BIRD IMPACT ASSESSMENT STUDY

Proposed Mainstream Graskoppies Wind Energy Facility near Loeriesfontein in the Northern Cape Province

December 2016

Revised July 2017

Prepared by:

AERIMAGE Photography (Pty) Ltd t/a

Chris van Rooyen Consulting

VAT#: 4580238113

email: vanrooyen.chris@gmail.com

Tel: +27 (0)82 4549570 cell

DECLARATION OF INDEPENDENCE

I, Chris van Rooyen as duly authorised representative of Chris van Rooyen Consulting, and working under the supervision of and in association with Albert Froneman (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003, hereby confirm my independence (as well as that of Chris van Rooyen Consulting) as a specialist and declare that neither I nor Chris van Rooyen Consulting have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which SiVEST was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed Wind Energy Facilities.

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Full Name: Chris van Rooyen
Position: Director

RELEVANT EXPERTISE

Chris van Rooyen

Chris has 20 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 more than 160 power line and 30 renewable energy 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 (Pr.Sci.Nat)

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). He is a registered Professional Natural Scientist in the field of zoological science with the South African Council of Natural Scientific Professionals (SACNASP). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – Endangered Wildlife 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 they are 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.

Nico Laubscher

Nico holds a D.Sc. from the University of Potchefstroom and was head of the Statistics Division, National Research Institute for Mathematical Sciences of the CSIR from 1959 – 1975. He retired in 1989 as head of the Centre for Statistical Consultation at the University of Stellenbosch. Nico held several offices, including President of the South African Statistical Association, and editor of the South African Statistical Journal. Nico has more than five decades' experience in statistical analysis and data science applications, including specialisation in model building with massive data sets, designing of experiments for process improvement and analysis of data so obtained, and statistical process control. He also has published peer reviewed papers in several leading statistical journals, including Annals of Mathematical Statistics, American Statistical Journal, Technometrics and The American Statistician. He currently operates as a private statistical consultant to industry and academia.

EXECUTIVE SUMMARY

The proposed Mainstream Graskoppies Wind Farm will have a variety of impacts on avifauna which range from low to high. The impacts are (1) displacement of priority species due to disturbance during construction phase (2) displacement of priority species due to habitat destruction during construction phase (3) displacement of priority species due to disturbance during operational phase (4), collisions of priority species with the turbines in the operational phase, and (5) electrocution of priority species on the internal MV powerlines.

Displacement of priority species due to disturbance during construction phase is likely to be a temporary medium negative impact, but can be reduced to low with the application of mitigation measures. Mitigation measures are:

- the restriction of construction activities to the construction footprint area, no access to the remainder of the property during the construction period,
- measures to control noise and dust,
- maximum use of existing access roads and
- the implementation of a 300m exclusion zone around waterpoints.

Displacement of priority species due to habitat destruction during construction phase is likely to be a medium negative impact and will remain so, despite the application of mitigation measures. Mitigation measures comprise the following:

- the recommendations of the specialist ecological study must be strictly adhered to,
- maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum,
- a 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place,
- post-construction monitoring should be implemented to make comparisons with baseline conditions possible, and if densities of key priority species are proven to be significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species.

Displacement of priority species due to disturbance during the operational phase is likely to be of low significance and it could be further reduced through the application of mitigation measures, namely the restriction of operational activities to the plant area and no access to other parts of the property unless it is necessary for wind farm related work.

Collisions of priority species with the turbines in the operational phase are likely to be a high negative impact but it could be reduced to medium negative through the application of mitigation measures. Mitigation measures are the following:

- A 300m no-go buffer is proposed around water points and pans as they serve as focal points for bird activity,
- formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (as an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and again every five years thereafter),

- the minimum turbine tip height should ideally be no less than 50m to reduce the risk of Red Lark mortality during display flight activity,
- depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be,
- if turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations),
- lighting of the wind farm (for example security lights) should be kept to a minimum, and lights should be directed downwards (provided this complies with Civil Aviation Authority regulations).

The electrocution of priority species on the internal MV powerlines is rated as a potentially medium impact which could be reduced to low through the use of bird friendly designs.

Finally, it is concluded that, after taking into account the expected impact of proposed renewable energy projects within a 40km radius around Helios MTS, that the cumulative impact of the proposed Graskoppies WEF on priority avifauna, if appropriate mitigation is implemented, will range from minor to insignificant.

Table of Contents

Appendices

APPENDIX A: HABITAT EXAMPLES
APPENDIX B: METHODOLOGY OF PRE-CONSTRUCTION MONITORING
APPENDIX C: STATISTICAL ANALYSIS
APPENDIX D: OTHER RENEWABLE ENERGY DEVELOPMENTS WITHIN 40KM RADIUS

Definition of terms:

Greater study area: This refers to the area that comprises the four proposed development areas, i.e. Graskoppies WEF, Ithemba WEF, Hartebeest Leegte WEF and !Xha Boom WEF, as well as a control area and immediate environs.

Development areas: This refers to the area that comprises the four proposed development areas, i.e. Graskoppies WEF, Ithemba WEF, Hartebeest Leegte WEF and !Xha Boom WEF.

Development area: This refers to the area that comprises the proposed Graskoppies WEF area.

1. INTRODUCTION & BACKGROUND

1.1 Project Description

South Africa Mainstream Renewable Power Developments (Pty) Ltd (hereafter referred to as Mainstream) are proposing to construct a wind farm and associated infrastructure near Loeriesfontein in the Northern Cape Province of South Africa. The proposed development will consist of a 235MW maximum export capacity wind farm referred to as Graskoppies Wind Farm. In addition, the overall objective of the project is to generate electricity to feed into the National Grid.

The proposed development will encompass the installation of wind turbines and associated infrastructure, in order to generate electricity that is to be fed into the Eskom grid. The facility will have a maximum export capacity of up to 235MW and will be referred to as the Graskoppies Wind Farm. The wind farm will consist of up to 70 turbines, each with a generation capacity between 3 and 5MW. The generated electricity will be fed into the national grid at the Helios Substation via a 132kV power line. It should however be noted that this 132kV power line will require a separate Environmental Authorisation and is being conducted as a part of a separate Basic Assessment (BA) process. The total area of the project infrastructure has not been determined and will be determined during the EIA phase, however the total extent of the development area is approximately 5088 / hectares. The total buildable area for the proposed Wind Farm is 2468.27 hectares.

1.2 Project Location

The proposed wind farm is located approximately 70km north of Loeriesfontein in the Northern Cape Province and straddles the boundary between the Hantam and Khai-Ma Local Municipalities.

The study area is on the following properties:

- Eastern portion of Portion 2 of the Farm Graskoppies No. 176; and
- Eastern portion of Portion 1 of the Farm Hartebeest Leegte No. 216.

The project site has been identified by Mainstream based on wind resource, grid connection suitability, competition, flat topography, land availability and site access. The buildable area of the site will however be determined by sensitive areas identified during the EIA.

The key components of the project are detailed below.

1.3 Wind Farm Technical Details

1.3.1 Turbines

The total amount of developable area is approximately 5088 hectares. The total buildable area for the proposed Wind Farm is 2468.27 hectares. The wind turbines and all other project infrastructure will be placed strategically within the development area based on environmental constraints. The size of the wind turbines will depend on the development area and the total generation capacity that can be produced as a result. The wind turbines will therefore likely have a hub height of up to 160m and a rotor diameter of up to 160m. Each wind turbine will have a foundation diameter of up to 25m and will be approximately 3m deep, however, these dimensions may be larger if geotechnical conditions dictate as such. The hardstand area occupied by each wind turbine will be up to 0.5 hectares (85m x 60m). The excavation area will be approximately 1 000m² in sandy soils due to access requirements and safe slope stability requirements. A hard standing area / platform of approximately 2 400m2 (60m x 40m) per turbine will be required for turbine crane usage. There will be up to 70 wind turbines constructed with a capacity up to 235MW. The electrical generation capacity for each turbine will range between 3MW and 5MW, depending on the final wind turbine selected for the proposed development. It must be noted that the final selection for the turbine type will be conducted after the project has been selected as a Preferred Bidder project under the DoE REIPPPP. This is as a result of technology constantly changing as time progresses.

1.3.2 Electrical Connections

The wind turbines will be connected to the proposed 132kV on-site Graskoppies substation using buried (up to a 1.5m depth) medium voltage cables except where a technical assessment of the proposed design suggests that overhead lines are more appropriate such as over rivers, gullies and long runs. Where overhead power lines are to be constructed, self-supported or H-pole tower types will be used. The height will vary based on the terrain, but will ensure minimum Overhead Line (OHL) clearances with buildings, roads and surrounding infrastructure will be maintained. The dimensions of the specific OHL structure types will depend on electricity safety requirements. The exact location of the towers, the selection of the final OHL structure types and the final designs will comply with the best practise and SANS requirements.

1.3.3 Roads

Internal access roads with a maximum width of 20m are initially being proposed for the construction phase. This is however only temporary as the width of proposed internal access roads will be reduced to approximately 6 – 8m for maintenance purposes during the operational phase. The proposed internal access roads will include the net load carrying surface excluding any V drains that might be required.

1.3.4 Temporary Construction Lay Down Area

The temporary construction lay down area will be approximately 10 000m² (100m x 100m) and will include an access road and contractor's site office area of up to 5 000m^2. A hard standing area / platform of approximately 2 400m^2 (60m x 40m) per turbine will be required for turbine crane usage.

1.3.5 Operations and Maintenance Buildings

The operation and maintenance buildings will include an on-site spares storage building, a workshop and operations building with a total combined footprint that will not exceed 5 000m^2. The operation and maintenance buildings will be situated in proximity to the wind farm substation due to requirements for power, water and access.

1.3.6 Other Associated Infrastructure

Other infrastructure includes the following:

- Fencing (if required) will be up to 5m where required and will be either mesh or palisade.

The key technical details and infrastructure required is presented in the table below.

Table i: Summary of technical details

Project Name	DEA Reference	Farm name and area	Technical details and infrastructure necessary for the proposed project
Graskoppies Wind Farm	To be announced	▪ Eastern portion of Portion 2 of the Farm Graskoppies No.176; and ▪ Eastern portion of Portion 1 of the Farm Hartebeest Leegte No.216 Development Area: 5088 ha	▪ Up to **70 wind turbines**, between 3 and 5MW, with a maximum export capacity up to 235MW. ▪ Wind turbines will have a hub height of up to 160m and a rotor diameter of up to 160m. ▪ **132kV on-site Graskoppies IPP Substation** ▪ The turbines will be connected via **medium voltage cables** to the proposed 132kV on-site Graskoppies IPP Substation**.** ▪ Internal **access roads** are proposed to be up to 20 m wide. This would however only be for the construction phase as the width of the internal access roads will be reduced to 6 - 8m during the operational phase. ▪ A temporary construction **lay down area.** ▪ A **hard standing area / platform** per turbine. ▪ The **operations and maintenance buildings**, including an on-site spares storage building, a workshop and an operations building. ▪ **Fencing** (if required) will be up to 5m where required and will be either mesh or palisade.

This bird impact assessment study deals specifically with the proposed Graskoppies Wind Energy Facility (WEF) and associated infrastructure, except the grid connection, which is dealt with as a separate application.

See Figure 1 below for a map of the study area.

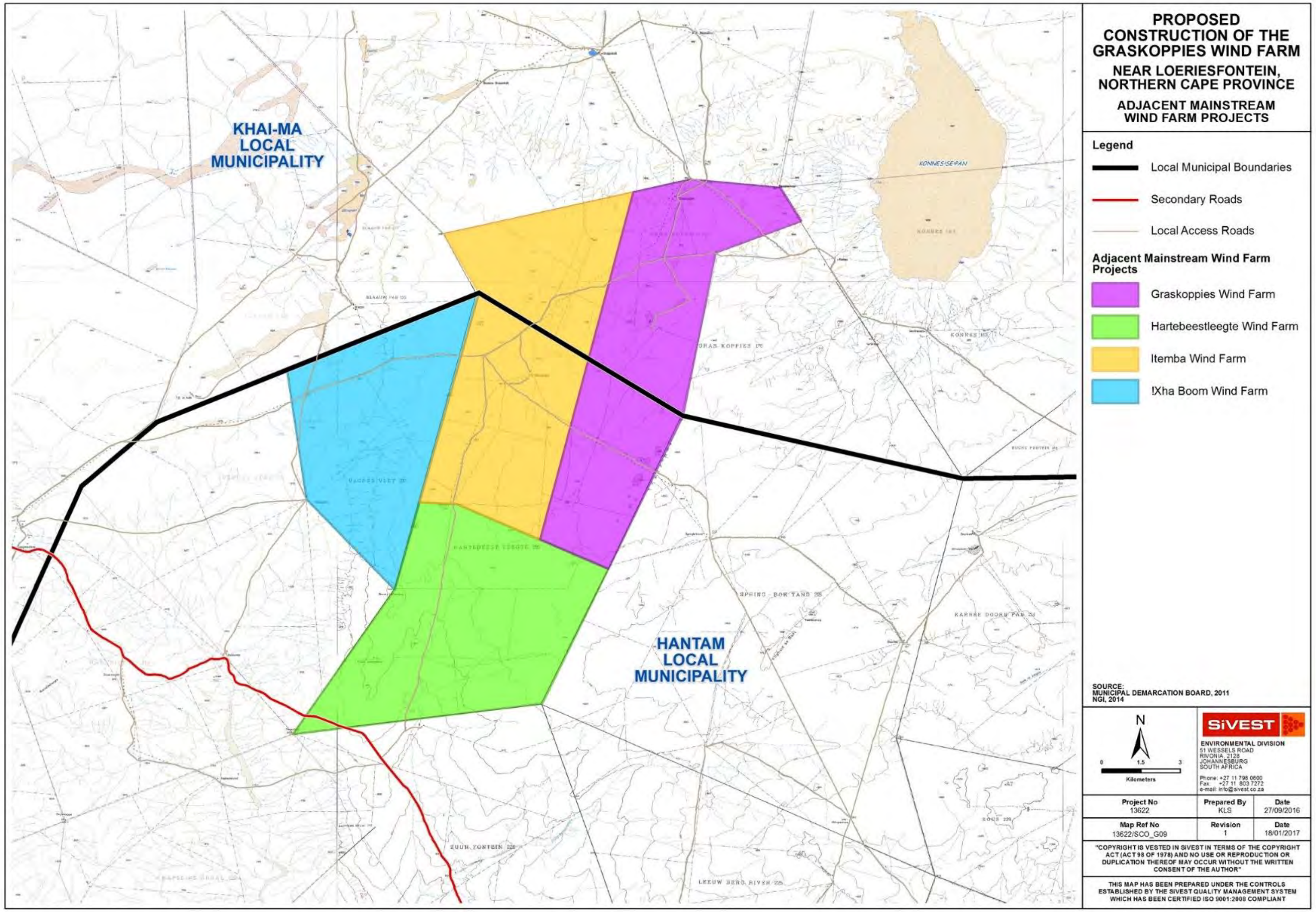

Figure 1: Map of the four proposed Mainstream Wind Farms, indicating the locality of the proposed Graskoppies Wind Farm.

Figure 2: Close-up view of proposed Mainstream Graskoppies WEF study site on a background of satellite imagery.

2. TERMS OF REFERENCE

The terms of reference for this avifaunal impact assessment study are as follows:

- Describe the affected environment from an avifaunal habitat perspective.
- Discuss any applicable legislation pertaining to impacts on avifauna.
- Identify gaps in baseline data.
- Assess the expected impacts.
- Provide a sensitivity map of the proposed development site from an avifaunal perspective.

3. SOURCES OF INFORMATION AND METHODOLOGY

The following methods were applied to compile this report:

- Bird distribution data of the South African Bird Atlas 2 (SABAP 2) was obtained from the Animal Demography Unit of the University of Cape Town, as a means to ascertain which species occurs within the broader area i.e. within an area consisting of nine pentad grid cells within which the proposed WEFs are situated. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is approximately 8 × 7.6 km. Between June 2010 and August 2016, a total of 21 full protocol cards (i.e. 21 surveys lasting a minimum of two hours or more each) have been completed for this area (see Figure 3).
- The national threatened status of all priority species was determined with the use of the most recent edition of the Red Data 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 IUCN Red List of Threatened Species Version 2016.2.[1]
- A classification of vegetation types was obtained from Southern African Bird Atlas 1 (Harrison *et al.* 1997) and the National Vegetation Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford 2006).
- The Important Bird Areas of Southern Africa (Barnes 1998; Marnewick *et al*. 2015) was consulted for information on potentially relevant Important Bird Areas (IBAs).
- Satellite imagery was used in order to view the broader development area on a landscape level and to help identify bird habitat on the ground.
- Information on the micro habitat level was obtained through a pre-construction monitoring programme which was conducted over four seasons between November 2015 and September 2016.
- The primary source of information on avifaunal diversity, abundance and flight patterns at the site were the results of the pre-construction programme. The primary methods of data capturing were

[1] http://www.iucnredlist.org/

walk transect counts, drive transect counts, focal point monitoring, vantage point counts and incidental sightings (see **APPENDIX A** for a detailed explanation of the monitoring methods).

- Information gained from previous Environmental Impact Assessments at three neighbouring sites in close proximity to the current site, namely Khobab WEF (under construction), Loeriesfontein WEF (under construction), and Dwarsrug WEF (authorised in 2015) assisted in providing a comprehensive picture of avifaunal abundance and diversity in the greater area.

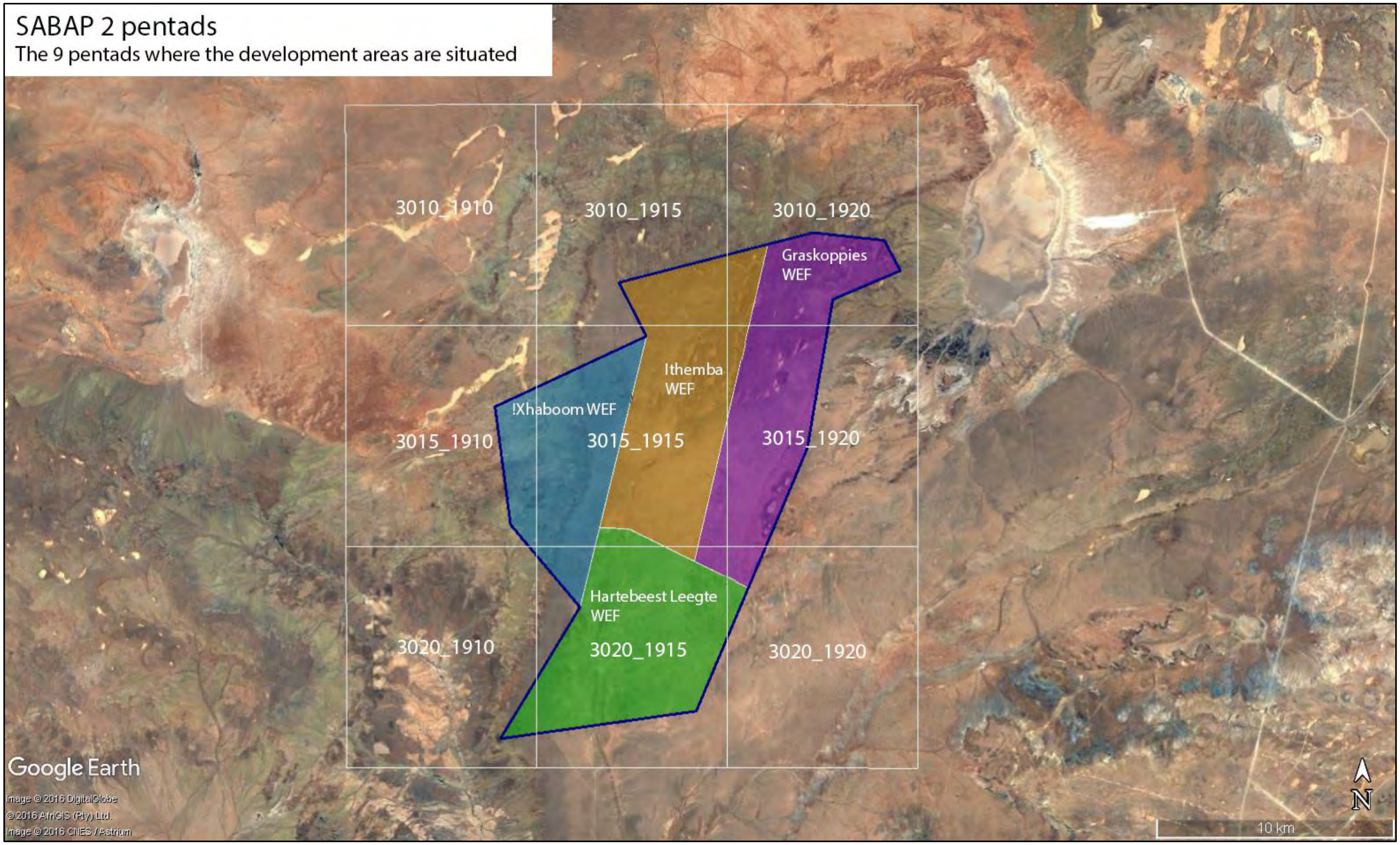

Figure 3: Area covered by the SABAP2 pentads.

4. ASSUMPTIONS & LIMITATIONS

The following assumptions and limitations are applicable in this study:

- A total of 21 full protocol lists has been completed to date for the 9 pentads where the study area is located (i.e. listing surveys lasting a minimum of two hours each). This is a fairly comprehensive dataset which provides a reasonably accurate snapshot of the avifauna which could occur at the proposed site. For purposes of completeness, the list of species that could be encountered was supplemented with personal observations, general knowledge of the area, SABAP1 records (Harrison *et al.* 1997) and the results of the 12-months pre-construction monitoring.
- 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.
- To date, few comprehensive studies (other than a number of environmental impact reports), and no peer-reviewed scientific papers, are available on the impacts wind farms have on birds in South Africa. The precautionary principle was therefore applied throughout. The World Charter for Nature, which was adopted by the UN General Assembly in 1982, was the first international endorsement of the precautionary principle[2]. The principle was implemented in an international treaty as early as the 1987 Montreal Protocol and, among other international treaties and declarations, is reflected in the 1992 Rio Declaration on Environment and Development. Principle 15 of the 1992 Rio Declaration states that: "in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation."
- Even in the international arena predicted mortality rates are often significantly off the mark, indicating that this is still a fledgling science in many respects, even in developed countries like Spain with an established wind industry (Ferrer *et al.* 2012).
- Priority species were taken from the updated list of priority species for wind farms compiled for the Avian Wind Farm Sensitivity Map (Retief *et al.* 2012).
- The study area was defined as the area which comprises the four application sites for the Mainstream WEFs and immediate environs. The development area refers to the proposed Graskoppies WEF.
- No comparative assessment was undertaken of the various powerline connection alternatives. This will form part of a separate Basic Assessment (BA).

5. LEGISLATIVE CONTEXT

5.1 Agreements and conventions

[2] http://www.unep.org

Table 5-1 below lists agreements and conventions which South Africa is party to and which is relevant to the conservation of avifauna[3]

Table 5-1: 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

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

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 Endangered Species of Wild Flora and Fauna, (CITES), Washington DC, 1973	CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	Global
Ramsar Convention on Wetlands of International Importance, Ramsar, 1971	The Convention on Wetlands, called the Ramsar Convention,	Global

	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.	
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 Best Practice Guidelines

The South African *"Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa" (*Jenkins, A.R., Van Rooyen, C.S., Smallie, J.J., Anderson, M.D., & A.H. Smit. 2011) are followed for this study. This document was published by the Endangered Wildlife Trust (EWT) and Birdlife South Africa (BLSA) in March 2011, and subsequently revised in 2011, 2012 and 2015.

6. DESCRIPTION OF THE AFFECTED ENVIRONMENT

6.1 Natural environment

The development area is located on a vast, arid, topographically uniform plain. The habitat is very uniform, and consists of Bushmanland Basin Shrubland. Bushmanland Basin Shrubland consists of dwarf shrubland dominated by a mixture of low, sturdy and spiny (and sometimes also succulent) shrubs (*Rhigozum, Salsola, Pentzia, Eriocephalus*), 'white' grasses (*Stipagrostis*) and in years of high rainfall also abundant annual flowering plants such as species of *Gazania* and *Leysera* (Mucina & Rutherford 2006). A number of ephemeral drainage lines flow though the development area, but they only hold water for brief periods after exceptional rainfall events, which are rare events. The study area is extremely arid with a mean annual rainfall of 170.5mm, with peak rainfall between March and July[4]. The temperatures are highest on average in January, at around 22.8 °C. The lowest average temperatures in the year occur in July, when it is around 9.9 °C.[5] The development area is situated in

[4] South African Rain Atlas http://wsopuppenkiste.wiso.uni-goettingen.de/rainfall

[5] http://en.climate-data.org/location/27137/

an ecological transitional zone between the Nama Karoo and Succulent Karoo biomes (Harrison *et al.* 1997). In comparison with Succulent Karoo, the Nama Karoo has higher proportions of grass and tree cover. The ecotonal nature of the study area is apparent from the presence of typical avifauna of both Succulent and Nama Karoo e.g. Karoo Eremomela *Eremomela gregalis* (Succulent Karoo) and Red Lark *Calendulauda burra* (Nama Karoo). The two Karoo vegetation types support a particularly high diversity of bird species endemic to Southern Africa, particularly in the family *Alaudidae* (Larks). Its avifauna typically comprises ground-dwelling species of open habitats (Harrison *et al.* 1997). Because rainfall in the Nama Karoo falls mainly in summer, while peak rainfall in the Succulent Karoo occurs mainly in winter, it provides opportunities for birds to migrate between the Succulent and Nama Karoo, to exploit the enhanced conditions associated with rainfall. Many typical karroid species are nomads, able to use resources that are patchy in time and space (Barnes 1998).

A feature of the arid landscape where the development area is located is the presence of pans. Pans are endorheic wetlands having closed drainage systems; water usually flows in from small catchments but with no outflow from the pan basins themselves. They are typical of poorly drained, relatively flat and dry regions. Water loss is mainly through evaporation, sometimes resulting in saline conditions, especially in the most arid regions. Water depth is shallow (<3m), and flooding characteristically ephemeral (Harrison *et al.* 1997). Although the development area itself does not contain any significant pans, there is a major pan, known as Konnes se Pan, situated approximately 3km north-east of the development area, and a series of small pans, known as Die Soutkomme, in the east of the development area. When these pans hold water (which is only likely after exceptional rainfall events which may occur only once a decade or more), waterbird movement to and from these pans is possible, including Greater Flamingo *Phoenicopterus roseus* and Lesser Flamingo *Phoenicopterus minor*. It is possible that nocturnal flamingo movement might take place over the proposed wind farm sites between the coast and the abovementioned pans, although this should be sporadic rather than regularly.

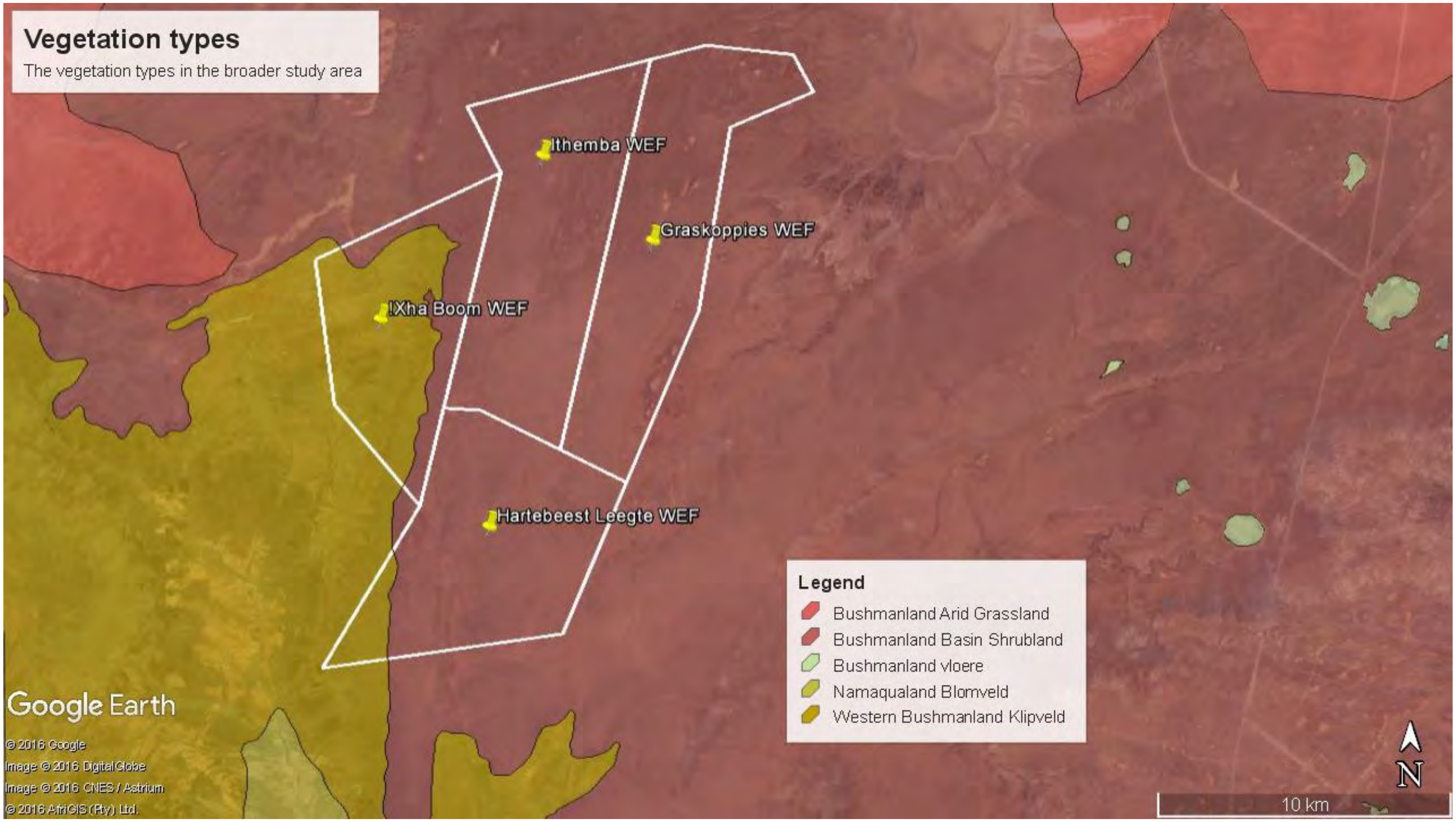

Figure 4: Vegetation types in the greater study area, indicating the homogenous character of the habitat at the proposed WEFs (Mucina & Rutherford 2006).

6.2 Modified environment

Whilst the distribution and abundance of the bird species in the broader development area are mostly associated with natural vegetation, as this comprises virtually all the habitat, it is also necessary to examine the few external modifications to the environment that have relevance for birds.

The following avifaunal-relevant anthropogenic habitat modifications were recorded within the broader development area:

- **Water points:** The land use in the broader development area is mostly small stock farming. The entire area is divided into grazing camps, with several boreholes with associated water reservoirs and drinking troughs. In this arid environment, open water is a big draw card for several bird species, including priority species such as Martial Eagle, Verreaux's Eagle and Sclater's Lark that use the open water troughs to bath and drink.
- **Transmission lines:** The Aries - Helios 400kV transmission line runs approximately 25km east of the proposed WEF areas. The transmission towers are used by raptors for perching and roosting, and also for breeding. Three Martial Eagle nests were recorded on the Aries - Helios 400kV transmission line east of the proposed sites, two of which were active during the monitoring period (see Figure 4). The study area contains many fence-lines which are used by several priority species for perching.

APPENDIX B provides a photographic record of the habitat in the study area. A map of the study area, indicating the location of water points, raptor nests and HV lines is shown in Figure 5.

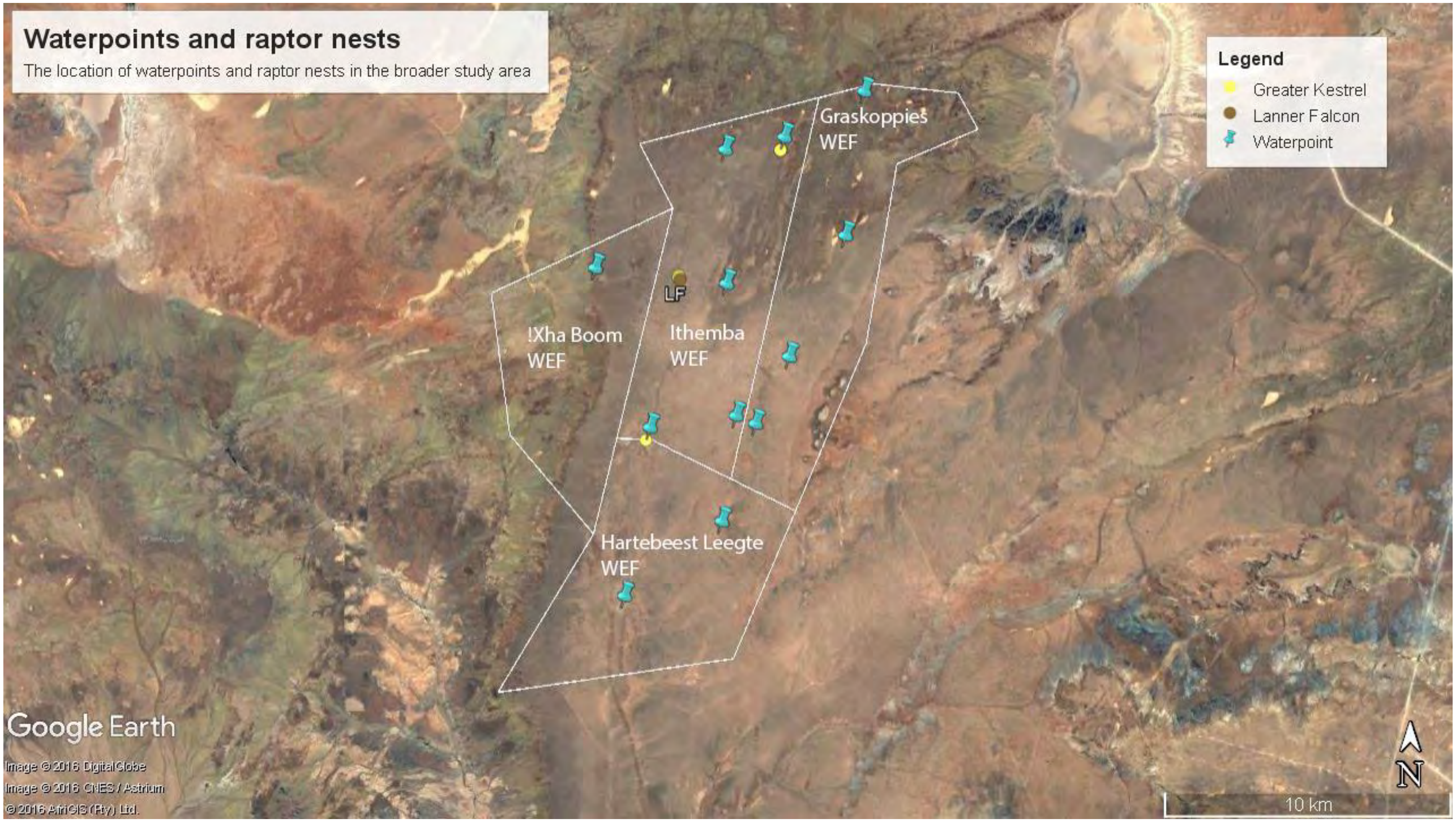

Figure 5: Location of water points and raptor nests in the greater area.

