AVIFAUNAL WALK-THROUGH REPORT

PROPOSED SUTHERLAND 2 WIND ENERGY FACILITY AND ASSOCIATED GRID INFRASTRUCTURE NEAR SUTHERLAND IN THE NORTHERN CAPE PROVINCE

November 2022

AFRIMAGE Photography (Pty) Ltd t/a:

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EXECUTIVE SUMMARY

Chris van Rooyen Consulting was contracted by Nala Environmental to conduct a “walk-through” of the authorised 140MW Sutherland 2 Wind Energy Facility (WEF) site (12/12/20/1782/3/AM5), on behalf of Sutherland 2 Wind Farm (Pty) Ltd, to identify any avifaunal sensitivities to be considered for the final layout of the wind turbines associated with the WEF.

The Sutherland WEF has been selected as a preferred bidder as part of the REIPPPP and is currently finalizing the required layouts and documentation in order to meet financial close requirements. The original authorised layout of 47 wind turbines has been reduced by 46% to 25 wind turbines, and this layout was assessed during the walk-through exercise, with a view to including any required mitigation measures in an updated Environmental Management Programme (EMPr).

METHODOLOGY

A four-day site inspection was conducted in August 2022 to record all avifaunal sensitivities on, and in the immediate vicinity of the WEF project site, which could influence the layout of the wind turbines. Emphasis was placed on confirming the location of priority species nests, particularly species of conservation concern (SCC), which may be impacted by the proposed WEF. The data gathered during the 12-months monitoring, in 2015 -2016, and subsequent nests searches in June and July 2019, and April, November and December 2021, were also taken into account. Priority species were defined as species included on the list of priority species of the Avian Wind Farm Sensitivity Map of South Africa compiled by Birdlife South Africa (Retief *et al.* 2012).

RESULTS

Appendix 3 lists the species Van Rooyen *et al*. (2016) recorded during a year of pre-construction monitoring in 2015 -2016. The 50 species that were recorded on and around the project site during the walk-through and nest searches in August 2022 are listed in Table 1.

RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final EMPr. These recommendations are based on the pre-construction monitoring conducted in 2015-2016 (Van Rooyen *et al*. 2016) and the walk-through exercises and nest inspections in 2019, 2021, and 2022, and **replace the recommendations contained in the original Avian Impact Assessment Report (Jenkins 2011), which are now outdated**:

<u>**Design phase**</u>

- A 3km turbine exclusion zone must be implemented around identified Verreaux’s Eagle nests, and a 660m turbine exclusion zone along the escarpment (Figure 2).
- A programme of observer-based or automated Shutdown on Demand (SDoD) to reduce potential Verreaux’s Eagle turbine collisions must be implemented within the 3 – 5.2km medium-risk buffer zone.
- It is recommended that turbine exclusion zones are implemented around all sources of surface water as indicated by the bat and aquatic specialists, as a pre-cautionary measure against SCC and other priority species collisions (Figure 5).
- All internal 33kV medium voltage cables are to be buried, if technically possible.

- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs to run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor friendly.
- Bird flight diverters are to be fitted to all internal overhead lines, as well as the sections of the 132kV grid connection as indicated in Figure 4, according to the applicable Eskom Engineering Instruction.
- All wind turbines within the 3 – 5.2km zone must have one blade painted in signal red according to pattern no.4 depicted in Figure (i) below. It is acknowledged that blade painting as a mitigation strategy is still in an experimental phase in South Africa, but research indicates that it has a very good chance of reducing raptor mortality, based on research conducted in Norway (see Simmons *et al*. 2021 (Appendix 5) for an explanation of the science and research behind this mitigation method).

