AVIFAUNAL IMPACT ASSESSMENT

Moriri Solar Photovoltaic (PV) Energy Facility, Northern Cape Province (PV2)

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EXECUTIVE SUMMARY

Great Karoo Renewable Energy (Pty) Ltd is proposing the construction and operation of a photovoltaic (PV) solar energy facility, to be known as the Moriri Solar PV Facility, and associated infrastructure on Portion 0 of Farm Rondavel 85, located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province. The project is planned as part of a larger cluster of renewable energy projects, which include two (2) 140MW Wind Energy Facilities (known as Merino Wind Farm and Angora Wind Farm) two (2) additional 100MW PV facilities (known as Nku Solar PV and Kwana Solar PV), as well as the grid connection infrastructure connecting the renewable energy facilities to the existing Eskom Gamma Substation.

A preferred project site with an extent of ~29 909ha and a development area of ~577ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Moriri Solar PV Facility with a contracted capacity of up to 100MW.

The SABAP2 data indicates that a total of 164 bird species could potentially occur within the broader area – Appendix 1 provides a comprehensive list of all the species. Of these, 61 species are classified as priority species and 12 of these are South African Red List species. Of the priority species, 27 are likely to occur regularly at the development area.

The table below is a table with a summarised assessment of the anticipated impacts.

Summarised assessment of the anticipated impacts

Environmental Parameter	Nature of the Impact	Rating prior to mitigation	Rating post mitigation
Avifauna	Displacement of priority species due to disturbance associated with construction of the PV plant and associated infrastructure.	55 MEDIUM	45 MEDIUM
	Displacement of priority species due to habitat transformation associated with construction of the PV plant and associated infrastructure.	65 HIGH	44 MEDIUM
	Mortality of priority species due to collisions with solar panels.	20 LOW	20 LOW
	Entrapment of large-bodied birds in the double perimeter fence.	36 MEDIUM	20 LOW
	Mortality of priority species due to electrocution on the medium voltage internal reticulation network	42 MEDIUM	10 LOW
	Mortality of priority species due to collisions with the medium voltage internal reticulation network	36 MEDIUM	20 LOW
	Displacement of priority species due to disturbance associated with decommissioning of the PV plant and associated infrastructure.	55 MEDIUM	45 MEDIUM

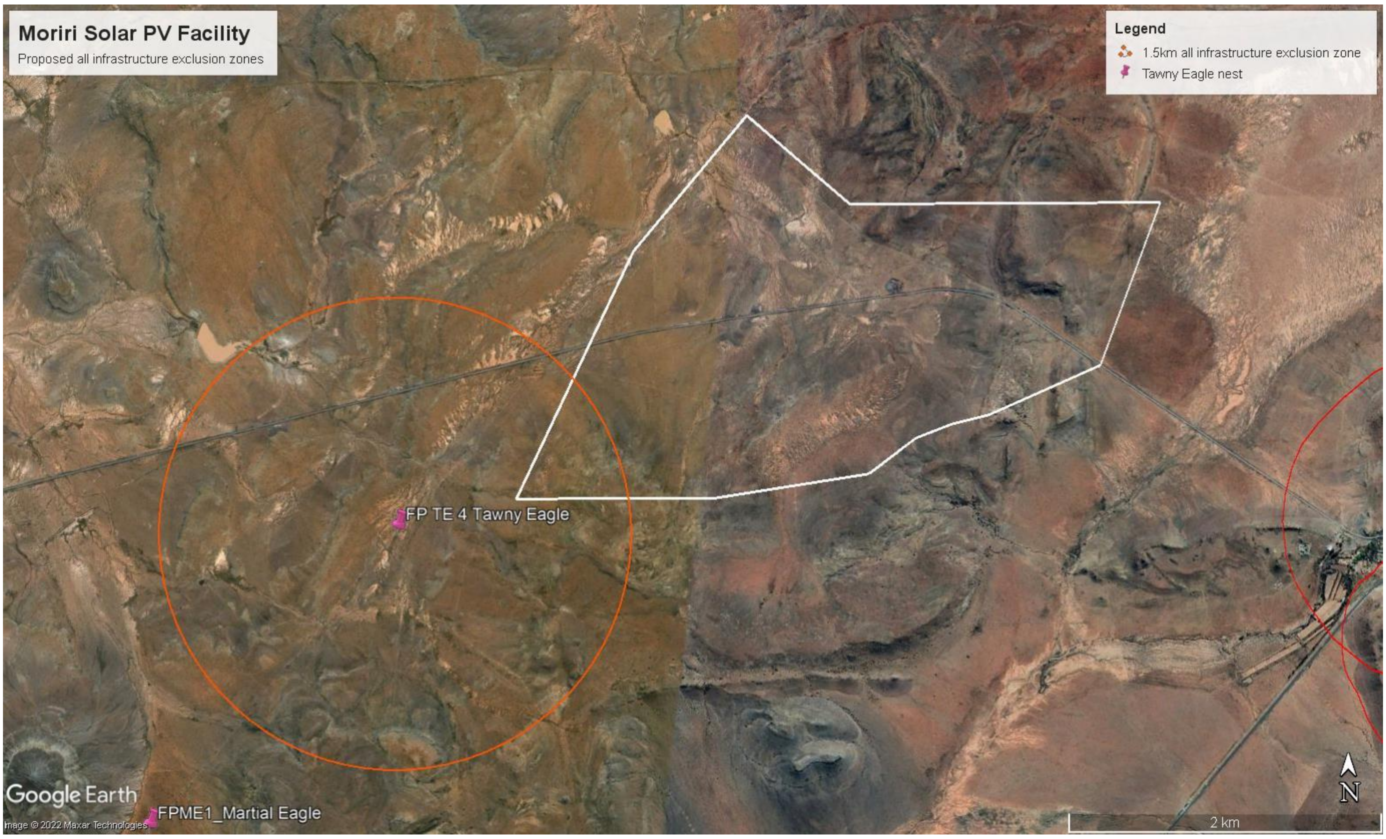
	AVERAGE SIGNIFICANCE RATING	44 MEDIUM	29 LOW

ENVIRONMENTAL SENSITIVITIES

- **Nests of Red Listed eagles: 1.5km all infrastructure No-Go zone**

A 1.5km infrastructure free buffer zone must be implemented around the Tawny Eagle (SA status: Endangered) nest on the Droërivier Hydra 2 400kV transmission line at -31.445988° 23.583921°. This is to prevent any disturbance of the birds at the nest during the construction phase which could lead them to abandon the nest.

See figure below for the avifaunal sensitivities identified from a PV solar perspective.



CUMULATIVE IMPACTS

Cumulative effects are commonly understood to be impacts from different projects that combine to result in significant change, which could be larger than the sum of all the individual impacts. The assessment of cumulative effects therefore needs to consider all renewable energy projects within a 30 km radius that have received an EA at the time of starting the environmental impact process, as well as the proposed Great Karoo Cluster projects. There are currently ten renewable energy projects authorised within a 30 km radius around the proposed five Great Karoo Cluster projects. The locality of renewable projects (affected properties) which are authorised are displayed in Figure 9.

The total affected land parcel area taken up by authorised renewable energy projects within the 30 km radius is approximately 774 km². The total land parcel area affected by the Great Karoo Renewable Energy Cluster equates to approximately 299 km². The combined land parcel area affected by authorised renewable energy developments within the 30 km radius around the proposed Great Karoo Renewable Energy Cluster, including the Great Karoo Renewable Energy Cluster, thus equals approximately 1 073 km². Of this, the proposed Moriri Solar PV project constitute ~0.5% (5.77km²). The cumulative impact of the proposed Moriri Solar PV project is thus anticipated to be **low** after mitigation.

The total area within the 30km radius around the proposed projects equates to about 4 396 km² of similar habitat. The total combined size of the land parcels potentially affected by renewable energy projects will equate to ~24% of the available untransformed habitat in the 30km radius. However, the actual physical footprint of the renewable energy facilities will be much smaller than the land parcel areas themselves. Furthermore, each of these projects must still be subject to a competitive bidding process where only the most competitive projects will win a power purchase agreement required for the project to proceed to construction. The cumulative impact of all the proposed renewable energy projects is estimated to be **moderate**.

CONCLUSIONS

The proposed 100 MW Moriri Photovoltaic (PV) Solar Energy Facility will have a range of potential pre-mitigation impacts on priority avifauna ranging from low to high, which is expected to be reduced to medium and low with appropriate mitigation. No fatal flaws were discovered during the investigations.

CONTENTS

DETAILS OF THE SPECIALIST

Chris van Rooyen (Bird Specialist)

Chris has 22 years' experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in numerous power line and wind generation projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is currently (2016) accepted as the industry standard. Chris also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Albert Froneman (Bird and GIS Specialist)

Albert has an M. Sc. in Conservation Biology from the University of Cape Town and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and he is currently jointly coordinating pre-construction monitoring programmes at several wind farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

1. INTRODUCTION

Great Karoo Renewable Energy (Pty) Ltd is proposing the construction and operation of a photovoltaic (PV) solar energy facility, to be known as the Moriri Solar PV Facility, and associated infrastructure on Portion 0 of Farm Rondavel 85, located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province. The project is planned as part of a larger cluster of renewable energy projects, which include two (2) 140MW Wind Energy Facilities (known as Merino Wind Farm and Angora Wind Farm) two (2) additional 100MW PV facilities (known as Nku Solar PV and Kwana Solar PV), as well as the grid connection infrastructure connecting the renewable energy facilities to the existing Eskom Gamma Substation.

A preferred project site with an extent of ~29 909ha and a development area of ~577ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Moriri Solar PV Facility with a contracted capacity of up to 100MW.

The Moriri Solar PV Facility project site is proposed to accommodate the following infrastructure, which will enable the facility to supply a contracted capacity of up to 100MW:

- Solar PV array comprising PV modules and mounting structures.
- Inverters and transformers.
- Cabling between the panels.
- 33/132kV onsite facility substation.
- Cabling from the onsite substation to the collector substation (either underground or overhead).
- Electrical and auxiliary equipment required at the collector substation that serves that solar energy facility, including switchyard/bay, control building, fences, etc.
- Battery Energy Storage System (BESS).
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.
- Laydown areas.
- Access roads and internal distribution roads.

The solar PV facility is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer's intention to bid the Moriri Solar PV Facility under the Department of Mineral Resources and Energy's (DMRE's) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country's electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Moriri Solar PV Facility set to inject up to 100MW into the national grid.

Please see Figures 1 and 2 for a map of the proposed development.

Figure 1: Locality map of the development area of the proposed 100 MW Moriri Solar Photovoltaic (PV) Facility

Figure 2: Close-up of proposed 100 MW Moriri Solar Photovoltaic (PV) Facility development area.

2 PROJECT SCOPE

The purpose of the specialist study is to determine the main issues and potential impacts of the proposed project/s on existing information and field assessments:

- Describe the affected environment from an avifaunal perspective
- Discuss gaps in baseline data and other limitations and describe the expected impacts associated with the solar facilities and associated infrastructure
- Identify potential sensitive environments and receptors that may be impacted on by the proposed facility and the types of impacts (i.e. direct, indirect and cumulative) that are most likely to occur.
- Determine the nature and extent of potential impacts during the construction, operational and decommissioning phases.
- Identify 'No-Go' areas, where applicable.
- Recommend mitigation measures to reduce the impact of the expected impacts to acceptable levels.
- Conclude with an impact statement whether the PV facility is fatally flawed or may be authorised.

3 OUTLINE OF METHODOLOGY AND INFORMATION REVIEWED

The following information sources were consulted to conduct this study:

- Bird distribution data from the Southern African Bird Atlas Project 2 (SABAP 2) was obtained (http://sabap2.adu.org.za/), in order to ascertain which species occur in the pentads where the proposed development is located. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5' × 5'). Each pentad is approximately 8 × 7.6 km. To get a more representative impression of the birdlife, a consolidated data set was obtained for a total of 6 pentads some of which intersect and others that are near the development area, henceforth referred to as "the broader area". The decision to include multiple pentads around the development are was influenced by the fact that many of the pentads in the area have few completed full protocol surveys. The additional pentads and their data augment the bird distribution data. The 6 pentad grid cells are the following: 3125_2330, 3125_2335, 3125_2340, 3130_2330, 3130_2335, and 3130_2340 (see Figure 33). A total of 48 full protocol lists (i.e. bird listing surveys lasting a minimum of two hours each) and 66 ad hoc protocol lists (surveys lasting less than two hours but still yielding valuable data) have been completed to date for the 6 pentads where the development area is located. The SABAP2 data was therefore regarded as a reliable reflection of the avifauna which occurs in the area, but the data was also supplemented by data collected during the site surveys and general knowledge of the area.
- A classification of the vegetation types in the development area was obtained from the Atlas of Southern African Birds 1 (SABAP1) and the National Vegetation Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford 2006).
- The national threatened status of all priority species was determined with the use of the most recent edition of the Red List Book of Birds of South Africa, Lesotho and Swaziland (Taylor *et al.* 2015), and the latest authoritative summary of southern African bird biology (Hockey *et al.* 2005).
- The global threatened status of all priority species was determined by consulting the latest (2021.2) IUCN Red List of Threatened Species (http://www.iucnredlist.org/).
- The Important Bird and Biodiversity Areas of South Africa (Marnewick *et al.* 2015; http://www.birdlife.org.za/conservation/important-bird-areas) was consulted for information on potentially relevant Important Bird Areas (IBAs).
- An intensive internet search was conducted to source information on the impacts of solar facilities on avifauna.
- Satellite imagery (Google Earth © 2021) was used in order to view the broader area on a landscape level and to help identify bird habitat on the ground.
- The South African National Biodiversity BGIS map viewer was used to determine the locality of the development area relative to National Protected Areas.