7. AVIFAUNA

A total of 56 species were recorded in the broader study area (i.e. the WEF sites[6], control area and immediate surroundings) during the pre-construction monitoring from all data sources (drive transects, walk transects, VP watches, focal point counts and incidental sightings), of which 12 (21.4%) are priority species. See Table 7-1 for a list of all priority species that were recorded by SABAP1 and 2 in the broader study area, as well as those that could potentially occur in the development area itself. Table 7–2 lists all species (priority and non-priority) recorded during pre-construction monitoring in the broader study area and table 7-3 lists only the priority species recorded at the development areas, and method through which they were recorded.

7.1 Transect counts

The **drive** transects were surveyed three times per seasonal survey. A total of 8 059 individual birds were recorded during drive transect counts at the development areas, of which 354 were priority species and 7 705 were non-priority species, belonging to 52 species (12 priority species and 40 non-priority species). At the control area, a total of 844 birds were recorded during drive transect counts, of which 31 were priority species and 813 non-priority species, belonging to 47 species (7 priority species and 40 non-priority species).

The **walk** transects were counted 32 times, i.e. 8 times per season. A total of 10 920 individual birds were recorded at the development areas, of which 173 were priority species and 10 747 non-priority species, belonging to 44 species (8 priority species and 36 non-priority species). At the control area, a total of 1 307 birds were recorded, of which 54 were priority species and 2 0153 non-priority species, belonging to 43 species (4 priority species and 39 non-priority species).

An Index of Kilometric Abundance (IKA = birds/km) was calculated for each priority species, and also for all priority species combined recorded during transect counts. This was done separately for drive transects and walk transects. Figures 6 and 7 shows the relative abundance of priority species recorded during the pre-construction monitoring through drive and walk transects.

[6] The area that was covered in the 12-months pre-construction monitoring included all four Mainstream WEFs, all of which are situated in similar habitat - see APPENDIX A

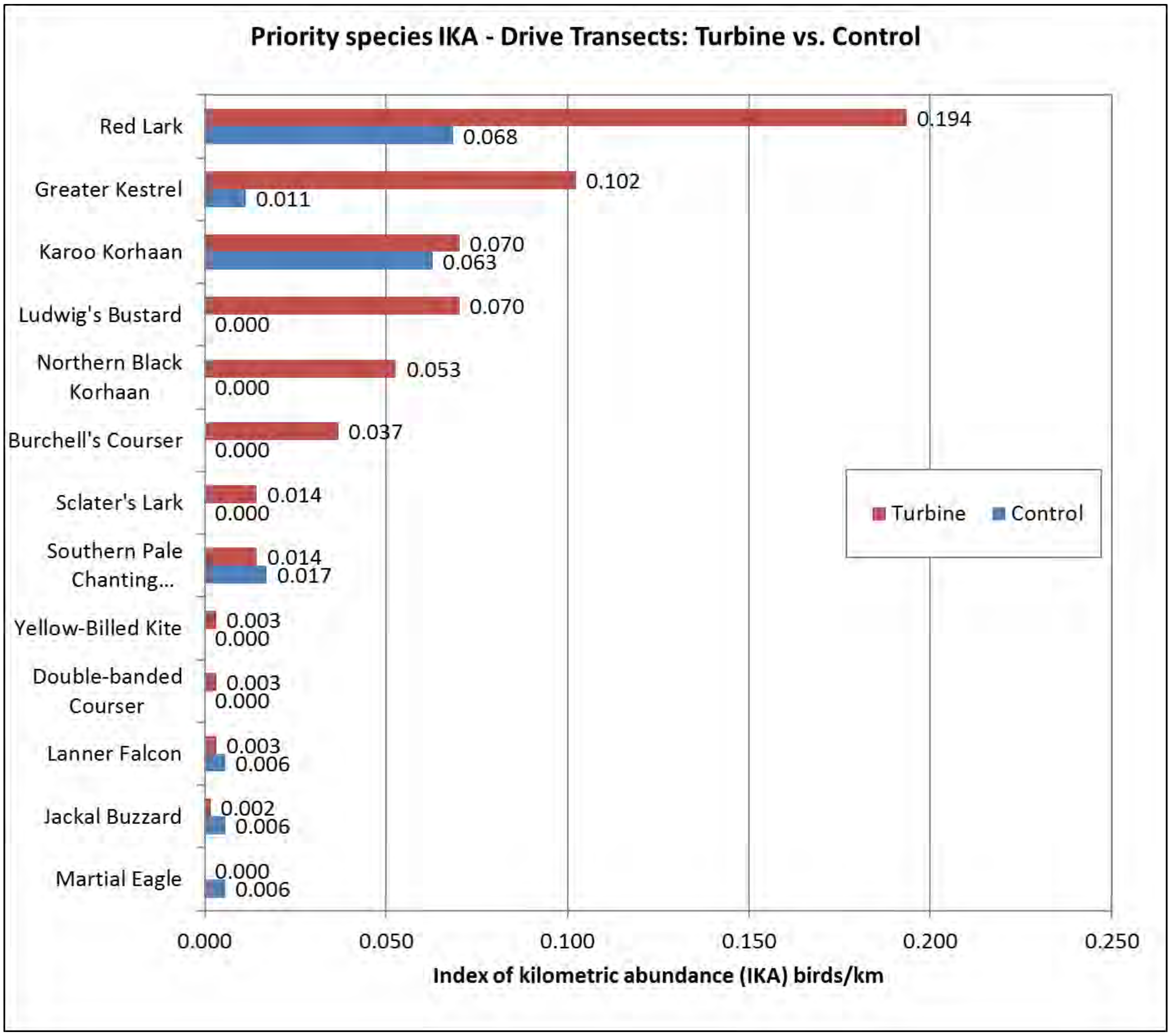

Figure 6: Priority species recorded at the WEF sites and control site through drive transect surveys

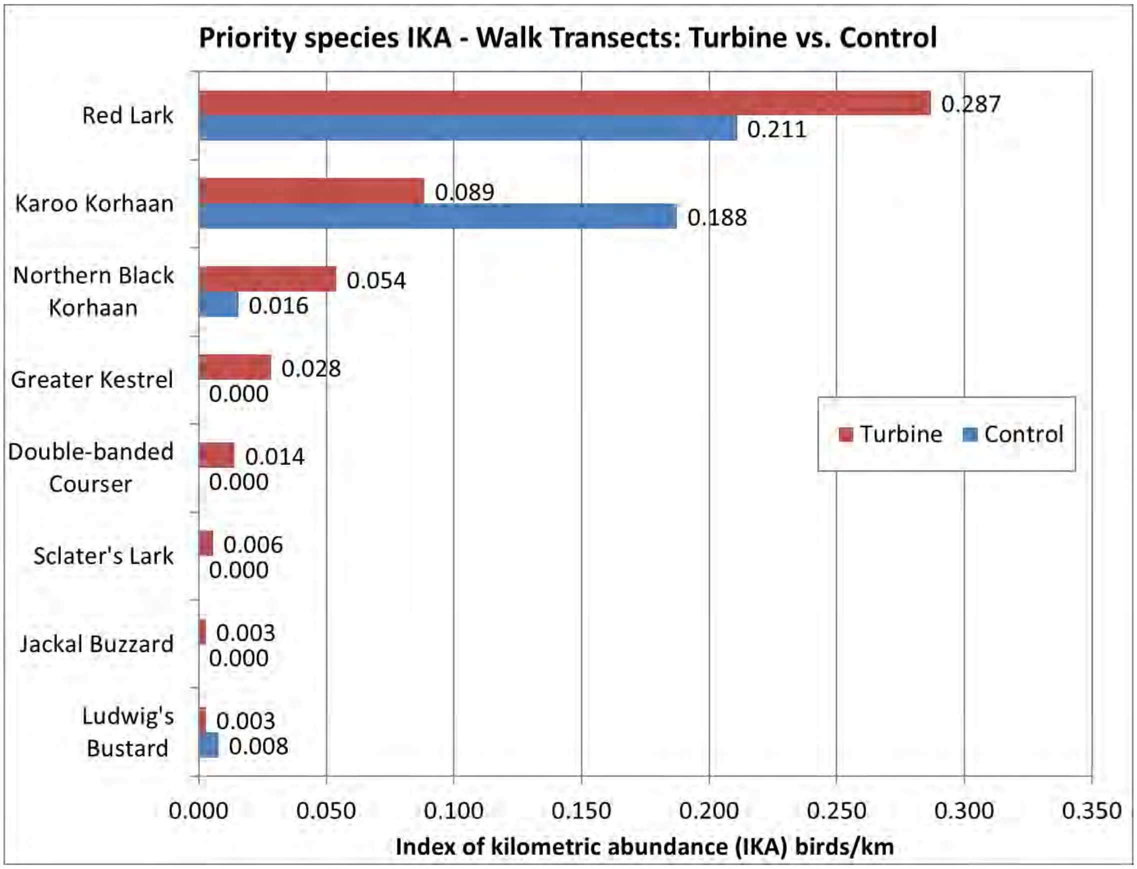

Figure 7: Priority species recorded at the WEF sites and control site through walk transect surveys

7.1.1 Overall species composition

The broader study area supports a relatively low diversity and abundance of avifauna, which is to be expected in an arid area like Bushmanland. Based on species diversity recorded during transect surveys, the development areas and control area are essentially similar as far as priority species are concerned. The higher counts at the development areas is most likely a result of the difference in survey effort, and does not reflect any intrinsic differences in habitat quality or species diversity.

7.1.2 Abundance

The abundance of priority species at the development areas is low, with less than one bird per kilometre recorded during transect counts - 0.743 birds/km were recorded on drive transects, and 0.905 birds/km were recorded during walk transects. Red Lark and Greater Kestrel emerged as the two most abundant priority species at the development areas during drive transect counts, and Red Lark and Karoo Korhaan were the two most abundant species during walk transects. Red Lark, Karoo Korhaan, Northern Black Korhaan and Greater Kestrel definitely breed in the study area, and Ludwig's Bustard, Burchell's Courser and Double-banded Courser potentially too, although no evidence of bustard display areas or nests were recorded. Raptors were generally sparse with

Greater Kestrel the most frequently recorded species during both the drive and walk transects. Other raptors were recorded sporadically in very low numbers.

7.1.3 Spatial distribution of transect records and incidental sightings at the turbine site

Figure 8 below indicates the spatial distribution of priority species recorded during transect counts and incidental sightings in the broader study area.

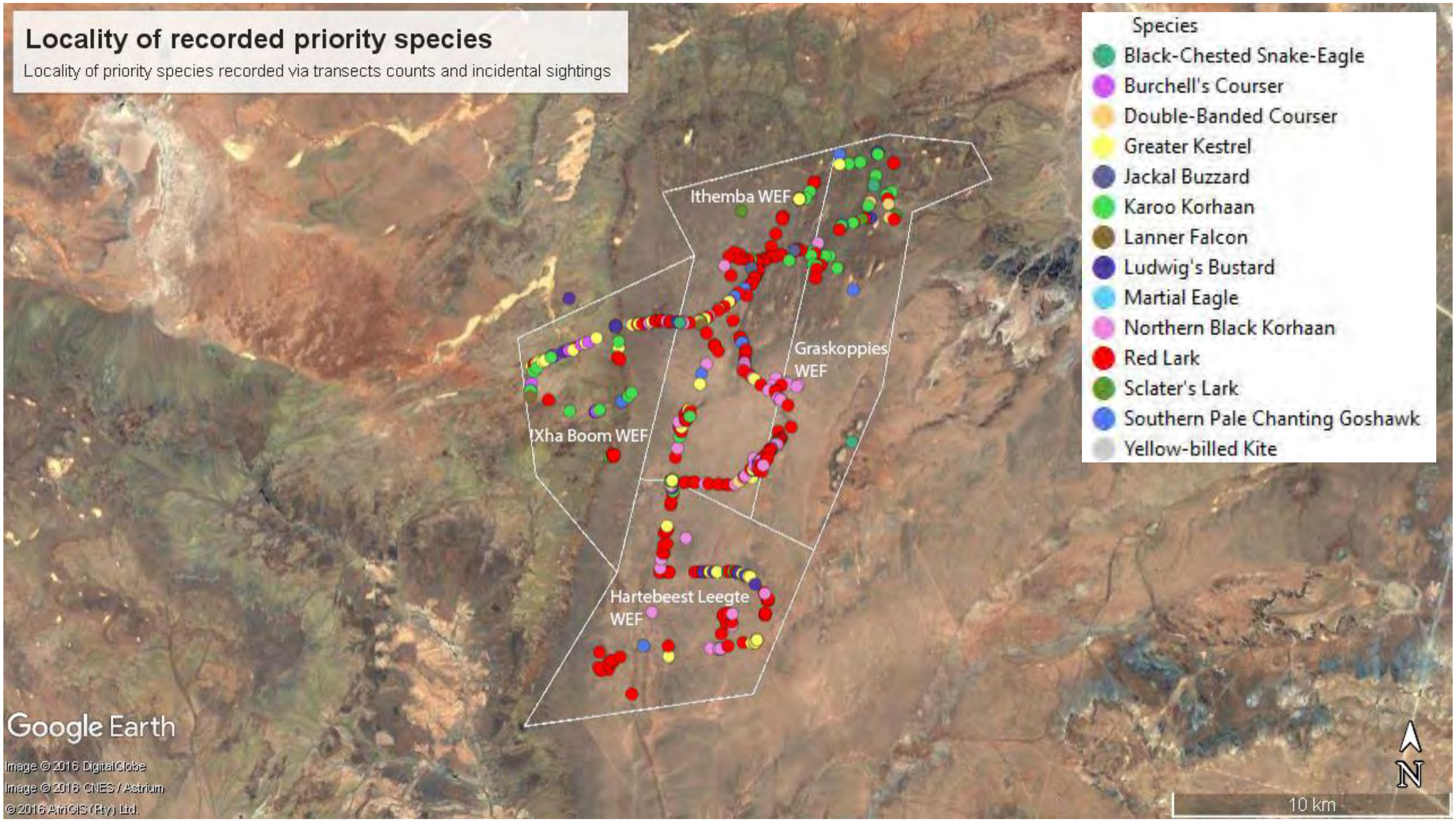

Figure 8: Spatial distribution of sightings of priority species recorded during transect counts. It also includes incidental counts.

Visual inspection of the distribution patterns indicates some possible trends. Burchell's Courser shows a clear preference for the gravel plains in the west, with Karoo Korhaan and Sclater's Lark similarly favouring the gravel plains in the west and north of the study area. Close inspection of Red Lark records indicates a possible preference for sandy areas, although the species was also recorded in gravel plains, although in lower numbers. Ludwig's Bustard were mostly recorded in the west and south, in both sandy and gravel areas. The rest of the priority species were generally recorded in low numbers with no clear indications of bird/habitat associations, with random sightings scattered all over the site and immediate surroundings. This is to be expected given the uniformity of the habitat in the study area (see APPENDIX B).

Table 7-1 below lists all the priority species that could **potentially** occur at the development area, based on SABAP1 and SABAP2 data, and the results of the pre-construction monitoring. Priority species recorded during pre-construction surveys at the development areas are shaded. The following abbreviations and acronyms are used:

VU	Vulnerable
NT	Near threatened
EN	Endangered
SAE	Southern African endemic or near endemic
Ct	Collisions with turbines
Dd	Displacement through disturbance
Dh	Displacement habitat transformation
Ep	Electrocution on the internal MV overhead powerlines

Table 7-2 lists **all** the species (priority and non-priority) recorded during the pre-construction surveys and incidental counts. Table 7-3 lists the manner in which the priority species were recorded.

Table 7-1: Priority species (Retief *et al.* 2012) potentially occurring at the development area. **Species recorded in the development areas are shaded.**

Name	**Scientific name**	**Regional threatened status (Taylor et al. 2015)**	**Global threatened status (IUCN 2016)**	**BLSA/EWT Priority rating (on scale of 170 – 395)**	**Terrestrial**	**Soaring**	**Likelihood of occurrence**	**Potential impact**
Martial Eagle	*Polemaetus bellicosus*	EN	NT	330		x	Confirmed. One incidental sighting of a flying bird in the broader area, and recorded briefly flying high over the study area. Could sporadically be attracted to water troughs.	Ct, Dd, Ep
Ludwig's Bustard	*Neotis ludwigii*	SAE, EN	EN	320	x		Confirmed. Occurrence likely to be linked to habitat conditions. The species is nomadic and a partial migrant and may occur sporadically.	Ct, Cp, Dd,
Secretarybird	*Sagittarius serpentarius*	VU	VU	320	x	x	Low. May occur sporadically	Ct, Cp, Dd,
Kori Bustard	*Ardeotis kori*	NT	Least concern	280	x		Low. May occur sporadically. Lack of dry watercourses with trees may be an inhibiting factor.	Ct, Cp, Dd,

Name	Scientific name	Regional threatened status (Taylor et al. 2015)	Global threatened status (IUCN 2016)	BLSA/EWT Priority rating (on scale of 170 – 395)	Terrestrial	Soaring	Likelihood of occurrence	Potential impact
Lanner Falcon	*Falco biarmicus*	VU	Least concern	280		x	Confirmed. Breeding resident. Most likely to perch on fence lines running through the study area, but may also be attracted to the water points where it hunts small birds.	Ct
Sclater's Lark	*Spizocorys sclateri*	SAE, NT	NT	240	x		Confirmed. The species is nomadic and may occur sporadically.	Dd Dh
Steppe Buzzard	*Buteo vulpinus*		Least concern	210		x	Low. Most likely to be associated with utility lines and fence lines. May occur sporadically	Ct
Verreaux's Eagle	*Aquila verreauxi*	VU	Least concern	360		x	Confirmed. Solitary single birds were recorded sporadically. Could sporadically be attracted to water troughs, one individual was recorded drinking at a water trough.	Ct, Ep

Name	Scientific name	Regional threatened status (Taylor et al. 2015)	Global threatened status (IUCN 2016)	BLSA/EWT Priority rating (on scale of 170 – 395)	Terrestrial	Soaring	Likelihood of occurrence	Potential impact
Black-chested Snake-Eagle	*Circaetus pectoralis*		Least concern	230		x	Confirmed. May visit water points.	Ct, Ep
Southern Pale Chanting Goshawk	*Melierax canorus*	SAE	Least concern	200	x	x	Confirmed. Habitat is very suitable for the species.	Ct, Dd
Karoo Korhaan	*Eupodotis vigorsii*	SAE, NT	Least concern	190	x		Confirmed. One of the most commonly recorded terrestrial species. Occurs all over the study area.	Ct, Dd, Cp
Northern Black Korhaan	*Afrotis afraoides*	SAE	Least concern	180	x		Confirmed. One of the most commonly recorded terrestrial species. Occurs all over the study area.	Ct, Dd, Cp
Greater Kestrel	*Falco rupicoloides*		Least concern	174		x	Confirmed. Encountered all over the study area, but most likely to be associated with utility lines and fences which are used for perching.	Ct
Yellow-billed Kite	*Milvus aegyptius*		Least concern	0		x	Confirmed. May visit water points sporadically.	Ct

Name	Scientific name	Regional threatened status (Taylor et al. 2015)	Global threatened status (IUCN 2016)	BLSA/EWT Priority rating (on scale of 170 – 395)	Terrestrial	Soaring	Likelihood of occurrence	Potential impact
Spotted Eagle-Owl	*Bubo africanus*	Least concern	Least concern	170	Nocturnal raptor but flight characteristics more like terrestrial species		High. Could be encountered anywhere in the study area.	Ct
Jackal Buzzard	*Buteo rufofuscus*	SAE	Least concern	125		x	Confirmed. Most likely to be associated with utility lines and fence lines. May occur sporadically, particularly immature birds.	Ct
Burchell's Courser	*Cursorius rufus*	SAE, VU	Least concern	140	x		Confirmed. Mostly recorded in the west of the study area.	Ct
Double-banded Courser	*Rhinoptilus africanus*	NT	Least concern	154	x		Confirmed. Recorded sparsely all over the study area.	Ct
Booted Eagle	*Aquila pennatus*		Least concern	230		x	Confirmed. Most likely to be encountered foraging on the wing over the site, and coming down to water points to bath and drink.	Ct
Greater Flamingo	*Phoenicopterus roseus*	NT	LC	290	Waterbird which undertakes long distance,		Low. Might be attracted to large pans outside the study area, but occurrence is linked to standing water.	Ct

					nocturnal powered flight.		This will only happen after exceptional rain events, perhaps once a decade during which the pan will contain standing water for a short period.	
Lesser Flamingo	*Phoeniconaias minor*	NT	NT	290	Waterbird which undertakes long distance, nocturnal powered flight.		Low. Might be attracted to large pans outside the study area, but occurrence is linked to standing water. This will only happen after exceptional rain events, perhaps once a decade during which the pan will contain standing water for a short period.	Ct

Table 7-2 lists all the priority species recorded during the pre-construction surveys, vantage point watches and incidental counts, as well as the manner in which they were recorded. Table 7-3 lists all the non-priority species recorded during the pre-construction surveys.

Table 7-2: Priority species recorded during pre-construction surveys, vantage point watches and incidental counts.

Priority Species	Taxonomic Name	Development areas	Control area	Incidental sighting	VP: Development areas	VP: Control area
Black-Chested Snake-Eagle	*Circaetus pectoralis*			*	*	
Booted Eagle	*Aquila pennatus*				*	
Burchell's Courser	*Cursorius rufus*	*		*	*	
Double-banded Courser	*Rhinoptilus africanus*	*		*		
Greater Kestrel	*Falco rupicoloides*	*	*	*	*	*
Jackal Buzzard	*Buteo rufofuscus*	*	*			
Karoo Korhaan	*Eupodotis vigorsii*	*	*	*	*	
Lanner Falcon	*Falco biarmicus*	*	*	*	*	
Ludwig's Bustard	*Neotis ludwigii*	*	*	*	*	
Martial Eagle	*Polemaetus bellicosus*		*		*	
Northern Black Korhaan	*Afrotis afraoides*	*	*	*	*	
Red Lark	*Calendulauda burra*	*	*	*	*	
Sclater's Lark	*Spizocorys sclateri*	*		*	*	
Southern Pale Chanting Goshawk	*Melierax canorus*	*		*	*	
Verreaux's Eagle	*Aquila verreauxii*				*	
Yellow-Billed Kite	*Milvus aegyptius*	*				
16	**Total:**	**12**	**8**	**11**	**13**	**1**

Table 7- 3: Non-priority species recorded during pre-construction surveys.

Non-Priority Species	Taxonomic name	Development areas	Control area
Acacia Pied Barbet	*Tricholaema leucomelas*		*
African Pipit	*Anthus cinnamomeus*	*	
Anteating Chat	*Myrmecocichla formicivora*	*	*
Barn Swallow	*Hirundo rustica*	*	*
Black-Eared Sparrowlark	*Eremopterix australis*	*	*
Bokmakierie	*Telophorus zeylonus*	*	*
Cape Bunting	*Emberiza capensis*		*
Cape Crow	*Corvus capensis*		*
Cape Penduline-Tit	*Anthoscopus minutus*	*	*
Cape Sparrow	*Passer melanurus*	*	*
Cape Turtle-dove	*Streptopelia capicola*		*
Capped Wheatear	*Oenanthe pileata*	*	
Chat Flycatcher	*Bradornis infuscatus*	*	*
Common Fiscal	*Lanius collaris*	*	*
Common Quail	*Coturnix coturnix*	*	
Eastern Clapper Lark	*Mirafra [apiata] fasciolata*	*	
Egyptian Goose	*Alopochen aegyptiaca*	*	
European Bee-eater	*Merops apiaster*		*
Familiar Chat	*Cercomela familiaris*	*	*
Greater Striped Swallow	*Hirundo cucullata*	*	*
Grey Tit	*Parus afer*		*
Grey-backed Cisticola	*Cisticola subruficapilla*		*
Grey-backed Sparrowlark	*Eremopterix verticalis*	*	*
Karoo Chat	*Cercomela schlegelii*	*	*
Karoo Eremomela	*Eremomela gregalis*	*	*
Karoo Long-Billed Lark	*Certhilauda subcoronata*	*	*
Karoo Prinia	*Prinia maculosa*	*	*
Karoo Scrub-Robin	*Cercotrichas coryphoeus*	*	*
Large-Billed Lark	*Galerida magnirostris*	*	*
Lark-Like Bunting	*Emberiza impetuani*	*	*
Laughing Dove	*Streptopelia senegalensis*		*
Little Swift	*Apus affinis*		*
Long-billed Crombec	*Sylvietta rufescens*		*
Mountain Wheatear	*Oenanthe monticola*		*
Namaqua Dove	*Oena capensis*	*	*
Namaqua Sandgrouse	*Pterocles namaqua*	*	*
Pied Crow	*Corvus albus*	*	*
Red-Billed Teal	*Anas erythrorhyncha*	*	
Red-Capped Lark	*Calandrella cinerea*	*	*
Red-Headed Finch	*Amadina erythrocephala*	*	
Rock Kestrel	*Falco rupicolus*	*	*
Rock Martin	*Hirundo fuligula*		*
Rufous-Eared Warbler	*Malcorus pectoralis*	*	*
Sabota Lark	*Calendulauda sabota*	*	
South African Shelduck	*Tadorna cana*	*	
Southern Masked-weaver	*Ploceus velatus*	*	*
Southern Pale Chanting Goshawk	*Melierax canorus*		*
Speckled Pigeon	*Columba guinea*	*	*
Spike-Heeled Lark	*Chersomanes albofasciata*	*	*
Spotted Thick-Knee	*Burhinus capensis*	*	
Spur-Winged Goose	*Plectropterus gambensis*	*	
Stark's Lark	*Spizocorys starki*	*	
Tractrac Chat	*Cercomela tractrac*	*	*
White-rumped Swift	*Apus caffer*	*	*
White-throated Canary	*Crithagra albogularis*	*	*
Yellow Canary	*Crithagra flaviventris*	*	*
Yellow-bellied Eremomela	*Eremomela icteropygialis*	*	*
57	**Total:**	**44**	**45**
Grand Total		**56**	**53**

7.2 Vantage point watches

Twelve priority species were recorded during vantage point (VP) watches. A total of 528 hours of vantage point watches (12 hours per sampling period per vantage point) was completed at 11 VPs in order to record flight patterns of priority species at the development areas. In the four sampling periods, priority species were recorded flying over the development areas for a total of 2 hours and 5 minutes[7]. A total of 114 individual flights were recorded. Of these, 1 (0.87%) flight was at high altitude (>220m = above rotor height), 11 (9.64%) were at medium altitude (approximately within rotor height i.e. between 30m and 220m) and 102 (89.47%) were at a low altitude (below rotor height <30m). The passage rate for priority species over the VP areas (all flight heights) was 0.27 birds/hour[8]. See Figure 9 below for the duration of flights within the VP areas for each species, at each height class[9].

For purposes of flight analyses, priority species recorded during VP watches were classified in two classes (see also statistical analysis **APPENDIX C**):

- Terrestrial species: Birds that spend most of the time foraging on the ground. They do not fly often and then generally short distances at low to medium altitude, usually powered flight. Some larger species undertake longer distance flights at higher altitudes, when commuting between foraging and roosting areas. At the wind farm site, korhaans, bustards and larks were included in this category.
- Soaring species: Species that spend a significant time on the wing in a variety of flight modes including soaring, kiting, hovering and gliding at medium to high altitudes. At the wind farm site, the diurnal raptor species that were recorded during VP watches were included in this class.

[7] The flight time for Sclater's Lark was excluded from this total. Flocks of the species were recorded feeding in the area on two occasions while performing ongoing low altitude, short distance "hopping" flights between foraging areas for hours on end. This is an outlier in the database and was therefore excluded from the analysis to prevent the data being skewed (see also APPENDIX 3 on this point).

[8] For calculating the passage rate, a distinction was drawn between passages and flights. A passage may consist of several flights e.g. every time an individual bird changes height or mode of flight; this was recorded as an individual flight, although all the flights still form part of the same passage.

[9] Flight duration was calculated by multiplying the flight time with the number of individuals in the flight e.g. if the flight time was 30 seconds and it contained two individuals, the flight duration was 30 seconds x 2 = 60 seconds.

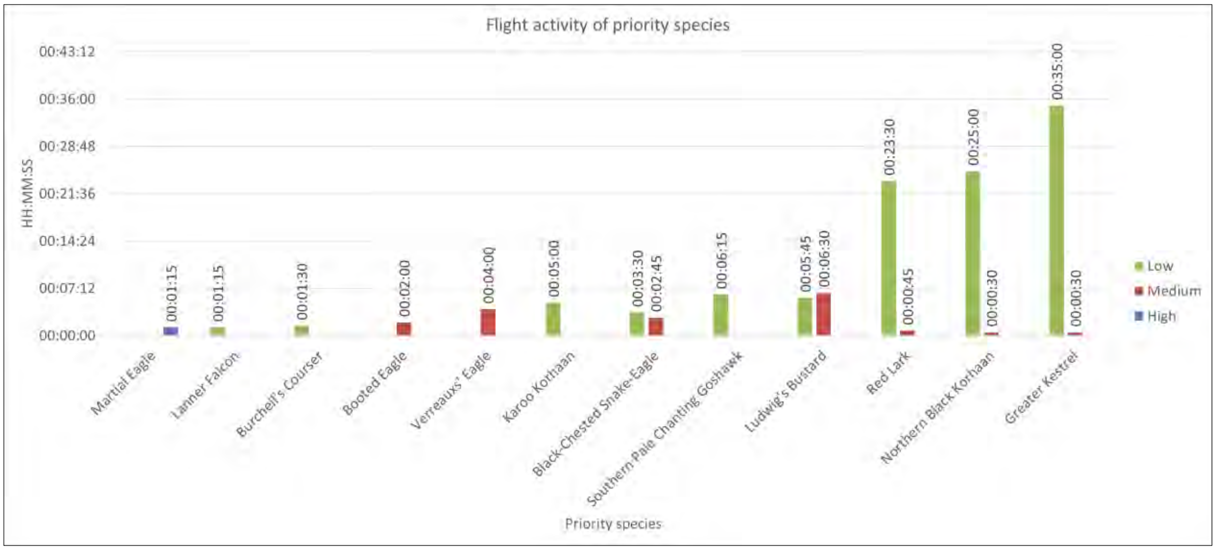

Figure 9: Flight duration and heights recorded for priority species (Y axis = hours: minutes: seconds). Duration (hours: minutes: seconds) are indicated on the bars. High/Blue/>220m, Medium/Red/30 to 220m, Low/Green/<30m.

7.2.1 Collision risk rating

A site-specific collisions risk rating for each priority species recorded during VP watches was calculated to give an indication of the likelihood of an individual of the specific species to collide with the turbines. This was calculated taking into account the following factors:

- The duration of rotor height flights;
- the susceptibility to collisions, based on morphology (size) and behaviour (soaring, predatory, ranging behaviour, flocking behaviour, night flying, aerial display and habitat preference) using the ratings for priority species in the Avian Wind Farm Sensitivity Map of South Africa (Retief *et al*. 2012); and
- the planned number of turbines.

This was done in order to gain some understanding of which species are likely to be most at risk of collision at these specific sites. The formula used is as follows[10]:

Duration of medium height flights (decimal hours) x collision susceptibility calculated as the sum of morphology and behaviour ratings x number of planned turbines[11] ÷100.

The results are displayed in Table 4-4 and Figure 10 below.

Table 4-4: Site specific collision risk rating for all priority species recorded during VP watches at the development areas.

Species	Duration of flights (hr)	Collision rating	No of turbines	Risk rating
Lanner Falcon	0.00	85	280	0.00
Southern Pale Chanting Goshawk	0.00	65	280	0.00
Martial Eagle	0.00	90	280	0.00
Burchell's Courser	0.00	35	280	0.00
Sclater's Lark	0.00	45	280	0.00
Karoo Korhaan	0.00	60	280	0.00
Greater Kestrel	0.01	52	280	1.21
Red Lark	0.01	35	280	1.23
Northern Black Korhaan	0.01	55	280	1.28
Booted Eagle	0.03	80	280	7.47
Black-Chested Snake-Eagle	0.05	80	280	10.27
Verreauxs' Eagle	0.07	110	280	20.53
Ludwig's Bustard	0.11	80	280	24.27
Average	0.02	67.08	280	5.10

[10] It is important to note that the formula does not incorporate avoidance behaviour. This may differ between species and may have a significant impact on the size of the risk associated with a specific species. It is generally assumed that 95-98% of birds will successfully avoid the turbines (SNH 2010). It is also important to note that there is not necessarily a direct correlation between time spent at rotor height, and the likelihood of collision.

[11] As at the time of the report compilation.

