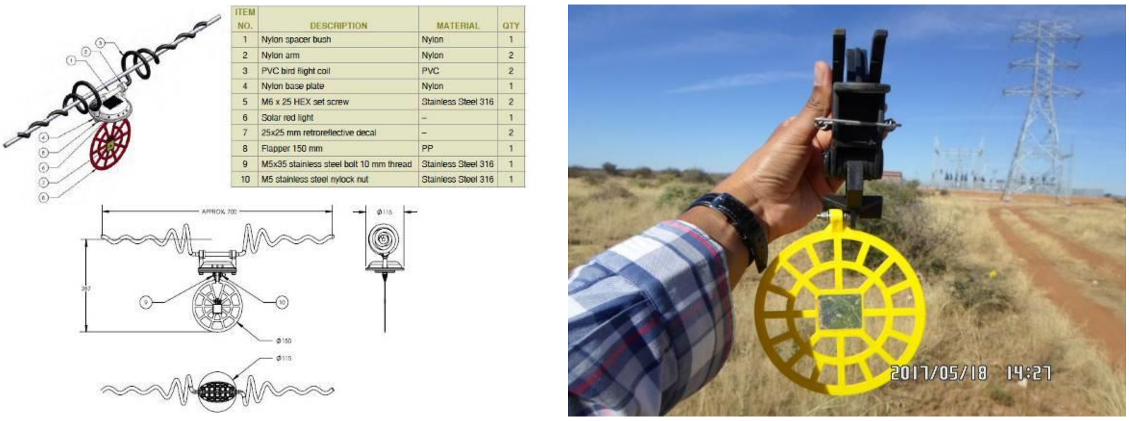


Figure 19: Two bird-friendly tower designs to be considered for the current project.

- All new and planned power lines should be fitted with bird flight diverters (see Figure 20). For the current project it is proposed that the overhead powerlines consider the fitment of dynamic devices such as the "Viper live bird flapper" and nocturnal LED solar-charged bird diverters owing to potential nocturnal flyovers by flamingo taxa. Flappers should be applied to earth wires while alternating between different colours (e.g. between black and yellow or black and red) and should be fitted to the middle 60 % of the span (corresponding to the lower part of the span). All flappers should be spaced at 5 m intervals from each other.



ITEM NO.	DESCRIPTION	MATERIAL	QTY
1	Nylon spacer bush	Nylon	1
2	Nylon arm	Nylon	2
3	PVC bird flight coil	PVC	2
4	Nylon base plate	Nylon	1
5	M6 x 25 HEX set screw	Stainless Steel 316	2
6	Solar red light	–	1
7	25x25 mm retroreflective decal	–	2
8	Flapper 150 mm	PP	1
9	M5x35 stainless steel bolt 10 mm thread	Stainless Steel 316	1
10	M5 stainless steel nylock nut	Stainless Steel 316	1

Figure 20: Examples of bird flight diverters to be used on the power lines: Nocturnal LED solar-charged bird diverter (left) and Viper live bird flapper (right).

4.11.5 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.

4.12 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 post construction monitoring be implemented to augment existing data:

- At least one additional pre-construction survey is recommended, consisting of a minimum of 2 days which is necessary to inform the final EMPr during operation. The survey should coincide with the **peak wet season** when most of the nearby wetland features in the wider study region are inundated.
- A post-construction survey during operation with a minimum of 3 x 3-4 day surveys over 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 the use of installed video cameras) 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 species of conservation concern.
- It is possible that mortalities due to collision will occur at the powerlines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities caused by the powerline network. Monitoring should be implemented once a month for at least one year. All searches should be done on foot. 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 species of conservation concern.

OBJECTIVE 1: Minimize 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	» Construction and operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	**Responsibility**	**Timeframe**
• 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, flashers, 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)
• 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)
• Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
• Implement post-construction monitoring and carcass surveys	OM & CER	Directly after construction and during operation - At least 3 surveys, each 3-4 days for a 6 month period
• Implement pre-construction monitoring protocols (as per Jenkins et al., 2017)	OM & CER	Prior to construction - At least 1 survey of 2 days (during wet season)
• 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	• Implement at least one pre-construction survey consisting of a minimum of 2 days.