- The DFFE National Screening Tool was used to determine the assigned avian sensitivity of the development area.
- The following sources were consulted to determine the investigation protocol that is required for the site:
    - Procedures for the Assessment and Minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of NEMA when applying for Environmental Authorisation (Gazetted October 2020)
    - Guidelines for the Implementation of the Terrestrial Flora (3c) & Terrestrial Fauna (3d) Species Protocols for EIAs in South Africa produced by the South African National Biodiversity Institute on behalf of the Department of Environment, Forestry and Fisheries (2020).
    - The BirdLife South Africa (BLSA) Guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa. BirdLife South Africa by Jenkins, A.R., Ralston-Patton, Smit- Robinson, A.H. 2017 (hereafter referred to as the Solar Guidelines) were consulted to determine the level of survey effort that is required.
- The main source of information on the avifaunal diversity and abundance at the project site and development area is an integrated pre-construction monitoring programme which was implemented at the project site, covering three proposed PV projects and two proposed wind energy projects (four surveys were completed for the PV sites over a period of one year) (See Appendix 3).

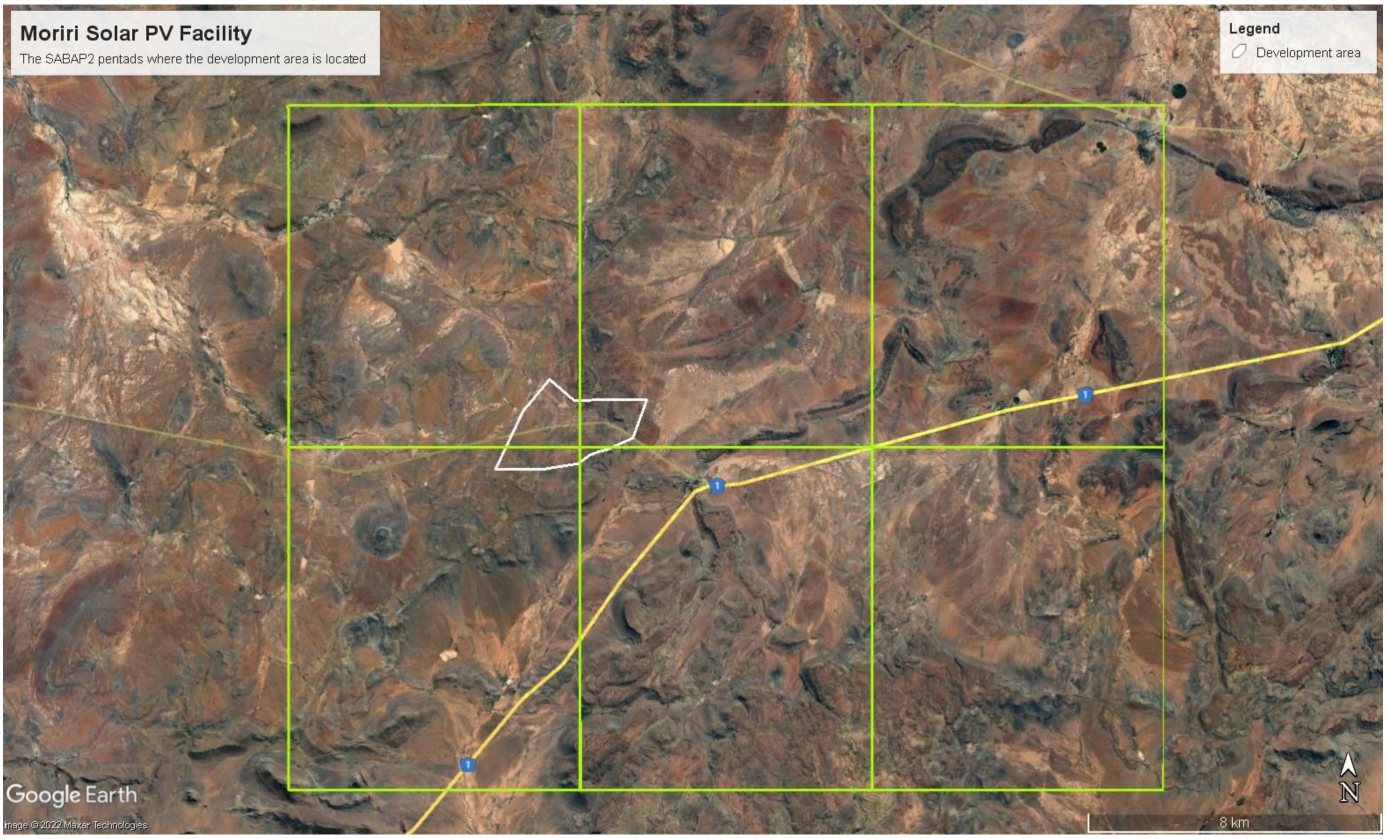


Figure 3: Area covered by the six SABAP2 pentads.

4 ASSUMPTIONS AND LIMITATIONS

This study assumed that the sources of information used in this report are reliable. In this respect, the following must be noted:

- The focus of the study is primarily on the potential impacts on solar priority species which were defined as follows:
    - South African Red List species;
    - South African endemics and near-endemics;
    - Waterbirds; and
    - Raptors

- The impact of solar installations on avifauna is a new field of study, with only two published scientific study on the impact of PV facilities on avifauna in South Africa (Rudman et al., 2017; Visser et al., 2019); and one related study on the impacts of concentrated solar power facilities on wildlife in South Africa (Jeal et al., 2019). Strong reliance was therefore placed on expert opinion and data from existing monitoring programmes at solar facilities in the USA where monitoring has been ongoing since 2013. The pre-cautionary principle was applied throughout as the full extent of impacts on avifauna at solar facilities is not presently known.
- The assessment of impacts is based on the baseline environment as it currently exists in the project site.
- Conclusions in this study are based on experience of these and similar species in different parts of South Africa. Bird behaviour can never be entirely reduced to formulas that will be valid under all circumstances.
- The project site is defined as on Portion 0 of Farm Rondavel 85.
- The development area is that identified area (located within the project site) where the Moriri Solar PV Facility is planned to be located. This area has been selected as a practicable option for the facility, considering technical preference and constraints. The development area is ~577ha in extent.
- The broader area refers to the area covered by the six SABAP2 pentads (see Figure 3).

5 LEGISLATIVE CONTEXT

There is no legislation pertaining specifically to the impact of solar facilities and associated electrical infrastructure on avifauna.

5.1 Agreements and conventions

Table 1 below lists agreements and conventions which South Africa is party to and which is relevant to the conservation of avifauna[1].

Table 1: Agreements and conventions which South Africa is party to and which is relevant to the conservation of avifauna.

Convention name	Description	Geographic scope
African-Eurasian Waterbird Agreement (AEWA)	The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and the Canadian Archipelago. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community in an effort to establish coordinated conservation and management of migratory waterbirds throughout their entire migratory range.	Regional
Convention on Biological Diversity (CBD), Nairobi, 1992	The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives: The conservation of biological diversity The sustainable use of the components of biological diversity The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.	Global
Convention on the Conservation of Migratory Species of Wild Animals, (CMS), Bonn, 1979	As an environmental treaty under the aegis of the United Nations Environment Programme, CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.	Global
Convention on the International Trade in	CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is	Global

[1] (BirdLife International (2016) Country profile: South Africa. Available from: http://www.birdlife.org/datazone/country/south_africa. Checked: 2016-04-02).

Endangered Species of Wild Flora and Fauna, (CITES), Washington DC, 1973	to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	
Ramsar Convention on Wetlands of International Importance, Ramsar, 1971	The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.	Global
Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia	The Signatories will aim to take co-ordinated measures to achieve and maintain the favourable conservation status of birds of prey throughout their range and to reverse their decline when and where appropriate.	Regional

5.2 National legislation

5.2.1 Constitution of the Republic of South Africa, 1996

The Constitution of the Republic of South Africa provides in the Bill of Rights that: Everyone has the right –

(a) to an environment that is not harmful to their health or well-being; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –

- (i) prevent pollution and ecological degradation;
- (ii) promote conservation; and
- (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

5.2.2 The National Environmental Management Act 107 of 1998 (NEMA)

The National Environmental Management Act 107 of 1998 (NEMA) creates the legislative framework for environmental protection in South Africa and is aimed at giving effect to the environmental right in the Constitution. It sets out a number of guiding principles that apply to the actions of all organs of state that may significantly affect the environment. Sustainable development (socially, environmentally and economically) is one of the key principles, and internationally accepted principles of environmental management, such as the precautionary principle and the polluter pays principle, are also incorporated. NEMA also provides that a wide variety of listed developmental activities, which may significantly affect the environment, may be performed only after an environmental impact assessment has been done and authorization has been obtained from the relevant authority. Many of these listed activities can potentially have negative impacts on bird populations in a variety of ways. The clearance of natural vegetation, for instance, can lead to a loss of habitat and may depress prey populations, while erecting structures needed for generating and distributing energy, communication, and so forth can cause mortalities by collision or electrocution.

NEMA makes provision for the prescription of procedures for the assessment and minimum criteria for reporting on identified environmental themes (Sections 24(5)(a) and (h) and 44) when applying for environmental authorisation. The Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, 30 October 2020 is applicable in the case of solar PV developments.

5.2.3 The National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA) and the Threatened or Protected Species Regulations, February 2007 (TOPS Regulations)

The most prominent statute containing provisions directly aimed at the conservation of birds is the National Environmental Management: Biodiversity Act 10 of 2004 read with the Threatened or Protected Species Regulations, February 2007 (TOPS Regulations). Chapter 1 sets out the objectives of the Act, and they are aligned with the objectives of the Convention on Biological Diversity, which are the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of the benefits of the use of genetic resources. The Act also gives effect to CITES, the Ramsar Convention, and the Bonn Convention on Migratory Species of Wild Animals. The State is endowed with the trusteeship of biodiversity and has the responsibility to manage, conserve and sustain the biodiversity of South Africa.

5.3 Provincial Legislation

The current legislation applicable to the conservation of fauna and flora in the Northern Cape is the Northern Cape Nature Conservation Act No 9 of 2009. It provides for the sustainable utilisation of wild animals, aquatic biota and plants; the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora; describes offences and penalties for contravention of the Act; provides for the appointment of nature conservators to implement the provisions of the Act; provides for the issuing of permits and other authorisations; and provides for matters connected therewith.

6 BASELINE ASSESSMENT

6.1 Important Bird Areas

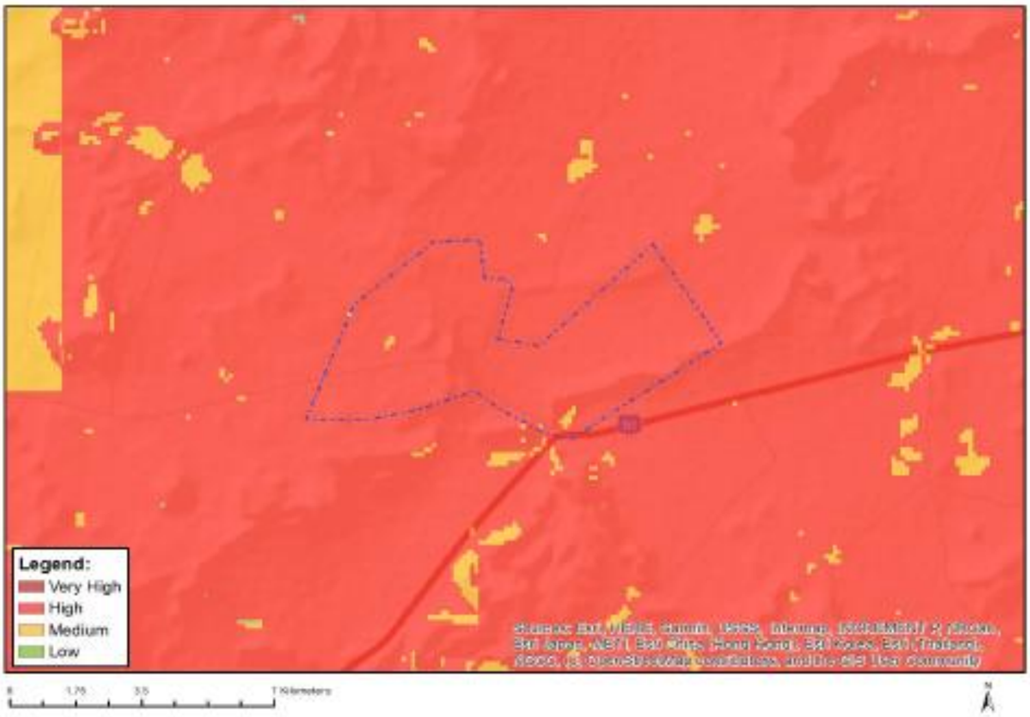
There are no Important Bird Areas (IBA) within a 60km radius around the proposed Moriri PV Facility. The closest IBA to the project site is the Platberg-Karoo Conservancy IBA SA037 which is located 63km away at its closest point. It is therefore highly unlikely that the proposed development will have a negative impact on any IBA due to the distance from the project site.

6.2 DFFE National Screening Tool

The project site and immediate environment is classified as **Medium and High** sensitivity for terrestrial animals according to the Terrestrial Animal Species Theme[2]. The High classification is linked to the potential occurrence of Ludwig's Bustard (Globally and Regionally Endangered), and the Medium classification is linked to the potential occurrence of Verreaux's Eagle (Regionally Vulnerable). The development site contains confirmed habitat for species of conservation concern (SCC) as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, 30 October 2020, namely listed on the IUCN Red List of Threatened Species or South Africa's National Red List website as Critically Endangered, Endangered or Vulnerable. The habitat for SCCs was confirmed during the surveys i.e. Ludwig's Bustard (Globally and Regionally Endangered), Lanner Falcon (Regionally Vulnerable), Tawny Eagle (Regionally Endangered) and Martial Eagle (Globally and Regionally Endangered). Lanner Falcon was recorded on the project site during surveys. Based on the field surveys, the classification of **High** sensitivity for avifauna in the screening tool is therefore confirmed (see Figure 4).

[2] Note that the Avian theme for PV in the Screening Tool is incorrect, as it displays the sensitivities for bats, and not birds.

MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



Where only a sensitive plant unique number or sensitive animal unique number is provided in the screening report and an assessment is required, the environmental assessment practitioner (EAP) or specialist is required to email SANBI at eiadatarequests@sanbi.org.za listing all sensitive species with their unique identifiers for which information is required. The name has been withheld as the species may be prone to illegal harvesting and must be protected. SANBI will release the actual species name after the details of the EAP or specialist have been documented.