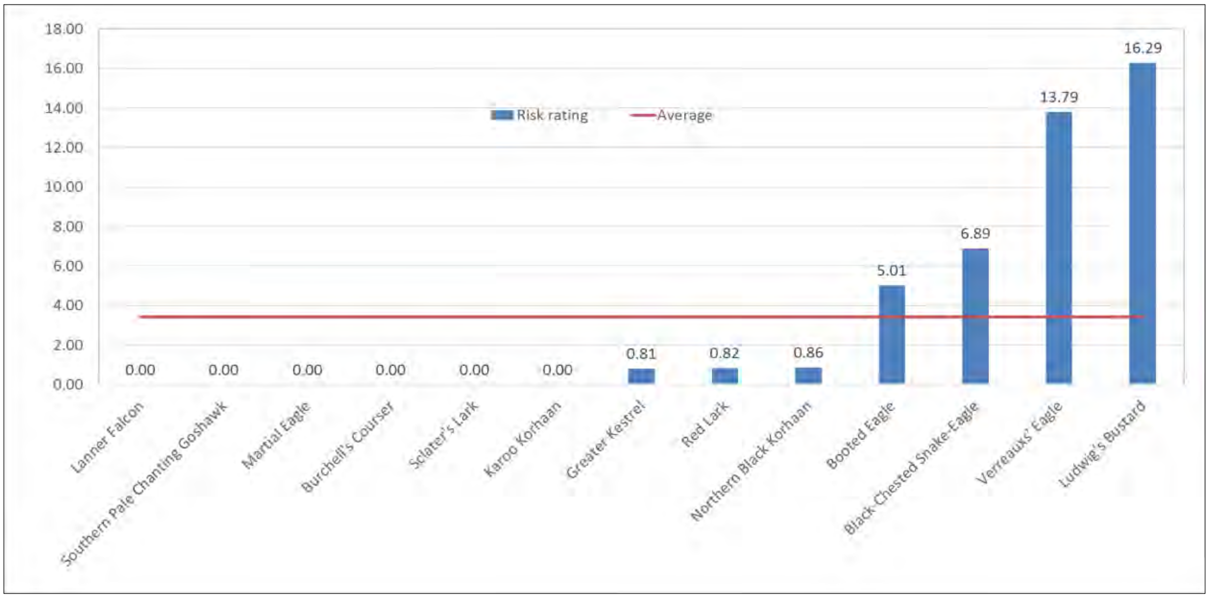

Figure 10: Collision risk rating for priority species.

7.2.2 Sample size and representativeness of flight data

The computations and the outcome of the data exhibited in the tables and graphs in the statistical analysis (see **APPENDIX C**) illustrate that the pre-construction survey may be taken to be statistically representative of the flight activity of the soaring and terrestrial priority species of birds that occur in the development areas. It has also been demonstrated that more samples would not yield a meaningful improvement in the accuracy and precision of the results.

See **APPENDIX C** for a detailed explanation of the statistical methods.

7.2.3 Spatial distribution of flight activity

Flight maps were prepared, indicating the spatial distribution of passages of those priority species which emerged with higher than average collision risk ratings i.e. Ludwig's Bustard, Verreaux's Eagle, Black-chested Snake-Eagle and Booted Eagle as observed from the various vantage points (see Figures 11-14 below). This was done by overlaying a 100m x 100m grid over the survey area. Each grid cell was then given a weighting score taking into account the duration and distance of individual flight lines through a grid cell and the number of individual birds associated with each flight crossing the grid cell. It is important to interpret these maps bearing in mind the amount of time that each species spent flying over the site i.e. the "High" category on the map for Ludwig's Bustard is not equivalent to the "High" category on the map for Booted Eagle, as the flight duration for Ludwig's Bustard is much higher than the flight duration for Booted Eagle.

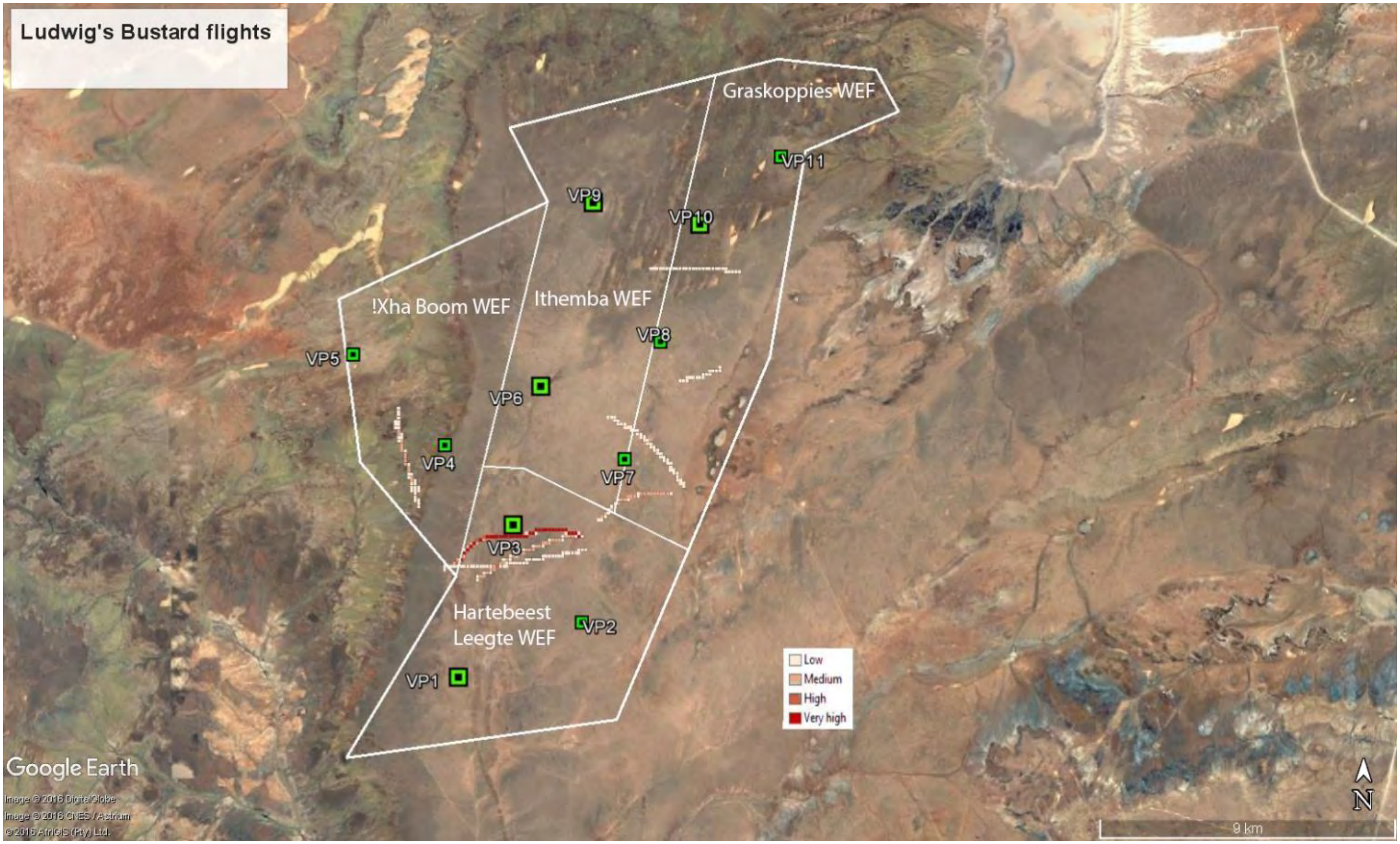

Figure 11: Spatial distribution and intensity of flights of Ludwig's Bustard. The green squares indicate the location of vantage points.

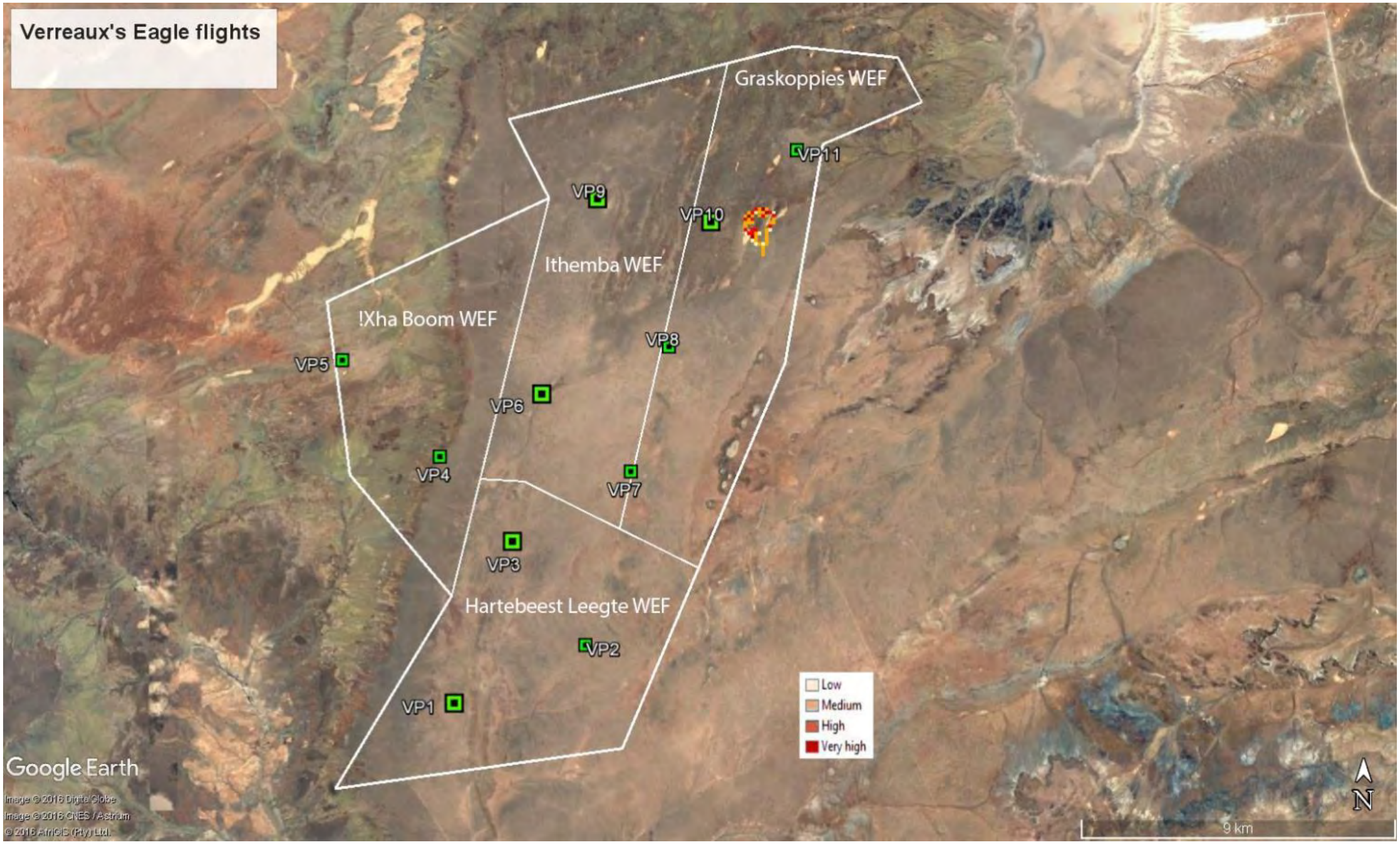

Figure 12: Spatial distribution and flight intensity of Verreaux's Eagle flights. The green squares indicate the location of vantage points.

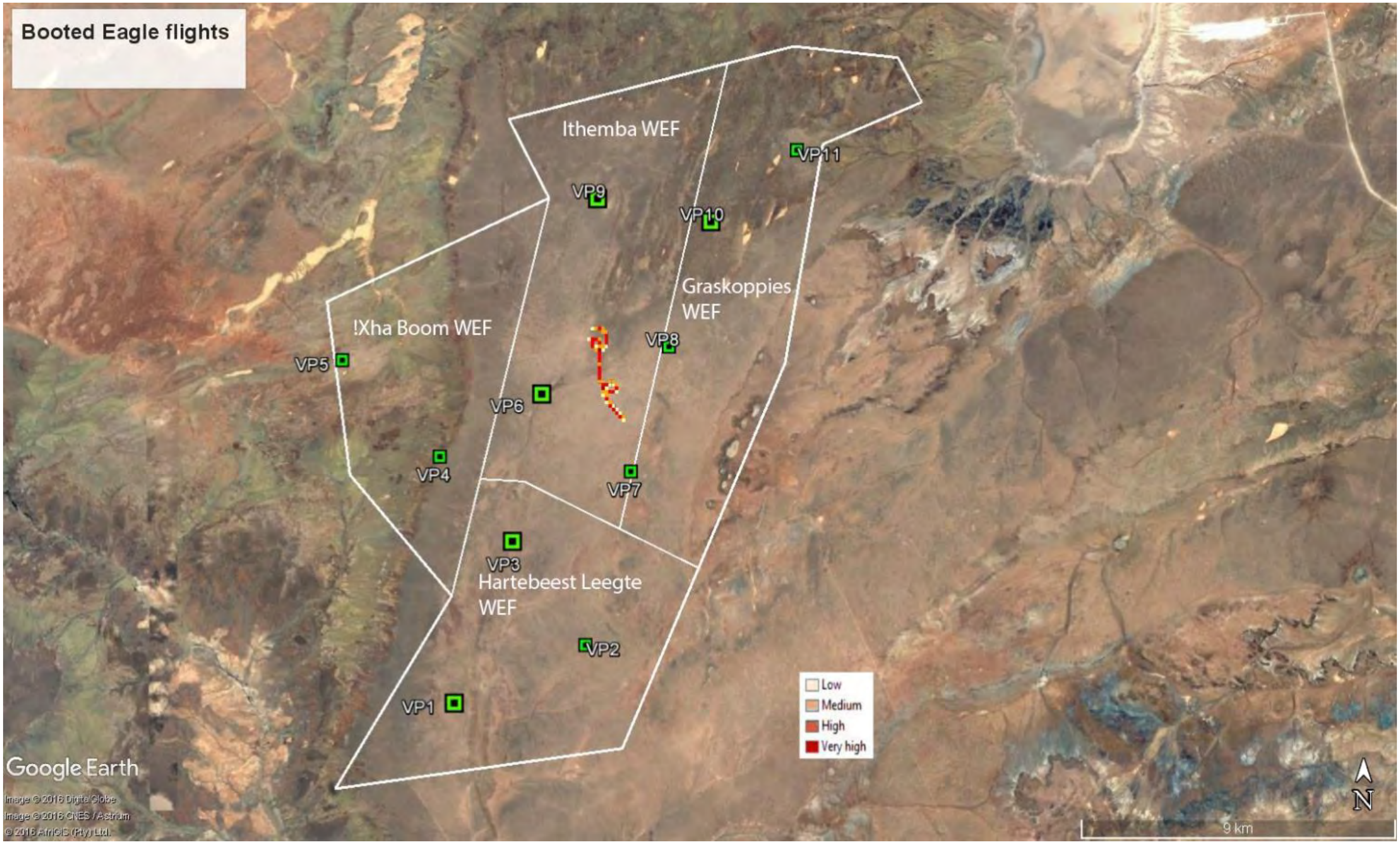

Figure 13: Spatial distribution and flight intensity of Booted Eagle flights. The green squares indicate the location of vantage points.

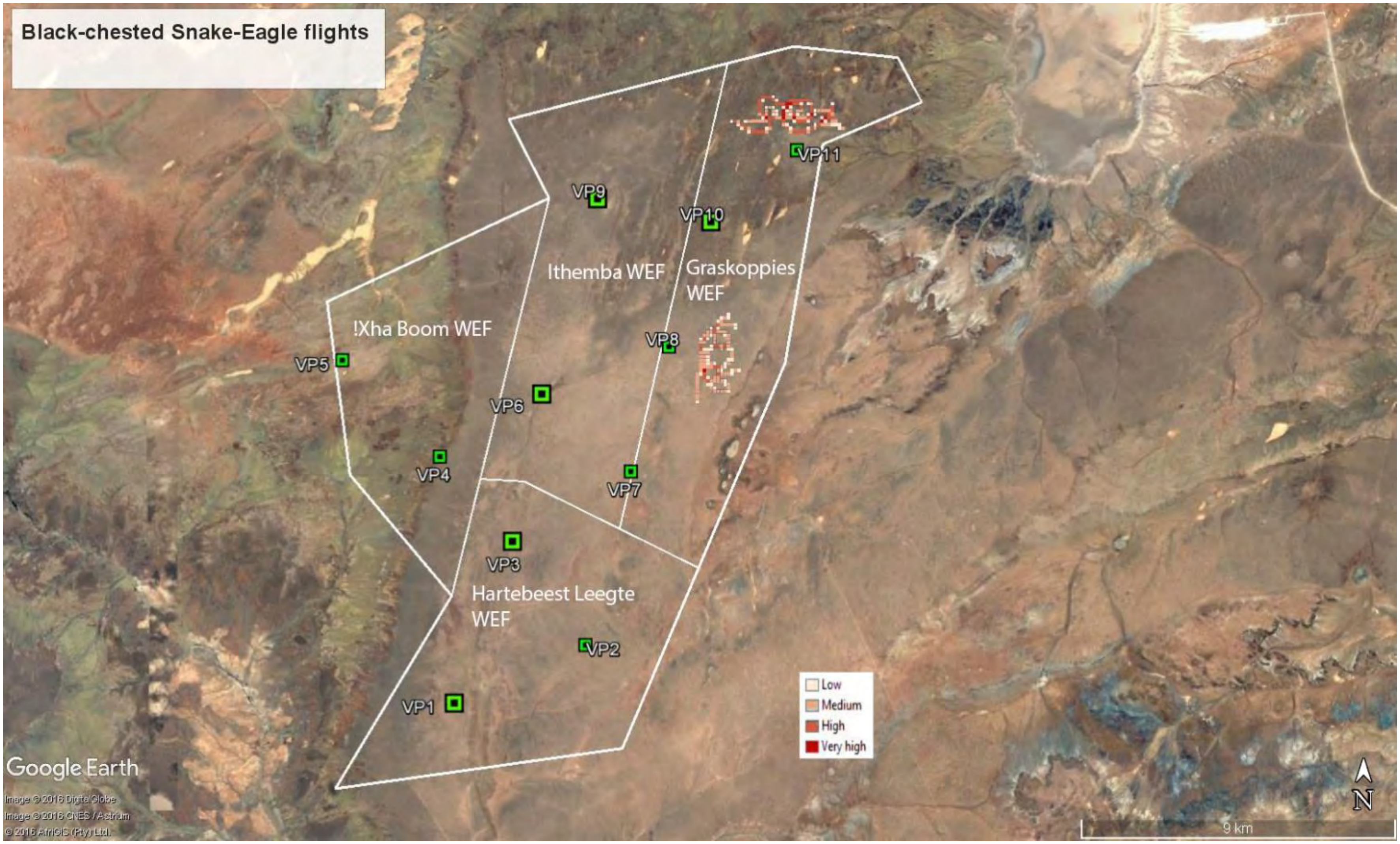

Figure 14: Spatial distribution and flight intensity of Black-chested Snake-Eagle flights. The green squares indicate the location of vantage points.

7.3 Focal points

Two focal points (FP1 and FP2) of potential bird activity were monitored at the development area, and two (FP3 and FP4) outside the development area (see APPENDIX A):

- FP1: A borehole. In the winter of 2016 a solitary adult Verreaux's Eagle was recorded at the borehole, confirming the importance of the water troughs to raptors.
- FP2: Die Soutkomme pans. The pans were dry for the duration of the monitoring; therefore, no priority species were observed.
- FP3: A borehole. In the winter of 2016 a pair of Greater Kestrels nested in the windmill.
- FP4: Konnes se Pan. The pan was dry for the duration of the monitoring. According to a local landowner the pan very seldom holds water, on average about once in a decade.

8. DESCRIPTION OF EXPECTED IMPACTS

The effects of a wind farm on birds are highly variable and depend on a wide range of factors including the specification of the development, the topography of the surrounding land, the habitats affected and the number and species of birds present. With so many variables involved, the impacts of each wind farm must be assessed individually. The principal areas of concern with regard to effects on birds are listed below. Each of these potential effects can interact with each other, either increasing the overall impact on birds or, in some cases, reducing a particular impact (for example where habitat loss or displacement causes a reduction in birds using an area which might then reduce the risk of collision):

- Collision mortality on the wind turbines;
- Displacement due to disturbance during construction and operation of the wind farm;
- Displacement due to habitat change and loss;
- Electrocution of priority species on the internal medium voltage (MV) powerlines;
- Collision with the proposed power line grid connections[12]; and
- Displacement due to disturbance during the construction of the power line grid connection[13].

It is important to note that the assessment is made on the status quo as it is currently on site. The possible change in land use in the broader development area is not taken into account because the extent and nature of future developments are unknown at this stage. It is however highly unlikely that the land use will change in the foreseeable future.

[12] Not assessed in this assessment report.

[13] Ibid

8.1 Collision mortality on wind turbines[14]

Wind energy generation has experienced rapid worldwide development over recent decades as its environmental impacts are considered to be relatively lower than those caused by traditional energy sources, with reduced environmental pollution and water consumption (Saidur *et al.*, 2011). However, bird fatalities due to collisions with wind turbines have been consistently identified as a main ecological drawback of wind energy (Drewitt and Langston, 2006).

Collisions with wind turbines appear to kill fewer birds than collisions with other man-made infrastructures, such as power lines, buildings or even traffic (Calvert *et al.* 2013; Erickson *et al.* 2005). Nevertheless, estimates of bird deaths from collisions with wind turbines worldwide range from 0 to almost 40 deaths per turbine per year (Sovacool, 2009). The number of birds killed varies greatly between sites, with some sites posing a higher collision risk than others, and with some species being more vulnerable (e.g. Hull *et al.* 2013; May *et al.* 2012a). These numbers may not reflect the true magnitude of the problem, as some studies do not account for detectability biases such as those caused by scavenging, searching efficiency and search radius (Bernardino *et al.* 2013; Erickson *et al.* 2005; Huso and Dalthorp 2014). Additionally, even for low fatality rates, collisions with wind turbines may have a disproportionate effect on some species. For long-lived species with low productivity and slow maturation rates (e.g. raptors), even low mortality rates can have a significant impact at the population level (e.g. Carrete *et al.* 2009; De Lucas *et al.* 2012a; Drewitt and Langston, 2006). The situation is even more critical for species of conservation concern, which sometimes are most at risk (e.g. Osborn *et al.* 1998).

High bird fatality rates at several wind farms have raised concerns among the industry and scientific community. High profile examples include the Altamont Pass Wind Resource Area (APWRA) in California because of high fatality of Golden eagles (*Aquila chrysaetos*), Tarifa in Southern Spain for Griffon vultures (*Gyps fulvus*), Smøla in Norway for White-tailed eagles (*Haliaatus albicilla*), and the port of Zeebrugge in Belgium for gulls (*Larus* sp.) and terns (*Sterna* sp.) (Barrios and Rodríguez, 2004; Drewitt and Langston, 2006; Everaert and Stienen, 2008; May *et al.* 2012a; Thelander *et al.* 2003). Due to their specific features and location, and characteristics of their bird communities, these wind farms have been responsible for a large number of fatalities that culminated in the deployment of additional measures to minimize or compensate for bird collisions. However, currently, no simple formula can be applied to all sites; in fact, mitigation measures must inevitably be defined according to the characteristics of each wind farm and the diversity of species occurring there (Hull *et al.* 2013; May *et al.* 2012b). A deep understanding of the factors that explain bird collision risk and how they interact with one another is therefore crucial to proposing and implementing valid mitigation measures.

8.1.1 Species-specific factors

- Morphological features

[14] This section is adapted from a recent (2014) review paper by Ana Teresa Marques, Helena Batalha, Sandra Rodrigues, Hugo Costa, Maria João Ramos Pereira, Carlos Fonseca, Miguel Mascarenhas, Joana Bernardino. *Understanding bird collisions at wind farms: An updated review on the causes and possible mitigation strategies*. Biological Conservation 179 (2014) 40–52

Certain morphological traits of birds, especially those related to size, are known to influence collision risk with structures such as power lines and wind turbines. The most likely reason for this is that large birds often need to use thermal and orographic updrafts to gain altitude, particularly for long distance flights. Thermal updrafts (thermals) are masses of hot, rising wind that form over heated surfaces, such as plains. Being dependent on solar radiation, they occur at certain times of the year or the day. Conversely, orographic lift (slope updraft), is formed when wind is deflected by an obstacle, such as mountains, slopes or tall buildings. Soaring birds use these two types of lift to gain altitude (Duerr *et al.* 2012). Janss (2000) identified weight, wing length, tail length and total bird length as being collision risk determinant. Wing loading (ratio of body weight to wing area) and aspect ratio (ratio of wing span squared to wing area) are particularly relevant, as they influence flight type and thus collision risk (Bevanger, 1994; De Lucas *et al.* 2008; Herrera-Alsina *et al.* 2013; Janss, 2000). Birds with high wing loading, such as the Griffon Vulture (*Gyps fulvus*), seem to collide more frequently with wind turbines at the same sites than birds with lower wing loadings, such as Common Buzzards (*Buteo buteo*) and Short-toed Eagles (*Circaetus gallicus*), and this pattern is not related with their local abundance (Barrios and Rodríguez, 2004; De Lucas *et al.* 2008). High wing-loading is associated with low flight manoeuvrability (De Lucas *et al.* 2008), which determines whether a bird can escape an encountered object fast enough to avoid collision.

<u>Graskoppies WEF</u>
Priority species that could potentially be vulnerable to wind turbine collisions due to morphological features (high wing loading) are Northern Black Korhaan, Karoo Korhaan, Kori Bustard and Ludwig's Bustard.

- Sensorial perception

Birds are assumed to have excellent visual acuity, but this assumption is contradicted by the large numbers of birds killed by collisions with man-made structures (Drewitt and Langston, 2008; Erickson *et al.* 2005). A common explanation is that birds collide more often with these structures in conditions of low visibility, but recent studies have shown that this is not always the case (Krijgsveld *et al.* 2009). The visual acuity of birds seems to be slightly superior to that of other vertebrates (Martin, 2011; McIsaac, 2001). Unlike humans, who have a broad horizontal binocular field of 120°, some birds have two high acuity areas that overlap in a very narrow horizontal binocular field (Martin, 2011). Relatively small frontal binocular fields have been described for several species that are particularly vulnerable to power line collisions, such as vultures (Gyps *sp.*) cranes and bustards (Martin and Katzir, 1999; Martin and Shaw, 2010; Martin, 2012, 2011; O'Rourke *et al.* 2010). Furthermore, for some species, their high resolution vision areas are often found in the lateral fields of view, rather than frontally (e.g. Martin and Shaw, 2010; Martin, 2012, 2011; O'Rourke *et al.* 2010). Finally, some birds tend to look downwards when in flight, searching for conspecifics or food, which puts the direction of flight completely inside the blind zone of some species (Martin and Shaw, 2010; Martin, 2011). For example, the visual fields of vultures (Gyps *sp.*) include extensive blind areas above, below and behind the head and enlarged supra-orbital ridges (Martin *et al.* 2012). This, combined with their tendency to angle their head toward the ground in flight, might make it difficult for them to see wind turbines ahead, which might at least partially explain their high collision rates with wind turbines (Martin, 2012).

Currently, there is little information on whether noise from wind turbines can play a role in bird collisions with wind turbines. Nevertheless, wind turbines with whistling blades are expected to experience fewer avian collisions than silent ones, with birds hearing the blades in noisy (windy) conditions. However, the hypothesis that louder blade noises (to birds) result in fewer fatalities has not been tested so far (Dooling, 2002).

Graskoppies WEF

Many of the priority species at the proposed wind farm probably have high resolution vision areas found in the lateral fields of view, rather than frontally, e.g., the bustards, korhaans and passerines. The possible exceptions to this are the raptors which all have wider binocular fields, although as pointed out by Martin (2011, 2012), this does not necessarily result in these species being able to avoid obstacles better.

- Phenology

It has been suggested that resident birds would be less prone to collision, due to their familiarity with the presence of the structures (Drewitt and Langston, 2008). However, recent studies have shown that, within a wind farm, raptor collision risk and fatalities are higher for resident than for migrating birds of the same species. An explanation for this may be that resident birds generally use the wind farm area several times while a migrant bird crosses it just once (Krijgsveld *et al.* 2009). However, other factors like bird behaviour are certainly relevant. Katzner *et al.* (2012) showed that Golden Eagles performing local movements fly at lower altitudes, putting them at a greater risk of collision than migratory eagles. Resident eagles flew more frequently over cliffs and steep slopes, using low altitude slope updrafts, while migratory eagles flew more frequently over flat areas and gentle slopes, where thermals are generated, enabling the birds to use them to gain lift and fly at higher altitudes. Also, Johnston *et al.* (2014) found that during migration when visibility is good Golden Eagles can adjust their flight altitudes and avoid the wind turbines.

At two wind farms in the Strait of Gibraltar, the majority of Griffon Vulture deaths occurred in the winter. This probably happened because thermals are scarcer in the winter, and resident vultures in that season probably relied more on slope updrafts to gain lift (Barrios and Rodríguez, 2004). The strength of these updrafts may not have been sufficient to lift the vultures above the turbine blades, thereby exposing them to a higher collision risk. Additionally, migrating vultures did not seem to follow routes that crossed these two wind farms, so the number of collisions did not increase during migratory periods. Finally, at Smøla, collision risk modelling showed that White-tailed Eagles are most prone to collide during the breeding season, when there is increased flight activity in rotor swept zones (Dahl *et al.* 2013).

The case seems to be different for passerines, with several studies documenting high collision rates for migrating passerines at certain wind farms, particularly at coastal or offshore sites. However, comparable data on collision rates for resident birds is lacking. This lack of information may result from fewer studies, lower detection rates and rapid scavenger removal (Johnson *et al.* 2002; Lekuona and Ursua, 2007). One of the few studies reporting passerine collision rates (from Navarra, northern Spain) documents higher collision rates in the autumn migration period, but it is unclear if this is due to migratory behaviour or due to an increase in the number of individuals because of recently fledged juveniles (Lekuona and Ursua, 2007).

Graskoppies WEF

The priority species recorded at the site during the 12 months monitoring are mostly resident species. Exceptions are Yellow-billed Kite, which is an intra-African breeding migrant, and Booted Eagle which is a both an intra –

African migrant and a Palaearctic migrant. Ludwig's Bustard could be considered a seasonal partial migrant (Shaw 2013).

- Bird behaviour

Flight type seems to play an important role in collision risk, especially when associated with hunting and foraging strategies. Kiting flight, which is used in strong winds and occurs in rotor swept zones, has been highlighted as a factor explaining the high collision rate of Red-tailed Hawks (*Buteo jamaicensis*) at APWRA (Hoover and Morrison, 2005). The hovering behaviour exhibited by Common Kestrels (*Falco tinnunculus*) when hunting may also explain the fatality levels of this species at wind farms in the Strait of Gibraltar (Barrios and Rodríguez, 2004). Kiting and hovering are associated with strong winds, which often produce unpredictable gusts that may suddenly change a bird's position (Hoover and Morrison, 2005). Additionally, while birds are hunting and focused on prey, they might lose track of wind turbine positions (Krijgsveld *et al.* 2009; Smallwood *et al.* 2009).

Collision risk may also be influenced by behaviour associated with a specific sex or age. In Belgium, only adult Common Terns (*Sterna hirundo*) were impacted by a wind farm (Everaert and Stienen, 2007) and the high fatality rate was sex-biased (Stienen *et al.* 2008). In this case, the wind farm is located in the foraging flight path of an important breeding colony, and the differences between fatality of males and females can be explained by the different foraging activity during egg-laying and incubation (Stienen *et al.* 2008). Another example comes from Portugal, where recent findings showed that the mortality of the Skylark (*Alauda arvensis*) is sex and age biased, and affecting mainly adult males. This was related with the characteristic breeding male song-flights that make them more vulnerable to collision with wind turbines (Morinha *et al.* 2014).

Social behaviour may also result in a greater collision risk with wind turbines due to a decreased awareness of the surroundings. Several authors have reported that flocking behaviour increases collision risk with power lines as opposed to solitary flights (e.g. Janss, 2000). However, caution must be exercised when comparing the particularities of wind farms with power lines, as some species appear to be vulnerable to collisions with power lines but not with wind turbines, e.g. indications are that bustards, which are highly vulnerable to power line collisions, are not prone to wind turbine collisions – a Spanish database of over 7000 recorded turbine collisions contains no Great Bustards *Otis tarda* (A. Camiña 2012a).

Several collision risk models incorporate other variables related to bird behaviour. Flight altitude is widely considered important in determining the risk of bird collisions with offshore and onshore wind turbines, as birds that tend to fly at the height of rotor swept zones are more likely to collide (e.g. Band *et al.* 2007; Furness *et al.* 2013; Garthe and Hüppop, 2004).

<u>Graskoppies WEF</u>

The priority species at the wind farm can be classified as either terrestrial species or soaring species, with some, e.g. Secretarybird exhibiting both types of flight behaviour.

Terrestrial species spend most of the time foraging on the ground. They do not fly often and then generally short distances at low to medium altitude, usually powered flight. At the wind farm site, korhaans, bustards and larks are included in this category. Some larger species undertake longer distance flights at higher altitudes (especially

Ludwig's Bustard). Soaring species spend a significant time on the wing in a variety of flight modes including soaring, kiting, hovering and gliding at medium to high altitudes. At the wind farm site, the raptor species are included in this class. Based on the potential time spent potentially flying at rotor height, soaring species are usually at greater risk of collision.

However, specific behaviour of some terrestrial species might put them at risk of collision, e.g. display flights of Northern Black Korhaan and specifically the endemic Red Lark, might place them within the rotor swept zone.

Red Larks conduct display flights when breeding, which is opportunistic and can happen at any time following rains – most breeding activity takes place between August and May (Hockey *et al.* 2005).