	• Implement post-construction surveys during operation with a minimum of 3 x 3-4 day surveys over a six month period (including the peak wet season). • Surveys should coincide with the peak wet season when most of the wetland features in the wider study region are inundated. • Obtain quantified data on waterbird richness and potential flyways, which will contribute towards our understanding of impacts related to collision trauma with the panels. • Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. • Conduct post-construction monitoring in a systematic manner by means of direct observations and the use of installed video cameras and carcass searches. • 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: Minimize collisions and electrocution associated with powerlines

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

Mitigation: Action/Control	Responsibility	Timeframe
• Apply bird deterrent devices to all new powerlines	ECO & CER	Construction
• Implement post-construction monitoring and carcass surveys	OM & CER	Operation - once a month for at least one year
• Compile management programme to assess efficacy of mitigation and on-going research/trials	OM	Operation (on-going)
• Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT	OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement post-construction monitoring to quantify bird mortalities caused by the powerline network. All searches should be done on foot. • 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.

4.13 Opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Freegold Harmony (Pty) Ltd to compile an avifauna baseline report for the proposed Harmony One Plant Solar PV facility and associated infrastructure with a contracted capacity of up to 30MW located in the town of Welkom and 14km north west of the town of Virginia, Free State Province.

Five avifaunal habitat types were identified on the study area and surroundings, ranging from moist mixed and secondary grassland, grassy depressions and inundated quarries to transformed and landscape/manicured areas. The study area was also surrounded by a number of pans and the Witpan Dam, which provided foraging and roosting habitat for a large number of waterbird taxa. Approximately 178 bird species are expected to occur in the wider study area, of which 88 species were observed in the study area (during two surveys). The expected richness included 11 threatened or near threatened species, 14 southern African endemics and 11 near-endemic species. The vulnerable Lanner Falcon (*Falco biarmicus*) was observed on the study site (during a fly-over), while the near threatened Greater flamingo (Ph*oenicopterus roseus*) and Lesser Flamingo (*Phoeniconaias minor*) were observed at the nearby Witpan Dam. Ten southern African endemics and six near-endemic species were confirmed on the study site.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was predicted to be moderate-high to low after mitigation (depending on the type of impact). **However, the risk for waterbirds and shorebirds (including flamingo taxa) colliding with the PV infrastructure remained eminent due to the presence of inundated pans and dams in the study area and dispersal routes coinciding with the study area**. **Waterbird interactions with the PV infrastructure was predicted as persistent due to the spatial location of the proposed footprint site (surrounded by water features of which some sustain large numbers of birds).** It was strongly recommended that the proposed mitigation measures and monitoring protocols (e.g. post construction monitoring) be implemented during the construction and operational phase of the project (e.g. the installation of appropriate bird diverters to minimise the potential risk of collision trauma in birds).

5. REFERENCES

Birdlife South Africa. 2022. *BirdLife South Africa Checklist of Birds in South Africa*, 2022.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L. 1993. *Distance Sampling: Estimating abundance of biological populations*. Chapman and Hall, London.

Clarke, K.R. & Warwick, R.M. 1994. *Changes in marine communities: An approach to statistical analysis and interpretation*. Natural Environmental Research Council, United Kingdom.

Del Hoyo, J., Elliott, A. & Christie, D.A. eds. 1992-2011. *Handbook of the Birds of the World.* Vol 1-16. Lynx Edicions, Barcelona.

Geoterrainimage. 2015. *The South African National Land cover Dataset*. Version 05.

Gill, F, Donsker, D., & Rasmussen, P. (Eds). 2022. *IOC World Bird List* (v 12.2). Doi 10.14344/IOC.ML.12.1. http://www.worldbirdnames.org/.