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Aves-Neotis ludwigii
Medium	Aves-Aquila verreauxii
Medium	Mammalia-Bunolagus monticularis

Figure 4: The National Web-Based Environmental Screening Tool map of the three PV project sites, indicating sensitivities for the Terrestrial Animal Species theme. The High sensitivity classification is linked to Ludwig's Bustard (*Neotis ludwigii*).

6.3 Protected Areas

The project site does not fall within a formally protected area.

6.4 Biomes and vegetation types

The project site, within which the development area is located, falls within the Nama Karoo biome (Mucina & Rutherford 2006). It consists of a flat plain with a number of inselbergs containing steep, boulder-strewn slopes, exposed rocky ridges and low cliffs. Two vegetation types are found in the development site, the dominant one being Eastern Upper Karoo, which is found on the plains and Upper Karoo Hardeveld occurring on the ridges (Mucina & Rutherford 2006). Eastern Upper Karoo is dominated by dwarf mycrophyllus shrubs, with white grasses of the genera Aristida and Eragrostis. On the steep slopes, mountain ridges and koppies, Upper Karoo Hardeveld is found which is characterised by dwarf Karoo scrub with drought tolerant grasses of genera such as Aristida, Eragrostis and Stipagrostis (Mucina & Rutherford 2006). The project site contains several large earth dams.

The Moriri PV development area itself is located on a plain and contains one inselberg and one earth dam.

Temperatures in the project site ranges between 30˚C in January (summer) and 0˚C in July (winter), and average rainfall happens mostly between November and April and averages about 400mm per year, which makes for a fairly arid climate. Winters are very dry. The land is used for sheep and game farming.

Whilst the distribution and abundance of the bird species in the development area are typical of the broad vegetation type, it is also necessary to examine bird habitats in more detail as it may influence the distribution and behaviour of priority species. These are discussed in more detail below. The priority species most likely associated with the various bird habitat features are listed in Table 2.

6.5 Bird habitat

6.5.1 Nama Karoo

The vegetation at the development area consists of Karoo shrub.

6.5.2 Surface water

The development area contains one source of surface water, namely two boreholes with water troughs which is situated in the extreme north of the development area.

6.5.3 High voltage lines

There are a number of high voltage line that run to the north-east of the development area. Transmission lines are an important breeding substrate for raptors in the Karoo, due to the lack of large trees (Jenkins *et al.* 2013). There is a newly established Tawny Eagle nest situated approximately 800m from the development area border on the Droërivier – Hydra 1 400kV transmission line (see Appendix 2). The nest was first recorded in July 2021, when an adult bird was observed on the nest.

See Appendix 2 for photographic record of habitat features in the development area and immediate surroundings.

7 AVIFAUNA IN THE DEVELOPMENT AREA

7.1 South African Bird Atlas Project 2

The SABAP2 data indicates that a total of 164 bird species could potentially occur within the broader area – Appendix 1 provides a comprehensive list of all the species. Of these, 61 species are classified as priority species (see definition of priority species in section 4) and 12 of these are South African Red List species. Of the priority species, 27 are likely to occur regularly at the development area (see Table 2 below).

Table 2 below lists all the priority species that are likely to occur regularly and the possible impact on the respective species by the proposed solar energy infrastructure. The following abbreviations and acronyms are used:

- NT = Near threatened
- VU = Vulnerable
- EN = Endangered

Table 2: Priority species with a medium to high likelihood of occurring at the development area.

Species	Taxonomic name	SABAP2 reporting rate		Status		Recorded during surveys	Endemic/near-endemic	Waterbird	Raptor	Habitat feature						Impact					
		Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status					Nama Karoo	Surface water	Agriculture	Ridges	Alien trees	HV lines	PV panel collisions	Displacement - disturbance	Displacement - habitat loss	Entrapment in fences	Electrocution on the MV OHL	Collision with the MV OHL
Ludwig's Bustard	*Neotis ludwigii*	45.83	7.58	EN	EN	x				x		x					x	x	x		x
Jackal Buzzard	*Buteo rufofuscus*	43.75	16.67			x			x	x	x		x		x					x	
Black-headed Canary	*Serinus alario*	25.00	0.00				x			x	x					x	x	x			
Sickle-winged Chat	*Emarginata sinuata*	56.25	7.58			x	x			x						x	x	x			
Tawny Eagle	*Aquila rapax*	12.50	3.03	VU	EN	x			x	x	x			x	x		x			x	
Fiscal Flycatcher	*Melaenornis silens*	33.33	3.03				x			x				x		x					
Pale Chanting Goshawk	*Melierax canorus*	45.83	13.64			x			x	x	x			x	x					x	
Karoo Korhaan	*Eupodotis vigorsii*	52.08	7.58	LC	NT	x				x							x	x	x		x
Large-billed Lark	*Galerida magnirostris*	50.00	13.64			x	x			x						x	x	x			
Karoo Prinia	*Prinia maculosa*	43.75	7.58			x	x			x						x	x	x			
Grey Tit	*Melaniparus afer*	18.75	4.55			x	x			x				x		x					
Booted Eagle	*Hieraaetus pennatus*	6.25	0.00			x			x	x	x		x		x	x				x	
Martial Eagle	*Polemaetus bellicosus*	10.42	1.52	VU	EN	x			x	x	x			x	x		x			x	
Karoo Eremomela	*Eremomela gregalis*	2.08	6.06			x	x			x						x	x	x			
Fairy Flycatcher	*Stenostira scita*	12.50	1.52				x			x						x	x	x			
Egyptian Goose	*Alopochen aegyptiaca*	37.50	6.06			x		x			x	x								x	x

Species	Taxonomic name	SABAP2 reporting rate		Status		Recorded during surveys	Endemic/near-endemic	Waterbird	Raptor	Habitat feature						Impact					
		Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status					Nama Karoo	Surface water	Agriculture	Ridges	Alien trees	HV lines	PV panel collisions	Displacement - disturbance	Displacement - habitat loss	Entrapment in fences	Electrocution on 3MV OHL	Collision with the MV OHL
Greater Kestrel	*Falco rupicoloides*	31.25	3.03			x			x	x				x	x	x				x	
Rock Kestrel	*Falco rupicolus*	41.67	3.03			x			x	x			x	x	x	x					
South African Shelduck	*Tadorna cana*	47.92	4.55			x		x			x										x
Black-eared Sparrow-Lark	*Eremopterix australis*	18.75	3.03			x	x			x						x	x	x			
Pied Starling	*Lamprotornis bicolor*	35.42	9.09			x	x					x		x		x					
Layard's Warbler	*Curruca layardi*	25.00	1.52			x				x						x	x	x			
Cape White-eye	*Zosterops virens*	10.42	1.52			x	x			x				x							
Spotted Eagle-Owl	*Bubo africanus*	8.33	0.00						x	x			x	x			x			x	
Secretarybird	*Sagittarius serpentarius*	12.50	6.06	VU	VU				x	x	x			x			x	x	x		
Lanner Falcon	*Falco biarmicus*	2.08	3.03	VU	VU	x			x	x	x	x	x	x	x	x				x	

7.1 Pre-construction surveys

Pre-construction avifaunal surveys were undertaken at the project site during the following time envelopes:

- 27 October to 7 November 2020 (Survey 1)
- 04 to 08 January 2021 (Survey 2)
- 15 to 21 March 2021 (Survey 3)
- 05 to 09 July 2021 (Survey 4)

Surveys were conducted according to a Regime 3 site (high sensitivity) as defined in the Solar Guidelines (Jenkins *et al.* 2017) i.e. a minimum of four surveys conducted over 12 months.

The abundance of priority species (Index of kilometric abundance (IKA) = birds/km) recorded during the transect counts is displayed in Figure 5 and 6 below.

See Appendix 3 for a description of the pre-construction monitoring for the solar projects.

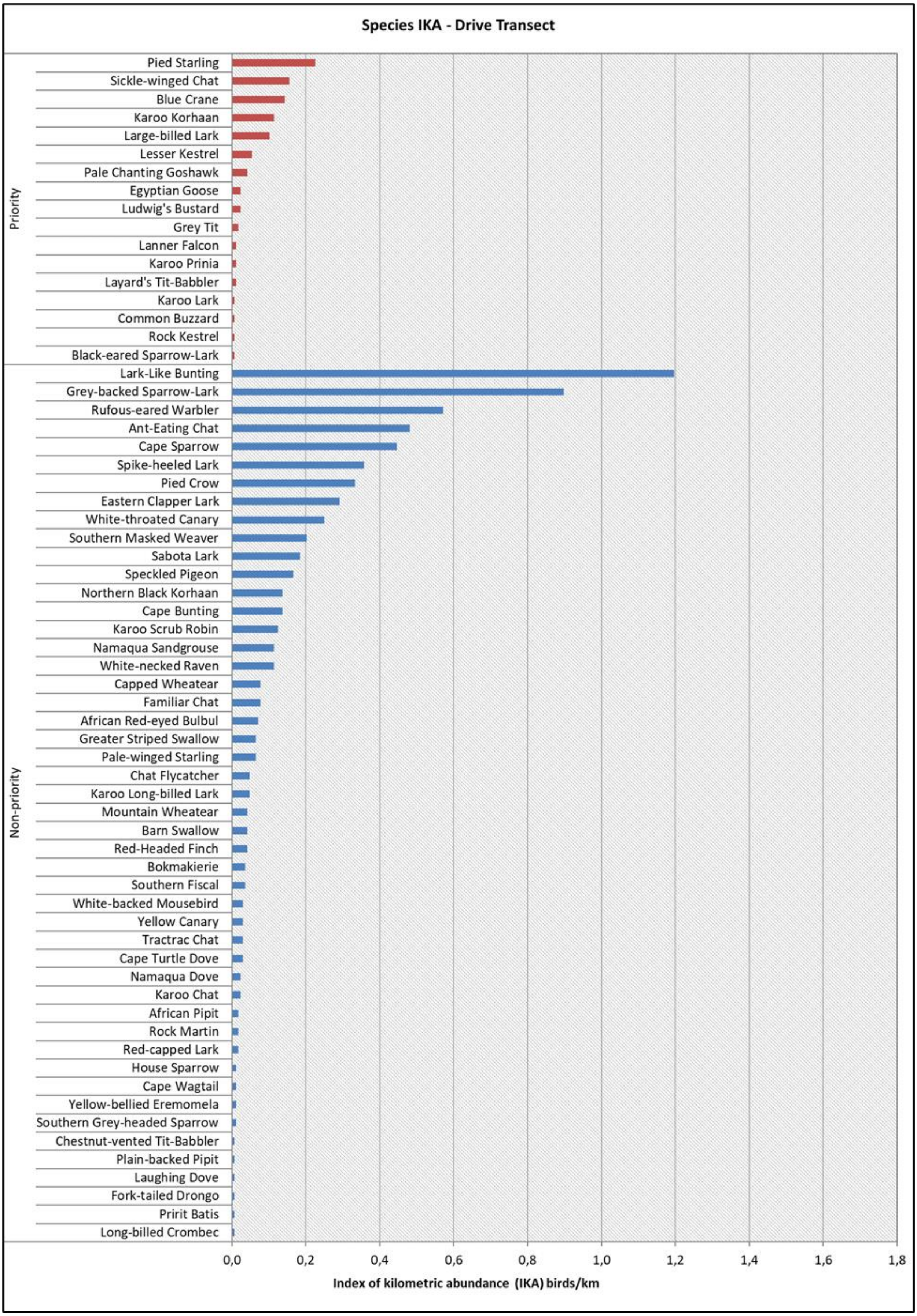


Figure 5: IKA for drive transect solar priority & non-priority species at the project site.

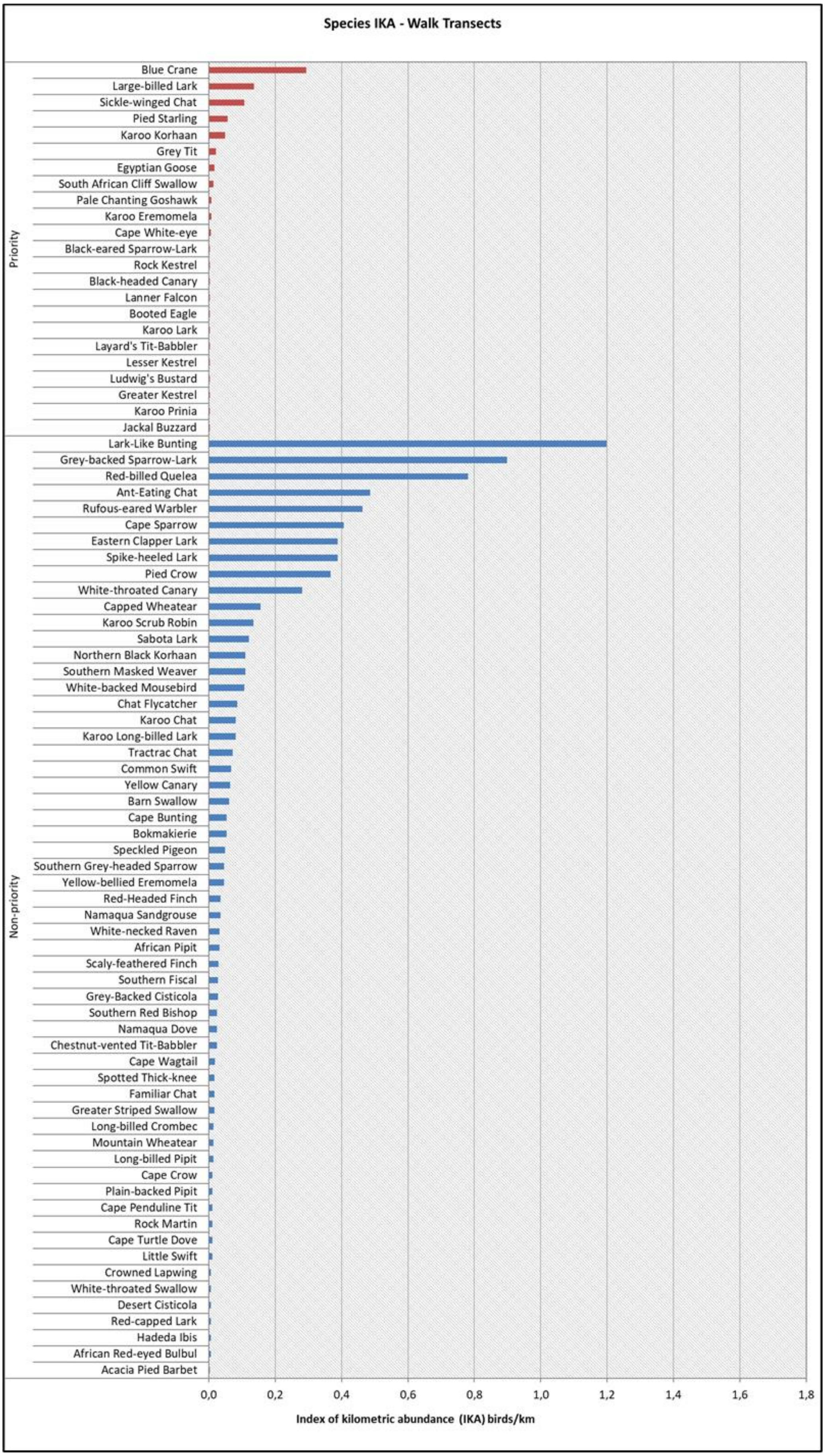


Figure 6: IKA for walk transect solar priority & non-priority species at the project site.