Birdlife SA has recently released figures of birds killed at wind farms in South Africa. To date, a total of seven collision mortalities of Red-capped Larks *Calandrella cinerea* have been recorded at one wind farm (Ralston *in litt* 2016). These collisions most likely happened during display flights which are very similar to those performed by Red Larks. In order to get a measure of the collision risk posed to Red Larks by wind turbines, an analysis was done of display flights recorded at three potential wind farm sites during February and March 2016, following good rains (Van Rooyen & Froneman 2016). A total of 82 display flights was observed and the maximum height of the bird was visually judged and recorded. An analysis of the flights is set out below in Figures 15 and 16.

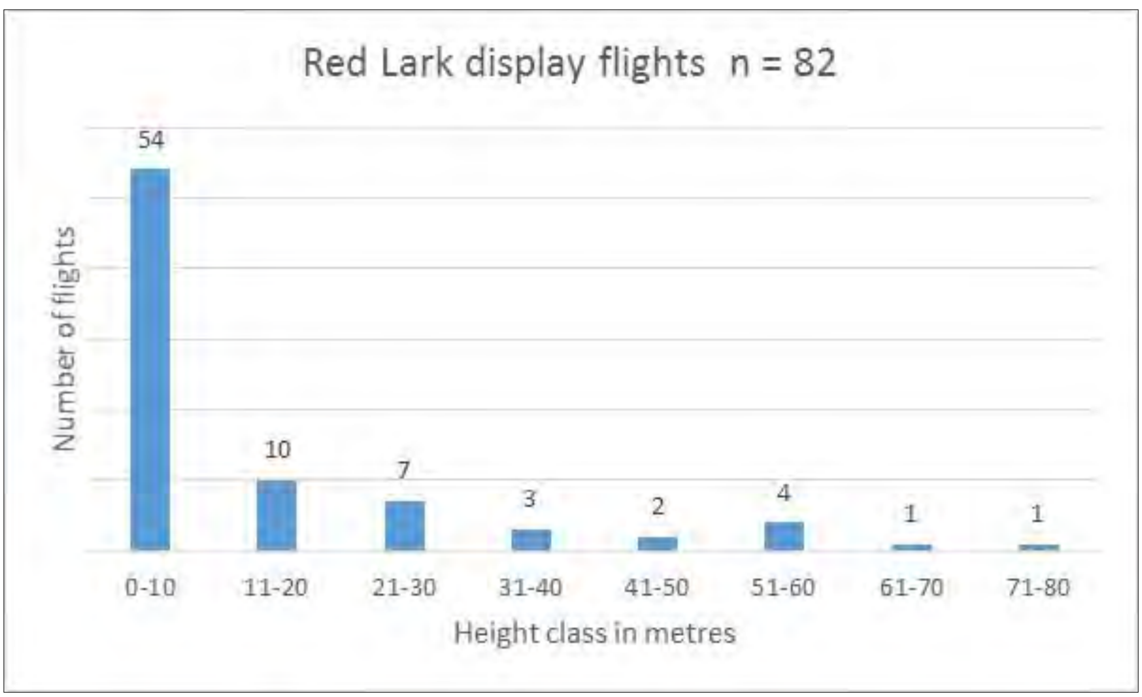

Figure 15: The number of Red Lark flights recorded at three proposed wind farm sites, broken down into height classes.

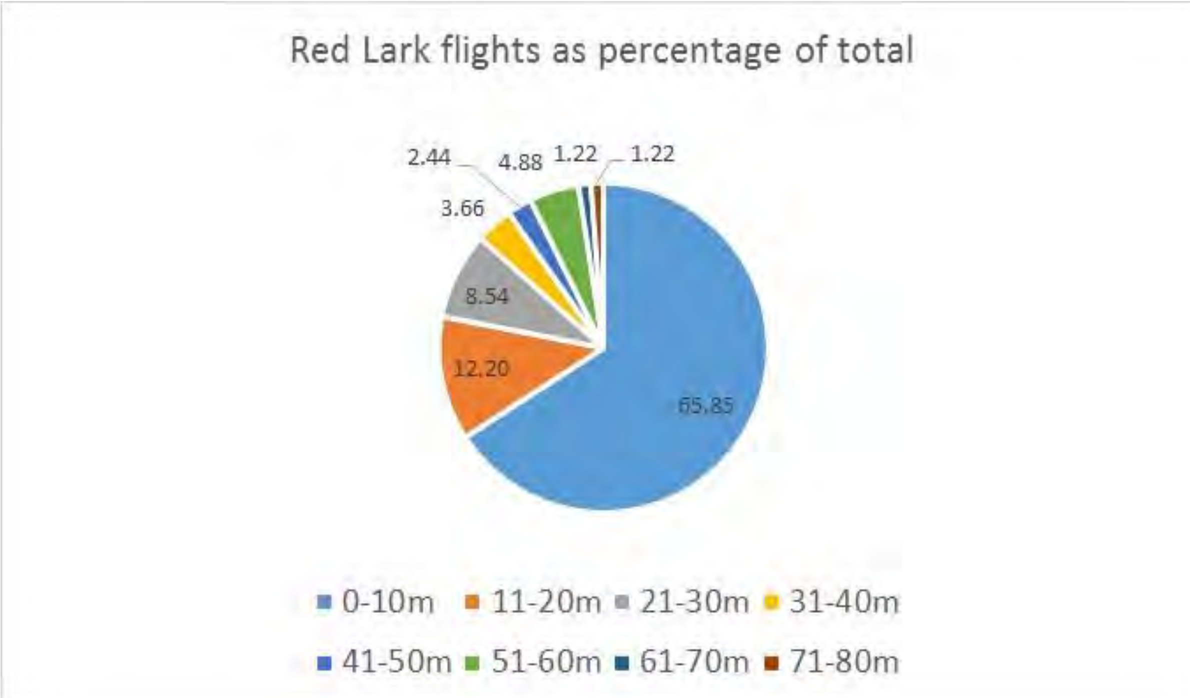

Figure 16: The number of Red Lark flights recorded at three proposed wind farm sites, broken down into percentages.

From the analysis of the dataset of 82 flights, the following emerged:

- 86.59% of display flights were 30m or lower,
- 90.24% were 40m or lower,
- 92.68% were 50m or lower, and
- 97.56% were 60m or lower.

The key issue as far as Red Larks is concerned is therefore the lower tip height.

The densities of the species in the study area is fairly low with a maximum density of 0.28 birds/km recorded during walk transects, compared to 2.33 birds/km in optimal habitat (Bio 3, 2013). Given the low densities of the birds at the site, it is likely that the habitat at the site i.e. a mixture of small-leaved shrubs and shrubby succulents, with drought resistant grasses, is not optimal for the species. The optimal habitat of the species is red sand dunes and sandy plains with scattered large seeded grasses, as is found in the Koa Valley about 50km to the north of the site (Hockey *et al*. 2005). Given the relatively low densities of the species at the site, mortalities at the site are not expected to significantly impact on the national population. It should also be pointed out that the assumption that Red Larks will be vulnerable to collisions is based on the behaviour of a different species. It could turn out that Red Larks for reasons as yet unknown, may not have the same vulnerability. Ideally a minimum rotor tip height of 50m should be used, and combined with rigorous post-construction monitoring and a commitment from the site operator to implement curtailment during periods of high flight activity, e.g. after good rains which triggers breeding activity, should significant mortality be recorded[15].

- Avoidance behaviours

Collision fatalities are also related to displacement and avoidance behaviours, as birds that do not exhibit either of these behaviours are more likely to collide with wind turbines. The lack of avoidance behaviour has been highlighted as a factor explaining the high fatality of White-tailed Eagles at Smøla wind farm, as no significant differences were found in the total amount of flight activity within and outside the wind farm area (Dahl *et al.* 2013). However, the birds using the Smøla wind farm are mainly sub-adults, indicating that adult eagles are being displaced by the wind farm (Dahl *et al.* 2013).

Two types of avoidance have been described (Furness *et al.*, 2013): ‘macro-avoidance’ whereby birds alter their flight path to keep clear of the entire wind farm (e.g. Desholm and Kahlert, 2005; Plonczkier and Simms, 2012; Villegas-Patraca *et al.* 2014), and ‘micro-avoidance’ whereby birds enter the wind farm but take evasive actions to avoid individual wind turbines (Band *et al.* 2007). This may differ between species and may have a significant impact on the size of the risk associated with a specific species. It is generally assumed that 95-98% of birds will successfully avoid the turbines (SNH 2010). It is also important to note that there is not necessarily a direct correlation between time spent at rotor height, and the likelihood of collision.

Displacement due to wind farms, which can be defined as reduced bird breeding density within a short distance of a wind turbines, has been described for some species (Pearce-Higgins *et al.* 2009). Birds exhibiting this type of displacement behaviour when defining breeding territories are less vulnerable to collisions, not because of morphological or site-specific factors, but because of altered behaviour (see also section 6.2 below).

<u>Graskoppies WEF sites</u>
It is anticipated that most birds at the proposed wind farm will successfully avoid the wind turbines[16]. Possible exceptions might be raptors engaged in hunting which might serve to distract them and place them at risk of collision (e.g. Jackal Buzzard), or birds engaged in display behaviour, e.g. Red Lark (see earlier discussion). Despite being potential collision candidates based on morphology and flight behaviour, bustards do not seem to be particularly vulnerable to wind turbine collisions, indicating a high avoidance rate. Complete macro-avoidance of the wind farm is unlikely for any of the priority species.

- Bird abundance

Some authors suggest that fatality rates are related to bird abundance, density or utilization rates (Carrete *et al.* 2012; Kitano and Shiraki, 2013; Smallwood and Karas, 2009), whereas others point out that, as birds use their territories in a non-random way, fatality rates do not depend on bird abundance alone (e.g. Ferrer *et al.* 2012; Hull *et al.* 2013). Instead, fatality rates depend on other factors such as differential use of specific areas within a

[15] A PhD study has been by commissioned by BLSA on Red Larks to study their behaviour in relation to wind farms, which is expected to commence in 2017.
[16] See footnote 8.

wind farm (De Lucas *et al.* 2008). For example, at Smøla, White-tailed Eagle flight activity is correlated with collision fatalities (Dahl *et al.* 2013). In the APWRA, Golden Eagles, Red-tailed Hawks and American Kestrels (*Falco spaverius*) have higher collision fatality rates than Turkey Vultures (*Cathartes aura*) and Common Raven (*Corvus corax*), even though the latter are more abundant in the area (Smallwood *et al.* 2009), indicating that fatalities are more influenced by each species' flight behaviour and turbine perception. Also, in southern Spain, bird fatality was higher in the winter, even though bird abundance was higher during the pre-breeding season (De Lucas *et al.* 2008).

<u>Graskoppies WEF</u>
The overall density of priority species recorded at the WEF sites was low at 0.74 birds/km for drive transects and 0.9 birds/km for walk transects. However, the abundance of priority species at the proposed wind farm site could fluctuate depending on season of the year, and particularly in response to rainfall. This is a common phenomenon in arid ecosystems, where stochastic rainfall events can trigger irruptions of insect populations which in turn attract large numbers of birds. In general, higher populations of priority species are likely to be present when the veld conditions are good, especially in the rainy season, which could trigger breeding activity. This could increase the risk of collisions due to heightened flight activity, especially of species such as Red Lark. Conversely, some species might be more at risk during dry conditions, e.g. Sclater's Lark which seems to increase in numbers during dry spells (Hockey *et al.* 2005).

8.1.2 Site-specific factors

- Landscape features

Susceptibility to collision can also heavily depend on landscape features at a wind farm site, particularly for soaring birds that predominantly rely on wind updrafts to fly (see previous section). Some landforms such as ridges, steep slopes and valleys may be more frequently used by some birds, for example for hunting or during migration (Barrios and Rodríguez, 2004; Drewitt and Langston, 2008; Katzner *et al.* 2012; Thelander *et al.* 2003). In APWRA, Red-tailed Hawk fatalities occur more frequently than expected by chance at wind turbines located on ridge tops and swales, whereas Golden Eagle fatalities are higher at wind turbines located on slopes (Thelander *et al.* 2003). Other birds may follow other landscape features, such as peninsulas and shorelines, during dispersal and migration periods. Kitano and Shiraki (2013) found that the collision rate of White-tailed Eagles along a coastal cliff was extremely high, suggesting an effect of these landscape features on fatality rates.

<u>Graskoppies WEF</u>
The proposed WEF sites do not contain many landscape features as the development area is situated on a vast flat plain. There are no natural waterbodies at the sites themselves, but several boreholes with water troughs. Boreholes with open water troughs are important sources of surface water and are used by various species, including large raptors such as Martial Eagle and Verreaux's Eagle, to drink and bath. Apart from raptors, smaller species congregate in large numbers around water troughs which in turn could attract raptors such as Lanner Falcon and Southern Pale Chanting Goshawk exposing them to collisions when they are distracted and hunting. It would therefore be advisable to create a pre-cautionary no-turbine zone around all water points, including water troughs at boreholes.

- Flight paths

Although the abundance of a species per se may not contribute to a higher collision rate with wind turbines, as previous discussed, areas with a high concentration of birds seem to be particularly at risk of collisions (Drewitt and Langston, 2006), and therefore several guidelines on wind farm construction advise special attention to areas located in migratory paths (e.g. Atienza *et al.* 2012; CEC, 2007; USFWS, 2012). As an example, Johnson *et al.* (2002) noted that over two-thirds of the carcasses found at a wind farm in Minnesota were of migrating birds. At certain times of the year, nocturnally migrating passerines are the most abundant species at wind farm, particularly during spring and fall migrations, and are also the most common fatalities (Strickland *et al.* 2011).

For territorial raptors like Golden Eagles, foraging areas are preferably located near to the nest, when compared to the rest of their home range. For example, in Scotland 98% of movements were registered at ranges less than 6 km from the nest, and the core areas were located within a 2–3 km radius (McGrady *et al.* 2002). These results, combined with the terrain features selected by Golden Eagles to forage such as areas closed to ridges, can be used to predict the areas used by the species to forage (McLeod *et al.* 2002), and therefore provide a sensitivity map and guidance to the development of new wind farms (Bright *et al.* 2006). In Spain, on the other hand, a study spanning 7 provinces with an estimated Golden Eagle population of 384 individuals, with a combined total of 46 years of post-construction monitoring, involving 5858 turbines, collisions did not occur at the nearest wind farm to the nest site but occurred in hunting areas with high prey availability far from the breeding territories, or randomly. A subset of data was used to investigate, inter alia, the relationship between collision mortality and proximity to wind turbines. Data was gathered for over a 12-year period. Analysis revealed that collisions are not related with the distance from the nest to the nearest turbine (Camiña 2014).

Wind farms located within flight paths can increase collision rates, as seen for the wind farm located close to a seabird breeding colony in Belgium (Everaert and Stienen, 2008). In this case, wind turbines were placed along feeding routes, and several species of gulls and terns were found to fly between wind turbines on their way to marine feeding grounds. Additionally, breeding adults flew closer to the structures when making frequent flights to feed chicks, which potentially increased the collision risk.

<u>Graskoppies WEF</u>
The proposed windfarm site is not located on any known or obvious flight paths. Visual inspection of the flight activity of the four species which had above average risk ratings, do not indicate any specific pattern for Booted Eagle and Black-chested Snake-Eagle with flights randomly distributed (see Figures 10-14). An area of potential denser flight activity is around water points, which could regularly attract several priority species, especially large raptors, as is possibly the case with the Verreaux's Eagle flights which were recorded in the vicinity of FP1. The Ludwig's Bustard flights show a broad east – west pattern, which could possibly be linked to the annual movement between the Nama and Succulent Karoo (Allan 1994, Shaw 2013).

- Food availability

Factors that increase the use of a certain area or that attract birds, like food availability, also play a role in collision risk. For example, the high density of raptors at the APWRA and the high collision fatality due to collision with turbines is thought to result, at least in part, from high prey availability in certain areas (Hoover and Morrison, 2005; Smallwood *et al.* 2001). This may be particularly relevant for birds that are less aware of obstructions such as wind turbines while foraging (Krijgsveld *et al.* 2009; Smallwood *et al.* 2009). It is speculated that the mortality of three Verreaux's Eagles in 2015 at a wind farm site in South Africa may have been linked to the availability of food (Smallie 2015).

<u>Graskoppies WEF</u>
In arid zones such as where this proposed wind farm is located, food availability is often linked to rainfall. It is a well-known fact that insect outbreaks may occur after rainfall events, which could draw in various priority species such as Ludwig's Bustard, Kori Bustard and various raptors (pers obs). This in turn could heighten the risk of collisions. Exceptional rain events may result in the Konnes se Pan holding water for a brief period. During such times the pan may attract waterbirds, including flamingos. Due to the very arid nature of the area, this is likely to be a very rare event, probably not more than once a decade.

- Weather

Certain weather conditions, such as strong winds that affect the ability to control flight manoeuvrability or reduce visibility, seem to increase the occurrence of bird collisions with artificial structures (Longcore *et al.* 2013). Some high bird fatality events at wind farms have been reported during instances of poor weather. For example, at an offshore research platform in Helgoland, Germany, over half of the bird strikes occurred on just two nights that were characterized by very poor visibility (Hüppop *et al.* 2006). Elsewhere, 14 bird carcasses were found at two adjacent wind turbines after a severe thunderstorm at a North American wind farm (Erickson *et al.* 2001). However, in these cases, there may be a cumulative effect of bad weather and increased attraction to artificial light. Besides impairing visibility, low altitude clouds can in turn lower bird flight height, and therefore increasing their collision risk with tall obstacles (Langston and Pullan, 2003). For wind farms located along migratory routes, the collision risk may not be the same throughout a 24-h period, as the flight altitudes of birds seem to vary. The migration altitudes of soaring birds have been shown to follow a typically diurnal pattern, increasing during the morning hours, peaking toward noon, and decreasing again in the afternoon, in accordance with general patterns of daily temperature and thermal convection (Kerlinger, 2010; Shamoun-Baranes *et al.* 2003).

Collision risk of raptors is particularly affected by wind. For example, Golden Eagles migrating over a wind farm in Rocky Mountain showed variable collision risk according to wind conditions, which decreased when the wind speed raised and increased under head- and tailwinds when compared to western crosswinds (Johnston *et al.* 2014).

<u>Graskoppies WEF</u>
Weather conditions at the proposed wind farm are likely to influence flight behaviour of soaring species in much the same manner as has been recorded elsewhere at wind farms. There is some indication that flight activity for all priority species (both soaring and terrestrial) is most prevalent during light to gentle breezes (see **APPENDIX C**).

8.1.3 Wind farm-specific factors

- Turbine features

Turbine features may play a role in collision risk. Older lattice-type towers have been associated with high collision risk, as some species exhibiting high fatality rates used the turbine poles as roosts or perches when hunting (Osborn *et al.* 1998; Thelander and Rugge, 2000). However, in more recent studies, tower structure did not influence the number of bird collisions, as it was not higher than expected according to their availability when compared to collisions with tubular turbines (Barrios and Rodríguez, 2004).

Turbine size has also been highlighted as an important feature, as higher towers have a larger rotor swept zone and, consequently, a larger collision risk area. While this makes intuitive sense, the majority of published scientific studies indicate that an increase in rotor swept area do not automatically translate into a larger collision risk. Turbine dimensions seem to play an insignificant role in the magnitude of the collision risk in general, relative to other factors such as topography, turbine location, morphology and a species' inherent ability to avoid the turbines, and may only be relevant in combination with other factors, particularly wind strength and topography (see Howell 1997, Barrios & Rodriguez 2004; Barclay *et al.* 2007, Krijgsveld *et al.* 2009, Smallwood 2013; Everaert 2014). Only two studies so far found a correlation between turbine hub height and mortality (De Lucas *et al.* 2008; Loss *et al.* 2013).

Rotor speed (revolutions per minute) also seems to be relevant, as faster rotors are responsible for higher fatality rates (Thelander *et al.* 2003). However, caution is needed when analysing rotor speed alone, as it is usually correlated with other features that may influence collision risk as turbine size, tower height and rotor diameter (Thelander *et al.* 2003), and because rotor speed is not proportional to the blade speed. In fact, fast spinning rotors have fast moving blades, but rotors with lower resolutions per minute may drive higher blade tip speeds.

<u>Graskoppies WEF</u>

Due to the fact that the turbine dimensions are constantly changing as newer models are introduced, it is best to take a pre-cautionary approach in order to anticipate any future potential changes in the turbine dimensions. The pre-construction monitoring programme worked on a potential rotor swept area of 30m – 220m to incorporate a wide range of models, based on feedback received from the client.

- Blade visibility

When turbine blades spin at high speeds, a motion smear (or motion blur) effect occurs, making wind turbines less conspicuous. This effect occurs both in the old small turbines that have high rotor speed and in the newer high turbines that despite having slower rotor speeds, achieve high blade tip speeds. Motion smear effect happens when an object is moving too fast for the brain to process the images and, as a consequence, the moving object appears blurred or even transparent to the observer. The effect is dependent on the velocity of the moving object and the distance between the object and the observer. The retinal-image velocity of spinning blades increases as birds get closer to them, until it eventually surpasses the physiological limit of the avian retina to process temporally changing stimuli. As a consequence, the blades may appear transparent and perhaps the rotor swept zone appears to be a safe place to fly (Hodos, 2003). For example, McIsaac (2001) showed that American Kestrels were not always able to distinguish moving turbine blades within a range of light conditions.

<u>Graskoppies WEF</u>

Motion smear is inherent to all wind turbines and will therefore also be a potential risk factor at the proposed wind farm.

- Wind farm configuration

Wind farm layout can also have a critical influence on bird collision risk. For example, it has been demonstrated that wind farms arranged perpendicularly to the main flight path may be responsible for a higher collision risk (Everaert *et al.* 2002 & Isselbacher and Isselbacher, 2001 in Hötker *et al.* 2006). At APWRA, wind farms located at the ends of rows, next to gaps in rows, and at the edge of local clusters were found to kill disproportionately more birds (Smallwood and Thellander, 2004). In this wind farm, serially arranged wind turbines that form wind walls are safer for birds (suggesting that birds recognize wind turbines and towers as obstacles and attempt to avoid them while flying), and fatalities mostly occur at single wind turbines or wind turbines situated at the edges of clusters (Smallwood and Thellander, 2004). However, this may be a specificity of APWRA. For instance, De Lucas *et al.* (2012a) found that the positions of the wind turbines within a row did not influence the turbine fatality rate of Griffon Vultures at Tarifa. Additionally, engineering features of the newest wind turbines require a larger minimum distance between adjacent wind turbines and in new wind farms it is less likely that birds perceive rows of turbines as impenetrable walls. In fact, in Greece it was found that the longer the distance between wind turbines, the higher is the probability that raptors will attempt to cross the space between them (Cárcamo *et al.* 2011).

<u>Graskoppies WEF</u>
The recorded flight behaviour of priority species at the proposed wind farm provided few clues with regard to potential areas of greater risk, largely due to the low frequency of flights, and uniformity of habitat. Turbine-free buffer zones are recommended around water points with surface water, based on the potential bird activity around these focal points.

8.2 Displacement due to disturbance

The displacement of birds from areas within and surrounding wind farms due to visual intrusion and disturbance in effect can amount to habitat loss. Displacement may occur during both the construction and operational phases of wind farms, and may be caused by the presence of the turbines themselves through visual, noise and vibration impacts, or as a result of vehicle and personnel movements related to site maintenance. The scale and degree of disturbance will vary according to site- and species-specific factors and must be assessed on a site-by-site basis (Drewitt & Langston 2006).

Unfortunately, few studies of displacement due to disturbance are conclusive, often because of the lack of before-and-after and control-impact (BACI) assessments. Onshore, disturbance distances (in other words the distance from wind farms up to which birds are absent or less abundant than expected) up to 800 m (including zero) have been recorded for wintering waterfowl (Pedersen & Poulsen 1991 as cited by Drewitt & Langston 2006), though 600 m is widely accepted as the maximum reliably recorded distance (Drewitt & Langston 2006). The variability of displacement distances is illustrated by one study which found lower post-construction densities of feeding European White-fronted Geese *Anser albifrons* within 600 m of the turbines at a wind farm in Rheiderland, Germany (Kruckenberg & Jaene 1999 as cited by Drewitt & Langston 2006), while another showed displacement of Pink-footed Geese *Anser brachyrhynchus* up to only 100–200 m from turbines at a wind farm in Denmark (Larsen & Madsen 2000 as cited by Drewitt & Langston 2006). Indications are that Great Bustard *Otis tarda* could be displaced by wind farms up to one kilometre from the facility (Langgemach 2008). An Austrian study found displacement for Great Bustards up to 600m (Wurm & Kollar as quoted by Raab *et al.* 2009). However, there is also evidence to the contrary; information on Great Bustard received from Spain points to the possibility of continued use of leks at operational wind farms (Camiña 2012b). Research on small grassland species in North America indicates that permanent displacement is uncommon and very species specific (e.g. see Stevens *et al.* 2013, Hale *et al.* 2014). There also seem to be little evidence for a persistent decline in passerine populations at wind farm sites in the UK (despite some evidence of turbine avoidance), with some species, including Skylark, showing increased populations after wind farm construction (see Pierce-Higgins *et al.* 2012). Populations of Thekla Lark *Galerida theklae* were found to be unaffected by wind farm developments in Southern Spain (see Farfan *et al.* 2009).

The consequences of displacement for breeding productivity and survival are crucial to whether or not there is likely to be a significant impact on population size. However, studies of the impact of wind farms on breeding birds are also largely inconclusive or suggest lower disturbance distances, though this apparent lack of effect may be due to the high site fidelity and long life-span of the breeding species studied. This might mean that the true impacts of disturbance on breeding birds will only be evident in the longer term, when new recruits replace existing breeding birds. Few studies have considered the possibility of displacement for short-lived passerines (such as larks), although Leddy *et al.* (1999) found increased densities of breeding grassland passerines with increased distance from wind turbines, and higher densities in the reference area than within 80m of the turbines. A review of minimum avoidance distances of 11 breeding passerines were found to be generally <100m from a wind turbine ranging from 14 – 93m (Hötker *et al.* 2006). A comparative study of nine wind farms in Scotland (Pearce-Higgens *et al.* 2009) found unequivocal evidence of displacement: Seven of the 12 species studied exhibited significantly lower frequencies of occurrence close to the turbines, after accounting for habitat variation, with equivocal evidence of turbine avoidance in a further two. No species were more likely to occur close to the turbines. Levels of turbine avoidance suggest breeding bird densities may be reduced within a 500m buffer of the turbines by 15–53%, with Common Buzzard *Buteo buteo*, Hen Harrier *Circus cyaneus*, Golden Plover *Pluvialis apricaria*, Snipe *Gallinago gallinago*, Curlew *Numenius arquata* and Wheatear *Oenanthe oenanthe* most affected. In a follow-up study, monitoring data from wind farms located on unenclosed upland habitats in the United Kingdom were collated to test whether breeding densities of upland birds were reduced as a result of wind farm construction or during wind farm operation. Red Grouse *Lagopus lagopus scoticus*, Snipe *Gallinago gallinago* and Curlew *Numenius arquata* breeding densities all declined on wind farms during construction. Red Grouse breeding densities recovered after construction, but Snipe and Curlew densities did not. Post-construction Curlew breeding densities on wind farms were also significantly lower than reference sites. Conversely, breeding densities of Skylark *Alauda arvensis* and Stonechat *Saxicola torquata* increased on wind farms during construction. Overall, there was little evidence for consistent post-construction population declines in any species, suggesting that wind farm construction can have greater impacts upon birds than wind farm operation (Pierce-Higgens *et al.* 2012).

The effect of birds altering their migration flyways or local flight paths to avoid a wind farm is also a form of displacement. This effect is of concern because of the possibility of increased energy expenditure when birds have to fly further, as a result of avoiding a large array of turbines, and the potential disruption of linkages between distant feeding, roosting, moulting and breeding areas otherwise unaffected by the wind farm. The effect depends on species, type of bird movement, flight height, distance to turbines, the layout and operational status of turbines, time of day and wind force and direction, and can be highly variable, ranging from a slight 'check' in flight direction, height or speed, through to significant diversions which may reduce the numbers of birds using areas beyond the wind farm (Drewitt & Langston 2006). A review of the literature suggests that none of the barrier effects identified so far have significant impacts on populations (Drewitt & Langston 2006). However, there are circumstances where the barrier effect might lead indirectly to population level impacts; for example, where a wind farm effectively blocks a regularly used flight line between nesting and foraging areas, or where several wind farms interact cumulatively to create an extensive barrier which could lead to diversions of many tens of kilometres, thereby incurring increased energy costs.

<u>Graskoppies WEF</u>
None of the priority species are likely to be permanently displaced due to disturbance, although displacement in the short term during the construction phase is very likely. The risk of permanent replacement is larger for large species such as Kori Bustard and Ludwig's Bustard, although displacement of the closely related Denham's Bustard (*Neotis denhami*) is evidently not happening at existing wind farms in the Eastern Cape (M. Langlands pers. comm). If the wind farm follows the modern trend of fewer, larger turbines (which seems to be the case), the risk of displacement due to disturbance is also lower. However, this will only be conclusively established through a post-construction monitoring programme.

8.3 Displacement due to habitat loss

The scale of permanent habitat loss resulting from the construction of a wind farm and associated infrastructure depends on the size of the project but, in general it, is likely to be small per turbine base. Typically, actual habitat loss amounts to 2–5% of the total development area (Fox *et al.* 2006 as cited by Drewitt & Langston 2006), though effects could be more widespread where developments interfere with hydrological patterns or flows on wetland or peatland sites (unpublished data). Some changes could also be beneficial. For example, habitat changes following the development of the Altamont Pass wind farm in California led to increased mammal prey availability for some species of raptor (for example through greater availability of burrows for Pocket Gophers *Thomomys bottae* around turbine bases), though this may also have increased collision risk (Thelander *et al.* 2003 as cited by Drewitt & Langston 2006).

However, the results of habitat transformation may be subtler, whereas the actual footprint of the wind farm may be small in absolute terms, the effects of the habitat fragmentation brought about by the associated infrastructure (e.g. power lines and roads) may be more significant. Sometimes Great Bustard can be seen close to or under power lines, but a study done in Spain (Lane *et al.* 2001 as cited by Raab *et al.* 2009) indicates that the total observation of Great Bustard flocks was significantly higher further from power lines than at control points. Shaw (2013) found that Ludwig's Bustard generally avoid the immediate proximity of roads within a 500m buffer. This means that power lines and roads also cause loss and fragmentation of the habitat used by the population in addition to the potential direct mortality. The physical encroachment increases the disturbance and barrier effects that contribute to the overall habitat fragmentation effect of the infrastructure (Raab *et al.* 2010). It has been shown that fragmentation of natural grassland in Mpumalanga (in that case by afforestation) has had a detrimental impact on the densities and diversity of grassland species (Alan *et al.* 1997).

Graskoppies WEF

The direct habitat transformation at the proposed wind farm is likely to be fairly minimal. The indirect habitat transformation could potentially have a bigger impact on priority species. It is expected that the densities of some larger terrestrial priority species may decrease due to this impact, e.g. Ludwig's Bustard, Karoo Korhaan and Northern Back Korhaan, but complete displacement is unlikely. The degree of displacement will only become apparent through post-construction monitoring. It is unlikely that raptors will be affected at all.

An issue that needs to be investigated is the potential of Red Lark displacement by the habitat transformation which will take place as a result of the proposed wind farms, due to the fact that the species is a range-restricted endemic. In a comprehensive study Hötker *et al.* 2006 calculated the following minimum turbine avoidance distances for several species, based on the analyses of a number of studies (see Table 8-2):

Table 8-2: Minimal distances (in metre) to wind farms in studies of different bird species as per Hötker *et al*. 2006

Species		Number of studies	Median	Mean	SD
Breeding season					
Mallard	*Anas platyrhynchos*	8	113	103	56
Black-tailed godwit	*Limosa limosa*	5	300	436	357
Oystercatcher	*Haematopus ostralegus*	8	25	85	113
Lapwing	*Vanellus vanellus*	13	100	108	110
Redshank	*Tringa totanus*	6	188	183	111
Skylark	*Alauda arvensis*	20	100	93	71
Meadow pipit	*Anthus pratensis*	9	0	41	53
Yellow wagtail	*Motacilla flava*	7	50	89	107
Blackbird	*Turdus merula*	5	100	82	76
Willow warbler	*Phylloscopus trochilus*	5	50	42	40
Chiffchaff	*Phylloscopus collybita*	5	50	42	40
Sedge warbler	*Acrocephalus schoenobaenus*	7	0	14	24
Reed warbler	*Acrocephalus scirpaceus*	11	25	56	70
Marsh warbler	*Acrocephalus palustris*	9	25	56	68
Whitethroat	*Sylvia communis*	9	100	79	65
Reed bunting	*Emberiza schoeniclus*	13	25	56	70
Linnet	*Carduelis cannabina*	5	125	135	29
Non-breeding season					
Grey heron	*Ardea cinerea*	6	30	65	97
Wigeon	*Anas penelope*	9	300	311	163
Swan spp.		8	125	150	139
Goose spp.		13	300	373	226
Mallard	*Anas platyrhynchos*	9	200	161	139
Diving ducks		12	213	219	122
Common buzzard	*Buteo buteo*	15	25	50	53
Kestrel	*Falco tinnunculus*	14	0	26	45
Curlew	*Numenius arquata*	24	190	212	176
Oystercatcher	*Haematopus ostralegus*	6	15	55	81
Lapwing	*Vanellus vanellus*	32	135	260	410
Common snipe	*Gallinago gallinago*	5	300	403	221
Golden plover	*Pluvialis apricaria*	22	135	175	167
Woodpigeon	*Columba palumbus*	5	100	160	195
Common gull	*Larus canus*	6	50	113	151
Black-headed gull	*Larus ridibundus*	15	0	97	211
Skylark	*Alauda arvensis*	6	0	38	59
Starling	*Sturnus vulgaris*	16	0	30	54
Carrion crow	*Corvus corone*	16	0	53	103

Based on the above figures, it seems that the mean minimum avoidance distances for breeding passerines are generally <100m from a wind turbine - see Skylark, Meadow pipit, Yellow Wagtail, Blackbird, Willow Warbler, Chiffchaff, Sedge Warbler, Reed Warbler, Marsh Warbler, Whitethroat and Reed Bunting. It is obviously not known if Red Lark will respond in a similar way to turbines, but it could probably be assumed that their reaction should not be drastically different from the passerines listed above.