Gunerhan, H., Hepbasli, A. & Giresunlu, U. 2009. Environmental impacts from the solar energy systems. Energy Sources, Part A: *Recovery, Utilization and Environmental Effects* 31: 131-138.

Hardaker, T. 2022. Southern African Bird List - Version 11 - 29 August 2022.

Harrison, C., Lloyd, H. & Field, C. 2016. *Evidence review of the impact of solar farms on birds, bats and general ecology*. NEER012 report, Manchester Metropolitan University, UK.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. & Brown, C.J. (eds.). 1997. *The Atlas of Southern African Birds. Vol. 1 & 2*. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J. & Ryan, P.G. (eds.) 2005. *Roberts – Birds of Southern Africa*, VIIth ed. The Trustees of the John Voelker Bird Book Fund, Cape Town.

IUCN Red List of Threatened Species. Version 2022. http://www.iucnredlist.org/.

Jenkins, A.R, Ralston-Paton, S & Smit-Robinson, H.A. 2017. Best practice guidelines: Birds and Solar Energy. Guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa. BirdLife South Africa.

Kagen, R.A., Verner, T.C., Trail, PW & Espinoza, E.O. 2014. Avian mortality at solar energy facilities in southern California: A preliminary analysis. Unpublished report by the National Fish and Wildlife Forensics Laboratory, USA.

Kruger, R. 1999. *Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa.* M. Phil. Mini-thesis. University of the Orange Free State. Bloemfontein. South Africa.

Ledger, J. & Annegarn, H.J. 1981. Electrocution Hazards to the Cape Vulture (*Gyps coprotheres*) in South Africa. *Biological Conservation* 20: 15-24.

Marnewick, M.D., Retief, E.F., Theron, N.T., Wright, D.R. And Anderson, T.A. 2015. *Important Bird and Biodiversity Areas of South Africa*. Johannesburg: BirdLife South Africa.

McCrary, M.D., McKernan, R.L., Schreiber, R.W., Wagner, W.D. & Sciarotta, T.C. 1986. Avian mortality at a solar energy power plant. *Journal of Field Ornithology* 57: 135-141.

Mucina, L. & Rutherford, M.C. (eds.). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19*. South African National Biodiversity Institute, Pretoria.

Ruddock, M. and Whitfield, D.P. 2007. *A Review of disturbance distances in selected bird Species*. A report from Natural Research (Projects) Ltd to Scottish Natural Heritage.

Sutherland, W.J. 2006. *Ecological census techniques. A handbook*. 2nd Edn. Cambridge University Press.

Sutherland, W.J., Newton, I. and Green, R. E. 2004. *Bird Ecology and Conservation. A handbook of techniques*. Oxford University Press.

Taylor, M.R., Peacock, F. & Wanless, R. (eds.). 2015. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg

Tsoutsos, T., Frantzeskaki, N. & Gekas, V. 2005. Environmental impacts from solar energy technologies. *Energy Policy* 33: 289-296.

Van Rooyen, C.S. 2000. An overview of Vulture Electrocutions in South Africa. *Vulture News* 43: 5-22.

Van Rooyen, C.S. & Taylor, P.V. 1999. *Bird streamers as probable cause of electrocutions in South Africa*. EPRI Workshop on Avian Interactions with Utility Structures, Charleston, South Carolina.

Vosloo, H. 2003. Birds and power lines. *ESI Africa* 3: 38.

Walston Jr. L.J., Rollins, K.E., LaGory, K.E., Smith, K.P. & Meyers, S.A. 2016. A preliminary assessment of avian mortality at utility-scale solar energy facilities in the United States. *Renewable Energy* 92 (2016) 405-414.

Watson, D.M. 2003. The 'standardized search': An improved way to conduct bird surveys. *Austral Ecology* 28: 515-525

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Appendix 1: A shortlist of bird species recorded on the development area 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 grids 2800_2640 and 2800_2645 (the eight surrounding grids were also consulted) and from personal observations. The reporting rates include submissions made during the June and July 2022 surveys.