The overall abundance of priority species at the project site was low, with an average of 0.96 birds/km recorded during drive transect counts, and 0.75 birds/km during walk transects. For all birds combined (priority and non-priority species), IKA for drive transect counts was 7.92 birds/km, and for walk transects it was 8.39, which is moderate.

8 IMPACT ASSESSMENT

A literature review reveals a scarcity of published, scientifically examined information regarding large-scale PV plants and birds. The reason for this is mainly that large-scale PV plants is a relatively recent phenomenon. The main source of information for these types of impacts are from compliance reports and a few government-sponsored studies relating to recently constructed solar plants in the south-west United States. In South Africa, one published scientific study has been completed on the impacts of PV plants in a South African context (Visser *et al.* 2018).

In summary, the main impacts of PV plants on avifauna which have emerged so far include the following:

- Displacement due to disturbance associated with the construction of the solar PV plant and associated infrastructure
- Displacement due to habitat transformation associated with the construction of the solar PV plant and associated infrastructure
- Collisions with the solar panels
- Entrapment in perimeter fences

8.1 Introduction

Increasingly, human-induced climate change is recognized as a fundamental driver of biological processes and patterns. Historic climate change is known to have caused shifts in the geographic ranges of many plants and animals, and future climate change is expected to result in even greater redistributions of species (National Audubon Society 2015). In 2006 WWF Australia produced a report on the envisaged impact of climate change on birds worldwide (Wormworth, J. & Mallon, K. 2006). The report found that:

- Climate change now affects bird species' behaviour, ranges and population dynamics;
- Some bird species are already experiencing strong negative impacts from climate change;
- In future, subject to greenhouse gas emissions levels and climatic response, climate change will put large numbers bird species at risk of extinction, with estimates of extinction rates varying from 2 to 72%, depending on the region, climate scenario and potential for birds to shift to new habitat.

Using statistical models based on the North American Breeding Bird Survey and Audubon Christmas Bird Count datasets, the National Audubon Society assessed geographic range shifts through the end of the century for 588 North American bird species during both the summer and winter seasons under a range of future climate change scenarios (National Audubon Society 2015). Their analysis showed the following:

- 314 of 588 species modelled (53%) lose more than half of their current geographic range in all three modelled scenarios.
- For 126 species, loss occurs without accompanying range expansion.
- For 188 species, loss is coupled with the potential to colonize new areas.

Climate sensitivity is an important piece of information to incorporate into conservation planning and adaptive management strategies. The persistence of many birds will depend on their ability to colonize climatically suitable areas outside of current ranges and management actions that target climate change adaptation.

South Africa is among the world's top 10 developing countries required to significantly reduce their carbon emissions (Seymore *et al.* 2014), and the introduction of low-carbon technologies into the country's compliment of power generation will greatly assist with achieving this important objective (Walwyn & Brent 2015). Given that South Africa receives among the highest levels of solar radiation on earth (Fluri 2009; Munzhedi *et al.* 2009), it is clear that solar power generation should feature prominently in future efforts to convert to a more sustainable energy mix in order to combat climate change, also from an avifaunal impact perspective. However, while the expansion of solar power generation is undoubtedly a positive development for avifauna in the longer term in that it will help reduce the effect of climate change and thus habitat transformation, it must also be acknowledged that renewable energy facilities, including solar PV facilities, in themselves have some potential for negative impacts on avifauna.

A literature review reveals a scarcity of published, scientifically examined information regarding large-scale PV plants and birds. The reason for this is mainly that large-scale PV plants are a relatively recent phenomenon. The main source of information for these types of impacts are from compliance reports and a few government-sponsored studies relating to recently constructed solar plants in the south-west United States. In South Africa, only one published scientific study has been completed on the impacts of PV plants in a South African context (Visser *et al.* 2018).

8.2 Impacts associated with PV plant

8.2.1 Impact trauma (collisions)

This impact refers to collision-related fatality i.e. fatality resulting from the direct contact of the bird with a project structure(s). This type of fatality has been occasionally documented at solar projects of all technology types (McCrary *et al.* 1986; Hernandez *et al.* 2014; Kagan *et al.* 2014). In some instances, the bird is not killed outright by the collision impact, but succumbs to predation later, as it cannot avoid predators due to its injured state.

Sheet glass used in commercial and residential buildings has been well established as a hazard for birds. When the sky is reflected in the sheet glass, birds fail to see the building as an obstacle and attempt to fly through the glass, mistaking it for empty space (Loss *et al.* 2014). Although very few cases have been reported it is possible that the reflective surfaces of solar panels could constitute a similar risk to avifauna.

An extremely rare but potentially related problem is the so-called "lake effect" i.e. it seems possible that reflections from solar facilities' infrastructure, particularly large sheets of dark blue photovoltaic panels, may attract birds in flight across the open desert, who mistake the broad reflective surfaces for water (Kagan *et al.* 2014)[3]. The unusually high percentage of waterbird mortalities at the Desert Sunlight PV facility (44%) may support the "lake effect" hypothesis (West 2014). Although in the case of Desert Sunlight, the proximity of

[3] This could either result in birds colliding directly with the solar panels or getting stranded and unable to take off again because many aquatic bird species find it very difficult and sometimes impossible to take off from dry land e.g. grebes and cormorants. This exposes them to predation, even if they do not get injured through direct collisions with the panels.

evaporation ponds may act as an additional risk increasing factor, in that birds are both attracted to the water feature and habituated to the presence of an accessible aquatic environment in the area. This may translate into the misinterpretation of diffusely reflected sky or horizontal polarised light source as a body of water. However, due to limited data it would be premature to make any general conclusions about the influence of the lake effect or other factors that contribute to fatality of water-dependent birds. The activity and abundance of water-dependent species near solar facilities may depend on other site-specific or regional factors, such as the surrounding landscape (Walston *et al.* 2015). Koskiuch *et al.* (2020) found that water-obligate birds, which rely on water for take-off and landing, occurred at 90% (9/10) of site-years at 7 sites in the Sonoran and Mojave Deserts Bird Conservation Region in the USA from January 2013 to September 2018. However, they stressed that their statements should not be interpreted as evidence there will be water-obligate bird mortality at PV facilities developed in areas with concentrations of migrating or overwintering water obligates because the causal mechanism for fatality risk is unknown. Until such time that enough scientific evidence has been collected to discount the "lake effect" hypothesis, it must be considered as a potential source of impacts.

Weekly mortality searches at 20% coverage were conducted at the 250MW, 1300ha California Valley Solar Ranch PV site (Harvey & Associates 2014a and 2014b). According to the information that could be sourced from the internet (two quarterly reports), 152 avian mortalities were reported for the period 16 November 2013 – 15 February 2014, and 54 for the period 16 February 2014 – 15 May 2014, of which approximately 90% were based on feather spots which precluded a finding on the cause of death. These figures give an estimated unadjusted 1 030 mortalities per year, which is obviously an underestimate as it does not include adjustments for carcasses removed by scavengers and missed by searchers. The authors stated clearly that these quarterly reports do not include the results of searcher efficiency trials, carcass removal trials, or data analyses, nor does it include detailed discussions.

In a report by the National Fish and Wildlife Forensic Laboratory (Kagan *et al.* 2014), the cause of avian mortalities was estimated based on opportunistic avian carcass collections at several solar facilities, including the 550MW, 1 600ha Desert Sunlight PV plant. Impact trauma emerged as the highest identifiable cause of avian mortality, but most mortality could not be traced to an identifiable cause.

Walston *et al.* (2015) conducted a comprehensive review of avian fatality data from large scale solar facilities (all technology types) in the USA. Collision as cause of death (19 birds) ranked second at Desert Sunlight PV plant and California Valley Solar Ranch (CVSR) PV plant, after unknown causes. Cause of death could not be determined for over 50% of the fatality observations and many carcasses included in these analyses consisted only of feather spots (feathers concentrated together in a small area) or partial carcasses, thus making determination of cause of death difficult. It is anticipated that some unknown fatalities were caused by predation or some other factor unrelated to the solar project. However, they found that the lack of systematic data collection and standardization was a major impediment in establishing the actual extent and causes of fatalities across all projects.

The only scientific investigation of potential avifaunal impacts that has been performed at a South African PV facility was completed in 2016 at the 96MW Jasper PV solar facility (28°17′53″S, 23°21′56″E) which is located on the Humansrus Farm, approximately 4 km south-east of Groenwater and 30km east of Postmasburg in the Northern Cape Province (Visser *et al.* 2019). The Jasper PV facility contains 325 360 solar panels over a footprint of 180 hectares with the capacity to deliver 180 000 MWh of renewable electricity annually. The solar panels face north at a fixed 20° angle, reaching a height of approximately 1.86 m relative to ground level with a distance of 3.11 m between successive rows of panels. Mortality surveys were conducted from the 14th of September 2015 until the 6th of December 2015, with a total of seven mortalities recorded among the solar panels which gives an average rate of 0.003 birds per hectare surveyed per month. All fatalities were inferred from feather spots. Extrapolated bird mortality within the solar field at the Jasper PV facility was 435 birds/yr

(95% CI 133 - 805). The broad confidence intervals result from the small number of birds detected. The mortality estimate is likely conservative because detection probabilities were based on intact birds, and probably decrease for older carcasses and feather spots. The study concluded inter alia that the short study period, and lack of comparable results from other sources made it difficult to provide a meaningful assessment of avian mortality at PV facilities. It further stated that despite these limitations, the few bird fatalities that were recorded might suggest that there is no significant collision-related mortality at the study site. The conclusion was that to fully understand the risk of solar energy development on birds, further collation and analysis of data from solar energy facilities across spatial and temporal scales, based on scientifically rigorous research designs, is required (Visser *et al.* 2018).

The results of the available literature lack compelling evidence of collisions as a cause of large-scale mortality among birds at PV facilities. Kosciuch *et al*. (2020) synthesized results from fatality monitoring studies at 10 photovoltaic solar facilities across 13 site years in California and Nevada in the USA. Annual fatality rates never exceeded 2.99 fatalities/MW/year (1.03 fatalities/hectare/year), and 3 of the four top species detected were ground-dwelling species.

It is clear from this limited literature survey that the lack of systematic and standardised data collection is a major problem in the assessment of the causes and extent of avian mortality at all types of solar facilities, regardless of the technology employed. Until statistically tested results emerge from existing compliance programmes and more dedicated scientific research, conclusions will inevitably be largely speculative and based on professional opinion.

Based on the lack of evidence to the contrary, it is not foreseen that collisions with the solar panels at the PV facility will be a significant impact. The priority species which would most likely be potentially affected by this impact are mostly small, ground-dwelling birds which forage between the solar panels, and possibly raptors which prey on them.

Based on the lack of evidence to the contrary, it is not foreseen that collisions with the solar panels at the PV facility will be a significant impact. The priority species which would most likely be potentially affected by this impact are mostly small birds which forage between the solar panels, and possibly raptors which prey on them, or forage for insects between the PV panels, e.g. Lesser Kestrels (i.e. if they are not completely displaced due to the habitat transformation). Due to the absence of large permanent waterbodies at or close to the development area, it is unlikely that waterbirds will be attracted to the solar arrays due to the "lake effect".

Priority species which could potentially be impacted due to collisions with the solar panels are the following: Black-headed Canary, Sickle-winged Chat, Fiscal Flycatcher, Large-billed Lark, Karoo Prinia, Grey Tit, Booted Eagle, Karoo Eremomela, Fairy Flycatcher, Greater Kestrel, Rock Kestrel, Black-eared Sparrow-Lark, Pied Starling, Layard's Warbler and Lanner Falcon.

8.2.2 Entrapment in perimeter fences

Visser *et al.* (2018) recorded a fence-line fatality (Orange River Francolin *Scleroptila gutturalis*) resulting from the bird being trapped between the inner and outer perimeter fence of the facility. This was further supported by observations of large-bodied birds unable to escape from between the two fences (e.g. Red-crested Korhaan *Lophotis ruficrista*) (Visser *et al.* 2019). Considering that one would expect the birds to be able to take off in the lengthwise direction (parallel to the fences), it seems possible that the birds panicked when they were approached by observers and thus flew into the fence.

It is not foreseen that entrapment of priority species in perimeter fences will be a significant impact at the PV facility. The priority species which could potentially be affected by this impact are most likely medium to large terrestrial species.

Priority species which could potentially be impacted due entrapment are the following: Ludwig's Bustard, Karoo Korhaan and Secretarybird.

8.2.3 Displacement due to habitat transformation associated with the construction of the solar PV facility

Ground-disturbing activities affect a variety of processes in arid areas, including soil density, water infiltration rate, vulnerability to erosion, secondary plant succession, invasion by exotic plant species, and stability of cryptobiotic soil crusts. These processes have the ability – individually and together – to alter habitat quality, often to the detriment of wildlife, including avifauna. Any disturbance and alteration to the desert landscape, including the construction and decommissioning of utility-scale solar energy facilities, has the potential to increase soil erosion. Erosion can physically and physiologically affect plant species and can thus adversely influence primary production and food availability for wildlife (Lovich & Ennen 2011).