There are currently 280 turbines planned for the four WEFs. If a 100m radius is drawn around each turbine and it be assumed that Red Larks will avoid this area, it means that an area of approximately 882 hectares could potentially experience reduced usage of or even complete avoidance by the species. For non-breeding skylarks and starlings, the minimum avoidance distances are considerably smaller i.e. <40m (based on 21 studies). If these are indicative of passerines in general, it would mean displacement of non-breeding Red Larks from an area of about 140 hectares. Dean *et al.* 1991 estimated the total suitable dune habitat for Red Larks at about 140 000 ha, centred around the Koa Valley. This figure is probably too conservative for the following reasons:

- Dean makes the following statement in the Red Lark SABAP 1 species account (Harrison *et al*. 1997)" …. atlas records, particularly in the eastern parts of its range, suggest it may be more common and widespread than previously thought"
- Red Larks are regularly recorded in what would be considered sub-optimal habitat e.g. at other wind farm sites near Helios MTS in Bushmanland Basin Shrubland (Van Rooyen *et al.* 2014a and b). The implication of this is that the species is in all likelihood more common outside of typical dune habitat than was previously thought. It seems that Bushmanland Basin Shrubland, of which a total of more than 3 million hectares is contained within the distribution range of the Red Lark, could potentially contain much larger numbers of the species than has been assumed up to now, especially in areas with an abundance of "white grasses".

There seems to be little evidence for a persistent decline in passerine populations at wind farm sites in the UK (despite evidence of turbine avoidance), with some species, including Skylark, showing increased populations after wind farm construction (see Pearce Higgins *et al.* 2012). Populations of Thekla Lark *Galerida theklae* were found to be unaffected by wind farm developments in Southern Spain (see Farfan *et al.* 2009). Of course, it cannot be assumed that Red Larks will show the same behavioural traits, but it is nonetheless interesting that seemingly conflicting evidence is emerging i.e. evidence of turbine avoidance by passerines, yet no declines at population level.

For the reasons stated above it would seem that the global population of Red Larks should be able to absorb the potential displacement impacts of the Graskoppies WEF.

8.4 Electrocution of priority species on the internal MV powerlines

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 2004). The electrocution risk is largely determined by the pole/tower design and the size of the bird. Species most at risk of electrocution are large raptors and vultures.

Graskoppies WEF

The species most at risk of electrocution on the internal overhead MV powerline network are the large raptors, particularly Martial Eagle and Verreaux's Eagle. Although the majority of the lines will be underground, there might be small sections e.g. those crossing drainage lines, which will be overhead.

9. IMPACT ASSESSMENT

9.1 Impact assessment methodology

The Impact Assessment Methodology assists in evaluating the overall effect of a proposed activity on the environment. The determination of the effect of an environmental impact on an environmental parameter is determined through a systematic analysis of the various components of the impact. This is undertaken using information that is available to the environmental practitioner through the process of the environmental impact assessment. The impact evaluation of predicted impacts was undertaken through an assessment of the significance of the impacts.

9.2 Determination of Significance of Impacts

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale i.e. site, local, national or global whereas Intensity is defined by the severity of the impact e.g. the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated using the following formula: (Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity. The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

9.3 Impact Rating System

Impact assessment must take account of the nature, scale and duration of effects on the environment whether such effects are positive (beneficial) or negative (detrimental). Each issue / impact is also assessed according to the project stages:

- planning
- construction
- operation
- decommissioning

Where necessary, the proposal for mitigation or optimisation of an impact is detailed. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

- Rating System Used to Classify Impacts

The rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the mitigation of the impact. Impacts have been consolidated into one rating. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

Table 8-1: Description of terms

NATURE

This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity.		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required.		
1	Site	The impact will only affect the site
2	Local/district	Will affect the local area or district
3	Province/region	Will affect the entire province or region
4	International and National	Will affect the entire country
PROBABILITY		
This describes the chance of occurrence of an impact		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
REVERSIBILITY		
This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource.	The impact will not result in the loss of any resources.

2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
DURATION		
This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity		
1	Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts on the environmental parameter. A cumulative effect/impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible Cumulative Impact	The impact would result in negligible to no cumulative effects
2	Low Cumulative Impact	The impact would result in insignificant cumulative effects
3	Medium Cumulative impact	The impact would result in minor cumulative effects
4	High Cumulative Impact	The impact would result in significant cumulative effects
INTENSITY / MAGNITUDE		
Describes the severity of an impact		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.

2	Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
Significance		

SIGNIFICANCE

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula:

(Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.

The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Points	**Impact Significance Rating**	**Description**
6 to 28	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive Low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive Medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive High impact	The anticipated impact will have significant positive effects.

74 to 96	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive Very high impact	The anticipated impact will have highly significant positive effects.

9.4 Impact ratings tables

IMPACT TABLE 1		
Environmental Parameter	*Avifauna*	
Issue/Impact/Environmental Effect/Nature	*Displacement of priority species due to disturbance during **construction** phase*	
Extent	*The impact will only affect the site.*	
Probability	*Impact will certainly occur (greater than a 75% chance of occurrence) for some species, particularly the larger ones.*	
Reversibility	*Partly reversible. The construction activities will inevitably cause temporary displacement of some priority species. Once the source of the disturbance has been removed, i.e. the noise and movement associated with the construction activities, most species should re-colonise the areas which have not been transformed by the footprint. However, the indirect effect of habitat fragmentation could result in lower densities of priority species.*	
Irreplaceable loss of resources	*Marginal loss of resources. The displacement of priority species is likely to be partial.*	
Duration	*Short term. Once the source of the disturbance has been removed, i.e. the noise and movement associated with the construction activities, priority species should re-colonise the areas which have not been transformed by the footprint, albeit possibly at a lower density.*	
Cumulative effect	*Minor cumulative impact. The priority species that occur (or are likely to occur) at the proposed site all have large distribution ranges, the cumulative impact of displacement would therefore be at most locally significant in some instances, rather than regionally or nationally significant (see also Section 10 below).*	
Intensity/magnitude	*High. Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease.*	
Significance Rating	*Medium significance.*	
	Pre-mitigation impact rating	Post mitigation impact rating

IMPACT TABLE 1		
Extent	1	1
Probability	4	2
Reversibility	2	1
Irreplaceable loss	2	2
Duration	1	1
Cumulative effect	3	2
Intensity/magnitude	3	2
Significance rating	-39 (medium negative)	-18 (low negative)
Mitigation measures	• Restrict the construction activities to the construction footprint area. • Do not allow any access to the remainder of the property during the construction period. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • A 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place.	

IMPACT TABLE 2		
Environmental Parameter	*Avifauna*	
Issue/Impact/Environmental Effect/Nature	*Displacement of priority species due to habitat destruction during **construction** phase*	
Extent	*The impact will only affect the site.*	
Probability	*Impact will certainly occur (greater than a 75% chance of occurrence)*	
Reversibility	*Partly reversible. The footprint of the wind farm is an inevitable result of the development, but it is likely that priority species will still utilise the site, albeit at lower densities.*	
Irreplaceable loss of resources	*Marginal loss of resources. It is likely that priority species will still utilise the site albeit at lower densities.*	
Duration	*Long term. The habitat transformation will be permanent*	
Cumulative effect	*Moderate cumulative impact. There are several renewable energy developments planned around Loeriesfontein which could result in a significant area of transformed habitat, but only at a local scale, for some species (see also Section 10 below).*	
Intensity/magnitude	*Medium. It is likely that priority species will still utilise the site albeit at lower densities.*	
Significance Rating	*Medium significance.*	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	1	1
Probability	4	3
Reversibility	2	2
Irreplaceable loss	2	2
Duration	4	4
Cumulative effect	3	3
Intensity/magnitude	2	2
Significance rating	-32 (medium negative)	-30 (medium negative)
Mitigation measures	• The recommendations of the specialist ecological study must be strictly adhered to. • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • A 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place.	

IMPACT TABLE 2	
	• Post-construction monitoring should be implemented to make comparisons with baseline conditions possible. • If densities of key priority species are proven to be significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species.

IMPACT TABLE 3		
Environmental Parameter	*Avifauna*	
Issue/Impact/Environmental Effect/Nature	*Displacement of priority species due to disturbance during* ***operational*** *phase*	
Extent	*The impact will only affect the site.*	
Probability	*Probable. The impact may occur (between a 50% to 75% chance of occurrence).*	
Reversibility	*Partly reversible. The operational activities could cause displacement of some priority species, but the impact is likely to be much less than during the construction phase.*	
Irreplaceable loss of resources	*Marginal loss of resources. Habituation is likely for some species after the construction phase, especially smaller species.*	
Duration	*Long term. Although habituation may happen in some instances, it must be assumed that in some instances the impact may be long term i.e. for the life-time of the activity.*	
Cumulative effect	*Minor cumulative impact. The priority species that occur (or are likely to occur) at the proposed site all have large distribution ranges, the cumulative impact of displacement would therefore be locally significant at most, rather than regional or national (see also Section 9 below).*	
Intensity/magnitude	*Medium. Although habituation may happen in some instances, it must be assumed that in some instances the impact may be long term i.e. for the life-time of the activity.*	
Significance Rating	*Low significance.*	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	1	1
Probability	3	2
Reversibility	2	2
Irreplaceable loss	2	2
Duration	3	3
Cumulative effect	2	2
Intensity/magnitude	2	2
Significance rating	-26 (low negative)	-24 (low negative)
Mitigation measures	• Operational activities should be restricted to the plant area. Maintenance staff should not be allowed to access other parts of the property unless it is necessary for wind farm related work.	

IMPACT TABLE 4		
Environmental Parameter	*Avifauna*	
Issue/Impact/Environmental Effect/Nature	*Collisions of priority species with the turbines in the operational phase*	
Extent	*The impact will affect the local area or district*	
Probability	*Possible. The impact may occur (between 25% - 50% chance of occurrence).*	
Reversibility	*Partly reversible. Mitigation measures could reduce the risk of collisions.*	
Irreplaceable loss of resources	*Significant loss of resources.*	
Duration	*Long term. The risk of collision will be present for the life-time of the development.*	
Cumulative effect	*Moderate cumulative impact. The cumulative impact will depend largely on which species are killed. If Verreaux's Eagles or Martial Eagles are regularly killed, the regional impact could be significant (see also Section 10 below). However, the low reporting rate for priority species makes this an unlikely scenario.*	
Intensity/magnitude	*Medium. The wind turbines could cause mortality of some priority species.*	
Significance Rating	*Medium significance.*	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	2	2
Probability	2	2
Reversibility	2	2
Irreplaceable loss	3	3
Duration	3	3
Cumulative effect	3	3
Intensity/magnitude	3	2
Significance rating	-45 (medium negative)	-30 (medium negative)
Mitigation measures	• A 300m no-go buffer is proposed around water points and pans as they serve as focal points for bird activity. • Formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (Jenkins *et al.* 2011). The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The purpose of this would be (a) to	

IMPACT TABLE 4	
	establish if and to what extent displacement of priority species has occurred through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. • As an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and again every five years thereafter. The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the results of the monitoring through a process of adaptive management. • The minimum turbine tip height should be no less than 50m to reduce the risk of Red Lark mortality during display flight activity. • Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be. • If turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations). • Lighting of the wind farm (for example security lights) should be kept to a minimum. Lights should be directed downwards (provided this complies with Civil Aviation Authority regulations).

IMPACT TABLE 5		
Environmental Parameter	*Avifauna*	
Issue/Impact/Environmental Effect/Nature	*Mortality of priority species due to electrocution on the internal MV lines in the operational phase*	
Extent	*The impact could affect the local area or district*	
Probability	*Possible. The impact may occur (Between a 25% to 50% chance of occurrence)..*	
Reversibility	*Comletely reversible. Mitigation measures could eliminate the risk*	
Irreplaceable loss of resources	*Significant loss of resources.*	
Duration	*Long term. The risk of electrocution could potentially be present for the life-time of the development if not mitigated at the onset.*	
Cumulative effect	*Moderate cumulative impact. The cumulative impact will depend largely on which species are killed. If Verreaux's Eagles or Martial Eagles are regularly killed, the regional impact could be significant (see also Section 10 below). However, the low reporting rate for priority species makes this an unlikely scenario.*	
Intensity/magnitude	*Medium. The powerlines could cause mortality of some priority species.*	
Significance Rating	*Medium significance.*	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	2	2
Probability	2	1
Reversibility	1	1
Irreplaceable loss	3	3
Duration	3	3
Cumulative effect	3	1
Intensity/magnitude	3	1
Significance rating	-42 (medium negative)	-11 (low negative)
Mitigation measures	• The avifaunal specialist must approve the powerline design to ensure that bird-friendly structures are used .	

10. CUMULATIVE IMPACTS

A cumulative impact, in relation to an activity, is the impact of an activity that may not be significant on its own but may become significant when added to the existing and potential impacts arising from similar or other activities in the area.

Currently there is no agreed method for determining significant adverse cumulative impacts on ornithological receptors. The Scottish Natural Heritage (2005) recommends a five-stage process to aid in the ornithological assessment:

- Define the species/habitat to be considered;
- Consider the limits or 'search area' of the study;
- Decide the methods to be employed;
- Review the findings of existing studies; and
- Draw conclusions of cumulative effects within the study area.

10.1 Species to be considered

The potential cumulative impacts on the priority species listed in Table 7-1 were considered.

10.2 Area considered in the cumulative assessment

The Helios Main Transmission Substation (MTS) approximately 50km north of the town of Loeriesfontein forms the hub of a proposed renewable energy node which is situated within a 40km radius around the MTS (See Figure 16 below). Within this 40km radius around the MTS, the habitat (karoo shrubland on gravel and sandy plains) and land-use (small-stock farming) is very uniform.

Table 10-1 below lists the other renewable energy projects which are currently approved, under construction or in an environmental impact assessment process within a 40km radius around Helios MTS (see also Figure 17 below) . **APPENDIX D** provides details of mitigation measures proposed for the impacts associated with these projects as detailed in the respective EIAs.

Table 10-1: List of other renewable projects within a 40km radius around Helios MTS

Project	Current status of EIA/development	Proponent	Capacity	Farm details	Footprint
Khobab Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 2 of Farm Sous 226	3 200 ha
Loeriesfontein Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 1 & 2 of Farm Aan de Karree Doorn Pan 213	3 453 ha
Hantam PV Solar Energy Facility	Environmental Authorisation issued / Approved under RE IPPPP	Solar Capital (Pty) Ltd	Up to 525MW	RE of Farm Narosies 228	1 338 ha
Orlight Loeriesfontein PV Solar Power Plant	Environmental Authorisation issued	Orlight SA (Pty) Ltd	70MW	Pt 5 of Farm Kleine Rooiberg 227	334 ha
Dwarsrug Wind Farm	Environmental Authorisation issued	Mainstream Renewable Power	140MW	Remainder of Brak Pan 212 Stinkputs 229	6 800 ha
Kokerboom 1 Wind Farm	Environmental Impact Assessment (EIA) underway	Business Venture Investments No. 1788 (Pty) Ltd (BVI)	240MW	• Remainder of the Farm Leeuwbergrivier No. 1163 • Remainder of the Farm Kleine Rooiberg No. 227	6 674 ha
Kokerboom 2 Wind Farm	Environmental Impact Assessment (EIA) underway	Business Venture Investments No. 1788 (Pty) Ltd (BVI)	240MW	• Remainder of the Farm Springbok Pan No. 1164 • Remainder of the Farm Springbok Tand No. 215	6 500 ha
Xha! Boom Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	• Portion 2 of Georg's Vley No 217	1897 ha
Hartebeest Leegte Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	• Remainder of Hartebeest Leegte No 216	3083 ha

Ithemba Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	• Portion 2 of Graskoppies No 176 & Portion 1 of Hartebeest Leegte No 216	3008
				Total	**36 282**

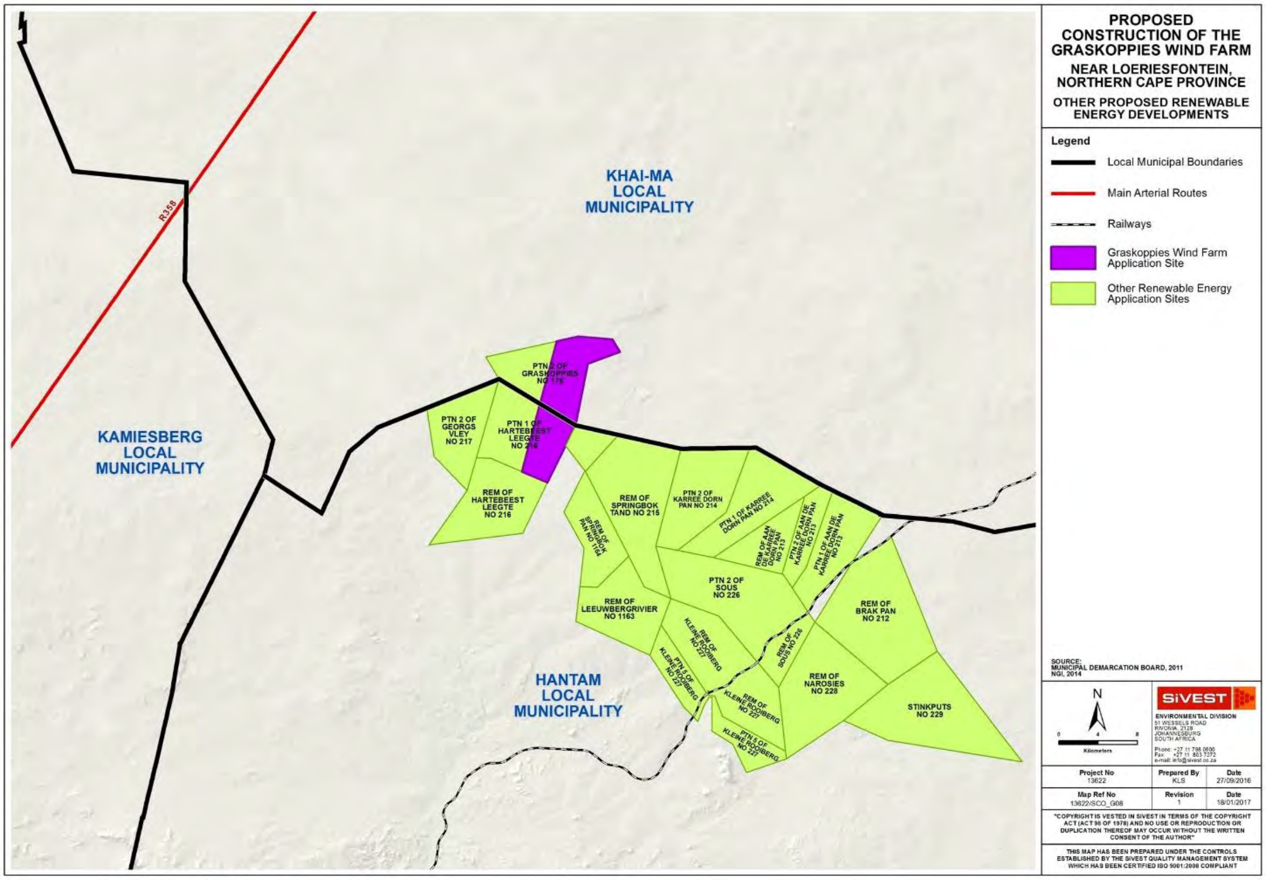

Figure 17: Existing renewable energy applications within a 40km radius around Helios MTS

10.3 Current impacts

Below is a summary of the typical threats currently facing avifauna in the Karoo environment (Marnewick *et al*. 2015):

10.3.1 Overgrazing

This results in a depletion of palatable plant species, erosion, and encroachment by Karoo shrubs. The result is loss of suitable habitat and a decrease in the availability of food for large terrestrial birds.

10.3.2 Poisoning

Strychnine poison was used extensively in the past to control damage-causing predators, such as Black-backed Jackal *Canis mesomelas* and Caracal *Caracal caracal*, and reduced scavenging raptor populations. The use of poison may be continuing, and the potential impacts on threatened raptor species has not been confirmed or quantified.

10.3.3 Road-kills

Many birds are commonly killed on roads, especially nocturnal species such as Spotted Eagle-Owl.

10.3.4 Renewable energy developments

Several wind and solar developments have been approved for development within a 40km radius around Helios MTS (see Table 10-1). The combined footprint of these proposed developments is approximately 28 299 hectares[17]. This has implications for several priority species, both in terms of collision mortality for some species, especially raptors, and displacement due to permanent habitat transformation, which affects most of the priority species to some degree.

10.3.5 Powerlines

Numerous existing and new power lines are significant threats to large terrestrial priority species in the Karoo. Power lines kill substantial numbers of all large terrestrial bird species in the Karoo, including threatened species such as Karoo Korhaan, Kori Bustard and Ludwig's Bustard (Jenkins *et al*. 2010; Shaw, J. 2013) There is currently no completely effective mitigation method to prevent collisions.

10.3.6 Climate change

Climate change scenarios for the region predict slightly higher summer rainfall by 2050, and increased rainfall variability. Droughts are expected to become more severe. The climate change is predicted to have both positive and negative consequences for priority species. Increased summer rainfall could improve survival, and conversely drought years can lower long-term average survival. Large, mainly resident species dependent on rainfall are also more vulnerable to climate change. This would include the slow-breeding Martial Eagle, which also exhibit extended parental care. Severe hailstorms kill many priority species and could become more frequent.

10.3.7 Shale gas fracking

There is a potential threat of shale gas fracking throughout the Karoo. Populations of bird species may be locally reduced through disturbance caused by lights, vibration, vehicles and dust, and may be affected by pollutants in ponds containing contaminated water produced by returned fracking fluids.

10.3.8 Persecution

Although it is difficult to prove, the direct persecution of raptors such as Verreaux's Eagle and Martial Eagle for stock predation is still taking place (R. Visagie pers. comm).

[17] In the case of projects already authorised or under construction, the actual infrastructure footprint (and not the land parcel size) was considered. This information was obtained through internet searches. In the case of projects currently undergoing an environmental impact assessment process, the size of the land parcel was used as the actual footprint size has as yet not been finalised.

10.4 Methods

The cumulative impact of the proposed WEF was assessed individually for each priority species (see Table 10-2 below).

The factors considered in assessing the potential species-specific impacts are:

- Level of current impact on priority species in study area (all impacts);
- Susceptibility to renewable energy impacts i.e. collisions with turbines and displacement through habitat transformation and disturbance;
- The percentage of habitat which is likely to be impacted by the combined footprint of all the proposed renewable energy projects.
- The avifaunal mitigation measures proposed for the renewable energy projects listed in Table 10-1 (where available).

Table 10-2 below sets out the criteria applied to rank potential cumulative impacts:

Table 10-2: Framework for assessing significance of cumulative effects

Significance	Effect
Severe	Effects that the decision-maker must take into account because the receptor/resource is irretrievably compromised, resulting in a fatal flaw.
Major	Effects that may become a key decision-making issue, potential fatal-flaw.
Moderate	Effects that are unlikely to affect the viability of the project, but mitigation might be required.
Minor	Effects which might be locally/site significant, but probably insignificant for the greater study area.
Not Significant	Effects that are within the ability of the resource to absorb such change both at local/site level and within the greater study area.

10.5 Assumptions and limitations: cumulative impacts

- The information on the other renewable energy projects in the study area was received from SiVEST and independently sourced from various websites, but the accuracy of these sources cannot be guaranteed.
- The assessment takes into account the potential impact of the associated grid connections as well.

10.6 Assessment

See Table 10-3 below for a systematic exposition of the expected cumulative impacts of the existing renewable energy projects and the Graskoppies WEF on priority species within a 40km radius around Helios MTS.

Table 10-3: Expected cumulative impacts

Priority species	Level of current and future impacts on species	Susceptibility to renewable energy impacts	Preferred habitat within a 40km radius around Helios MTS	Approximate size of preferred habitat within a 40km radius around Helios MTS (ha)	Extent of habitat potentially affected by the existing renewable applications and the Graskoppies WEF (ha)	Expected combined cumulative impact of Graskoppies WEF and existing renewable applications: Pre-mitigation	Expected combined cumulative impact of Graskoppies WEF and existing renewable applications: Post-mitigation
Karoo Korhaan	Low: Powerlines, solar, overgrazing, climate change	Low	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Northern Black Korhaan	Low: Powerlines, solar, overgrazing, climate change	Low	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Kori Bustard	High: Powerlines,solar, overgrazing, climate change	Low	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Lanner Falcon	Low: Powerlines, poisoning, road kills, solar, WEF	Medium?	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Ludwig's Bustard	High: Powerlines, solar, overgrazing, climate change	Low	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Martial Eagle	High: Powerlines, persecution, solar, overgrazing, WEFs, climate	High	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Secretarybird	High: Powerlines, solar , overgrazing, WEFs, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Booted Eagle	Medium: Solar, overgrazing, WEFs, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Sclater’s Lark	Low: Powerlines, solar, overgrazing, climate change	Low	Karoo shrubland	510 000	38 750 (7.5%)	Not significant	Not significant
Red Lark	Low: Powerlines, solar, overgrazing, climate change	Medium?	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Black-chested Snake-Eagle	Medium: Solar, overgrazing, WEFs, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant

Priority species	Level of current and future impacts on species	Susceptibility to renewable energy impacts	Preferred habitat within a 40km radius around Helios MTS	Approximate size of preferred habitat within a 40km radius around Helios MTS (ha)	Extent of habitat potentially affected by the existing renewable applications and the Graskoppies WEF (ha)	Expected combined cumulative impact of Graskoppies WEF and existing renewable applications: Pre-mitigation	Expected combined cumulative impact of Graskoppies WEF and existing renewable applications: Post-mitigation
Southern Pale Chanting Goshawk	Low: Powerlines, solar, overgrazing, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Greater Kestrel	Low: Solar, overgrazing, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Spotted Eagle-Owl	Medium: Powerlines, solar, overgrazing, WEFs, climate change, road	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Jackal Buzzard	Medium: Solar, overgrazing, WEFs, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor
Burchell's Courser	Medium: Solar, overgrazing, WEFs, climate change	Low?	Karoo shrubland	510 000	38 750 (7.5%)	Not significant	Not significant
Double-banded Courser	Medium: Solar, overgrazing, WEFs, climate change	Low?	Karoo shrubland	510 000	38 750 (7.5%)	Not significant	Not significant
Steppe Buzzard	Medium: Solar, overgrazing, WEFs, climate change	High	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Yellow-billed Kite	Medium: Solar, overgrazing, WEFs, climate change	High?	Karoo shrubland	510 000	38 750 (7.5%)	Minor	Not significant
Verreaux's Eagle	High: Powerlines, persecution, solar, overgrazing, WEFs, climate	High	Karoo shrubland	510 000	38 750 (7.5%)	Moderate	Minor

10.7 Conclusions

The cumulative impact of the proposed Graskoppies WEF on priority avifauna within a 40km radius around the Helios MTS, should range from minor to insignificant, if appropriate mitigation is implemented.

10.8 No-Go Alternative

The no-go alternative will result in the current status quo being maintained as far as the avifauna is concerned. Overall, the very low human population in the study area is definitely advantageous to avifauna in general. The no-go option would be advantageous for the ecological integrity of the study area as far as avifauna is concerned.

11. ASSESSMENT OF ALTERNATIVES

There are two potential alternatives planned for the Graskoppies on-site substation (see Figure 2). Table 11 – 1 below provides a comparative assessment of the two alternatives from an avifaunal impact perspective.

Table 11 – 1: Comparative assessment of substation localities at the proposed Graskoppies Wind Farm

PREFERRED	The alternative will result in a low impact / reduce the impact
FAVOURABLE	The impact will be relatively insignificant
NOT PREFERRED	The alternative will result in a high impact / increase the impact
NO PREFERENCE	The alternative will result in equal impacts

Alternative	Preference	Reasons (incl. potential issues)
SUBSTATION ALTERNATIVES		
Substation Alternative 1	The alternative will result in equal impacts	The habitat at the proposed turbine site is highly homogenous. The impact that the substation will have on the available habitat is therefore likely to be similar, irrespective of where the substation is located.
Substation Alternative 2	The alternative will result in equal impacts	The habitat at the proposed turbine site is highly homogenous. The impact that the substation will have on the available habitat is therefore likely to be similar, irrespective of where the substation is located.

12. CONCLUSIONS

The proposed Mainstream Graskoppies Wind Farm will have a variety of impacts on avifauna which range from low to high. The impacts are (1) displacement of priority species due to disturbance during construction phase (2) displacement of priority species due to habitat destruction during construction phase (3) displacement of priority species due to disturbance during operational phase (4), collisions of priority species with the turbines in the operational phase, and (5) electrocution of priority species on the internal MV powerlines.

Displacement of priority species due to disturbance during construction phase is likely to be a temporary medium negative impact, but can be reduced to low with the application of mitigation measures. Mitigation measures are:

- the restriction of construction activities to the construction footprint area, no access to the remainder of the property during the construction period,
- measures to control noise and dust,
- maximum use of existing access roads and
- the implementation of a 300m exclusion zone around waterpoints.

Displacement of priority species due to habitat destruction during construction phase is likely to be a medium negative impact and will remain so, despite the application of mitigation measures. Mitigation measures comprise the following:

- the recommendations of the specialist ecological study must be strictly adhered to,
- maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum,
- a 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place,
- post-construction monitoring should be implemented to make comparisons with baseline conditions possible, and if densities of key priority species are proven to be significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species.

Displacement of priority species due to disturbance during the operational phase is likely to be of low significance and it could be further reduced through the application of mitigation measures, namely the restriction of operational activities to the plant area and no access to other parts of the property unless it is necessary for wind farm related work.

Collisions of priority species with the turbines in the operational phase are likely to be a high negative impact but it could be reduced to medium negative through the application of mitigation measures. Mitigation measures are the following:

- A 300m no-go buffer is proposed around water points and pans as they serve as focal points for bird activity,
- formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (as an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and again every five years thereafter),

- the minimum turbine tip height should ideally be no less than 50m to reduce the risk of Red Lark mortality during display flight activity,
- depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be,
- if turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations),
- lighting of the wind farm (for example security lights) should be kept to a minimum, and lights should be directed downwards (provided this complies with Civil Aviation Authority regulations).

The electrocution of priority species on the internal MV powerlines is rated as a potentially medium impact which could be reduced to low through the use of bird friendly designs.

Finally, it is concluded that, after taking into account the expected impact of proposed renewable energy projects within a 40km radius around Helios MTS, that the cumulative impact of the proposed Graskoppies WEF on priority avifauna, if appropriate mitigation is implemented, will range from minor to insignificant.

See Figure 18 below for a sensitivity map indicating proposed exclusion zones.

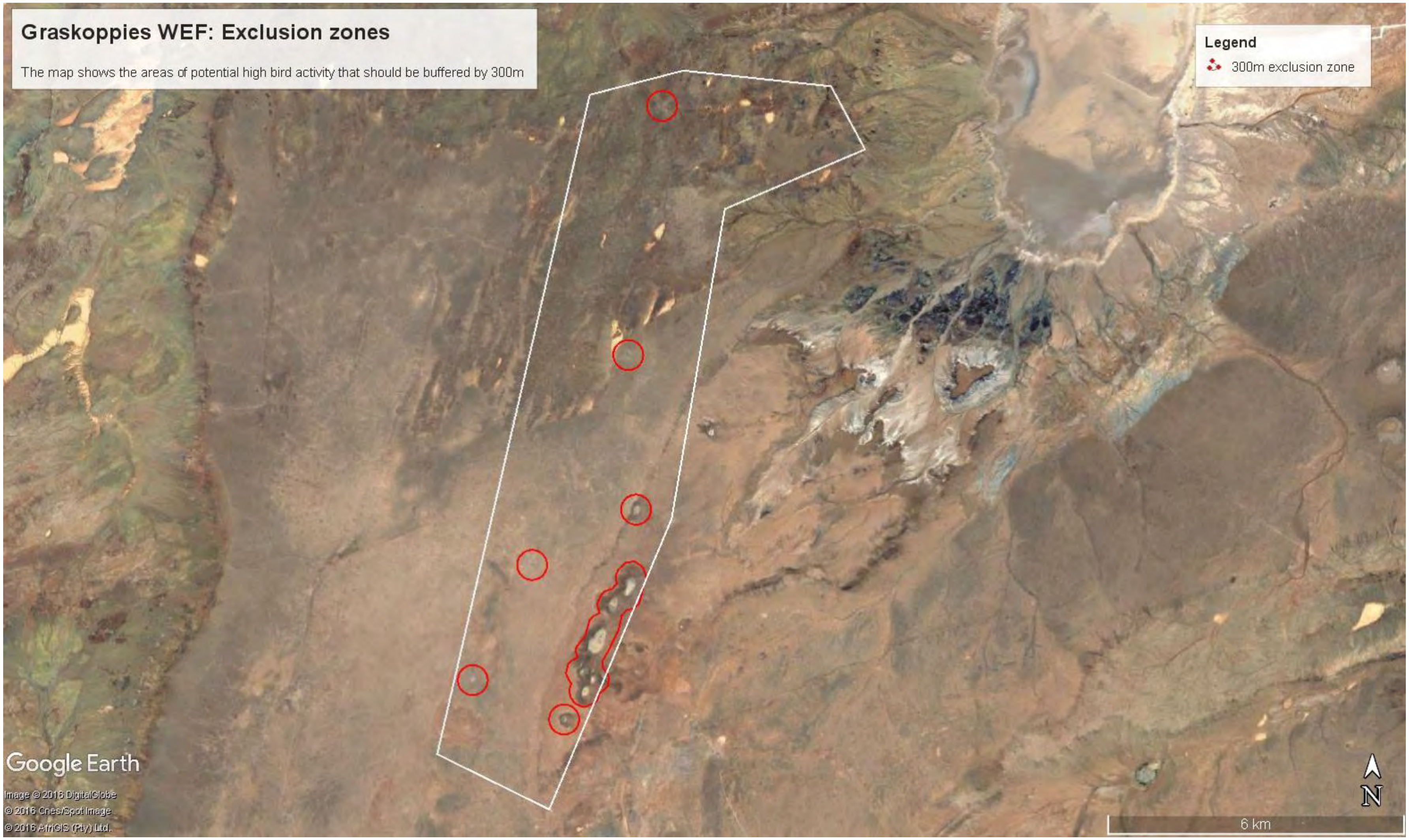

Figure 18: Sensitivity map of the study area, indicating proposed buffer zones (red circles) around waterpoints and pans.