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
78	Abdim's Stork	*Ciconia abdimii*		2.56	1	6.25	1
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	33.33	13	0.00	0
52	African Darter	*Anhinga rufa*	1	41.03	16	6.25	1
149	African Fish Eagle	*Haliaeetus vocifer*		15.38	6	0.00	0
418	African Hoopoe	*Upupa africana*	1	17.95	7	0.00	0
228	African Jacana	*Actophilornis africanus*		2.56	1	0.00	0
387	African Palm Swift	*Cypsiurus parvus*		58.97	23	0.00	0
692	African Pipit	*Anthus cinnamomeus*	1	76.92	30	18.75	3
197	African Rail	*Rallus caerulescens*		7.69	3	0.00	0
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	30.77	12	6.25	1
606	Common Reed Warbler	*Acrocephalus scirpaceus baeticatus*		41.03	16	0.00	0
81	African Sacred Ibis	*Threskiornis aethiopicus*	1	43.59	17	0.00	0
250	African Snipe	*Gallinago nigripennis*	1	33.33	13	6.25	1
85	African Spoonbill	*Platalea alba*		33.33	13	0.00	0
576	African Stonechat	*Saxicola torquatus*	1	79.49	31	12.50	2
208	African Swamphen	*Porphyrio madagascariensis*	1	79.49	31	6.25	1
119	Amur Falcon	*Falco amurensis*		2.56	1	0.00	0
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	56.41	22	18.75	3
493	Barn Swallow	*Hirundo rustica*		43.59	17	12.50	2

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
203	Black Crake	*Zapornia flavirostra*	1	20.51	8	0.00	0
64	Black Heron	*Egretta ardesiaca*		25.64	10	6.25	1
159	Black Sparrowhawk	*Accipiter melanoleucus*		5.13	2	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	94.87	37	12.50	2
431	Black-collared Barbet	*Lybius torquatus*	1	5.13	2	0.00	0
69	Black-crowned Night Heron	*Nycticorax nycticorax*		10.26	4	0.00	0
55	Black-headed Heron	*Ardea melanocephala*	1	38.46	15	0.00	0
5	Black-necked Grebe	*Podiceps nigricollis*		71.79	28	0.00	0
245	Blacksmith Lapwing	*Vanellus armatus*	1	92.31	36	31.25	5
860	Black-throated Canary	*Crithagra atrogularis*	1	79.49	31	6.25	1
130	Black-winged Kite	*Elanus caeruleus*		53.85	21	12.50	2
270	Black-winged Stilt	*Himantopus himantopus*	1	84.62	33	18.75	3
223	Blue Korhaan	*Eupodotis caerulescens*		2.56	1	6.25	1
839	Blue Waxbill	*Uraeginthus angolensis*		2.56	1	0.00	0
99	Blue-billed Teal	*Spatula hottentota*		74.36	29	6.25	1
722	Bokmakierie	*Telophorus zeylonus*	1	15.38	6	0.00	0
714	Brown-crowned Tchagra	*Tchagra australis*		2.56	1	0.00	0
509	Brown-throated Martin	*Riparia paludicola*	1	71.79	28	6.25	1
703	Cape Longclaw	*Macronyx capensis*	1	74.36	29	12.50	2
581	Cape Robin-Chat	*Cossypha caffra*	1	15.38	6	0.00	0
94	Cape Shoveler	*Spatula smithii*	1	79.49	31	12.50	2
786	Cape Sparrow	*Passer melanurus*	1	92.31	36	25.00	4
737	Cape Starling	*Lamprotornis nitens*	1	23.08	9	0.00	0
98	Cape Teal	*Anas capensis*	1	79.49	31	12.50	2