Solar energy facilities require substantial site preparation (including the removal of vegetation) that alters topography and, thus, drainage patterns to divert the surface flow associated with rainfall away from facility infrastructure. Channelling runoff away from plant communities can have dramatic negative effects on water availability and habitat quality in arid areas. Areas deprived of runoff from sheet flow support less biomass of perennial and annual plants relative to adjacent areas with uninterrupted water-flow patterns (Lovich & Ennen 2011).

The activities listed below are typically associated with the construction and operation of solar facilities and could have direct impacts on avifauna through the transformation of habitat (County of Merced 2014):

- Preparation of solar panel areas for installation, including vegetation clearing, grading, cut and fill;
- Excavation/trenching for water pipelines, cables, fibre-optic lines, and the septic system;
- Construction of piers and building foundations;
- Construction of new dirt or gravel roads and improvement of existing roads;
- Temporary stockpiling and side-casting of soil, construction materials, or other construction wastes;
- Soil compaction, dust, and water runoff from construction sites;
- Degradation of water quality in drainages and other water bodies resulting from project runoff;
- Maintenance of fire breaks and roads; and
- Weed removal, brush clearing, and similar land management activities related to the ongoing operation of the project.

These activities could have an impact on birds breeding, foraging and roosting in or in close proximity through transformation of habitat, which could result in temporary or permanent displacement.

In a study comparing the avifaunal habitat use in PV arrays with adjoining managed grassland at airports in the USA, DeVault *et al.* (2014) found that species diversity in PV arrays was reduced compared to the grasslands (37 vs 46), supporting the view that solar development is generally detrimental to wildlife on a local scale.

In order to identify functional and structural changes in bird communities in and around the development footprint, Visser *et al.* (2018) gathered bird transect data at the 180 hectares, 96MW Jasper PV solar facility in the Northern Cape, representing the solar development, boundary, and untransformed landscape. The study found both bird density and diversity per unit area was higher in the boundary and untransformed landscape, however, the extent therefore was not considered to be statistically significant. This indicates that the PV facility matrix is permeable to most species. However, key environmental features, including available habitat and vegetation quality are most likely the overriding factors influencing species' occurrence and their relative density within the development footprint. Her most significant finding was that the distribution of birds in the landscape changed, from a shrubland to open country and grassland bird community, in response to changes in the distribution and abundance of habitat resources such as food, water and nesting sites. These changes in resource availability patterns were detrimental to some bird species and beneficial to others. Shrubland specialists appeared to be negatively affected by the presence of the PV facility. In contrast, open country/grassland and generalist species, were favoured by its development (Visser *et al.* 2018).

As far as displacement, either completely or partially (reduced densities) due to habitat loss is concerned, it is highly likely that the same pattern of reduced avifaunal densities will manifest itself at the proposed PV facility. In addition, ground nesting species and some raptors are also likely to be impacted by the habitat transformation, as it will result in reduced prey availability and accessibility.

Priority species that could be negatively affected by displacement due to habitat loss are the following: Ludwig's Bustard, Karoo Korhaan, Secretarybird, Black-headed Canary, Sickle-winged Chat, Large-billed Lark, Karoo Prinia, Karoo Eremomela, Fairy Flycatcher, Black-eared Sparrow-Lark and Layard's Warbler

8.2.4 Displacement due to disturbance associated with the construction of the solar PV facility

As far as disturbance is concerned, it is likely that all the avifauna, including all the priority species, will be temporarily displaced in the footprint area, either completely or more likely partially (reduced densities) during the construction phase, due to the disturbance associated with the construction activities e.g. increased vehicle traffic, and short-term construction-related noise (from equipment) and visual disturbance.

At the PV facility, the priority species which would be most severely affected by disturbance would be ground nesting species, and those that utilise low shrubs for nesting, which are the following: Ludwig's Bustard, Karoo Korhaan, Black-headed Canary, Sickle-winged Chat, Large-billed Lark, Karoo Prinia, Karoo Eremomela, Fairy Flycatcher, Black-eared Sparrow-Lark, Layard's Warbler and Spotted Eagle-Owl. Large eagles breeding on the transmission lines in close proximity of the PV facility could also be at risk of disturbance i.e. Martial Eagle and Tawny Eagle.

8.3 Impacts associated with the medium voltage network

8.3.1 Electrocution of priority species on the internal medium voltage reticulation network

Medium voltage electricity poles could potentially pose an electrocution risk to raptors. Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2000). The electrocution risk is largely determined by the design of the electrical hardware.

While the intention is to place the majority of the medium voltage reticulation network underground at the PV facility, there are areas where the lines will run above ground. Priority species which could be at risk of electrocution on the medium voltage powerlines are the following: Tawny Eagle, Martial Eagle, Spotted Eagle-Owl, Booted Eagle, Greater Kestrel, Jackal Buzzard, Pale Chanting Goshawk, Lanner Falcon and Egyptian Goose.

8.3.2 Collisions with the internal medium voltage overhead lines

Collisions are the biggest threat posed by transmission lines to birds in southern Africa (Van Rooyen 2004). Most heavily impacted upon are bustards, storks, cranes and various species of waterbirds, and to a lesser extent, vultures. These species are mostly heavy-bodied birds with limited manoeuvrability, which makes it difficult for them to take the necessary evasive action to avoid colliding with transmission lines (Van Rooyen 2004, Anderson 2001).

From incidental record keeping by the Endangered Wildlife Trust, it is possible to give a measure of what species are generally susceptible to power line collisions in South Africa (see Figure 5 below).

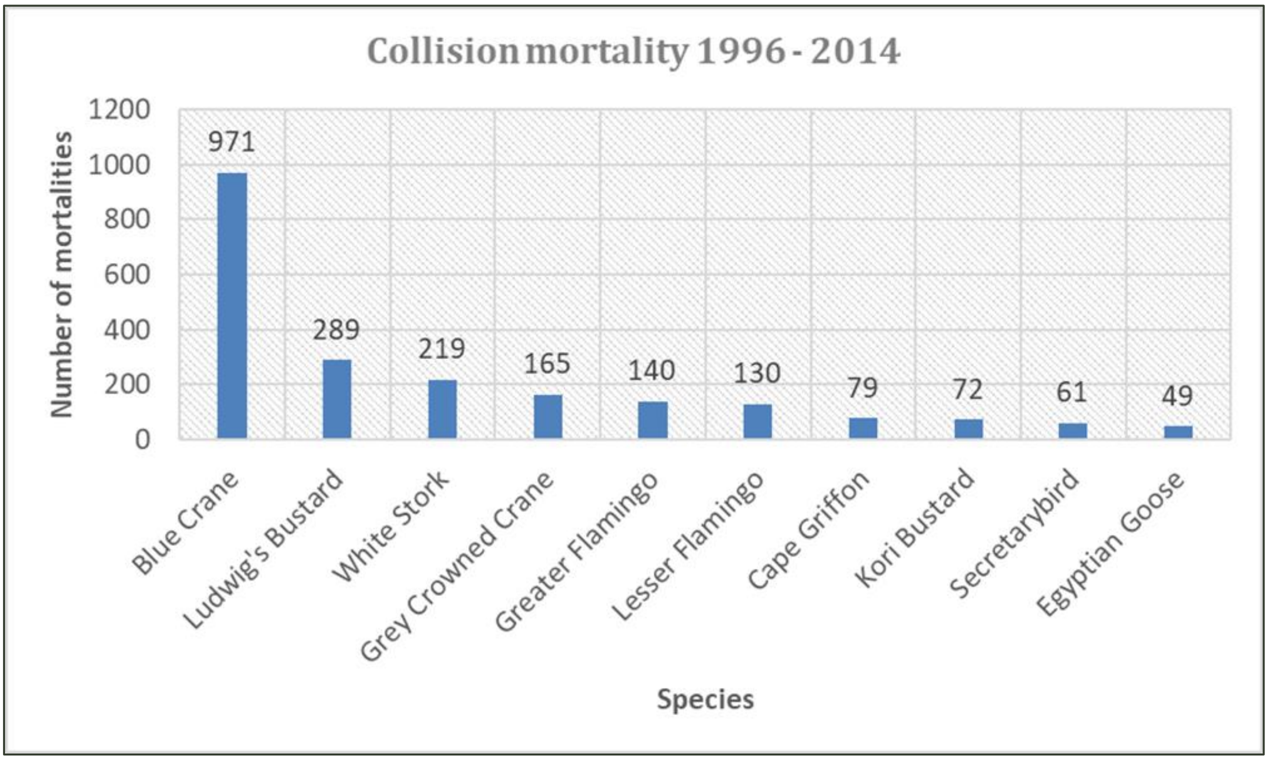


Figure 7: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/Endangered Wildlife Trust Strategic Partnership central incident register 1996 - 2014 (EWT unpublished data)

Power line collisions are generally accepted as a key threat to bustards (Raab *et al*. 2009; Raab *et al*. 2010; Jenkins & Smallie 2009; Barrientos *et al*. 2012, Shaw 2013). In one study, carcass surveys were performed under high voltage transmission lines in the Karoo for two years, and low voltage distribution lines for one year (Shaw 2013). Ludwig's Bustard was the most common collision victim (69% of carcasses), with bustards generally comprising 87% of mortalities recovered. Total annual mortality was estimated at 41% of the Ludwig's Bustard population, with Kori Bustards *Ardeotis kori* also dying in large numbers (at least 14% of the South African population killed in the Karoo alone). Karoo Korhaan was also recorded, but to a much lesser extent than Ludwig's Bustard. The reasons for the relatively low collision risk of this species probably include their smaller size (and hence greater agility in flight) as well as their more sedentary lifestyles, as local birds are familiar with their territory and are less likely to collide with power lines (Shaw 2013).

Using a controlled experiment spanning a period of nearly eight years (2008 to 2016), the Endangered Wildlife Trust (EWT) and Eskom tested the effectiveness of two types of line markers in reducing power line collision mortalities of large birds on three 400kV transmission lines near Hydra substation in the Karoo. Marking was highly effective for Blue Cranes, with a 92% reduction in mortality, and large birds in general with a 56% reduction in mortality, but not for bustards, including the endangered Ludwig's Bustard. The two different marking devices were approximately equally effective, namely spirals and bird flappers, they found no evidence supporting the preferential use of one type of marker over the other (Shaw *et al*. 2017).

While the intention is to place the majority of the medium voltage reticulation network underground at the PV facility, there are areas where the lines will run above ground. Priority species which most at risk of collisions with the medium voltage powerlines are the following: Egyptian Goose, Ludwig's Bustard, Karoo Korhaan, South African Shelduck, Secretarybird and Blue Crane.

9 IMPACT RATING

9.1 Determination of Significance of Impacts

Direct, indirect and cumulative impacts of the issues identified through the EIA process were assessed in terms of the following criteria:

- The nature, which includes a description of what causes the effect, what will be affected and how it will be affected.

- The extent, wherein it is indicated whether the impact will be
  - 1 = site only
  - 2 = local
  - 3 = regional
  - 4 = national
  - 5 = international

- The duration, wherein is indicated whether:
  - 1 = the lifetime of the impact will be of a very short duration (0–1 years)
  - 2 = the lifetime of the impact will be of a short duration (2-5 years)
  - 3 = medium-term (5–15 years)
  - 4 = long term (> 15 years)
  - 5 = permanent

- The consequences (magnitude), quantified on a scale from 0-10, where:
    - 0 = small and will have no effect on the environment
    - 2 = minor and will not result in an impact on processes
    - 4 = low and will cause a slight impact on processes
    - 6 = moderate and will result in processes continuing but in a modified way
    - 8 = high (processes are altered to the extent that they temporarily cease)
    - 10 = very high and results in complete destruction of patterns and permanent cessation of processes.

- The probability of occurrence, which describes the likelihood of the impact actually occurring. Probability is estimated on a scale of 1–5, where:
    - 1 = very improbable (probably will not happen)
    - 2 = improbable (some possibility, but low likelihood)
    - 3 = probable (distinct possibility)
    - 4 = highly probable (most likely)
    - 5 is definite (impact will occur regardless of any prevention measures)

- The significance, which is determined through a synthesis of the characteristics described above and is assessed as low, medium or high

- The status, which is described as either positive, negative or neutral.

- The degree to which the impact can be reversed.

- The degree to which the impact may cause irreplaceable loss of resources.

- The degree to which the impact can be mitigated.

The significance is calculated by combining the criteria in the following formula:
S = (E+D+M)P
S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The significance weightings for each potential impact are as follows:

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

9.2 Impact Assessment

The impact assessments are summarised in the tables below.

9.2.1 Construction Phase

Nature: *Displacement of priority species due to disturbance associated with construction of the PV plant and associated infrastructure.*		
	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	1 very short	1 very short
Magnitude	8 high	6 moderate
Probability	5 definite	5 definite
Significance	**55 MEDIUM**	**45 MEDIUM**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but to a limited extent	

Mitigation:

- Activity should as far as possible be restricted to the footprint of the infrastructure.
- Measures to control noise and dust should be applied according to current best practice in the industry.
- Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical.
- Access to the rest of the property must be restricted.
- The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint is concerned.
- Measures to control noise and dust should be applied according to current best practice in the industry
- A 1.5km infrastructure free buffer zone must be implemented around the Tawny Eagle nest on the Droërivier Hydra 1 400kV transmission line at -31.507460° 23.550963°.

Residual Risks:

The residual risk of displacement will be reduced but remain at a medium level after mitigation, if the proposed mitigation is implemented.

Nature: *During construction: Displacement of priority species due to habitat transformation associated with construction of the PV plant and associated infrastructure.*		
	Without mitigation	**With mitigation**
Extent	1 site only	1 site only
Duration	4 long term	4 long term
Magnitude	8 high	6 moderate
Probability	5 definite	4 improbable
Significance	**65 HIGH**	**44 MEDIUM**
Status (positive or negative)	Negative	Negative

Reversibility	High	High
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	To a limited extent	
Mitigation: • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • The mitigation measures proposed by the ecological and botanical specialist studies must be strictly implemented.		
Residual Risks: The residual risk of displacement will be reduced after mitigation, but will remain for some species due to the change in habitat.		