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APPENDIX A: BIRD HABITAT

Figure 1: Typical Bushmanland Basin Shrubland in a sandy area in the development area.

Figure 2: A fence line in the broader study area, one of the few man-made modifications in the landscape.

Figure 3: The development area contains a mixture of sandy and gravel areas. This is an example of a gravel area.

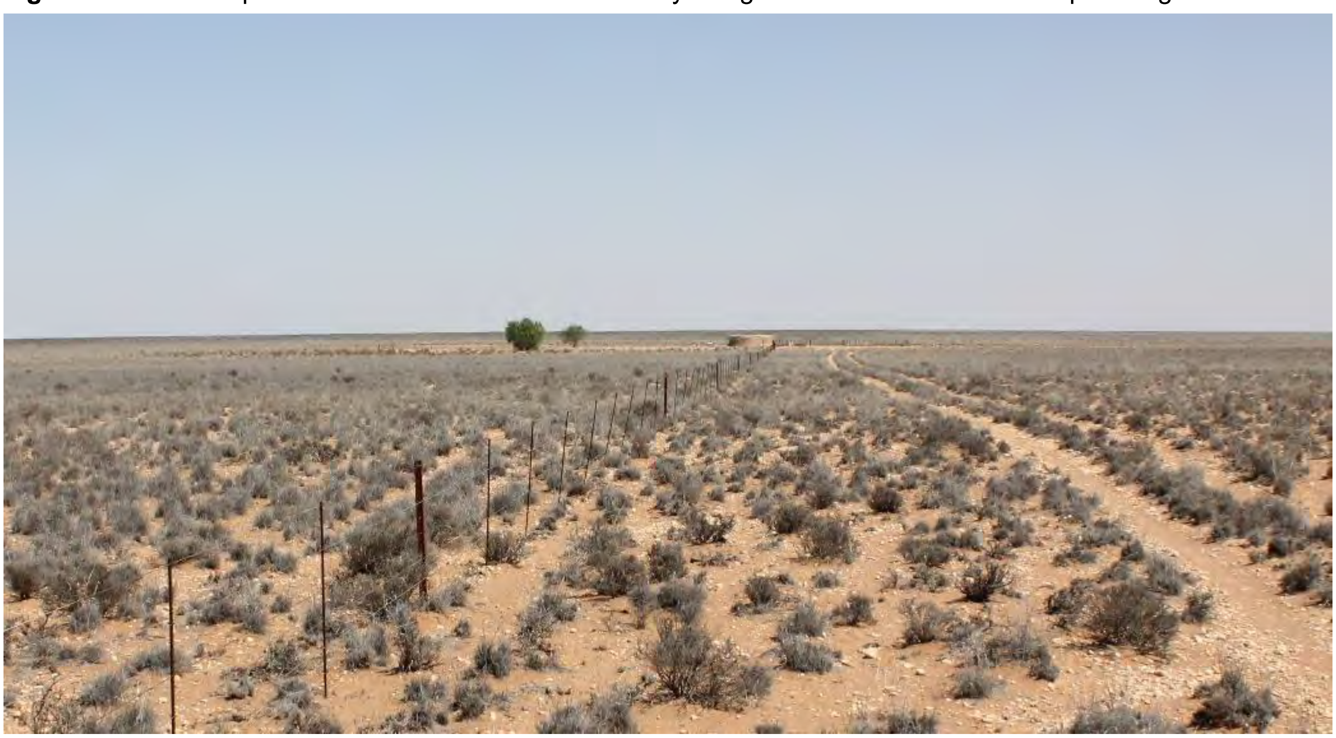


Figure 4: Boreholes is virtually the only source of surface water in the greater study area.

APPENDIX B: PRE-CONSTRUCTION METHODOLOGY

Objectives

The objective of the pre-construction monitoring at the proposed wind project was to gather baseline data over a period of 12-months on the following aspects pertaining to avifauna:

- The abundance and diversity of birds at the broader study area and a suitable control area to measure the potential displacement effect of the wind farm.
- Flight patterns of priority species at the broader study area to measure the potential collision risk with the turbines.

Methods

The monitoring protocol for the site is designed according to the latest version (2015) of *Jenkins A R; Van Rooyen C S; Smallie J J; Anderson M D & Smit H A. 2011. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa. Endangered Wildlife Trust and Birdlife South Africa.*

Monitoring surveys were conducted at the broader study area and a control area by four field monitors during the following periods:

- 10 – 23 November 2015
- 23 February – 03 March 2016
- 18 May - 30 May 2016
- 22 August – 1 September 2016

Monitoring was conducted in the following manner:

- Four drive transects were identified on the study area totalling 52.1km and one drive transect in the control site with a total length of 13.7km.
- Two observers travelling slowly (± 10km/h) in a vehicle records all species on both sides of the drive transect. The observers stop at regular intervals (every 500 m) to scan the environment with binoculars. Drive transects are counted three times per sampling session.
- In addition, eleven walk transects of 1km each were identified at the study area, and four at the control site, and counted 8 times per sampling season. All birds are recorded during walk transects.
- The following variables were recorded:
    - Species;
    - Number of birds;
    - Date;
    - Start time and end time;
    - Distance from transect (0-50 m, 50-100 m, >100 m);
    - Wind direction;
    - Wind strength (estimated Beaufort scale 1 - 7);
    - 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

  - Co-ordinates (priority species only).

- Eleven vantage points (VPs) were identified to record the flight altitude and patterns of priority species at the development areas. Two VPs were also identified on the control area. The following variables were recorded for each flight:
  - Species;
  - Number of birds;
  - Date;
  - Start time and end time;
  - Wind direction;
  - Wind strength (estimated Beaufort scale 1-7);
  - Weather (sunny; cloudy; partly cloudy; rain; mist);
  - Temperature (cold; mild; warm; hot);
  - Flight altitude (high i.e. >220m; medium i.e. 30m – 220m; low i.e. <30m);
  - Flight mode (soar; flap; glide; kite; hover); and
  - Flight time (in 15 second-intervals).

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 development areas by birds in order to measure potential displacement by the wind farm activities. The objective of vantage point counts was to measure the potential collision risk with the turbines. Priority species were identified using the November 2014 BLSA list of priority species for wind farms.

Four potential focal points of bird activity, two boreholes and two salt pans, one known as Die Soutkomme and the other as Konnes se Pan, were identified in the greater study area and monitored.

Figure 1 below indicates the area where monitoring was performed.

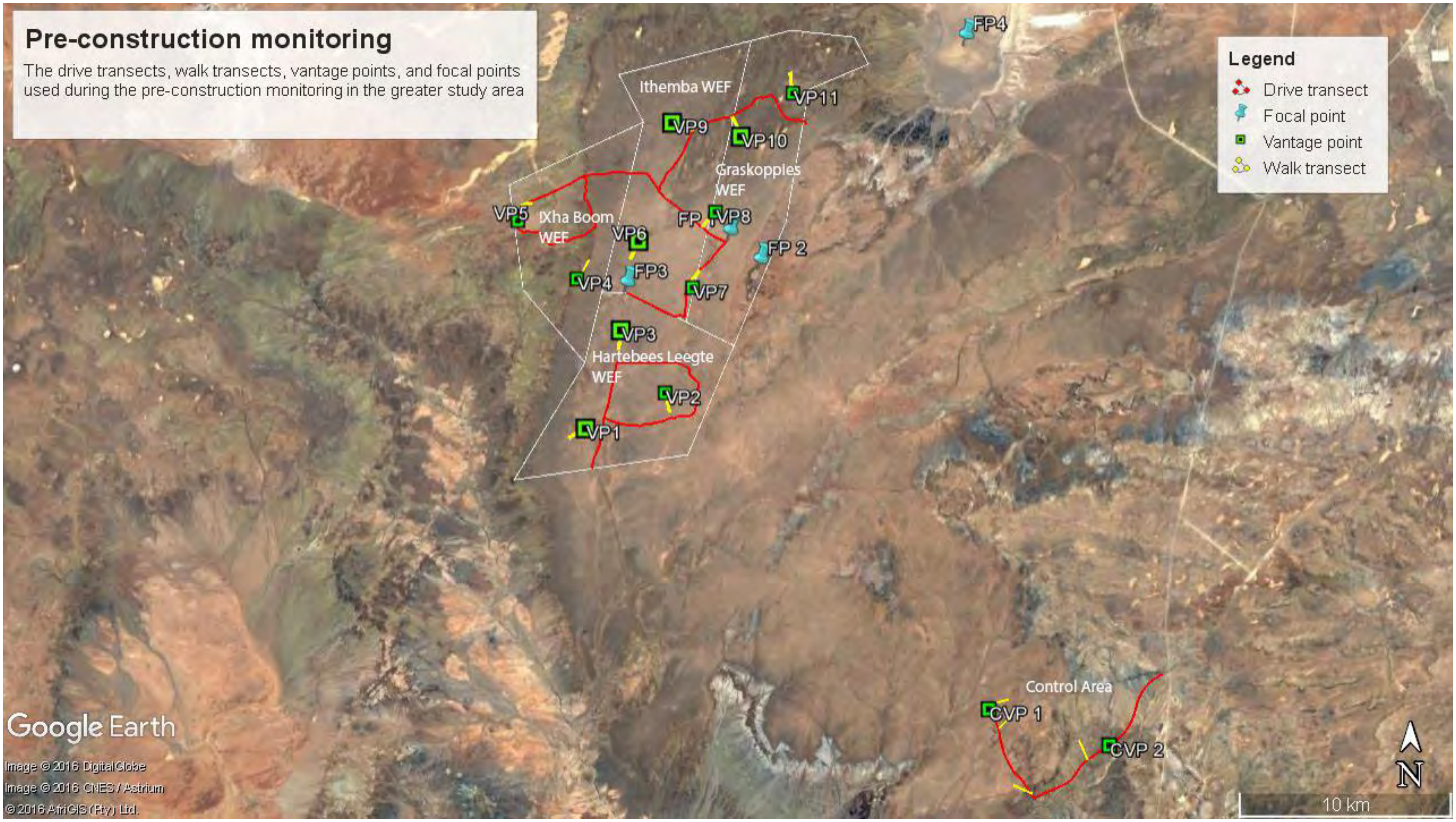


Figure 1: The map indicates the area where the pre-construction monitoring was performed.

APPENDIX C: STATISTICAL ANALYSIS

1. Introduction

This report is based on data captured in the MS Excel file "*Leeuwberg MRP VP Au Wi Sp Su AF 20161020 v1.xls*". That file contains records for each individual flight of priority species birds that were recorded at eleven vantage points set up at the development areas. Observations were recorded in sampling units of time referred to as "watch periods", each of three hours duration. The word "*flight"* indicates a group of birds flying or associating together. Individual birds in a flight were counted and recorded and these are referred to as "*individual*" counts. When no birds were seen during a watch period, the species was identified by the label "*None*". Every species is categorised into a "*Flight Class".* In this survey two flight classes were recorded viz. "Soaring" and "Terrestrial".

There were *176 watch periods* of three hours each, spread over the *eleven* vantage points, allocated to each of the four seasons as set out in Table *1*. Environmental and other relevant information were also recorded (e.g. Temperature, Wind Direction, Wind Speed, categories of height at which the birds were observed, etc.).

Table *1*. The survey dates.

Start Date	End Date	Season	Watch Periods	Hours Observed
2015-11-10	2015-11-19	Spring 2015	44	132
2016-02-23	2016-03-02	Summer 2015/16	44	132
2016-05-18	2016-05-29	Autumn 2016	44	132
2016-08-22	2016-08-27	Spring 2016	44	132

Basic summary statistics concerning the data are presented in this report in tables *A – I* in Section *A* of the Appendix. The matter of whether the data obtained are representative of the true occurrence of those birds identified as priority species is investigated. The sample size (number of watch periods) is also considered to establish the validity of the estimates of the average number of birds observed.

The statistical terminology used is defined and explained in Section *B* of the *Appendix* at the end of this report.

2. Descriptive statistics

Several tables of descriptive statistics are presented. The watch periods were all of the same length, viz. three hours and thus counts, averages and variabilities are expressed per *3* hours.

The following basic statistics were computed and presented in Section *A* of the *Appendix*.

- A count of the total number of individual birds (by species and flight class) observed during the survey against the *Height* at which they flew*.* These data are displayed as Table *A* in Section *A* of the *Appendix*.
- Table *B* shows the times that the soaring and terrestrial birds flew at medium height and at all heights. The times spent at medium height are expressed as a percentage of the total observed flying times. These percentages have to be interpreted with care and should always be seen together with the total flight time.
- Tables *C* – *G* provide summary statistics for insight into the behaviour of the species observed w.r.t. their presence according to season and their occurrence profiles during various weather conditions such as temperature, wind direction and wind strength.
- The counts observed during consecutive watch periods, also identified by season and vantage point, are listed separately in Table *H* (soaring birds) and Table *I* (terrestrial birds) in section *A* of the *Appendix*. These tables also contain updated average counts for consecutive watch periods.

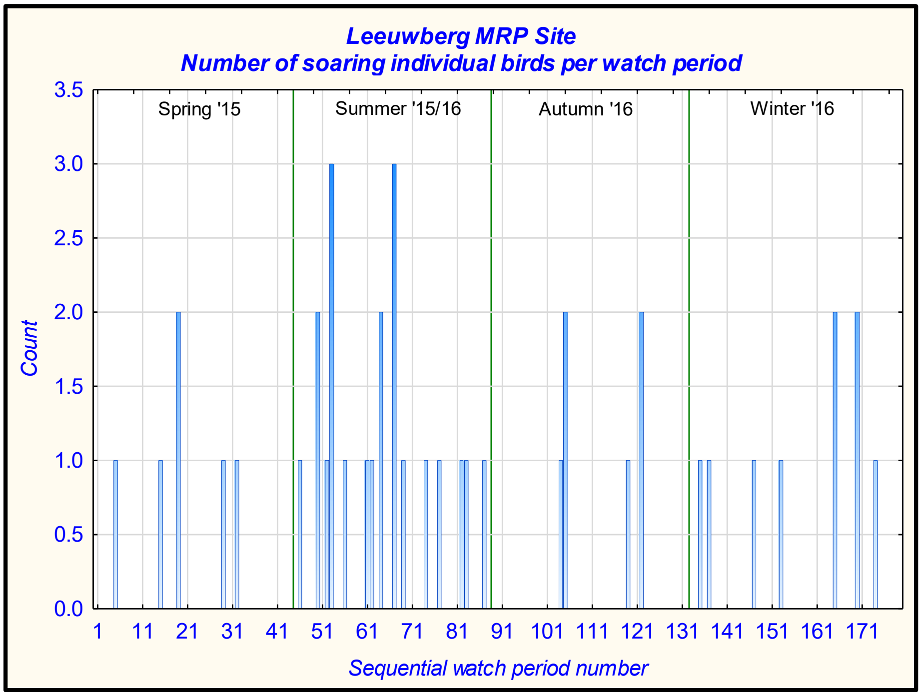
The computations were done using STATISTICA statistical software (Dell Inc., *2015*) and with routines developed for this purpose in "Statistica Visual Basic", the programming language of STATISTICA.

3. Estimation of the population mean

The descriptive statistics of average counts, standard deviations (*Std.Dev.*) and *95*% lower and upper confidence intervals (LCL and UCL) for the mean count per watch period for the data in each of the seasons are computed from the data in Tables *H* and *I*. The seasonal and overall estimates are listed in Tables *2* – *5*.

The computation of confidence intervals assumes that certain assumptions are to be met by the underlying distribution of counts. One possibility is to assume the normal distribution which is the default standard for such computations in statistical software packages.
The viability of such an assumption is investigated by plotting the raw data counts for soaring and terrestrial individual counts per watch period in their time sequence (see Figures *1* and *2*).

Figure *1*: Sequential time plot (by consecutive watch period number) of *individual* soaring bird counts.



The data for flight counts show that the occurrence of flights and individual counts of soarers are almost identical. Figure *1* thus closely represents the counts for both flights and individuals of soaring birds.

Figure *2*: Sequential time plot (by consecutive watch period number) of *individual* terrestrial bird counts.

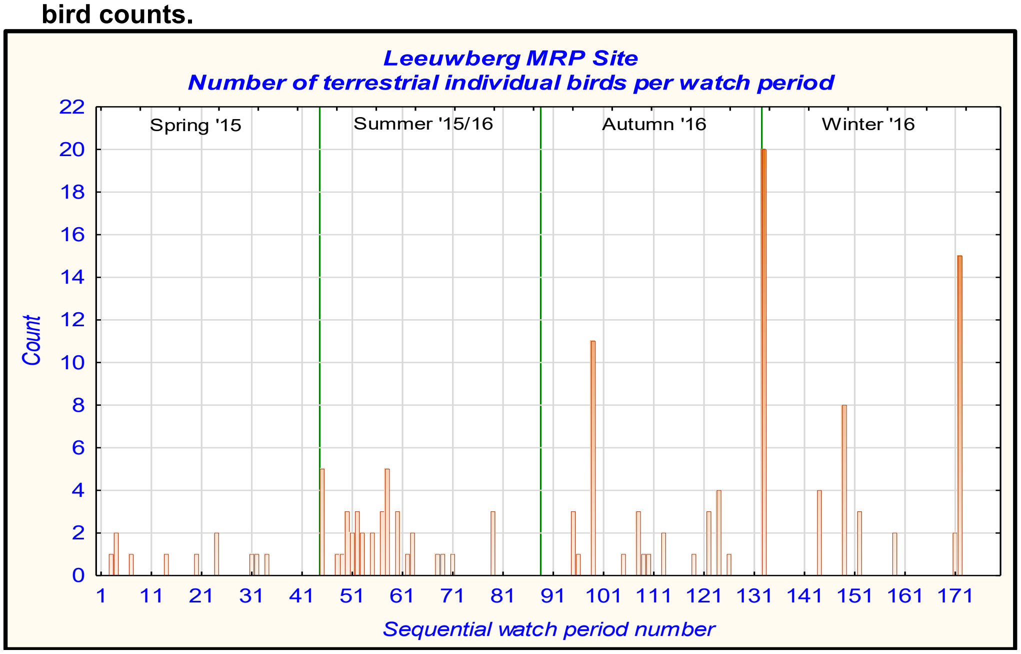
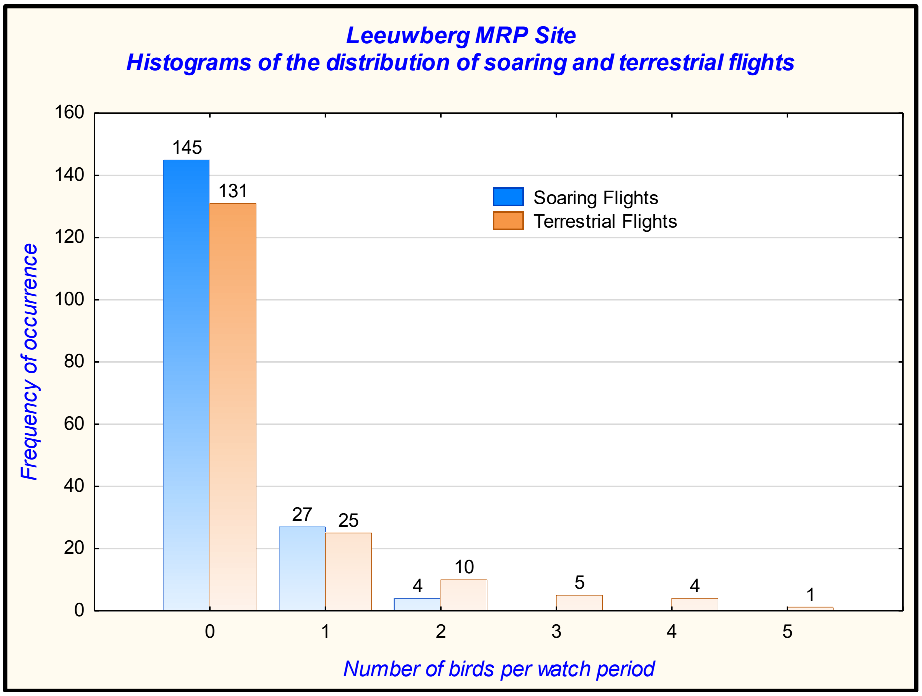


Figure *1* shows that relatively large numbers of individual terrestrial birds were recorded in three of the watch periods. Period *99* has *5* flights with *11* birds; period *133* has *3* flights with *20* individuals: one of these flights having *18* individuals of Sclater's Lark (*Spizocoris slateri*). Watch period *172* has a single flight of *15* individuals of Sclater's Lark.

The distribution of the counts (separately for soaring and terrestrial birds) is the supporting information required for estimating the average number of birds with confidence intervals. For this purpose it is flights (rather than individual counts) that will be considered for the purpose of investigating the counts distribution. It is thought that flights are the random events that materialise in each sampling unit (watch period) and thus determine the distribution. Sclater's Lark is known to occur in small groups of *6* to *20* birds as is confirmed by this data set. If these "outlying" counts were taken into account, a somewhat distorted image of the distribution may arise.

Figure *3* shows the *distribution* of counts for soaring as well as terrestrial bird flights over all seasons.

Figure *3*. Histogram of the distributions for soaring and terrestrial bird flight counts over all four seasons.



In general, for situations where *counts* are made per fixed sampling unit (in this case a watch period of 3*h*) the Poisson distribution is particularly relevant. The Poisson process is a probability model in which events (e.g. the sighting of a flight of birds) occur randomly and uniformly in time or space. The assumptions supporting such a model are independence of the events, individuality of each event and the uniform arrival of events over the time period of the sampling unit. Details of this is discussed by Kalbfleisch, 1985, pp. *128 – 133*. There may be arguments against the validity of these distributions underlying bird counts but they are probably as close to reality as can be hoped for. One way to recognise the Poisson distribution is that its average value and variance are identical (see Kalbfleisch, *1985*, p. *172*). This property is not unique to the Poisson - other distributions may also possess it.

If Poisson distributions are fitted to the two data sets plotted in Figure *3* a very good fit is obtained for the soaring flight counts. The distribution for terrestrial flights has a longer tail than the best fitting Poisson and the fit is not good. Even so, it is believed that the Poisson is a much more appropriate approximation than the normal distribution for both of these quite skew distributions. Thus calculations for sample size will be based on the assumption of a Poisson distribution for the counts.

4. Sample size

The basic statistics presented in Tables *2 – 3* for soaring birds show that the seasonal distributions, have values for mean and variance that are reasonably close together. This strengthens the assumption of underlying Poisson distributions.

Table *2* reports the statistics for the number of *flights* recorded over all watch periods for soaring birds. Tables *3, 4* and *5* report the same for individual soaring birds, terrestrial flights and terrestrial individuals respectively. The mathematical details of computing the confidence intervals and precisions are presented in section *C* of the Appendix.

Table *2*. Soaring birds, Flights: basic statistics with *95*% confidence interval and precision for the number of flights per *3*h watch period.

Season	Watch periods	Soaring birds: Flights						
		Count	Avg	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Spring '15	44	5	0.11	0.10	0.32	0.04	0.27	0.11
Summer '15/16	44	18	0.41	0.39	0.62	0.24	0.65	0.20
Autumn '16	44	4	0.09	0.08	0.29	0.02	0.23	0.10
Spring '16	44	8	0.18	0.20	0.45	0.08	0.36	0.14
All Grps	176	35	0.20	0.21	0.45	0.14	0.28	0.07

The interpretation of the data in Table *2* is virtually self-explanatory. The *95*% confidence limits for the average count in the Spring survey, for example, is (*0.04 – 0.27*). This leads to a precision for the estimate of the mean value for that season of *0.11*. The values in Tables *3 – 5* are interpreted similarly.

Table *3*. Soaring birds, Individuals: basic statistics with *95*% confidence interval and precision for the number of individuals per *3*h watch period.

Season	Watch periods	Soaring birds: Individuals						
		Count	Avg	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Spring '15	44	6	0.14	0.17	0.41	0.05	0.30	0.12
Summer '15/16	44	21	0.48	0.63	0.79	0.30	0.73	0.22
Autumn '16	44	6	0.14	0.21	0.46	0.05	0.30	0.12
Spring '16	44	9	0.20	0.26	0.51	0.09	0.39	0.15
All Grps	176	42	0.24	0.33	0.58	0.17	0.32	0.08

It was previously noted that the data for the flights and individuals for the soaring birds are not differing much from one another. Tables *2* and *3* confirm this – see for example the precision columns.

Table *4*. Terrestrial birds, Flights: basic statistics with *95*% confidence interval and precision for the number of individuals per *3*h watch period.

Season	Watch periods	Terrestrial birds: Flights						
		Count	Avg	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	44	11	0.25	0.28	0.53	0.12	0.45	0.16

Summer '15/16	44	32	0.73	1.27	1.13	0.50	1.03	0.26
Autumn '16	44	22	0.50	1.09	1.05	0.31	0.76	0.22
Spring '16	44	16	0.36	0.98	0.99	0.21	0.59	0.19
All Grps	176	81	0.46	0.92	0.96	0.37	0.57	0.10

Table *5*. Terrestrial birds, Individuals: basic statistics with *95*% confidence interval and precision for the number of individuals per *3*h watch period.

Season	Watch periods	Terrestrial birds: Individuals						
		Count	Avg	Variance	Std.Dev.	95% LCL	95% UCL	Precision
Summer '15	44	11	0.25	0.28	0.53	0.12	0.45	0.16
Summer '15/16	44	39	0.89	1.92	1.38	0.63	1.21	0.29
Autumn '16	44	32	0.73	3.51	1.87	0.50	1.03	0.26
Spring '16	44	54	1.23	15.25	3.91	0.92	1.60	0.34
All Grps	176	136	0.77	5.27	2.30	0.65	0.91	0.13

The largest precision (*d* = *0.34*) that occurs in any of Tables *3* – *5* is less than ½. This means that the average for any season could be estimated to within ½ a bird per *3*h watch period (with *95*% certainty). Thus the sample size of *N* = *44* per season is considered to provide adequate precision.

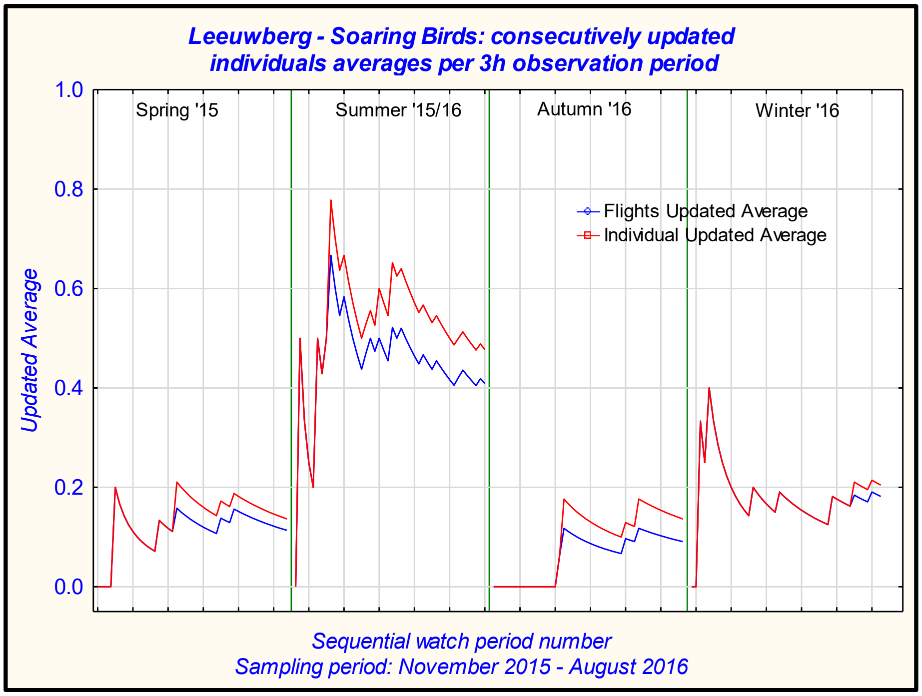
For another perspective on sample size, consider the Spring *2016* data for terrestrial individuals. If only *N* = *30* watch periods were used (but with the same average as estimated from the current data, viz. *1.23* per watch period, implying that the count was about *37*) then the calculation of sample size as set out in the appendix would lead to a *95*% precision of *0.42*. In that case a sample size of *30* watch periods would have been sufficiently large to achieve the requirement of better than ½ a bird precision.

5. Stability and Representativeness

Insight into the accuracy (i.e. closeness to the true value), representativeness and stability of the counting process may be obtained by noting that as the data are gathered watch period by watch period an improved estimate of the average number of birds occurring in the area will be achieved for each added count. As more data are gathered the more accurate the estimate will become. The issue is to determine if the updated average count begins to stabilise towards the end of the survey (and thus the conclusion that an accurate, representative sample has been achieved).

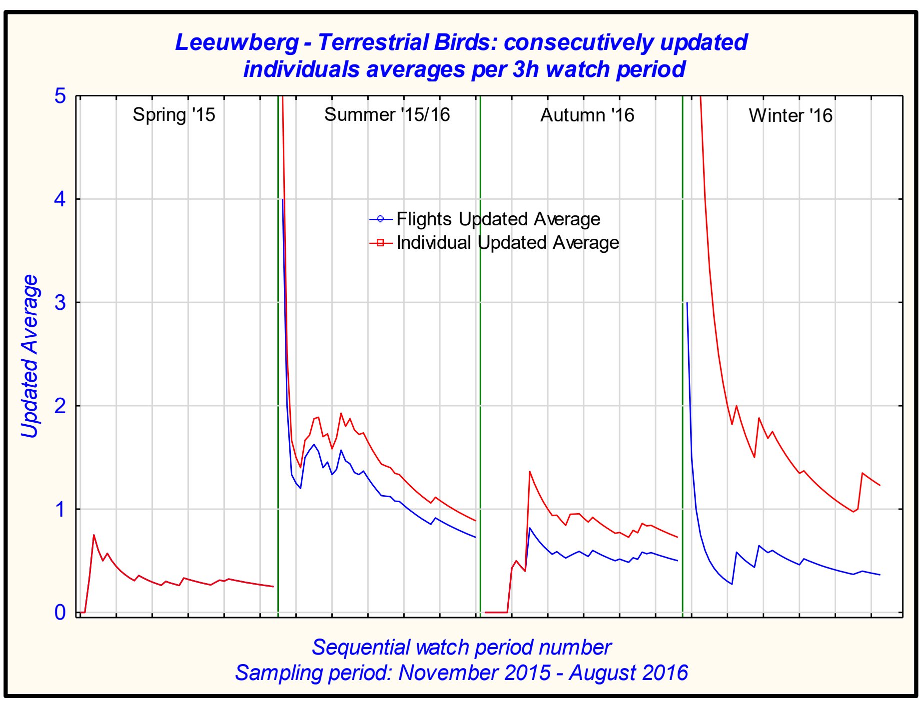
To investigate the behaviour of this process the average number of *flights* (and *individual*s) per *3*h watch period is computed from all preceding data as the data become available in consecutive watch periods. These updated averages are expected to vary to some extent in the initial stages of sampling but to stabilise as more data come in. Since the counts may vary (in principle) substantially over the seasons (especially for individual counts) the updated averages are determined separately for each season and are listed in Tables *H* and *I* in the Appendix. These data are plotted (by season) in Figure *4* for soaring birds and Figure *5* for terrestrial birds.

Figure *4*. Soaring birds: updated average for *Flight* and *Individual* counts, separately by season.



When a single red line appears in the chart, each recorded flight consisted of only a single bird. The graphs tend to flatten out towards the end of each separate season and that implies stability of the series of counts.

Figure *5*. Terrestrial birds: updated average for *Flight* and *Individual* counts, separately by season.



The information depicted in Figures *4* and *5* shows the extent to which stability in estimating the overall mean is achieved over time. In agreement with the computation of sample size reported in section *4*, these graphs confirm that the sample size was sufficiently large to estimate the average number of birds per season (or overall per year cycle) to within good precision.

6. Conclusion

The computations and the outcome of the data exhibited in the tables and graphs in this report show that the survey may be taken to be statistically representative of the soaring and terrestrial priority species of birds that occur in the area. It has also been demonstrated that more samples would not yield a meaningful improvement in the accuracy and precision of estimating the terrestrial mean number of birds per watch period.

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APPENDIX

A. Additional Statistics

Table A. Number of individual priority species birds recorded during the survey by Species, Flight Class and Flying Height distribution.

Species	Flight Class	Flying Height			Row Totals
		Low	Medium	High	
Verreauxs' Eagle	Soaring	0	0	1	1
Martial Eagle	Soaring	0	1	0	1
Booted Eagle	Soaring	0	0	1	1
Black-Chested Snake-Eagle	Soaring	2	0	2	4
Southern Pale Chanting Goshawk	Soaring	7	0	0	7
Lanner Falcon	Soaring	1	0	0	1
Greater Kestrel	Soaring	26	0	1	27
Count (Soaring)		36	1	5	42
Ludwig's Bustard	Terrestrial	8	0	6	14
Northern Black Korhaan	Terrestrial	30	0	1	31
Karoo Korhaan	Terrestrial	6	0	0	6
Burchell's Courser	Terrestrial	3	0	0	3
Red Lark	Terrestrial	48	0	1	49
Sclater's Lark	Terrestrial	33	0	0	33
Count (Terrestrial)		128	0	8	136
Total count (Overall)		164	1	13	178

Table B. Number of individual priority species birds recorded during the survey by Species, Flight Class, the number (N) that flew at medium / all heights and Flight Duration (minutes) at medium / all heights. The time at medium height is expressed as a percentage of the time at all heights.