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
316	Ring-necked Dove	*Streptopelia capicola*	1	97.44	38	18.75	3
686	Cape Wagtail	*Motacilla capensis*	1	92.31	36	6.25	1
450	Cardinal Woodpecker	*Dendropicos fuscescens*		7.69	3	0.00	0
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*		2.56	1	0.00	0
236	Chestnut-banded Plover	*Charadrius pallidus*		7.69	3	0.00	0
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	15.38	6	6.25	1
631	Cloud Cisticola	*Cisticola textrix*	1	33.33	13	6.25	1
154	Common (Steppe) Buzzard	*Buteo Buteo vulpinus*		7.69	3	6.25	1
263	Common Greenshank	*Tringa nebularia*		28.21	11	0.00	0
210	Common Moorhen	*Gallinula chloropus*	1	87.18	34	0.00	0
734	Common Myna	*Acridotheres tristis*	1	66.67	26	0.00	0
189	Common Quail	*Coturnix coturnix*		5.13	2	0.00	0
233	Common Ringed Plover	*Charadrius hiaticula*		12.82	5	0.00	0
258	Common Sandpiper	*Actitis hypoleucos*		25.64	10	6.25	1
421	Common Scimitarbill	*Rhinopomastus cyanomelas*	1	n/a	1	-	-
733	Common Starling	*Sturnus vulgaris*		2.56	1	0.00	0
378	Common Swift	*Apus apus*		2.56	1	0.00	0
843	Common Waxbill	*Estrilda astrild*	1	28.21	11	0.00	0
439	Crested Barbet	*Trachyphonus vaillantii*	1	41.03	16	0.00	0
242	Crowned Lapwing	*Vanellus coronatus*	1	92.31	36	12.50	2
251	Curlew Sandpiper	*Calidris ferruginea*		12.82	5	0.00	0
630	Desert Cisticola	*Cisticola aridulus*	1	53.85	21	0.00	0
352	Diederik Cuckoo	*Chrysococcyx caprius*		30.77	12	0.00	0
278	Double-banded Courser	*Rhinoptilus africanus*		20.51	8	6.25	1

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
89	Egyptian Goose	*Alopochen aegyptiaca*	1	79.49	31	18.75	3
404	European Bee-eater	*Merops apiaster*		28.21	11	0.00	0
678	Fairy Flycatcher	*Stenostira scita*		7.69	3	0.00	0
570	Familiar Chat	*Oenanthe familiaris*	1	2.56	1	0.00	0
665	Fiscal Flycatcher	*Melaenornis silens*		5.13	2	6.25	1
101	Fulvous Whistling Duck	*Dendrocygna bicolor*		25.64	10	0.00	0
395	Giant Kingfisher	*Megaceryle maxima*		5.13	2	0.00	0
83	Glossy Ibis	*Plegadis falcinellus*	1	79.49	31	12.50	2
56	Goliath Heron	*Ardea goliath*		53.85	21	6.25	1
4	Great Crested Grebe	*Podiceps cristatus*		28.21	11	0.00	0
58	Great Egret	*Ardea alba*		2.56	1	0.00	0
603	Great Reed Warbler	*Acrocephalus arundinaceus*		7.69	3	0.00	0
86	Greater Flamingo	*Phoenicopterus roseus*	1	69.23	27	37.50	6
230	Greater Painted-snipe	*Rostratula benghalensis*		2.56	1	0.00	0
502	Greater Striped Swallow	*Cecropis cucullata*		41.03	16	0.00	0
419	Green Wood Hoopoe	*Phoeniculus purpureus*		5.13	2	0.00	0
54	Grey Heron	*Ardea cinerea*	1	33.33	13	12.50	2
241	Grey Plover	*Pluvialis squatarola*		2.56	1	0.00	0
288	Grey-headed Gull	*Chroicocephalus cirrocephalus*	1	69.23	27	6.25	1
84	Hadada Ibis	*Bostrychia hagedash*	1	82.05	32	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*	1	76.92	30	6.25	1
784	House Sparrow	*Passer domesticus*	1	7.69	3	0.00	0
60	Intermediate Egret	*Ardea intermedia*		20.51	8	0.00	0
586	Kalahari Scrub Robin	*Cercotrichas paena*		2.56	1	6.25	1