9.2.2 Operational Phase

Nature: *Mortality of priority species due to collisions with solar panels.*		
	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	4 long term	4 long term
Magnitude	4 low	4 low
Probability	2 probable	2 probable
Significance	**20 LOW**	**20 LOW**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	No mitigation required	
Mitigation: • No mitigation is required due to the low significance.		
Residual Risks: Not applicable		

Nature: *Entrapment of large-bodied birds in the double perimeter fence.*		
	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	4 long term	4 long term
Magnitude	6 moderate	4 low
Probability	3 possible	2 improbable
Significance	**36 MEDIUM**	**20 LOW**

Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	
Mitigation: • It is recommended that a single perimeter fence is used.		
Residual Risks: The residual risk of electrocution will be low once mitigation is implemented.		

Nature: *Mortality of priority species due to electrocution on the medium voltage internal reticulation network*		
	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	4 long term	4 long term
Magnitude	8 high	4 low
Probability	3 possible	1 very improbable
Significance	**42 MEDIUM**	**10 LOW**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	
Mitigation: • Use underground cables as much as possible. • A raptor -friendly pole design must be used, and the pole design must be approved by the avifaunal specialist.		
Residual Risks: The residual risk of electrocution will be low once mitigation is implemented.		

Nature: *Mortality of priority species due to collisions with the medium voltage internal reticulation network*		
	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	4 long term	4 long term
Magnitude	6 medium	4 low
Probability	3 possible	2 improbable
Significance	**36 MEDIUM**	**20 LOW**
Status (positive or negative)	Negative	Negative

Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	

Mitigation:

- Use underground cables as much as possible.
- All internal medium voltage lines must be marked with Eskom approved Bird Flight Diverters according to the Eskom standard.

Residual Risks:

The residual risk of collision will still be present for Ludwig's Bustard, but significantly reduced for other species.

9.2.3 Decommissioning Phase

Nature: *Displacement of priority species due to disturbance associated with decommissioning of the PV plant and associated infrastructure.*

	Without mitigation	**With mitigation**
Extent	2 local	2 local
Duration	1 very short	1 very short
Magnitude	8 high	6 moderate
Probability	5 definite	5 definite
Significance	**55 MEDIUM**	**45 MEDIUM**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but to a limited extent	

Mitigation:

- Activity should as far as possible be restricted to the footprint of the infrastructure.
- Measures to control noise and dust should be applied according to current best practice in the industry.
- Maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum as far as practical.
- Access to the rest of the property must be restricted.
- The recommendations of the ecological and botanical specialist studies must be strictly implemented, especially as far as limitation of the construction footprint is concerned.
- Measures to control noise and dust should be applied according to current best practice in the industry

Residual Risks:

The residual risk of displacement will be reduced but remain at a medium level after mitigation, if the proposed mitigation is implemented.

The impacts are summarized, and a comparison made between pre-and post-mitigation phases as shown in Table 3 below. The rating of environmental issues associated with different parameters prior to, and post mitigation of a proposed activity was averaged.

Table 3: Comparison of summarised impacts on environmental parameters

Environmental Parameter	Nature of the Impact	Rating prior to mitigation	Rating post mitigation
Avifauna	Displacement of priority species due to disturbance associated with construction of the PV plant and associated infrastructure.	55 MEDIUM	45 MEDIUM
	Displacement of priority species due to habitat transformation associated with construction of the PV plant and associated infrastructure.	65 HIGH	44 MEDIUM
	Mortality of priority species due to collisions with solar panels.	20 LOW	20 LOW
	Entrapment of large-bodied birds in the double perimeter fence.	36 MEDIUM	20 LOW
	Mortality of priority species due to electrocution on the medium voltage internal reticulation network	42 MEDIUM	10 LOW
	Mortality of priority species due to collisions with the medium voltage internal reticulation network	36 MEDIUM	20 LOW
	Displacement of priority species due to disturbance associated with decommissioning of the PV plant and associated infrastructure.	55 MEDIUM	45 MEDIUM
	AVERAGE SIGNIFICANCE RATING	**44 MEDIUM**	**29 LOW**

10 ENVIRONMENTAL SENSITIVITIES

The following environmental sensitivities were identified from an avifaunal perspective in the development area:

- **Nests of Red Listed eagles: 1.5km all infrastructure No-Go zone**

A 1.5km infrastructure free buffer zone must be implemented around the Tawny Eagle (SA status: Endangered) nest on the Droërivier Hydra 2 400kV transmission line at -31.445988° 23.583921°. This is to prevent any disturbance of the birds at the nest during the construction phase which could lead them to abandon the nest.

See Figure 8 for the avifaunal sensitivities identified from a PV solar perspective.

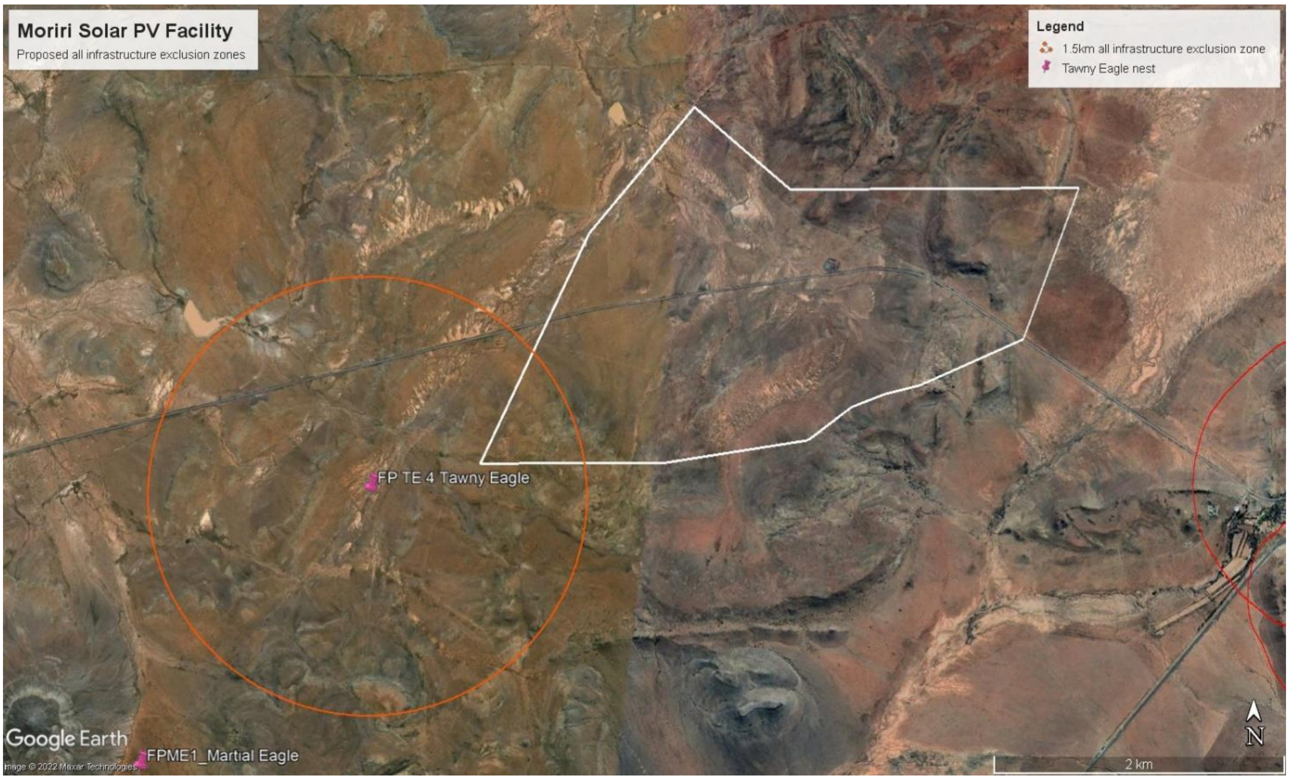


Figure 8: Avifaunal sensitivities (PV solar) at the Moriri Solar PV facility and associated infrastructure.

11 CUMULATIVE IMPACTS

Cumulative effects are commonly understood to be impacts from different projects that combine to result in significant change, which could be larger than the sum of all the individual impacts. The assessment of cumulative effects therefore needs to consider all renewable energy projects within a 30 km radius that have received an EA at the time of starting the environmental impact process, as well as the proposed Great Karoo Cluster projects. There are currently ten renewable energy projects authorised within a 30 km radius around the proposed five Great Karoo Cluster projects. The locality of renewable projects (affected properties) which are authorised are displayed in Figure 9.

The total affected land parcel area taken up by authorised renewable energy projects within the 30 km radius is approximately 774 km². The total land parcel area affected by the Great Karoo Renewable Energy Cluster equates to approximately 299 km². The combined land parcel area affected by authorised renewable energy developments within the 30 km radius around the proposed Great Karoo Renewable Energy Cluster, including the Great Karoo Renewable Energy Cluster, thus equals approximately 1 073 km². Of this, the proposed Moriri Solar PV project constitute ~0.5% (5.77km²). The cumulative impact of the proposed Moriri Solar PV project is thus anticipated to be **low** after mitigation.

The total area within the 30km radius around the proposed projects equates to about 4 396 km² of similar habitat. The total combined size of the land parcels potentially affected by renewable energy projects will equate to ~24% of the available untransformed habitat in the 30km radius. However, the actual physical footprint of the renewable energy facilities will be much smaller than the land parcel areas themselves. Furthermore, each of these projects must still be subject to a competitive bidding process where only the most competitive projects will win a power purchase agreement required for the project to proceed to construction. The cumulative impact of all the proposed renewable energy projects is estimated to be **moderate**.

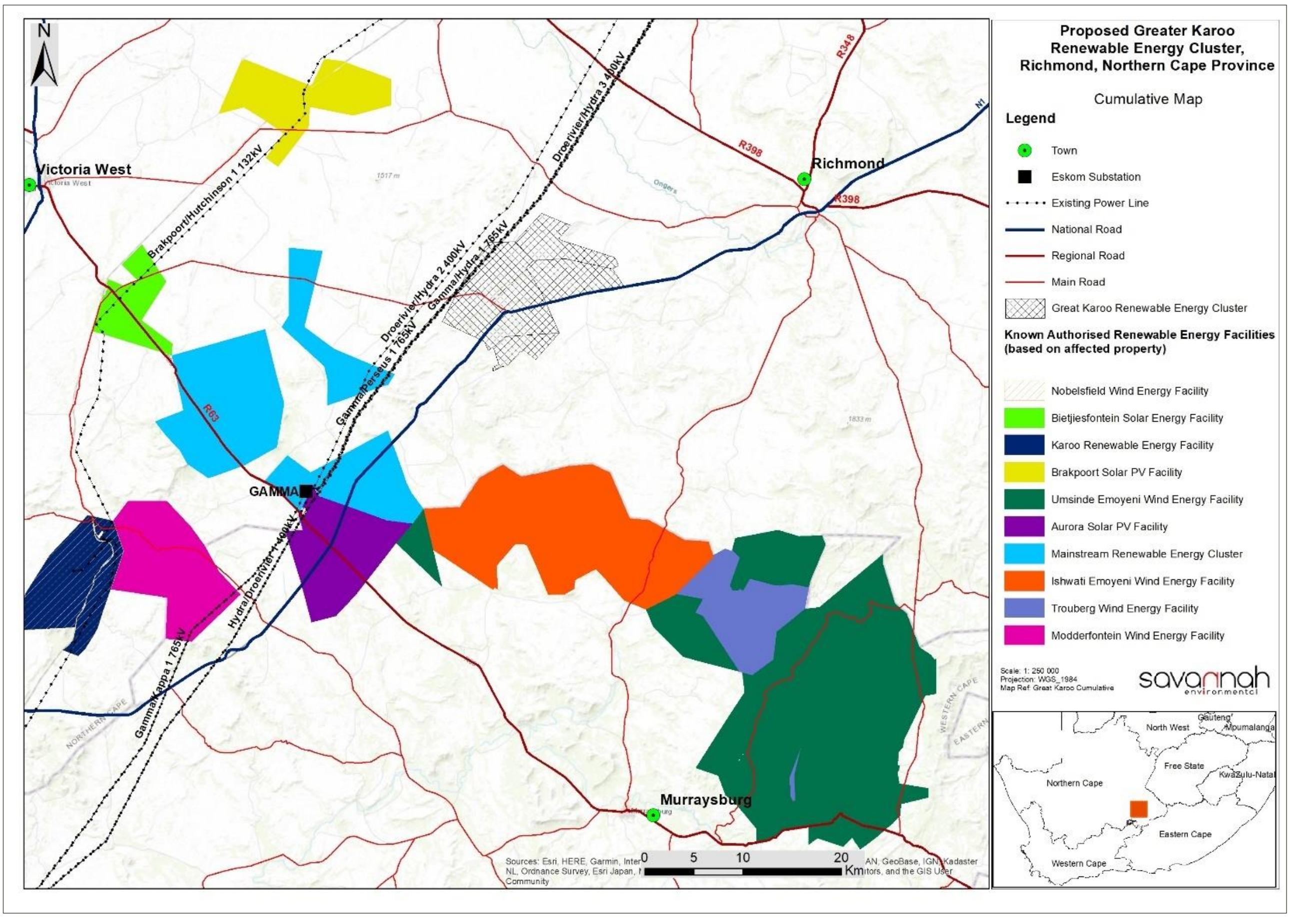


Figure 9: Regional EA applications for renewable energy projects located within a 30 km radius from the proposed Great Karoo Renewable Energy Cluster (Source: DEFF – Q3, 2021).