Species	Flight Class	Valid N and Flight Duration (minutes)				
		At Medium Height		At All Heights		% Time at Medium Ht
		N	Time (min)	N	Time (min)	
Verreauxs' Eagle	Soaring	1	4.00	1	4.00	100.0%
Booted Eagle	Soaring	1	2.00	1	2.00	100.0%
Black-Chested Snake-Eagle	Soaring	2	2.75	4	6.25	44.0%
Greater Kestrel	Soaring	1	0.50	27	35.50	1.4%
Martial Eagle	Soaring	0	0.00	1	1.25	0.0%

Southern Pale Chanting Goshawk	Soaring	0	0.00	7	6.25	0.0%
Lanner Falcon	Soaring	0	0.00	1	1.25	0.0%
Count (Soaring)		5	9.25	42	56.50	16.4%
Ludwig's Bustard	Terrestrial	6	6.50	14	12.25	53.1%
Red Lark	Terrestrial	1	0.75	49	24.25	3.1%
Northern Black Korhaan	Terrestrial	1	0.50	31	25.50	2.0%
Karoo Korhaan	Terrestrial	0	0.00	6	5.00	0.0%
Sclater's Lark	Terrestrial	0	0.00	33	4311.00*	0.0%
Burchell's Courser	Terrestrial	0	0.00	3	1.50	0.0%
Count (Terrestrial)		8	7.75	136	4379.50	0.2%
Total count (Overall)		13	17.00	178	4436.00	0.4%

* This value was verified manually from the raw data.

Table C: Number of individual priority species birds recorded by Species, Flight Class and Season.

Species	**Flight Class**	**Season**				**Row Totals**
		Summer ‘15	**Summer ‘16**	**Autumn16**	**Winter16**	
Verreauxs' Eagle	Soaring	0	0	0	1	1
Martial Eagle	Soaring	1	0	0	0	1
Booted Eagle	Soaring	0	0	0	1	1
Black-Chested Snake-Eagle	Soaring	2	2	0	0	4
Southern Pale Chanting Goshawk	Soaring	0	6	1	0	7
Lanner Falcon	Soaring	0	1	0	0	1
Greater Kestrel	Soaring	3	12	5	7	27
Count (Soaring)		6	21	6	9	42
Ludwig's Bustard	Terrestrial	0	11	3	0	14
Northern Black Korhaan	Terrestrial	7	15	9	0	31
Karoo Korhaan	Terrestrial	1	3	0	2	6
Burchell's Courser	Terrestrial	0	0	0	3	3
Red Lark	Terrestrial	3	10	20	16	49
Sclater's Lark	Terrestrial	0	0	0	33	33
Count (Terrestrial)		11	39	32	54	136
Total count (Overall)		17	60	38	63	178

Table D: Number of individual priority species birds recorded by Species, Flight Class and Temperature.

Species		**Temperature**	

	Flight Class	Cold	Mild	Warm	Hot	Row Totals
Verreauxs' Eagle	Soaring	1	0	0	0	1
Martial Eagle	Soaring	0	0	1	0	1
Booted Eagle	Soaring	0	1	0	0	1
Black-Chested Snake-Eagle	Soaring	0	2	2	0	4
Southern Pale Chanting Goshawk	Soaring	0	4	2	1	7
Lanner Falcon	Soaring	0	1	0	0	1
Greater Kestrel	Soaring	4	11	7	5	27
Count (Soaring)		5	19	12	6	42
Ludwig's Bustard	Terrestrial	1	10	2	1	14
Northern Black Korhaan	Terrestrial	5	14	5	7	31
Karoo Korhaan	Terrestrial	0	2	4	0	6
Burchell's Courser	Terrestrial	3	0	0	0	3
Red Lark	Terrestrial	16	26	2	5	49
Sclater's Lark	Terrestrial	18	15	0	0	33
Count (Terrestrial)		43	67	13	13	136
Total count (Overall)		48	86	25	19	178

Table E: Number of individual priority species birds, by Species, Flight Class and Weather Condition.

Species	Flight Class	Cloudy	Partly Cloudy	Sunny	Row Totals
Verreauxs' Eagle	Soaring	0	1	0	1
Martial Eagle	Soaring	0	0	1	1
Booted Eagle	Soaring	0	1	0	1
Black-Chested Snake-Eagle	Soaring	0	1	3	4
Southern Pale Chanting Goshawk	Soaring	0	4	3	7
Lanner Falcon	Soaring	0	0	1	1
Greater Kestrel	Soaring	0	10	17	27
Count (Soaring)		0	17	25	42
Ludwig's Bustard	Terrestrial	0	10	4	14
Northern Black Korhaan	Terrestrial	0	13	18	31
Karoo Korhaan	Terrestrial	0	3	3	6
Burchell's Courser	Terrestrial	0	0	3	3

Red Lark	Terrestrial	0	26	23	49
Sclater's Lark	Terrestrial	0	18	15	33
Count (Terrestrial)		0	70	66	136
Total count (Overall)		0	87	91	178

Table F: Number of individual priority species birds recorded by Species and Wind Direction.

Species	Flight Class	Wind Direction								Row Totals
		N	NE	E	SE	S	SW	W	NW	
Verreauxs' Eagle	Soaring	0	0	0	0	0	1	0	0	1
Martial Eagle	Soaring	0	0	0	0	0	1	0	0	1
Booted Eagle	Soaring	0	1	0	0	0	0	0	0	1
Black-Chested Snake-Eagle	Soaring	0	0	0	1	1	2	0	0	4
Southern Pale Chanting Goshawk	Soaring	0	0	1	1	0	1	1	3	7
Lanner Falcon	Soaring	0	0	0	0	0	1	0	0	1
Greater Kestrel	Soaring	1	1	1	2	1	11	0	10	27
Count (Soaring)		1	2	2	4	2	17	1	13	42
Ludwig's Bustard	Terrestrial	0	3	0	0	0	3	0	8	14
Northern Black Korhaan	Terrestrial	1	3	1	6	0	15	1	4	31
Karoo Korhaan	Terrestrial	0	0	0	0	1	3	0	2	6
Burchell's Courser	Terrestrial	0	3	0	0	0	0	0	0	3
Red Lark	Terrestrial	1	4	16	7	0	7	0	14	49
Sclater's Lark	Terrestrial	0	0	0	0	0	18	0	15	33
Count (Terrestrial)		2	13	17	13	1	46	1	43	136
Total count (Overall)		3	15	19	17	3	63	2	56	178

Table G: Number of individual priority species birds recorded by Species, Flight Class and Wind Strength (Beaufort scale).

Species	Flight Class	Light Air	Light Breeze	Gentle Breeze	Moderate Breeze	Fresh Breeze	Total
Verreauxs' Eagle	Soaring	0	1	0	0	0	1
Martial Eagle	Soaring	0	0	1	0	0	1
Booted Eagle	Soaring	0	1	0	0	0	1
Black-Chested Snake-Eagle	Soaring	0	0	4	0	0	4

Southern Pale Chanting Goshawk	Soaring	0	1	4	1	1	7
Lanner Falcon	Soaring	0	1	0	0	0	1
Greater Kestrel	Soaring	0	3	13	8	3	27
Count (Soaring)		0	7	22	9	4	42
Ludwig's Bustard	Terrestrial	0	7	5	2	0	14
Northern Black Korhaan	Terrestrial	0	8	13	9	1	31
Karoo Korhaan	Terrestrial	0	2	1	3	0	6
Burchell's Courser	Terrestrial	3	0	0	0	0	3
Red Lark	Terrestrial	11	14	18	4	2	49
Sclater's Lark	Terrestrial	0	33	0	0	0	33
Count (Terrestrial)		14	64	37	18	3	136
Total count (Overall)		14	71	59	27	7	178

Table H: ***Soaring Birds*: Flights and Individuals for priority species per watch period and by vantage point over time with updated averages per consecutive watch period.**

Watch Number	Date	Season	VP	Flights count	Flights Updated Avge *	Individuals count	Individuals Updated Avge*
1	2015-11-10	Spring '15	VP9	0.0	0.00	0.0	0.00
2	2015-11-10	Spring '15	VP8	0.0	0.00	0.0	0.00
3	2015-11-10	Spring '15	VP1	0.0	0.00	0.0	0.00
4	2015-11-10	Spring '15	VP1	0.0	0.00	0.0	0.00
5	2015-11-11	Spring '15	VP1	1.0	0.20	1.0	0.20
6	2015-11-11	Spring '15	VP10	0.0	0.17	0.0	0.17
7	2015-11-11	Spring '15	VP2	0.0	0.14	0.0	0.14
8	2015-11-11	Spring '15	VP1	0.0	0.13	0.0	0.13
9	2015-11-12	Spring '15	VP2	0.0	0.11	0.0	0.11
10	2015-11-12	Spring '15	VP1	0.0	0.10	0.0	0.10
11	2015-11-12	Spring '15	VP10	0.0	0.09	0.0	0.09
12	2015-11-12	Spring '15	VP11	0.0	0.08	0.0	0.08
13	2015-11-13	Spring '15	VP9	0.0	0.08	0.0	0.08
14	2015-11-13	Spring '15	VP8	0.0	0.07	0.0	0.07
15	2015-11-13	Spring '15	VP1	1.0	0.13	1.0	0.13
16	2015-11-13	Spring '15	VP2	0.0	0.13	0.0	0.13
17	2015-11-14	Spring '15	VP3	0.0	0.12	0.0	0.12
18	2015-11-14	Spring '15	VP7	0.0	0.11	0.0	0.11
19	2015-11-14	Spring '15	VP6	1.0	0.16	2.0	0.21
20	2015-11-14	Spring '15	VP4	0.0	0.15	0.0	0.20
21	2015-11-14	Spring '15	VP5	0.0	0.14	0.0	0.19
22	2015-11-14	Spring '15	VP9	0.0	0.14	0.0	0.18
23	2015-11-15	Spring '15	VP6	0.0	0.13	0.0	0.17
24	2015-11-15	Spring '15	VP4	0.0	0.13	0.0	0.17
25	2015-11-15	Spring '15	VP3	0.0	0.12	0.0	0.16
26	2015-11-15	Spring '15	VP7	0.0	0.12	0.0	0.15
27	2015-11-15	Spring '15	VP8	0.0	0.11	0.0	0.15
28	2015-11-16	Spring '15	VP5	0.0	0.11	0.0	0.14
29	2015-11-16	Spring '15	VP8	1.0	0.14	1.0	0.17
30	2015-11-16	Spring '15	VP9	0.0	0.13	0.0	0.17
31	2015-11-16	Spring '15	VP4	0.0	0.13	0.0	0.16
32	2015-11-16	Spring '15	VP6	1.0	0.16	1.0	0.19
33	2015-11-17	Spring '15	VP2	0.0	0.15	0.0	0.18
34	2015-11-17	Spring '15	VP1	0.0	0.15	0.0	0.18
35	2015-11-17	Spring '15	VP4	0.0	0.14	0.0	0.17

36	2015-11-17	Spring '15	VP6	0.0	0.14	0.0	0.17
37	2015-11-17	Spring '15	VP7	0.0	0.14	0.0	0.16
38	2015-11-17	Spring '15	VP3	0.0	0.13	0.0	0.16
39	2015-11-18	Spring '15	VP10	0.0	0.13	0.0	0.15
40	2015-11-18	Spring '15	VP11	0.0	0.13	0.0	0.15
41	2015-11-18	Spring '15	VP7	0.0	0.12	0.0	0.15
42	2015-11-18	Spring '15	VP5	0.0	0.12	0.0	0.14
43	2015-11-19	Spring '15	VP5	0.0	0.12	0.0	0.14
44	2015-11-19	Spring '15	VP3	0.0	0.11	0.0	0.14
45	2016-02-23	Summer '15/16	VP10	0.0	0.00	0.0	0.00
46	2016-02-23	Summer '15/16	VP11	1.0	0.50	1.0	0.50
47	2016-02-23	Summer '15/16	VP2	0.0	0.33	0.0	0.33
48	2016-02-23	Summer '15/16	VP1	0.0	0.25	0.0	0.25
49	2016-02-23	Summer '15/16	VP3	0.0	0.20	0.0	0.20
50	2016-02-23	Summer '15/16	VP4	2.0	0.50	2.0	0.50
51	2016-02-24	Summer '15/16	VP1	0.0	0.43	0.0	0.43
52	2016-02-24	Summer '15/16	VP2	1.0	0.50	1.0	0.50
53	2016-02-24	Summer '15/16	VP8	2.0	0.67	3.0	0.78
54	2016-02-24	Summer '15/16	VP9	0.0	0.60	0.0	0.70
55	2016-02-24	Summer '15/16	VP10	0.0	0.55	0.0	0.64
56	2016-02-24	Summer '15/16	VP11	1.0	0.58	1.0	0.67
57	2016-02-25	Summer '15/16	VP7	0.0	0.54	0.0	0.62
58	2016-02-25	Summer '15/16	VP3	0.0	0.50	0.0	0.57
59	2016-02-25	Summer '15/16	VP10	0.0	0.47	0.0	0.53
60	2016-02-25	Summer '15/16	VP11	0.0	0.44	0.0	0.50
61	2016-02-25	Summer '15/16	VP9	1.0	0.47	1.0	0.53
62	2016-02-25	Summer '15/16	VP8	1.0	0.50	1.0	0.56
63	2016-02-26	Summer '15/16	VP4	0.0	0.47	0.0	0.53
64	2016-02-26	Summer '15/16	VP6	1.0	0.50	2.0	0.60
65	2016-02-26	Summer '15/16	VP3	0.0	0.48	0.0	0.57
66	2016-02-26	Summer '15/16	VP7	0.0	0.45	0.0	0.55
67	2016-02-26	Summer '15/16	VP1	2.0	0.52	3.0	0.65
68	2016-02-26	Summer '15/16	VP2	0.0	0.50	0.0	0.63
69	2016-02-27	Summer '15/16	VP8	1.0	0.52	1.0	0.64
70	2016-02-27	Summer '15/16	VP9	0.0	0.50	0.0	0.62
71	2016-02-27	Summer '15/16	VP10	0.0	0.48	0.0	0.59
72	2016-02-27	Summer '15/16	VP11	0.0	0.46	0.0	0.57
73	2016-02-27	Summer '15/16	VP7	0.0	0.45	0.0	0.55
74	2016-02-27	Summer '15/16	VP3	1.0	0.47	1.0	0.57

75	2016-02-28	Summer '15/16	VP5	0.0	0.45	0.0	0.55
76	2016-02-28	Summer '15/16	VP9	0.0	0.44	0.0	0.53
77	2016-02-28	Summer '15/16	VP8	1.0	0.45	1.0	0.55
78	2016-02-28	Summer '15/16	VP6	0.0	0.44	0.0	0.53
79	2016-02-28	Summer '15/16	VP7	0.0	0.43	0.0	0.51
80	2016-02-29	Summer '15/16	VP1	0.0	0.42	0.0	0.50
81	2016-02-29	Summer '15/16	VP2	0.0	0.41	0.0	0.49
82	2016-02-29	Summer '15/16	VP6	1.0	0.42	1.0	0.50
83	2016-02-29	Summer '15/16	VP4	1.0	0.44	1.0	0.51
84	2016-02-29	Summer '15/16	VP5	0.0	0.43	0.0	0.50
85	2016-03-01	Summer '15/16	VP4	0.0	0.41	0.0	0.49
86	2016-03-01	Summer '15/16	VP6	0.0	0.40	0.0	0.48
87	2016-03-01	Summer '15/16	VP5	1.0	0.42	1.0	0.49
88	2016-03-02	Summer '15/16	VP5	0.0	0.41	0.0	0.48
89	2016-05-18	Autumn '16	VP10	0.0	0.00	0.0	0.00
90	2016-05-18	Autumn '16	VP11	0.0	0.00	0.0	0.00
91	2016-05-19	Autumn '16	VP10	0.0	0.00	0.0	0.00
92	2016-05-19	Autumn '16	VP11	0.0	0.00	0.0	0.00
93	2016-05-19	Autumn '16	VP5	0.0	0.00	0.0	0.00
94	2016-05-19	Autumn '16	VP9	0.0	0.00	0.0	0.00
95	2016-05-20	Autumn '16	VP1	0.0	0.00	0.0	0.00
96	2016-05-20	Autumn '16	VP2	0.0	0.00	0.0	0.00
97	2016-05-20	Autumn '16	VP10	0.0	0.00	0.0	0.00
98	2016-05-20	Autumn '16	VP11	0.0	0.00	0.0	0.00
99	2016-05-21	Autumn '16	VP3	0.0	0.00	0.0	0.00
100	2016-05-21	Autumn '16	VP7	0.0	0.00	0.0	0.00
101	2016-05-21	Autumn '16	VP1	0.0	0.00	0.0	0.00
102	2016-05-21	Autumn '16	VP2	0.0	0.00	0.0	0.00
103	2016-05-22	Autumn '16	VP9	0.0	0.00	0.0	0.00
104	2016-05-22	Autumn '16	VP8	1.0	0.06	1.0	0.06
105	2016-05-22	Autumn '16	VP4	1.0	0.12	2.0	0.18
106	2016-05-22	Autumn '16	VP5	0.0	0.11	0.0	0.17
107	2016-05-23	Autumn '16	VP7	0.0	0.11	0.0	0.16
108	2016-05-23	Autumn '16	VP3	0.0	0.10	0.0	0.15
109	2016-05-23	Autumn '16	VP2	0.0	0.10	0.0	0.14
110	2016-05-23	Autumn '16	VP1	0.0	0.09	0.0	0.14
111	2016-05-24	Autumn '16	VP1	0.0	0.09	0.0	0.13
112	2016-05-24	Autumn '16	VP2	0.0	0.08	0.0	0.13
113	2016-05-24	Autumn '16	VP3	0.0	0.08	0.0	0.12

114	2016-05-25	Autumn '16	VP11	0.0	0.08	0.0	0.12
115	2016-05-25	Autumn '16	VP10	0.0	0.07	0.0	0.11
116	2016-05-25	Autumn '16	VP8	0.0	0.07	0.0	0.11
117	2016-05-25	Autumn '16	VP9	0.0	0.07	0.0	0.10
118	2016-05-26	Autumn '16	VP4	0.0	0.07	0.0	0.10
119	2016-05-26	Autumn '16	VP6	1.0	0.10	1.0	0.13
120	2016-05-26	Autumn '16	VP7	0.0	0.09	0.0	0.13
121	2016-05-26	Autumn '16	VP3	0.0	0.09	0.0	0.12
122	2016-05-27	Autumn '16	VP6	1.0	0.12	2.0	0.18
123	2016-05-27	Autumn '16	VP7	0.0	0.11	0.0	0.17
124	2016-05-28	Autumn '16	VP8	0.0	0.11	0.0	0.17
125	2016-05-28	Autumn '16	VP5	0.0	0.11	0.0	0.16
126	2016-05-28	Autumn '16	VP9	0.0	0.11	0.0	0.16
127	2016-05-28	Autumn '16	VP6	0.0	0.10	0.0	0.15
128	2016-05-28	Autumn '16	VP4	0.0	0.10	0.0	0.15
129	2016-05-29	Autumn '16	VP6	0.0	0.10	0.0	0.15
130	2016-05-29	Autumn '16	VP4	0.0	0.10	0.0	0.14
131	2016-05-29	Autumn '16	VP5	0.0	0.09	0.0	0.14
132	2016-05-29	Autumn '16	VP8	0.0	0.09	0.0	0.14
133	2016-08-22	Winter '16	VP11	0.0	0.00	0.0	0.00
134	2016-08-22	Winter '16	VP6	0.0	0.00	0.0	0.00
135	2016-08-22	Winter '16	VP10	1.0	0.33	1.0	0.33
136	2016-08-22	Winter '16	VP3	0.0	0.25	0.0	0.25
137	2016-08-22	Winter '16	VP9	1.0	0.40	1.0	0.40
138	2016-08-22	Winter '16	VP8	0.0	0.33	0.0	0.33
139	2016-08-22	Winter '16	VP1	0.0	0.29	0.0	0.29
140	2016-08-22	Winter '16	VP2	0.0	0.25	0.0	0.25
141	2016-08-23	Winter '16	VP5	0.0	0.22	0.0	0.22
142	2016-08-23	Winter '16	VP4	0.0	0.20	0.0	0.20
143	2016-08-23	Winter '16	VP1	0.0	0.18	0.0	0.18
144	2016-08-23	Winter '16	VP2	0.0	0.17	0.0	0.17
145	2016-08-23	Winter '16	VP11	0.0	0.15	0.0	0.15
146	2016-08-23	Winter '16	VP10	0.0	0.14	0.0	0.14
147	2016-08-23	Winter '16	VP6	1.0	0.20	1.0	0.20
148	2016-08-23	Winter '16	VP3	0.0	0.19	0.0	0.19
149	2016-08-24	Winter '16	VP1	0.0	0.18	0.0	0.18
150	2016-08-24	Winter '16	VP2	0.0	0.17	0.0	0.17
151	2016-08-24	Winter '16	VP4	0.0	0.16	0.0	0.16
152	2016-08-24	Winter '16	VP5	0.0	0.15	0.0	0.15

153	2016-08-24	Winter '16	VP7	1.0	0.19	1.0	0.19
154	2016-08-24	Winter '16	VP6	0.0	0.18	0.0	0.18
155	2016-08-24	Winter '16	VP11	0.0	0.17	0.0	0.17
156	2016-08-24	Winter '16	VP10	0.0	0.17	0.0	0.17
157	2016-08-25	Winter '16	VP9	0.0	0.16	0.0	0.16
158	2016-08-25	Winter '16	VP8	0.0	0.15	0.0	0.15
159	2016-08-25	Winter '16	VP6	0.0	0.15	0.0	0.15
160	2016-08-25	Winter '16	VP7	0.0	0.14	0.0	0.14
161	2016-08-25	Winter '16	VP4	0.0	0.14	0.0	0.14
162	2016-08-25	Winter '16	VP5	0.0	0.13	0.0	0.13
163	2016-08-25	Winter '16	VP1	0.0	0.13	0.0	0.13
164	2016-08-25	Winter '16	VP2	0.0	0.13	0.0	0.13
165	2016-08-26	Winter '16	VP7	2.0	0.18	2.0	0.18
166	2016-08-26	Winter '16	VP9	0.0	0.18	0.0	0.18
167	2016-08-26	Winter '16	VP8	0.0	0.17	0.0	0.17
168	2016-08-26	Winter '16	VP3	0.0	0.17	0.0	0.17
169	2016-08-26	Winter '16	VP4	0.0	0.16	0.0	0.16
170	2016-08-26	Winter '16	VP5	1.0	0.18	2.0	0.21
171	2016-08-27	Winter '16	VP10	0.0	0.18	0.0	0.21
172	2016-08-27	Winter '16	VP11	0.0	0.18	0.0	0.20
173	2016-08-27	Winter '16	VP3	0.0	0.17	0.0	0.20
174	2016-08-27	Winter '16	VP7	1.0	0.19	1.0	0.21
175	2016-08-27	Winter '16	VP8	0.0	0.19	0.0	0.21
176	2016-08-27	Winter '16	VP9	0.0	0.18	0.0	0.20

* The updated averages (for each season) are computed over the number consecutive watch periods in the season.

Table I: ***Terrestrial Birds*: Flights and Individuals for priority species per watch period and by vantage point over time with updated averages per consecutive watch period.**

Watch Number	Date	Season	VP	Flights count	Flights Updated Avge *	Individuals count	Individuals Updated Avge*
1	2015-11-10	Spring '15	VP9	0.0	0.00	0.0	0.00
2	2015-11-10	Spring '15	VP8	0.0	0.00	0.0	0.00
3	2015-11-10	Spring '15	VP1	1.0	0.33	1.0	0.33
4	2015-11-10	Spring '15	VP1	2.0	0.75	2.0	0.75
5	2015-11-11	Spring '15	VP1	0.0	0.60	0.0	0.60
6	2015-11-11	Spring '15	VP10	0.0	0.50	0.0	0.50
7	2015-11-11	Spring '15	VP2	1.0	0.57	1.0	0.57
8	2015-11-11	Spring '15	VP1	0.0	0.50	0.0	0.50
9	2015-11-12	Spring '15	VP2	0.0	0.44	0.0	0.44
10	2015-11-12	Spring '15	VP1	0.0	0.40	0.0	0.40
11	2015-11-12	Spring '15	VP10	0.0	0.36	0.0	0.36
12	2015-11-12	Spring '15	VP11	0.0	0.33	0.0	0.33
13	2015-11-13	Spring '15	VP9	0.0	0.31	0.0	0.31
14	2015-11-13	Spring '15	VP8	1.0	0.36	1.0	0.36
15	2015-11-13	Spring '15	VP1	0.0	0.33	0.0	0.33
16	2015-11-13	Spring '15	VP2	0.0	0.31	0.0	0.31
17	2015-11-14	Spring '15	VP3	0.0	0.29	0.0	0.29
18	2015-11-14	Spring '15	VP7	0.0	0.28	0.0	0.28
19	2015-11-14	Spring '15	VP6	0.0	0.26	0.0	0.26
20	2015-11-14	Spring '15	VP4	1.0	0.30	1.0	0.30
21	2015-11-14	Spring '15	VP5	0.0	0.29	0.0	0.29
22	2015-11-14	Spring '15	VP9	0.0	0.27	0.0	0.27
23	2015-11-15	Spring '15	VP6	0.0	0.26	0.0	0.26
24	2015-11-15	Spring '15	VP4	2.0	0.33	2.0	0.33
25	2015-11-15	Spring '15	VP3	0.0	0.32	0.0	0.32
26	2015-11-15	Spring '15	VP7	0.0	0.31	0.0	0.31
27	2015-11-15	Spring '15	VP8	0.0	0.30	0.0	0.30
28	2015-11-16	Spring '15	VP5	0.0	0.29	0.0	0.29
29	2015-11-16	Spring '15	VP8	0.0	0.28	0.0	0.28
30	2015-11-16	Spring '15	VP9	0.0	0.27	0.0	0.27
31	2015-11-16	Spring '15	VP4	1.0	0.29	1.0	0.29
32	2015-11-16	Spring '15	VP6	1.0	0.31	1.0	0.31
33	2015-11-17	Spring '15	VP2	0.0	0.30	0.0	0.30
34	2015-11-17	Spring '15	VP1	1.0	0.32	1.0	0.32
35	2015-11-17	Spring '15	VP4	0.0	0.31	0.0	0.31

36	2015-11-17	Spring '15	VP6	0.0	0.31	0.0	0.31
37	2015-11-17	Spring '15	VP7	0.0	0.30	0.0	0.30
38	2015-11-17	Spring '15	VP3	0.0	0.29	0.0	0.29
39	2015-11-18	Spring '15	VP10	0.0	0.28	0.0	0.28
40	2015-11-18	Spring '15	VP11	0.0	0.28	0.0	0.28
41	2015-11-18	Spring '15	VP7	0.0	0.27	0.0	0.27
42	2015-11-18	Spring '15	VP5	0.0	0.26	0.0	0.26
43	2015-11-19	Spring '15	VP5	0.0	0.26	0.0	0.26
44	2015-11-19	Spring '15	VP3	0.0	0.25	0.0	0.25
45	2016-02-23	Summer '15/16	VP10	4.0	4.00	5.0	5.00
46	2016-02-23	Summer '15/16	VP11	0.0	2.00	0.0	2.50
47	2016-02-23	Summer '15/16	VP2	0.0	1.33	0.0	1.67
48	2016-02-23	Summer '15/16	VP1	1.0	1.25	1.0	1.50
49	2016-02-23	Summer '15/16	VP3	1.0	1.20	1.0	1.40
50	2016-02-23	Summer '15/16	VP4	3.0	1.50	3.0	1.67
51	2016-02-24	Summer '15/16	VP1	2.0	1.57	2.0	1.71
52	2016-02-24	Summer '15/16	VP2	2.0	1.63	3.0	1.88
53	2016-02-24	Summer '15/16	VP8	1.0	1.56	2.0	1.89
54	2016-02-24	Summer '15/16	VP9	0.0	1.40	0.0	1.70
55	2016-02-24	Summer '15/16	VP10	2.0	1.45	2.0	1.73
56	2016-02-24	Summer '15/16	VP11	0.0	1.33	0.0	1.58
57	2016-02-25	Summer '15/16	VP7	2.0	1.38	3.0	1.69
58	2016-02-25	Summer '15/16	VP3	4.0	1.57	5.0	1.93
59	2016-02-25	Summer '15/16	VP10	0.0	1.47	0.0	1.80
60	2016-02-25	Summer '15/16	VP11	1.0	1.44	3.0	1.88
61	2016-02-25	Summer '15/16	VP9	0.0	1.35	0.0	1.76
62	2016-02-25	Summer '15/16	VP8	1.0	1.33	1.0	1.72
63	2016-02-26	Summer '15/16	VP4	2.0	1.37	2.0	1.74
64	2016-02-26	Summer '15/16	VP6	0.0	1.30	0.0	1.65
65	2016-02-26	Summer '15/16	VP3	0.0	1.24	0.0	1.57
66	2016-02-26	Summer '15/16	VP7	0.0	1.18	0.0	1.50
67	2016-02-26	Summer '15/16	VP1	0.0	1.13	0.0	1.43
68	2016-02-26	Summer '15/16	VP2	1.0	1.13	1.0	1.42
69	2016-02-27	Summer '15/16	VP8	1.0	1.12	1.0	1.40
70	2016-02-27	Summer '15/16	VP9	0.0	1.08	0.0	1.35
71	2016-02-27	Summer '15/16	VP10	1.0	1.07	1.0	1.33
72	2016-02-27	Summer '15/16	VP11	0.0	1.04	0.0	1.29
73	2016-02-27	Summer '15/16	VP7	0.0	1.00	0.0	1.24
74	2016-02-27	Summer '15/16	VP3	0.0	0.97	0.0	1.20

75	2016-02-28	Summer '15/16	VP5	0.0	0.94	0.0	1.16
76	2016-02-28	Summer '15/16	VP9	0.0	0.91	0.0	1.13
77	2016-02-28	Summer '15/16	VP8	0.0	0.88	0.0	1.09
78	2016-02-28	Summer '15/16	VP6	0.0	0.85	0.0	1.06
79	2016-02-28	Summer '15/16	VP7	3.0	0.91	3.0	1.11
80	2016-02-29	Summer '15/16	VP1	0.0	0.89	0.0	1.08
81	2016-02-29	Summer '15/16	VP2	0.0	0.86	0.0	1.05
82	2016-02-29	Summer '15/16	VP6	0.0	0.84	0.0	1.03
83	2016-02-29	Summer '15/16	VP4	0.0	0.82	0.0	1.00
84	2016-02-29	Summer '15/16	VP5	0.0	0.80	0.0	0.98
85	2016-03-01	Summer '15/16	VP4	0.0	0.78	0.0	0.95
86	2016-03-01	Summer '15/16	VP6	0.0	0.76	0.0	0.93
87	2016-03-01	Summer '15/16	VP5	0.0	0.74	0.0	0.91
88	2016-03-02	Summer '15/16	VP5	0.0	0.73	0.0	0.89
89	2016-05-18	Autumn '16	VP10	0.0	0.00	0.0	0.00
90	2016-05-18	Autumn '16	VP11	0.0	0.00	0.0	0.00
91	2016-05-19	Autumn '16	VP10	0.0	0.00	0.0	0.00
92	2016-05-19	Autumn '16	VP11	0.0	0.00	0.0	0.00
93	2016-05-19	Autumn '16	VP5	0.0	0.00	0.0	0.00
94	2016-05-19	Autumn '16	VP9	0.0	0.00	0.0	0.00
95	2016-05-20	Autumn '16	VP1	3.0	0.43	3.0	0.43
96	2016-05-20	Autumn '16	VP2	1.0	0.50	1.0	0.50
97	2016-05-20	Autumn '16	VP10	0.0	0.44	0.0	0.44
98	2016-05-20	Autumn '16	VP11	0.0	0.40	0.0	0.40
99	2016-05-21	Autumn '16	VP3	5.0	0.82	11.0	1.36
100	2016-05-21	Autumn '16	VP7	0.0	0.75	0.0	1.25
101	2016-05-21	Autumn '16	VP1	0.0	0.69	0.0	1.15
102	2016-05-21	Autumn '16	VP2	0.0	0.64	0.0	1.07
103	2016-05-22	Autumn '16	VP9	0.0	0.60	0.0	1.00
104	2016-05-22	Autumn '16	VP8	0.0	0.56	0.0	0.94
105	2016-05-22	Autumn '16	VP4	1.0	0.59	1.0	0.94
106	2016-05-22	Autumn '16	VP5	0.0	0.56	0.0	0.89
107	2016-05-23	Autumn '16	VP7	0.0	0.53	0.0	0.84
108	2016-05-23	Autumn '16	VP3	1.0	0.55	3.0	0.95
109	2016-05-23	Autumn '16	VP2	1.0	0.57	1.0	0.95
110	2016-05-23	Autumn '16	VP1	1.0	0.59	1.0	0.95
111	2016-05-24	Autumn '16	VP1	0.0	0.57	0.0	0.91
112	2016-05-24	Autumn '16	VP2	0.0	0.54	0.0	0.88
113	2016-05-24	Autumn '16	VP3	2.0	0.60	2.0	0.92

114	2016-05-25	Autumn '16	VP11	0.0	0.58	0.0	0.88
115	2016-05-25	Autumn '16	VP10	0.0	0.56	0.0	0.85
116	2016-05-25	Autumn '16	VP8	0.0	0.54	0.0	0.82
117	2016-05-25	Autumn '16	VP9	0.0	0.52	0.0	0.79
118	2016-05-26	Autumn '16	VP4	0.0	0.50	0.0	0.77
119	2016-05-26	Autumn '16	VP6	1.0	0.52	1.0	0.77
120	2016-05-26	Autumn '16	VP7	0.0	0.50	0.0	0.75
121	2016-05-26	Autumn '16	VP3	0.0	0.48	0.0	0.73
122	2016-05-27	Autumn '16	VP6	2.0	0.53	3.0	0.79
123	2016-05-27	Autumn '16	VP7	0.0	0.51	0.0	0.77
124	2016-05-28	Autumn '16	VP8	3.0	0.58	4.0	0.86
125	2016-05-28	Autumn '16	VP5	0.0	0.57	0.0	0.84
126	2016-05-28	Autumn '16	VP9	1.0	0.58	1.0	0.84
127	2016-05-28	Autumn '16	VP6	0.0	0.56	0.0	0.82
128	2016-05-28	Autumn '16	VP4	0.0	0.55	0.0	0.80
129	2016-05-29	Autumn '16	VP6	0.0	0.54	0.0	0.78
130	2016-05-29	Autumn '16	VP4	0.0	0.52	0.0	0.76
131	2016-05-29	Autumn '16	VP5	0.0	0.51	0.0	0.74
132	2016-05-29	Autumn '16	VP8	0.0	0.50	0.0	0.73
133	2016-08-22	Winter '16	VP11	3.0	3.00	20.0	20.00
134	2016-08-22	Winter '16	VP6	0.0	1.50	0.0	10.00
135	2016-08-22	Winter '16	VP10	0.0	1.00	0.0	6.67
136	2016-08-22	Winter '16	VP3	0.0	0.75	0.0	5.00
137	2016-08-22	Winter '16	VP9	0.0	0.60	0.0	4.00
138	2016-08-22	Winter '16	VP8	0.0	0.50	0.0	3.33
139	2016-08-22	Winter '16	VP1	0.0	0.43	0.0	2.86
140	2016-08-22	Winter '16	VP2	0.0	0.38	0.0	2.50
141	2016-08-23	Winter '16	VP5	0.0	0.33	0.0	2.22
142	2016-08-23	Winter '16	VP4	0.0	0.30	0.0	2.00
143	2016-08-23	Winter '16	VP1	0.0	0.27	0.0	1.82
144	2016-08-23	Winter '16	VP2	4.0	0.58	4.0	2.00
145	2016-08-23	Winter '16	VP11	0.0	0.54	0.0	1.85
146	2016-08-23	Winter '16	VP10	0.0	0.50	0.0	1.71
147	2016-08-23	Winter '16	VP6	0.0	0.47	0.0	1.60
148	2016-08-23	Winter '16	VP3	0.0	0.44	0.0	1.50
149	2016-08-24	Winter '16	VP1	4.0	0.65	8.0	1.88
150	2016-08-24	Winter '16	VP2	0.0	0.61	0.0	1.78
151	2016-08-24	Winter '16	VP4	0.0	0.58	0.0	1.68
152	2016-08-24	Winter '16	VP5	1.0	0.60	3.0	1.75

153	2016-08-24	Winter '16	VP7	0.0	0.57	0.0	1.67
154	2016-08-24	Winter '16	VP6	0.0	0.55	0.0	1.59
155	2016-08-24	Winter '16	VP11	0.0	0.52	0.0	1.52
156	2016-08-24	Winter '16	VP10	0.0	0.50	0.0	1.46
157	2016-08-25	Winter '16	VP9	0.0	0.48	0.0	1.40
158	2016-08-25	Winter '16	VP8	0.0	0.46	0.0	1.35
159	2016-08-25	Winter '16	VP6	2.0	0.52	2.0	1.37
160	2016-08-25	Winter '16	VP7	0.0	0.50	0.0	1.32
161	2016-08-25	Winter '16	VP4	0.0	0.48	0.0	1.28
162	2016-08-25	Winter '16	VP5	0.0	0.47	0.0	1.23
163	2016-08-25	Winter '16	VP1	0.0	0.45	0.0	1.19
164	2016-08-25	Winter '16	VP2	0.0	0.44	0.0	1.16
165	2016-08-26	Winter '16	VP7	0.0	0.42	0.0	1.12
166	2016-08-26	Winter '16	VP9	0.0	0.41	0.0	1.09
167	2016-08-26	Winter '16	VP8	0.0	0.40	0.0	1.06
168	2016-08-26	Winter '16	VP3	0.0	0.39	0.0	1.03
169	2016-08-26	Winter '16	VP4	0.0	0.38	0.0	1.00
170	2016-08-26	Winter '16	VP5	0.0	0.37	0.0	0.97
171	2016-08-27	Winter '16	VP10	1.0	0.38	2.0	1.00
172	2016-08-27	Winter '16	VP11	1.0	0.40	15.0	1.35
173	2016-08-27	Winter '16	VP3	0.0	0.39	0.0	1.32
174	2016-08-27	Winter '16	VP7	0.0	0.38	0.0	1.29
175	2016-08-27	Winter '16	VP8	0.0	0.37	0.0	1.26
176	2016-08-27	Winter '16	VP9	0.0	0.36	0.0	1.23

* The updated averages (for each season) are computed over the number consecutive watch periods in the season.