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
583	Karoo Scrub Robin	*Cercotrichas coryphoeus*		2.56	1	6.25	1
1104	Karoo Thrush	*Turdus smithi*	1	10.26	4	0.00	0
237	Kittlitz's Plover	*Charadrius pecuarius*		25.64	10	6.25	1
114	Lanner Falcon	*Falco biarmicus*	1	2.56	1	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	84.62	33	25.00	4
87	Lesser Flamingo	*Phoeniconaias minor*	1	64.10	25	25.00	4
125	Lesser Kestrel	*Falco naumanni*		7.69	3	0.00	0
604	Lesser Swamp Warbler	*Acrocephalus gracilirostris*	1	82.05	32	0.00	0
646	Levaillant's Cisticola	*Cisticola tinniens*	1	92.31	36	0.00	0
67	Little Bittern	*Ixobrychus minutus*		5.13	2	0.00	0
59	Little Egret	*Egretta garzetta*		33.33	13	0.00	0
6	Little Grebe	*Tachybaptus ruficollis*	1	79.49	31	12.50	2
253	Little Stint	*Calidris minuta*		56.41	22	0.00	0
385	Little Swift	*Apus affinis*	1	61.54	24	0.00	0
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		2.56	1	0.00	0
818	Long-tailed Widowbird	*Euplectes progne*	1	64.10	25	18.75	3
103	Maccoa Duck	*Oxyura maccoa*		58.97	23	12.50	2
397	Malachite Kingfisher	*Corythornis cristatus*		17.95	7	0.00	0
361	Marsh Owl	*Asio capensis*		2.56	1	0.00	0
262	Marsh Sandpiper	*Tringa stagnatilis*		23.08	9	0.00	0
456	Melodious Lark	*Mirafra cheniana*	1	n/a			
564	Mountain Wheatear	*Myrmecocichla monticola*		2.56	1	6.25	1
318	Namaqua Dove	*Oena capensis*		28.21	11	0.00	0
637	Neddicky	*Cisticola fulvicapilla*	1	41.03	16	12.50	2

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
1035	Northern Black Korhaan	*Afrotis afraoides*	1	82.05	32	12.50	2
179	Orange River Francolin	*Scleroptila gutturalis*		15.38	6	0.00	0
1171	Orange River White-eye	*Zosterops pallidus*	1	23.08	9	0.00	0
838	Orange-breasted Waxbill	*Amandava subflava*	1	51.28	20	0.00	0
269	Pied Avocet	*Recurvirostra avosetta*		66.67	26	6.25	1
394	Pied Kingfisher	*Ceryle rudis*		10.26	4	6.25	1
746	Pied Starling	*Lamprotornis bicolor*	1	64.10	25	6.25	1
846	Pin-tailed Whydah	*Vidua macroura*	1	35.90	14	6.25	1
57	Purple Heron	*Ardea purpurea*		41.03	16	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	61.54	24	6.25	1
708	Red-backed Shrike	*Lanius collurio*		2.56	1	0.00	0
837	Red-billed Firefinch	*Lagonosticta senegala*		20.51	8	0.00	0
805	Red-billed Quelea	*Quelea quelea*	1	61.54	24	12.50	2
97	Red-billed Teal	*Anas erythrorhyncha*	1	82.05	32	0.00	0
488	Red-capped Lark	*Calandrella cinerea*	1	35.90	14	6.25	1
314	Red-eyed Dove	*Streptopelia semitorquata*	1	84.62	33	6.25	1
392	Red-faced Mousebird	*Urocolius indicus*	1	43.59	17	0.00	0
820	Red-headed Finch	*Amadina erythrocephala*		25.64	10	0.00	0
212	Red-knobbed Coot	*Fulica cristata*	1	92.31	36	25.00	4
453	Red-throated Wryneck	*Jynx ruficollis*		5.13	2	0.00	0
50	Reed Cormorant	*Microcarbo africanus*	1	79.49	31	6.25	1
940	Rock Dove	*Columba livia*		12.82	5	0.00	0
256	Ruff	*Calidris pugnax*		64.10	25	6.25	1
458	Rufous-naped Lark	*Mirafra africana*	1	41.03	16	6.25	1