Nature: *Cumulative impacts associated with renewable energy facilities*

- *Displacement due to disturbance associated with the construction of the renewable energy facility and associated infrastructure*
- *Displacement due to habitat transformation associated with the construction and operation of the renewable energy facility and associated infrastructure*
- *Collisions with the solar panels*
- *Collison with wind turbines*
- *Entrapment in perimeter fences*
- *Displacement due to disturbance associated with the decommissioning of the renewable energy facilities and associated infrastructure*
- *Mortality of priority species due to electrocution on the medium voltage internal reticulation networks*
- *Mortality of priority species due to collisions with the medium voltage internal reticulation networks*

	Cumulative impact of the proposed Moriri Solar PV project within a 30km radius (post mitigation).	**Cumulative impact of the proposed Great Karoo Renewable energy Cluster and other authorised renewable energy projects within a 30km radius (post mitigation)**
Extent	2 local	3 regional
Duration	4 long term	4 short term
Magnitude	2 minor	6 moderate
Probability	3 probable	4 highly probable

Significance	**24 LOW**	**52 MEDIUM**
Status (positive/negative)	Negative	Negative
Reversibility	High	High
Loss of resources?	No	Yes
Can impacts be mitigated?	Yes	
Confidence in findings: Medium.		
Mitigation: • All mitigation measures listed in this report for the Moriri Solar PV Facility and all mitigation measures relevant to avifauna listed in the various specialist reports for the Great Karoo Renewable Energy Cluster and the other planned projects within a 30km radius of the Great Karoo Renewable Energy Cluster.		

12 ENVIRONMENTAL MANAGEMENT PROGRAMME

For each anticipated impact, management recommendations for the design, construction, and operational phase (where appropriate) are included in the project EMPr (see Appendix 4).

13 CONCLUSIONS

The proposed 100 MW Moriri Photovoltaic (PV) Solar Energy Facility will have a range of potential pre-mitigation impacts on priority avifauna ranging from low to high, which is expected to be reduced to medium and low with appropriate mitigation. No fatal flaws were discovered during the investigations.

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APPENDIX 1: SABAP 2 SPECIES LIST FOR THE BROADER AREA

Species	Taxonomic name	Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status
Acacia Pied Barbet	*Tricholaema leucomelas*	50.00	9.09		
African Fish Eagle	*Haliaeetus vocifer*	2.08	0.00		
African Harrier-Hawk	*Polyboroides typus*	6.25	3.03		
African Hoopoe	*Upupa africana*	16.67	3.03		
African Palm Swift	*Cypsiurus parvus*	8.33	3.03		
African Pipit	*Anthus cinnamomeus*	20.83	3.03		
African Red-eyed Bulbul	*Pycnonotus nigricans*	60.42	13.64		
African Reed Warbler	*Acrocephalus baeticatus*	10.42	0.00		
African Rock Pipit	*Anthus crenatus*	8.33	0.00	NT	NT
African Sacred Ibis	*Threskiornis aethiopicus*	12.50	0.00		
African Spoonbill	*Platalea alba*	6.25	4.55		
African Stonechat	*Saxicola torquatus*	2.08	0.00		
Alpine Swift	*Tachymarptis melba*	4.17	0.00		
Ant-eating Chat	*Myrmecocichla formicivora*	62.50	25.76		
Barn Swallow	*Hirundo rustica*	29.17	12.12		
Black Harrier	*Circus maurus*	2.08	0.00	EN	EN
Black Stork	*Ciconia nigra*	4.17	0.00	LC	VU
Black-eared Sparrow-Lark	*Eremopterix australis*	18.75	3.03		
Black-headed Canary	*Serinus alario*	25.00	0.00		
Black-headed Heron	*Ardea melanocephala*	12.50	0.00		
Blacksmith Lapwing	*Vanellus armatus*	37.50	4.55		
Black-throated Canary	*Crithagra atrogularis*	25.00	1.52		
Black-winged Kite	*Elanus caeruleus*	2.08	0.00		
Black-winged Stilt	*Himantopus himantopus*	12.50	1.52		
Blue Crane	*Grus paradisea*	62.50	18.18	VU	NT
Bokmakierie	*Telophorus zeylonus*	56.25	13.64		
Booted Eagle	*Hieraaetus pennatus*	6.25	0.00		
Brown-hooded Kingfisher	*Halcyon albiventris*	4.17	0.00		
Brown-throated Martin	*Riparia paludicola*	14.58	0.00		
Buffy Pipit	*Anthus vaalensis*	6.25	0.00		
Cape Bunting	*Emberiza capensis*	37.50	4.55		
Cape Canary	*Serinus canicollis*	12.50	3.03		
Cape Crow	*Corvus capensis*	8.33	4.55		
Cape Penduline Tit	*Anthoscopus minutus*	29.17	4.55		
Cape Robin-Chat	*Cossypha caffra*	31.25	3.03		
Cape Shoveler	*Spatula smithii*	2.08	1.52		
Cape Sparrow	*Passer melanurus*	83.33	16.67		
Cape Teal	*Anas capensis*	4.17	3.03		
Cape Turtle Dove	*Streptopelia capicola*	62.50	6.06		
Cape Wagtail	*Motacilla capensis*	64.58	4.55		
Cape Weaver	*Ploceus capensis*	4.17	1.52		
Cape White-eye	*Zosterops virens*	10.42	1.52		

Species	Taxonomic name	Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status
Capped Wheatear	*Oenanthe pileata*	20.83	4.55		
Chat Flycatcher	*Melaenornis infuscatus*	54.17	7.58		
Chestnut-vented Warbler	*Curruca subcoerulea*	16.67	1.52		
Common Buzzard	*Buteo buteo*	2.08	7.58		
Common Greenshank	*Tringa nebularia*	10.42	1.52		
Common Moorhen	*Gallinula chloropus*	2.08	0.00		
Common Sandpiper	*Actitis hypoleucos*	2.08	0.00		
Common Swift	*Apus apus*	2.08	1.52		
Common Waxbill	*Estrilda astrild*	14.58	1.52		
Desert Cisticola	*Cisticola aridulus*	22.92	3.03		
Diederik Cuckoo	*Chrysococcyx caprius*	10.42	1.52		
Double-banded Courser	*Rhinoptilus africanus*	4.17	0.00		
Dusky Sunbird	*Cinnyris fuscus*	25.00	0.00		
Eastern Clapper Lark	*Mirafra fasciolata*	70.83	21.21		
Egyptian Goose	*Alopochen aegyptiaca*	37.50	6.06		
European Bee-eater	*Merops apiaster*	16.67	0.00		
Fairy Flycatcher	*Stenostira scita*	12.50	1.52		
Familiar Chat	*Oenanthe familiaris*	27.08	6.06		
Fiscal Flycatcher	*Melaenornis silens*	33.33	3.03		
Fork-tailed Drongo	*Dicrurus adsimilis*	6.25	1.52		
Greater Flamingo	*Phoenicopterus roseus*	4.17	1.52	LC	NT
Greater Kestrel	*Falco rupicoloides*	31.25	3.03		
Greater Striped Swallow	*Cecropis cucullata*	33.33	10.61		
Grey Heron	*Ardea cinerea*	8.33	1.52		
Grey Tit	*Melaniparus afer*	18.75	4.55		
Grey-backed Cisticola	*Cisticola subruficapilla*	29.17	6.06		
Grey-backed Sparrow-Lark	*Eremopterix verticalis*	39.58	15.15		
Grey-winged Francolin	*Scleroptila afra*	8.33	1.52		
Hadada Ibis	*Bostrychia hagedash*	33.33	1.52		
Hamerkop	*Scopus umbretta*	8.33	1.52		
Helmeted Guineafowl	*Numida meleagris*	12.50	1.52		
House Sparrow	*Passer domesticus*	22.92	3.03		
Jackal Buzzard	*Buteo rufofuscus*	43.75	16.67		
Karoo Chat	*Emarginata schlegelii*	25.00	6.06		
Karoo Eremomela	*Eremomela gregalis*	2.08	6.06		
Karoo Korhaan	*Eupodotis vigorsii*	52.08	7.58	LC	NT
Karoo Lark	*Calendulauda albescens*	2.08	0.00		
Karoo Long-billed Lark	*Certhilauda subcoronata*	54.17	9.09		
Karoo Prinia	*Prinia maculosa*	43.75	7.58		
Karoo Scrub Robin	*Cercotrichas coryphoeus*	83.33	19.70		
Karoo Thrush	*Turdus smithi*	39.58	3.03		
Kittlitz's Plover	*Charadrius pecuarius*	6.25	1.52		
Lanner Falcon	*Falco biarmicus*	2.08	3.03	LC	VU
Large-billed Lark	*Galerida magnirostris*	50.00	13.64		
Lark-like Bunting	*Emberiza impetuani*	72.92	19.70		
Laughing Dove	*Spilopelia senegalensis*	35.42	7.58		

Species	Taxonomic name	Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status
Layard's Warbler	*Curruca layardi*	25.00	1.52		
Lesser Kestrel	*Falco naumanni*	2.08	1.52		
Lesser Swamp Warbler	*Acrocephalus gracilirostris*	12.50	0.00		
Levaillant's Cisticola	*Cisticola tinniens*	6.25	0.00		
Little Bittern	*Ixobrychus minutus*	2.08	0.00		
Little Grebe	*Tachybaptus ruficollis*	4.17	0.00		
Little Stint	*Calidris minuta*	4.17	0.00		
Little Swift	*Apus affinis*	22.92	3.03		
Long-billed Crombec	*Sylvietta rufescens*	14.58	0.00		
Ludwig's Bustard	*Neotis ludwigii*	45.83	7.58	EN	EN
Malachite Sunbird	*Nectarinia famosa*	8.33	0.00		
Marsh Sandpiper	*Tringa stagnatilis*	2.08	0.00		
Martial Eagle	*Polemaetus bellicosus*	10.42	1.52	VU	EN
Mountain Wheatear	*Myrmecocichla monticola*	43.75	6.06		
Namaqua Dove	*Oena capensis*	14.58	10.61		
Namaqua Sandgrouse	*Pterocles namaqua*	29.17	3.03		
Neddicky	*Cisticola fulvicapilla*	0.00	1.52		
Nicholson's Pipit	*Anthus nicholsoni*	14.58	1.52		
Northern Black Korhaan	*Afrotis afraoides*	72.92	21.21		
Orange River White-eye	*Zosterops pallidus*	4.17	0.00		
Pale Chanting Goshawk	*Melierax canorus*	45.83	13.64		
Pale-winged Starling	*Onychognathus nabouroup*	62.50	3.03		
Pearl-breasted Swallow	*Hirundo dimidiata*	4.17	0.00		
Pied Avocet	*Recurvirostra avosetta*	16.67	6.06		
Pied Crow	*Corvus albus*	81.25	48.48		
Pied Starling	*Lamprotornis bicolor*	35.42	9.09		
Pink-billed Lark	*Spizocorys conirostris*	2.08	0.00		
Pin-tailed Whydah	*Vidua macroura*	16.67	1.52		
Plain-backed Pipit	*Anthus leucophrys*	18.75	1.52		
Pririt Batis	*Batis pririt*	2.08	1.52		
Red-billed Quelea	*Quelea quelea*	29.17	3.03		
Red-billed Teal	*Anas erythrorhyncha*	14.58	3.03		
Red-capped Lark	*Calandrella cinerea*	20.83	0.00		
Red-eyed Dove	*Streptopelia semitorquata*	35.42	4.55		
Red-faced Mousebird	*Urocolius indicus*	14.58	3.03		
Red-headed Finch	*Amadina erythrocephala*	4.17	9.09		
Red-knobbed Coot	*Fulica cristata*	6.25	0.00		
Red-winged Starling	*Onychognathus morio*	20.83	4.55		
Reed Cormorant	*Microcarbo africanus*	2.08	0.00		
Rock Kestrel	*Falco rupicolus*	41.67	3.03		
Rock Martin	*Ptyonoprogne fuligula*	58.33	7.58		
Rufous-cheeked Nightjar	*Caprimulgus rufigena*	4.17	0.00		
Rufous-eared Warbler	*Malcorus pectoralis*	75.00	28.79		
Sabota Lark	*Calendulauda sabota*	52.08	9.09		
Scaly-feathered Weaver	*Sporopipes squamifrons*	0.00	3.03		
Secretarybird	*Sagittarius serpentarius*	12.50	6.06	VU	VU

Species	Taxonomic name	Full protocol reporting rate	ad hoc protocol reporting rate	Global status	Regional status
Short-toed Rock Thrush	*Monticola brevipes*	2.08	1.52		
Sickle-winged Chat	*Emarginata sinuata*	56.25	7.58		
South African Cliff Swallow	*Petrochelidon spilodera*	12.50	6.06		
South African Shelduck	*Tadorna cana*	47.92	4.55		
Southern Fiscal	*Lanius collaris*	62.50	7.58		
Southern Double-collared Sunbird	*Cinnyris chalybeus*	2.08	0.00		
Southern Grey-headed Sparrow	*Passer diffusus*	35.42	4.55		
Southern Masked Weaver	*Ploceus velatus*	66.67	10.61		
Southern Red Bishop	*Euplectes orix*	31.25	7.58		
Speckled Pigeon	*Columba guinea*	54.17	10.61		
Spike-heeled Lark	*Chersomanes albofasciata*	77.08	18.18		
Spotted Eagle-Owl	*Bubo africanus*	8.33	0.00		
Spotted Thick-knee	*Burhinus capensis*	2.08	1.52		
Spur-winged Goose	*Plectropterus gambensis*	8.33	4.55		
Tawny Eagle	*Aquila rapax*	12.50	3.03	VU	EN
Three-banded Plover	*Charadrius tricollaris*	33.33	0.00		
Tractrac Chat	*Emarginata tractrac*	2.08	4.55		
Verreaux's Eagle	*Aquila verreauxii*	18.75	1.52	LC	VU
Wattled Starling	*Creatophora cinerea*	4.17	0.00		
Western Barn Owl	*Tyto alba*	2.08	0.00		
Western Cattle Egret	*Bubulcus ibis*	2.08	0.00		
White-backed Mousebird	*Colius colius*	45.83	7.58		
White-breasted Cormorant	*Phalacrocorax lucidus*	4.17	0.00		
White-necked Raven	*Corvus albicollis*	35.42	10.61		
White-rumped Swift	*Apus caffer*	14.58	9.09		
White-throated Canary	*Crithagra albogularis*	62.50	10.61		
White-throated Swallow	*Hirundo albigularis*	14.58	1.52		
Yellow Canary	*Crithagra flaviventris*	16.67	4.55		
Yellow-bellied Eremomela	*Eremomela icteropygialis*	39.58	9.09		
Yellow-billed Duck	*Anas undulata*	20.83	3.03		

APPENDIX 2: HABITAT FEATURES AT THE DEVELOPMENT AREA

Figure 1: Typical Nama Karoo habitat in the project site.