B. *Definition of terms*

These notes explain some of the terminology used in the report.

Average: The *average value* (also referred to as the *mean value*) is a measure of the location of the centre of gravity of a data distribution.

Variability: The *variance* is a measure of the variability of the observed data (e.g. counts per *3*h) around the mean value of the data. Its square root, the *standard deviation*, does the same but is scaled to the same units as those of the observed data.

Confidence Interval: A *confidence interval* for the true mean of a population (e.g. the true mean of the number of terrestrial birds occurring in an area) is an interval, computed from a random sample, that reflects the uncertainty of the estimate based on a single sample. If it were possible to take the infinite number of all possible samples of size *N* per season *(*in the present case of sampling) and a *95*% confidence interval for the mean is computed in each case, then *0.95*N* of those intervals will contain the true mean value. The larger the sample size, the narrower the confidence interval. On the other hand, the larger the standard deviation of a distribution, the wider the confidence interval for the mean. The lower limit of the confidence interval is denoted by LCL and the upper limit by UCL.

Precision: A sample *estimate* of a parameter that describes a population (e.g. it's true mean) depends on the sample size and is desired to be close to the true value of the parameter. The closeness of such an estimate to the true value is known as its *accuracy*. The precision of an estimate relates to the variability of the measurements. The closer together the data, the more precise the estimate. Half the width of the confidence interval for the parameter is defined as the *precision* of the estimate of the parameter. The larger the sample size the better (smaller) the precision.

Distribution of counts: It is recognised that counts of events (randomly distributed over space or time) that took place, for example, in a fixed time period (e.g. the count of birds in a watch period of fixed length) may have a *Poisson distribution* when the events occur randomly over time. The mean value and variance (the squared standard deviation) of a Poisson distribution are identical. This means that large mean values (of counts per SU) imply poorer precision.

C. *Poisson distribution – confidence interval*

If the count of birds per sampling unit (SU) [i.e. a watch period] is assumed to have a Poisson distribution with an (unknown) average value of□□ and if *N* SUs were sampled (for example 2h watch periods are sampled *N = 30* times) the sum of the *N* counts also has a Poisson distribution (with true average □*N*), see Brownlee, *1960*, p. *141*.

The Poisson probability (which is characterised uniquely by its average parameter (in this case □*N*) for finding a count of X = x birds from the *N* SUs is given by: $P(X = x) = e^{-\lambda N}(\lambda N)^x \,/\, x!$, for values of *x = 0, 1, 2, ...*

A (*1* – □) confidence interval for the mean value, □*N*, of this Poisson is determined by a lower limit $L_1 = \frac{1}{2}\chi^2_{\beta/2}(2X)$ and an upper limit $L_2 = \frac{1}{2}\chi^2_{1-\beta/2}(2X+2)$, see Zar (2010), pp. 587 – 589. Here $\chi^2_\alpha(\nu)$ is the □-point of the chi-squared distribution with □□degrees of freedom, i.e. the χ^2-value with cumulative probability of □□up to that value. *X* denotes the count of the number of birds over *N* SUs.

This means that the coverage probability for □*N* , based on a count of *X* birds per *N* SUs is $P(L_1 \leq \lambda N \leq L_2) = 1 - \beta$. Thus a *1 –* □ confidence interval for □ (the expected average value per SU) is given by the interval $(L_1 / N; \quad L_2 / N)$.

These formulas were used to determine the confidence intervals in the Tables in Section *3* of the report.

D. *Poisson distribution – Sample Size*

Consider the question of how many watch periods (i.e. sampling units, *N*) must be sampled in order to obtain an estimate of the true count per SU with *precision* of "*d"* units with prescribed probability, e.g. 95%. Thus, what must *N* be so that the true mean count per SU lies in an interval of half-width *d* with certainty of 1 – □□ ?

As was indicated in the previous section, this interval is $(L_1 / N; \quad L_2 / N)$ and thus the precision is $d = \frac{1}{2}(L_2 - L_1) / N$. The true average is estimated from the observed total count, *X*, and is given by $\hat{\lambda} = X / N$. This estimate is NOT in the centre of the confidence interval, but even so, we shall take half of the width of the confidence interval and call it the *1 –* □ *precision*. A sample size that will be sufficiently large to provide an estimate of the true mean count per SU with an acceptable value for its precision (say $d = d_0$) must thus satisfy the inequality: $\frac{1}{2}(L_2 - L_1) / N \leq d_0$ or, solving for *N*:

(1) $$N \geq \tfrac{1}{2}(L_2 - L_1) / d_0 = \left(\chi^2_{1-\beta/2}(2X+2) - \chi^2_{\beta/2}(2X) \right) / 4d_0 .$$

If a count *of* $X = x$ is observed and a specified value for d_0 is desired, the sample size must be at least *N* as in (*1*). This allows the user to verify, for a given count, if the actual number of SU's is sufficiently large to achieve the desired precision.

APPENDIX D: OTHER RENEWABLE ENERGY DEVELOPMENTS WITHIN 40KM RADIUS

Project	Current status of EIA/development	Proponent	Capacity	Farm details	Footprint	Bird impact assessment study	Proposed mitigation
Khobab Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 2 of Farm Sous 226	3 200 ha	Yes	DISPLACEMENT • Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines (Jenkins *et al.* 2011). The purpose of this would be to establish if displacement of priority species has occurred and to what extent. The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the developer once these timelines have been finalised. • The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and ideally for at least three

							years thereafter. Thereafter the need for additional monitoring will be determined and agreed to with the developer. • Construction activity should be restricted to the immediate footprint of the infrastructure, and in particular to the proposed road network. Access to the remainder of the site should be prohibited to prevent unnecessary disturbance of priority species. <u>COLLISIONS</u> • Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines (Jenkins *et al.* 2011) (see previous section Displacement). The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and ideally for at least three years thereafter. Thereafter the need for additional

							monitoring will be determined and agreed to with the developer. The purpose of this would be (a) to establish if displacement of priority species has occurred and to what extent through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. • The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant. If flamingo mortality is recorded, depending on the severity of the problem, appropriate measures to record

							nocturnal flight movement would need to be implemented.
Loeriesfontein Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 1 & 2 of Farm Aan de Karree Doorn Pan 213	3 453 ha	Yes	DISPLACEMENT • Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines (Jenkins *et al.* 2011). The purpose of this would be to establish if displacement of priority species has occurred and to what extent. The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the developer once these timelines have been finalised. • The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and ideally for at least three years thereafter. Thereafter the need for additional monitoring will be

							determined and agreed to with the developer. • Construction activity should be restricted to the immediate footprint of the infrastructure, and in particular to the proposed road network. Access to the remainder of the site should be prohibited to prevent unnecessary disturbance of priority species. COLLISIONS • Formal monitoring should be resumed once the turbines have been constructed, as per best practice guidelines (Jenkins *et al.* 2011) (see previous section Displacement). The duration of the post-construction monitoring would need to be for at least an equivalent period to the pre-construction monitoring (four seasons); and ideally for at least three years thereafter. Thereafter the need for additional monitoring will be determined and agreed to with the developer. The

							purpose of this would be (a) to establish if displacement of priority species has occurred and to what extent through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. • The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant. If flamingo mortality is recorded, depending on the severity of the problem, appropriate measures to record nocturnal flight movement would need to be implemented.

Hantam PV Solar Energy Facility	Environmental Authorisation issued / Approved under RE IPPPP	Solar Capital (Pty) Ltd	Up to 525MW	RE of Farm Narosies 228	1 338 ha	No	n/a
Orlight Loeriesfontein PV Solar Power Plant	Environmental Authorisation issued	Orlight SA (Pty) Ltd	70MW	Pt 5 of Farm Kleine Rooiberg 227	334 ha	No	n/a
Dwarsrug Wind Farm	Environmental Authorisation issued	Mainstream Renewable Power	140MW	Remainder of Brak Pan 212 Stinkputs 229	6 800 ha	Yes	• Restrict the construction activities to the construction footprint area. Do not allow any access to the remainder of the property during the construction period. A 200m exclusion zone should be implemented around the existing water points where no construction activity or disturbance should take place. A 2km buffer zone has already been implemented around the Martial Eagle nests. • Little mitigation is possible to prevent the permanent habitat transformation caused by the construction of the wind farm infrastructure. To prevent unnecessary habitat destruction (i.e. more than is inevitable), the recommendations of the specialist ecological study must be strictly adhered to. It is especially important that maximum use is made of existing roads. A 200m exclusion zone should be implemented around the existing water points where no

							construction activity or disturbance should take place. A 2km buffer zone has already been implemented around the Martial Eagle nests. • Should the Martial Eagle nest become active before construction commences, monitoring of the breeding pair of Martial Eagles should be implemented during the construction phase, to ascertain if the 2km buffer zone is effective to prevent disturbance of the birds. • Should the Martial Eagle nest become occupied before construction commences, it is recommended that the flight activity of the juvenile Martial Eagle is monitored by monthly direct observations prior to construction commencing, from October – March i.e. after fledging up until it leaves its natal territory, to assess its flight patterns during this period when it will be most vulnerable to potential collision. This should give an indication of the extent of the potential curtailment (if any) that would be required to minimize the risk of collisions i.e. which turbines and for what period. This monitoring should be conducted pro-actively, i.e. before the first turbines are constructed in order to have baseline information available

							on flight behaviour before the turbines become operational. This will help in the pro-active identification of high risk areas which could form the focus of subsequent monitoring. • A 200m no-go buffer is proposed around water points as they serve as focal points for bird activity. This would require one turbine, i.e. No 34, to be moved slightly (about 20m). • Formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (Jenkins *et al.* 2011). The exact scope and nature of the post-construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. The purpose of this would be (a) to establish if and to what extent displacement of priority species has occurred through the altering of flight patterns post-construction, and (b) to search for carcasses at turbines. • As an absolute minimum, post-construction monitoring should be undertaken for the first two (preferably three) years of operation, and then repeated again in year 5, and again every five years thereafter. The exact scope and nature of the post-

							construction monitoring will be informed on an ongoing basis by the result of the monitoring through a process of adaptive management. • The environmental management plan should provide for the on-going inputs of a suitable experienced ornithological consultant to oversee the post-construction monitoring and assist with the on-going management of bird impacts that may emerge as the post-construction monitoring programme progresses. • Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods. • If turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations). • Lighting of the wind farm (for example security lights) should be kept to a minimum. Lights should be directed downwards (provided this complies with Civil Aviation Authority regulations).

							• A 2km buffer zone has already been implemented around the Martial Eagle nests. • A 1km buffer zone has already been implemented around Brakpan. • The proposed sub-transmission should be marked with Bird Flight Diverters (BFDs) for its entire length on the earth wire of the line, 5 metres apart, alternating black and white.
Hartebeest Leegte Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	Remainder of Hartebeest Leegte No 216		Yes	• The restriction of construction activities to the construction footprint area, no access to the remainder of the property during the construction period, • measures to control noise and dust, • maximum use of existing access roads and • the implementation of a 300m exclusion zone around waterpoints. • the recommendations of the specialist ecological study must be strictly adhered to, • maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum, • a 300m exclusion zone should be implemented around the

							existing water points and pans where no construction activity or disturbance should take place, • post-construction monitoring should be implemented to make comparisons with baseline conditions possible, and if densities of key priority species are proven to be significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species. • A 300m no-go buffer is proposed around water points and pans as they serve as focal points for bird activity, • formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (as an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and

							again every five years thereafter), • the minimum turbine tip height should ideally be no less than 50m to reduce the risk of Red Lark mortality during display flight activity, • depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be, • if turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations), • lighting of the wind farm (for example security lights) should be kept to a minimum, and lights should be directed downwards (provided this complies with Civil Aviation Authority regulations). •

Ithemba Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	Portion 2 of Graskoppies No 176 & Portion 1 of Hartebeest Leegte No 216		Yes	• The restriction of construction activities to the construction footprint area, no access to the remainder of the property during the construction period, • measures to control noise and dust, • maximum use of existing access roads and • the implementation of a 300m exclusion zone around waterpoints. • the recommendations of the specialist ecological study must be strictly adhered to, • maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum, • a 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place, • post-construction monitoring should be implemented to make comparisons with baseline conditions possible, and if densities of key priority species are proven to be

							significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species. • A 300m no-go buffer is proposed around water points and pans as they serve as focal points for bird activity, • formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (as an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and again every five years thereafter), • the minimum turbine tip height should ideally be no less than 50m to reduce the risk of Red Lark mortality during display flight activity, • depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality

							levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be, • if turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations), • lighting of the wind farm (for example security lights) should be kept to a minimum, and lights should be directed downwards (provided this complies with Civil Aviation Authority regulations).
Xha! Boom Wind Farm	EIA ongoing	Mainstream Renewable Power	140MW	Portion 2 of Georg's Vley No 217		Yes	• The restriction of construction activities to the construction footprint area, no access to the remainder of the property during the construction period, • measures to control noise and dust, • maximum use of existing access roads and

							• the implementation of a 300m exclusion zone around waterpoints. • the recommendations of the specialist ecological study must be strictly adhered to, • maximum use should be made of existing access roads and the construction of new roads should be kept to a minimum, • a 300m exclusion zone should be implemented around the existing water points and pans where no construction activity or disturbance should take place, • post-construction monitoring should be implemented to make comparisons with baseline conditions possible, and if densities of key priority species are proven to be significantly reduced due to the operation of the wind farm, the management of the wind farm must be engaged to devise ways of reducing the impact on these species. • A 300m no-go buffer is proposed around water points

							and pans as they serve as focal points for bird activity, • formal monitoring should be resumed once the turbines have been constructed, as per the most recent edition of the best practice guidelines (as an absolute minimum, post-construction monitoring should be undertaken for the first two years of operation, and then repeated again in year 5, and again every five years thereafter), • the minimum turbine tip height should ideally be no less than 50m to reduce the risk of Red Lark mortality during display flight activity, • depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels turn out to be significant, including selective curtailment of problem turbines during high risk periods if need be, • if turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing

							strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations), • lighting of the wind farm (for example security lights) should be kept to a minimum, and lights should be directed downwards (provided this complies with Civil Aviation Authority regulations). •

ADDENDUM TO THE AVIFAUNAL IMPACT ASSESSMENT CONDUCTED FOR THE PROPOSED MAINSTREAM GRASKOPPIES WIND ENERGY FACILITY NEAR LOERIESFONTEIN IN THE NORTHERN CAPE PROVINCE

Chris van Rooyen and Albert Froneman

June 2017

AFRIMAGE Photography (Pty) Ltd t/a
Chris van Rooyen Consulting
VAT#: 4580238113
email: vanrooyen.chris@gmail.com
Tel: +27 (0)82 4549570 cell

EXECUTIVE SUMMARY

The purpose of this addendum report is to assess whether the conclusions and recommendations of the Bird Impact Assessment Report compiled in December 2016 will be affected by a change in the proposed turbine dimensions from a hub height of up to 150m and rotor diameter of up to 150m, to a hub height of up to 160m and a rotor diameter of up to 160m. Assuming a 160m blade diametre and a 160m hub height, it means maximum height of the blade will be 240m (previously 225m) and minimum height will be 80m (previously 75m).

The conclusions and recommendations of the original Bird Impact Assessment Report remains unchanged by the proposed change in turbine dimensions. The reason for that are as follows:

- While the risk rating for Martial Eagle has increased with the new turbine dimensions, it is still below the average risk rating for priority species;
- The overall risk rating for priority species has increased by only 7.45%;
- The weight of published findings indicate that rotor swept area as a stand-alone issue is not a key factor in determining collision risk.

1. Background

The proposed Mainstream Leeuwberg renewable energy development will consist of four wind farms and associated infrastructure, namely !Xha Boom wind farm, Graskoppies wind farm, Hartebeest Leegte wind farm and Ithemba wind farm. Each wind farm will have a capacity of up to 235MW and consist of up to 70 turbines between 3MW and 5MW.

The original turbine dimensions on which the collision risk index for the four development areas was calculated were a hub height of up to 150m and a rotor diametre of up to 150m. Mainstream has subsequently decided to change the turbine dimensions to a hub height of up to 160m and a rotor diametre of up to 160m.

The purpose of this addendum report is to assess whether the conclusions and recommendations of the original Bird Impact Assessment Report compiled for the Graskoppies Wind Energy Facility (WEF) in December 2016 will be affected by the proposed change in the turbine dimensions.

2. Potential impact of revised turbine dimensions

The new turbine dimensions necessitate a re-assessment of the potential risk of collisions due to the increased rotor swept area, and taller hub height. Assuming a 160m blade diametre and a 160m hub height, it means that the maximum height of the blade will be 240m (previously 225m) and the minimum height will be 80m (previously 75m).

An elementary site-specific collisions risk rating for each priority species recorded during VP watches was calculated in December 2016, based on the original turbine dimensions, to give an indication of the likelihood of an individual of the specific species to collide with the turbines at this site. This was calculated taking into account the following factors:

- The duration of potential rotor height flights;
- the susceptibility to collisions, based on morphology (size) and behaviour (soaring, predatory, ranging behaviour, flocking behaviour, night flying, aerial display and habitat preference) using the ratings for priority species in the Avian Wind Farm Sensitivity Map of South Africa (Retief *et al.* 2012); and
- the number of planned turbines.

Due to the uncertainty with regard to final turbine dimensions at the start of the pre-construction monitoring, a precautionary approach was followed in order to cover as many potential turbine sizes as possible. The following dimensions were used:

- <30m below rotor height (low altitude)
- 30 – 220m within rotor height (medium altitude)

- >220 above rotor height (high altitude)

The formula used were as follows:

Duration of medium altitude flights x collision susceptibility calculated as the sum of morphology and behaviour ratings x number of planned turbines ÷100:

Figure 1 below shows the risk index for priority species, based on recorded medium altitude flights.

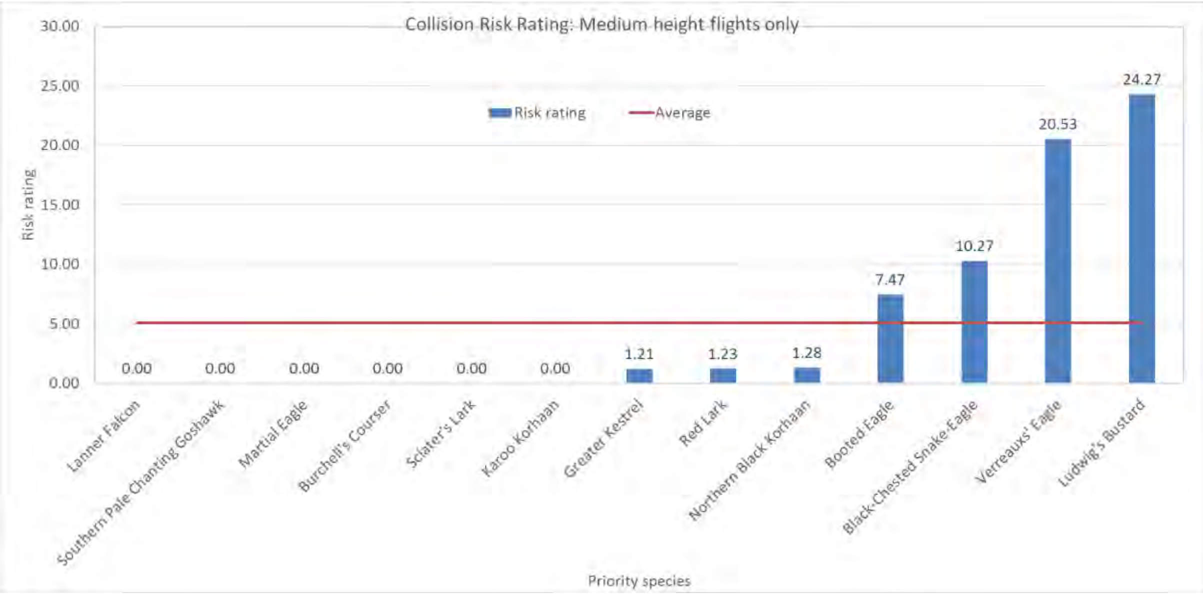

Figure 1: The site-specific collision risk rating for priority species based on medium altitude flights only.

The change in the potential turbine size necessitates a re-calculation of the risk index. As a pre-cautionary measure, all flights originally classified as above rotor height need to be included in the new calculation, as the maximum rotor height has now increased to 240m.

The formula used to calculate the revised collision risk index is as follows:

*Duration of medium **and high** altitude flights x collision susceptibility calculated as the sum of morphology and behaviour ratings x number of planned turbines ÷100:*

Figure 2 below shows the revised risk index for priority species, based on recorded medium and high altitude flights.

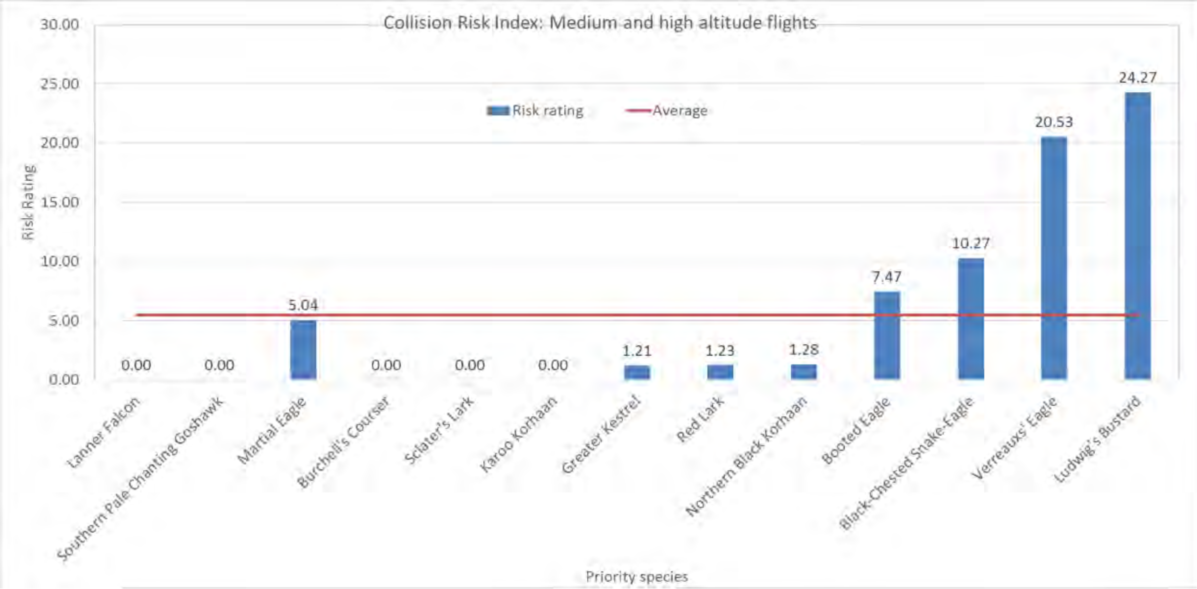

Figure 2: The revised site specific collision risk rating for priority species based on medium and high altitude flights.

The re-calculation of the risk index has resulted in an increase in the individual risk rating for Martial Eagle from 0 to 5.04 as a result of the inclusion of high altitude flights in the risk zone, and an increase in the average collision risk rating for priority species from 5.10 for the original turbine dimensions to 5.48 for the new turbine dimensions, which is an increase of 7.45%. However, the individual risk rating for Martial Eagle is still below the average risk rating for priority species. The individual risk ratings for the other priority species remained the same, as no high altitude flights were recorded for those species.

The inclusion of all the high altitude flights in the re-calculation is based on the assumption that a larger rotor-swept area will automatically increase the risk of collision. While this makes intuitive sense, it should be noted that the majority of published scientific studies indicate that an increase in rotor swept area do not automatically translate into a larger collision risk. Turbine dimensions seem to play an insignificant role in the magnitude of the collision risk in general, relative to other factors such as topography, turbine location, morphology and a species' inherent ability to avoid the turbines, and may only be relevant in combination with other factors, particularly wind strength and topography. While two studies found a correlation between turbine hub height and mortality (De Lucas *et al.* 2008; Loss *et al.* 2013), the majority did not (see Howell 1997, Barrios & Rodriguez 2004; Barclay *et al.* 2007, Krijgsveld *et al.* 2009, Smallwood 2013; Everaert 2014).

See below a summary of published findings on the topic:

- Howell *et al.* 1997 states on p.9: "The evidence to date from the Altamont Pass does not support the hypothesis that the larger rotor swept area (RSA) of the KVS – 33 turbines contributes proportionally to avian mortality, i.e. larger area results in more mortalities. On the contrary, the ratio of K-56 turbines to KVS-33 turbines rather than RSA was approximately 3.4:1 which as consistent with the 4.1:1 mortality ratio. It appears that the mortality occurred on a per-turbine basis, i.e. that each turbine simply presented an obstacle."

- Barrios & Rodriguez 2004 states on p. 80: "Most deaths and risk situations occurred in two rows at PESUR with little space between consecutive turbines. This windwall configuration (Orloff & Flannery 1992) might force birds that cross at the blade level to take a risk greater than in less closely spaced settings. However, little or no risk was recorded for five turbine rows at PESUR having exactly the same windwall spatial arrangement of turbines. Therefore, we conclude that physical structures had little effect on bird mortality unless in combination with other factors."
- Barclay *et al.* 2007 states on p. 384: "Our analysis of the data available from North America indicates that this has had different consequences for the fatality rates of birds and bats at wind energy facilities. It might be expected that as rotor swept area increased, more animals would be killed per turbine, but our analyses indicates that this is not the case. Rotor-swept area was not a significant factor in our analyses. In addition, there is no evidence that taller turbines are associated with increased bird fatalities. The per turbine fatality rate for birds was constant with tower height."
- De Lucas *et al.* 2008 states on p. 1702: "All else being equal, more lift is required by a griffon vulture over a taller turbine at a higher elevation and we found that such turbines killed more vultures compared to shorter turbines at lower elevations".
- Krijgsveld *et al.* 2009 states on p. 365: "The results reported in this paper indicate that collision risk of birds with larger multi-MW wind turbines is similar to that with smaller earlier-generation turbines, and much lower than expected based on the large rotor surface and high altitude-range of modern turbines… Clearly, more studies of collision victims are needed before we can confidently predict the relationship between size and configuration of wind turbines and the risk for birds to collide with a turbine".
- Smallwood et al. 2013 states on p.26 – 27 (see also Fig 9 on p.30): "Red-tailed hawk (*Buteo jamaicensis*) and all raptor fatality rates correlated inversely with increasing wind-turbine size (Figs. 9A,B)… Thousands of additional MW of capacity were planned or under construction in 2012, meaning that the annual toll on birds and bats will increase. However, the expected increase of raptor fatalities could be offset by reductions of raptor fatalities as older wind projects are repowered to new, larger wind turbines, especially if the opportunity is taken to carefully site the new wind turbines (Smallwood and Karas 2009, Smallwood *et al.* 2009)."
- Loss *et al.* 2014 states on p. 208: "The projected trend for a continued increase in turbine size coupled with our finding of greater bird collision mortality at taller turbines suggests that precaution must be taken to reduce adverse impacts to wildlife populations when making decisions about the type of wind turbines to install."
- Everaert, 2014 states on p. 228: "Combined with the mortality rates of several wind farms in the Netherlands (in similar European lowland conditions near wetlands or other areas with water), no significant relationship could be found between the number of collision fatalities and the rotor swept area of the turbines (Fig. 4). In contrast to

more common landscapes, Hötker (2006) also found no significant relationship between mortality rate and the size of wind turbines near wetlands and mountain ridges."

As can be seen from the above short literature survey, the weight of published findings indicate that rotor swept area as a stand-alone issue is not a key factor in the collision risk.

3. Conclusions

The conclusions and recommendations of the original Bird Impact Assessment Report remains unchanged by the proposed change in turbine dimensions. The reason for that are as follows:

- While the risk rating for Martial Eagle has increased with the new turbine dimensions, it is still below the average risk rating for priority species;
- The overall risk rating for priority species has increased by only 7.45%;
- The weight of published findings indicate that rotor swept area as a stand-alone issue is not a key factor in determining collision risk.

4. References

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AFRIMAGE Photography (Pty) Ltd Trading as:

Chris van Rooyen Consulting

vanrooyen.chris@gmail.com
Tel: +27 (0)82 4549570 cell
VAT#: 4580238113

30 Roosevelt Street
Robindale
Randburg
2194

To:

Stephan Jacobs
Environmental Consultant
SiVEST Environmental Division

11 October 2016

Dear Stephan

AMENDMENT TO THE AUTHORISATION FOR THE GRASKOPPIES WEF

Your email of 02 October 2017 concerning the new proposed turbine layout refers. The following pertinent issues were raised in your letter:

- The number of turbines which Mainstream will be submitting in the final layout has been changed to 47, as opposed to the original 70 turbine layout which we assessed in the original bird specialist study dated December 2016 and revised July 2017.
- The range of turbine to be changed from 2 - 5MW to 4 – 8MW. Mainstream will not be changing any of the assessed turbine parameters, i.e. hub height, rotor diameter, and maximum MW will remain the same.
- Material for turbine towers to change from just steel, to include steel and concrete – there will be no concrete batching on site, so it won't increase water usage, these will be pre-cast and transported in.
- Mainstream has consolidated all sensitive areas and removed all turbine locations from the sensitive areas in the buildable area. Further, Mainstream has added an additional 20^{2}m to the entire buildable area, to cater for possible slight increase in hardstand area.

Comments:

The new turbine layout represents a 32.8% reduction in the number of turbines. This is a positive development from a bird impact assessment perspective, as it reduces the risk of priority species collisions and reduces the potential displacement impact of habitat fragmentation. We are furthermore satisfied that the proposed changed layout avoids all avifaunal sensitive areas delineated in the original bird specialist study. No additional mitigation measures are required over and above those already recommended in the bird specialist study, all of which are still valid for the new layout.

We therefore recommend that the new layout be approved subject to the implementation of the mitigation measures as outlined in the original bird specialist study.

Chris van Rooyen

Albert Froneman