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
789	Scaly-feathered Weaver	*Sporopipes squamifrons*		2.56	1	6.25	1
105	Secretarybird	*Sagittarius serpentarius*		2.56	1	0.00	0
504	South African Cliff Swallow	*Petrochelidon spilodera*		20.51	8	0.00	0
90	South African Shelduck	*Tadorna cana*	1	61.54	24	6.25	1
707	Southern Fiscal	*Lanius collaris*	1	89.74	35	25.00	4
4142	Southern Grey-headed Sparrow	*Passer diffusus*	1	23.08	9	0.00	0
803	Southern Masked Weaver	*Ploceus velatus*	1	97.44	38	18.75	3
102	Southern Pochard	*Netta erythrophthalma*		66.67	26	12.50	2
808	Southern Red Bishop	*Euplectes orix*	1	84.62	33	18.75	3
390	Speckled Mousebird	*Colius striatus*		10.26	4	0.00	0
311	Speckled Pigeon	*Columba guinea*	1	92.31	36	6.25	1
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	46.15	18	0.00	0
368	Spotted Eagle-Owl	*Bubo africanus*		23.08	9	0.00	0
275	Spotted Thick-knee	*Burhinus capensis*		2.56	1	0.00	0
88	Spur-winged Goose	*Plectropterus gambensis*	1	71.79	28	12.50	2
62	Squacco Heron	*Ardeola ralloides*		64.10	25	6.25	1
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	74.36	29	18.75	3
238	Three-banded Plover	*Charadrius tricollaris*	1	84.62	33	6.25	1
851	Village Indigobird	*Vidua chalybeata*		7.69	3	0.00	0
735	Wattled Starling	*Creatophora cinerea*	1	41.03	16	6.25	1
61	Western Cattle Egret	*Bubulcus ibis*	1	79.49	31	18.75	3
305	Whiskered Tern	*Chlidonias hybrida*		48.72	19	0.00	0
104	White-backed Duck	*Thalassornis leuconotus*		12.82	5	0.00	0
391	White-backed Mousebird	*Colius colius*	1	15.38	6	0.00	0

#	Common Name	Scientific Name	Observed (Jun./Jul 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
763	White-bellied Sunbird	*Cinnyris talatala*		2.56	1	0.00	0
47	White-breasted Cormorant	*Phalacrocorax lucidus*	1	48.72	19	6.25	1
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	94.87	37	12.50	2
100	White-faced Whistling Duck	*Dendrocygna viduata*	1	84.62	33	6.25	1
383	White-rumped Swift	*Apus caffer*		25.64	10	0.00	0
495	White-throated Swallow	*Hirundo albigularis*		53.85	21	12.50	2
304	White-winged Tern	*Chlidonias leucopterus*		35.90	14	12.50	2
814	White-winged Widowbird	*Euplectes albonotatus*		2.56	1	0.00	0
599	Willow Warbler	*Phylloscopus trochilus*		17.95	7	0.00	0
264	Wood Sandpiper	*Tringa glareola*		23.08	9	0.00	0
866	Yellow Canary	*Crithagra flaviventris*		33.33	13	0.00	0
96	Yellow-billed Duck	*Anas undulata*	1	82.05	32	6.25	1
76	Yellow-billed Stork	*Mycteria ibis*		17.95	7	0.00	0
812	Yellow-crowned Bishop	*Euplectes afer*		30.77	12	6.25	1
629	Zitting Cisticola	*Cisticola juncidis*	1	46.15	18	0.00	0

Appendix 2: Preliminary density estimates of birds recorded from the study area and immediate surroundings during two independent surveys conducted during June and July 2022.