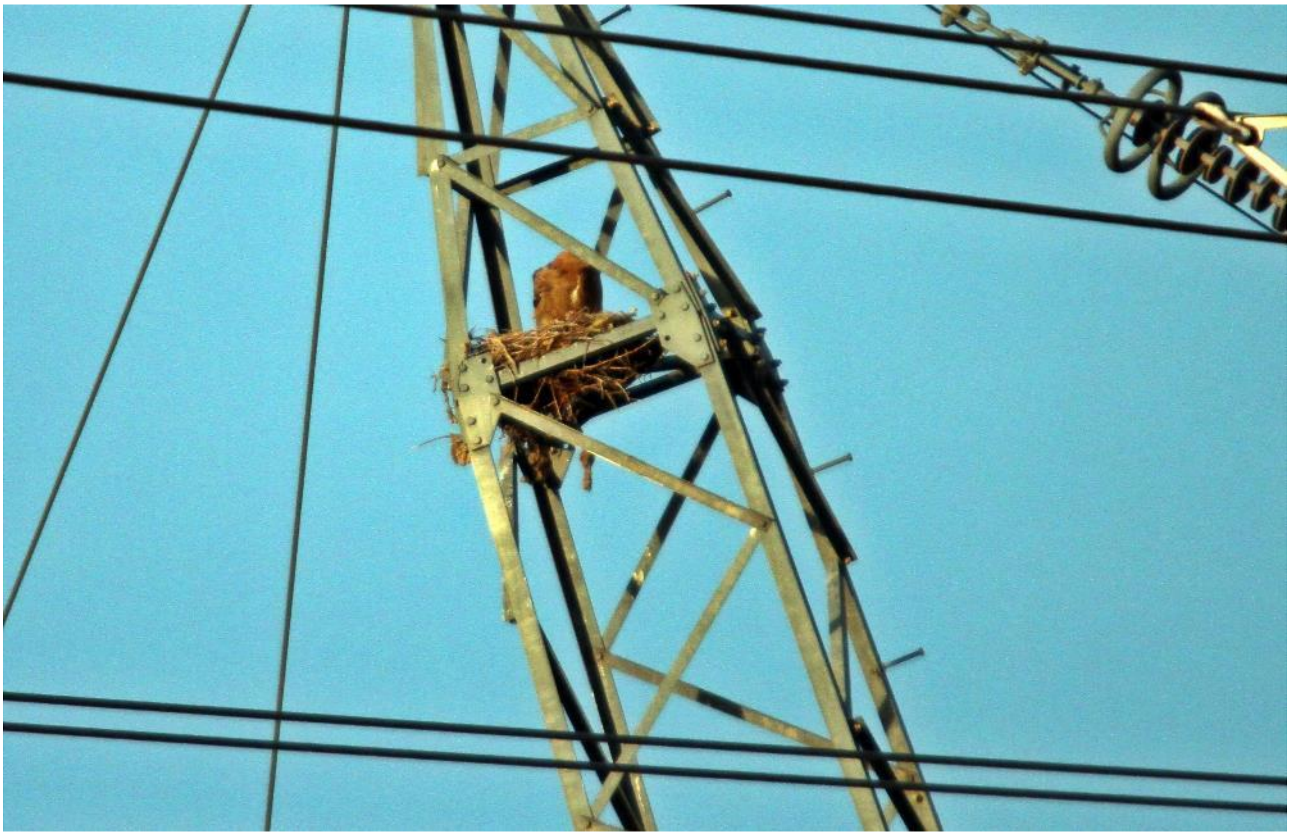

Figure 2: A Tawny Eagle nest (FPTE4) on the 1 Droërivier Hydra 400kV transmission line.

APPENDIX 3: PRE-CONSTRUCTION MONITORING

Monitoring for the Great Karoo PV projects was conducted in the following manner:

- Two drive transects were identified totalling 14km at the project site.
- Two monitors travelling slowly (± 10km/h) in a vehicle recorded all birds on both sides of the transect. The observers stopped at regular intervals (every 500m) to scan the environment with binoculars. Drive transects were counted three times per sampling session.
- In addition, 8 walk transects of 1km each were identified at various places in the project site, and 9 transects of 1km each specifically at each of the solar development areas. The transects were counted four times. All birds were recorded during walk transects.
- The following variables were recorded:
  - Species
  - Number of birds
  - Date
  - Start time and end time
  - Estimated distance from transect
  - Wind direction
  - Wind strength (estimated Beaufort scale)
  - Weather (sunny; cloudy; partly cloudy; rain; mist)
  - Temperature (cold; mild; warm; hot)
  - Behaviour (flushed; flying-display; perched; perched-calling; perched-hunting; flying-foraging; flying-commute; foraging on the ground) and

The aim with drive transects was primarily to record large priority species (i.e. raptors and large terrestrial species), while walk transects were primarily aimed at recording small passerines. The objective of the transect monitoring was to gather baseline data on the use of the project site by birds.

Figure 1 below indicates the location of the transects where monitoring was conducted.

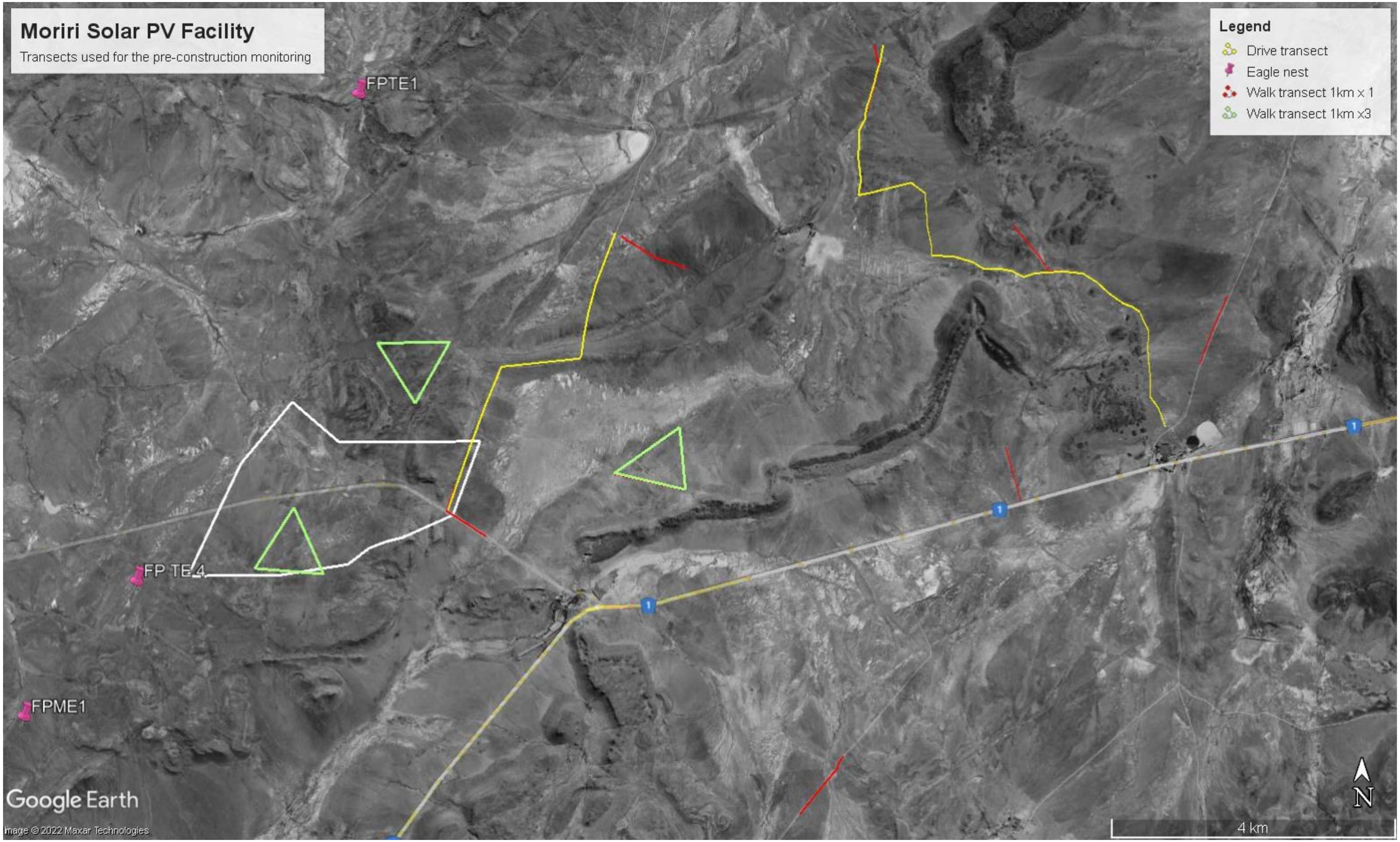

Figure 1: Area where monitoring was implemented, with position of drive transects and walk transects and the development area.

APPENDIX 4: ENVIRONMENTAL MANAGEMENT PROGRAMME

Management Plan for the Planning and Design Phase

Impact	Mitigation/Management Objectives and Outcomes	Mitigation/Management Actions	Monitoring		
			Methodology	*Frequency*	*Responsibility*
Avifauna: Entrapment					
Entrapment of medium and large terrestrial birds between the perimeter fences, leading to mortality.	Prevent mortality of avifauna	1. A single perimeter fence should be used[4].	Design the facility with a single perimeter fence.	Once-off during the planning phase.	Project Developer
Avifauna: Displacement					
Displacement of avifauna due to disturbance during construction activities.	Prevent displacement of avifauna	1. A 1.5km infrastructure free buffer zone must be implemented around the Tawny Eagle (SA status: Endangered) nest on the Droërivier Hydra 2 400kV transmission line at -31.445988° 23.583921°. This is to prevent any disturbance of the birds at the nest during the construction phase which could lead them to abandon the nest.	Design the facility with a 1.5km infrastructure free buffer zone must be implemented around the Tawny Eagle nest on the Droërivier Hydra 2 400kV transmission line at -31.445988° 23.583921°.	Once-off during the planning phase.	Project Developer
Avifauna: Mortality due to electrocutions on the internal 33kV network					
Electrocution of priority species on the 33kV network .	Prevention of electrocution mortality	1. Design the facility with underground cables as much as possible. 2. A raptor -friendly pole design must be used, and the pole design must be approved by the avifaunal specialist.	Design the facility with underground cabling and where impractical, use a bird friendly pole design approved by the avifaunal specialist.	Once-off during the planning phase.	Project Developer

[4] If a fence is used consisting of an outer diamond mesh fence and inner electric fence with a separation distance of approximately 100 mm or less, it should not pose any risk of entrapment for large terrestrial species and can be considered a single fence.

Management Plan for the Construction Phase

Impact	Mitigation/Management Objectives and Outcomes	Mitigation/Management Actions	Monitoring		
			Methodology	*Frequency*	*Responsibility*
Avifauna: Disturbance					
The noise and movement associated with the construction activities at the development footprint will be a source of disturbance which would lead to the displacement of avifauna from the area	Prevent unnecessary displacement of avifauna by ensuring that contractors are aware of the requirements of the Construction Environmental Management Programme (CEMPr.)	A site-specific CEMPr must be implemented, which gives appropriate and detailed description of how construction activities must be conducted. All contractors are to adhere to the CEMPr and should apply good environmental practice during construction. The CEMPr must specifically include the following: 1. No off-road driving; 2. Maximum use of existing roads, where possible; 3. Measures to control noise and dust according to latest best practice; 4. Restricted access to the rest of the property; 5. Strict application of all recommendations in the botanical specialist report pertaining to the limitation of the footprint.	1. Implementation of the CEMPr. Oversee activities to ensure that the CEMPr is implemented and enforced via site audits and inspections. Report and record any non-compliance. 2. Ensure that construction personnel are made aware of the impacts relating to off-road driving. 3. Construction access roads must be demarcated clearly. Undertake site inspections to verify. 4. Monitor the implementation of noise control mechanisms via site inspections and record and report non-compliance. 5. Ensure that the construction area is demarcated clearly and that construction personnel are made aware of these demarcations. Monitor via site inspections and report non-compliance.	1. On a daily basis 2. Weekly 3. Weekly 4. Weekly 5. Weekly	1. Contractor and ECO 2. Contractor and ECO 3. Contractor and ECO 4. Contractor and ECO 5. Contractor and ECO
Mortality of priority species due to collisions with the medium voltage internal reticulation network	Prevention of powerline collision mortality	Eskom approved bird flight diverters should be installed on the full span length of all 33kV overhead lines (according to Eskom guidelines - five metres apart). Light and dark colour devices must be alternated to provide contrast against both dark and light backgrounds respectively. These devices must be installed as soon as the conductors are strung.	Bird Flight Diverters must be installed as soon as the conductors are strung.	1. Once-off	1. Contractor and ECO

Management Plan for the Operational Phase

Impact	Mitigation/Management Objectives and Outcomes	Mitigation/Management Actions	Monitoring		
			Methodology	*Frequency*	*Responsibility*
Avifauna: Displacement due to habitat transformation					
Total or partial displacement of avifauna due to habitat transformation associated with the vegetation clearance and the presence of the solar PV plants and associated infrastructure.	Prevent unnecessary displacement of avifauna by ensuring that the rehabilitation of transformed areas is implemented by an appropriately qualified rehabilitation specialist, according to the recommendations of the botanical specialist study.	1. Develop a Habitat Restoration Plan (HRP). 2. Monitor rehabilitation via site audits and site inspections to ensure compliance. 3. Record and report any non-compliance.	1. Appointment of rehabilitation specialist to develop HRP. 2. Site inspections to monitor progress of HRP. 3. Adaptive management to ensure HRP goals are met.	1. Once-off 2. Once a year 3. As and when required	1. Project Developer 2. Facility Environmental Manager 3. Project Developer and Facility Operational Manager