Species	har02	har03	har04	har05	har06	har07	har08	har09	har10	har11	Mean birds/ha
African Pipit	2	1	1	1	1	2	0	0	0	0	**0.103**
Red-capped Lark	5	2	3	0	3	3	0	0	0.5	0	**0.212**
Zitting Cisticola	0.5	0.5	0.5	0.5	0	1	0	0	0.5	0	**0.045**
Cloud Cisticola	0.5	0	0.5	0.5	0.5	0.5	0	0	0	0	**0.032**
Common Myna	0	0	0	0	0	0	2	1	1.5	1	**0.071**
Desert Cisticola	0.5	0	0.5	0.5	0	0	0	0	0.5	0	**0.026**
Melodious Lark	1	0	0.5	0	1	0.5	0	0	0	0	**0.038**
Quailfinch	2	1	0	0	4	1.5	0	0	0	0	**0.109**
Southern Masked Weaver	1	0	0	0	0	0	0	2	2	2	**0.090**
White-browed Sparrow-weaver	0	0	0	0	0	0	4	8.5	11	9.5	**0.423**
Cape Longclaw	0.5	0	0	0	1	1.5	0	0	0	0	**0.038**
Southern Fiscal	0	0	0	0	0	0	0	0.5	0.5	0.5	**0.019**
Southern Red Bishop	0	0	0	0	1.5	12.5	0	0	5	0	**0.244**
Orange River White-eye	0	0	0	0	0	0	0	1	0	1	**0.026**
Ant-eating Chat	0	0	1	0.5	0	0	0	0	0	0	**0.019**
Black-chested Prinia	0	0	0	0	0	0	0	1	1	0	**0.026**
Black-throated Canary	0	0	0	0	0	0	0	1	0	1	**0.026**
Capped Wheatear	0.5	0.5	0	0	0	0	0	0	0	0	**0.013**
Cape Wagtail	1	0	0	0	0	0	0	0	0.5	0	**0.019**
Long-tailed Widowbird	0	0	0	0	5	15	0	0	0	0	**0.256**
Bokmakierie	0	0	0	0	0	0	0	1	0	1	**0.026**
Orange-breasted Waxbill	2.5	4	0	0	0	0	0	0	0	0	**0.083**
Pied Starling	0	0	0	0	0.5	0.5	0	0	0	0	**0.013**

Species	har02	har03	har04	har05	har06	har07	har08	har09	har10	har11	Mean birds/ha
Red-billed Quelea	0	0	0	0	100	250	0	0	0	0	**4.487**
Rufous-naped Lark	0	0	0	1	1.5	0	0	0	0	0	**0.032**
Neddicky	0	0	0	0	0	0	0	0	0.5	0	**0.006**
African Red-eyed Bulbul	0	0	0	0	0	0	0	0	0	2	**0.026**
Cape Robin-chat	0	0	0	0	0	0	0	0	0.5	0	**0.006**
Cape Sparrow	2	0	0	0	0	0	0	0	0	0	**0.026**
Cape Starling	0	0	0	0	0	0	0	0	0	2	**0.026**
Chestnut-vented Warbler	0	0	0	0	0	0	0	1	0	0	**0.013**
Familiar Chat	0	0	0	0	0	0	0	0	0	1	**0.013**
Levaillant's Cisticola	0	0	0	0	0	0.5	0	0	0	0	**0.006**
Southern Grey-headed Sparrow	0	0	0	0	0	0	0	0.5	0	0	**0.006**
Wattled Starling	0	0	0	0	0	0	0	0	0	6	**0.077**
Number of individuals	19.00	9.00	7.00	4.00	119.00	288.50	6.00	17.50	24.00	27.00	
Number of species	13	6	7	6	11	12	2	10	12	11	
Number of birds/ha	**24.36**	**11.54**	**8.97**	**5.13**	**152.56**	**369.87**	**7.69**	**22.44**	**30.77**	**34.62**	
Number of species/ha	**16.67**	**7.69**	**8.97**	**7.69**	**14.10**	**15.38**	**2.56**	**12.82**	**15.38**	**14.10**	
Average number of birds/ha	**66.79**										
Average number of species/ha	**11.54**										