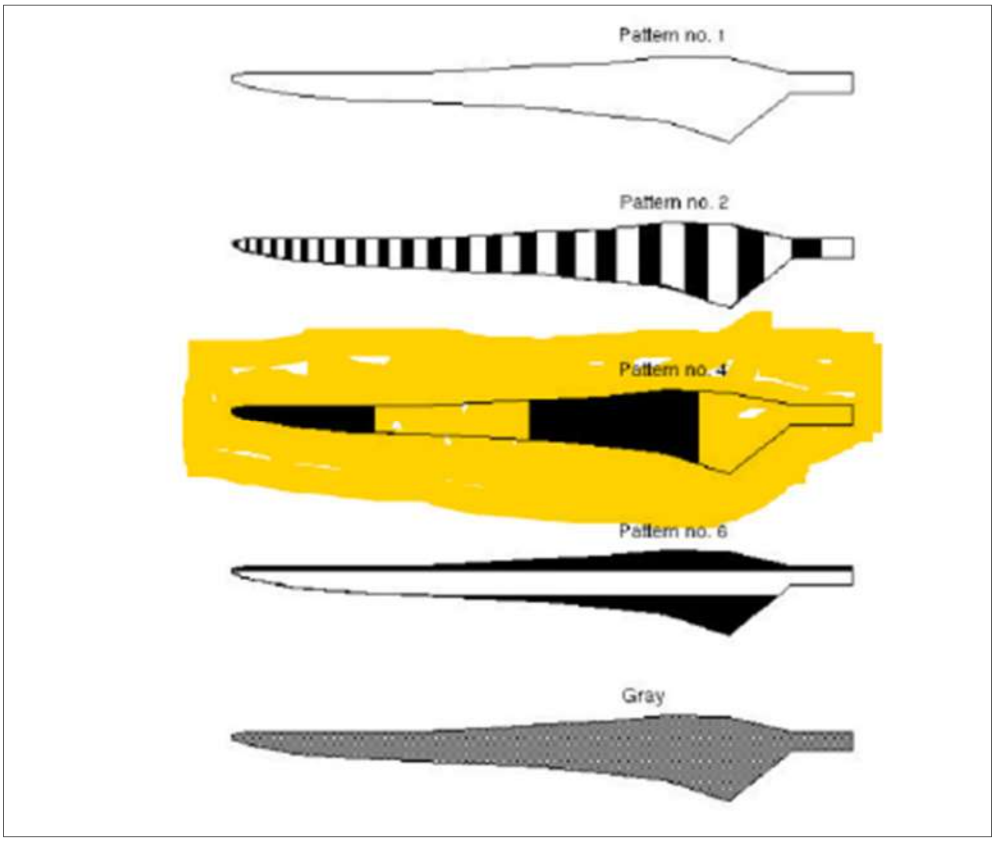

Figure (i): Pattern no.4 is the recommended pattern for blade painting at the WEF

Construction phase

- 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 strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.

Operational phase

- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal monitoring should be resumed once the wind turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-

construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines and a commercial operational date have been finalised.

- As a 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 for the operational life-time of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels exceed mortality thresholds determined by the avifaunal specialist at the time, in consultation with relevant experts, which may include measures such as expanding the SDoD beyond the current zones, selective curtailment of turbines during specific high-risk conditions or any other practical and effective mitigation.

IMPACT STATEMENT

The proposed WEF layout was reduced by 46% from the original 47 wind turbines to the current 25 wind turbines, and it **avoids all the recommended avifaunal buffer zones**. The proposed WEF layout is therefore deemed acceptable from an avifauna perspective, and it is recommended that the layout is approved, subject to the implementation of the mitigation measures as detailed in the final Environmental Management Programme (EMPr).

DETAILS OF THE SPECIALIST AND EXPERTISE TO COMPILE A WALK-THROUGH REPORT

See Appendix 4 for comprehensive curriculum vitae

Chris van Rooyen (Avifaunal Specialist)
Chris has decades of experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in numerous power line and wind generation projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is 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 (Avifaunal Specialist)
Albert has a Master of Science degree in Conservation Biology from the University of Cape Town and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and he is currently jointly coordinating pre-construction monitoring programmes at several wind farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Kevin Shaw (Field specialist)
Kevin began his career in the then Department of Forestry, working as a planner on the water catchment and drift sand areas of the southwestern Cape. He progressed to District Forest Officer and later District Conservation Officer, when he was transferred to the then Department of Nature Conservation for the Cape Provincial Administration, which later evolved into the Western Cape Nature Conservation Board. In 1995 he was appointed as one of two ornithologists for the province. He worked mainly with high priority species and participates in substantial collaboration with mainly tertiary institutions and non-government environmental organisations. Species that he has worked on include Blue Crane, Cape Vulture, African Penguin, Damara Tern, Cape Gannet, Coastal Cormorant species, waterbirds, House Crow and Mallard.

DECLARATION BY THE SPECIALIST

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

FINAL ENVIRONMENTAL MANAGEMENT PROGRAMME REPORT AND FINAL LAYOUT FOR THE AUTHORISED 140MW SUTHERLAND 2 WIND ENERGY FACILITY AND ASSOCIATED INFRASTRUCTURE, NORTHERN CAPE PROVINCE (DFFE REF: 12/12/20/1782/3) AND ASSOCIATED GRID CONNECTION (IPP PORTION OF THE 132KV ON-SITE SUBSTATION) INCLUDING THE 132KV OVERHEAD POWERLINE AND ESKOM PORTION OF THE ON-SITE SUBSTATION)

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447, Pretoria, 0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House, 473 Steve Biko Road, Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:				
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	Level 2	Percentage Procurement recognition	
Specialist name:	Chris van Rooyen			
Specialist Qualifications:	BA LLB			
Professional affiliation/registration:	I work under the supervision and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003			
Physical address:	6 Pladda Drive, Plettenberg Bay			
Postal address:	PO Box 2676, Fourways, 2122			
Postal code:	2055	Cell:	0824549570	
Telephone:	0824549570	Fax:		
E-mail:	Vanrooyen.chris@gmail.com			

2. DECLARATION BY THE SPECIALIST

I, Christiaan Stephanus van Rooyen, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Name of Company: Afrimage Photography t/a Chris van Rooyen Consulting

10 November 2022

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, Christiaan Stephanus van Rooyen, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

Afrimage Photography (Pty) Ltd t/a Chris van Rooyen Consulting

Name of Company

10 November 2022

Date

Signature of the Commissioner of Oaths

2022-11-10

Date

SOUTH AFRICAN POLICE SERVICE
PLETTENBERG BAY
2022 -11- 10
PLETTENBERGBAAI
SOUTH AFRICAN POLICE SERVICE

1 BACKGROUND

Sutherland 2 Wind Farm (Pty) Ltd received Environmental Authorisation (EA) (DFFE Ref: 12/12/20/1782/3), dated 10 November 2016 and further amendments to the EA dated 25 November 2016, 25 August 2017, 10 March 2020, 08 June 2020 and the latest 09 July 2021, for the development of the 140MW Sutherland 2 Wind Energy Facility (WEF) and associated infrastructure, in the Northern Cape Province. The WEF received an EA for the Independent Power Producer (IPP) portion of the on-site substation (DFFE Ref: 14/12/16/3/3/1/1814/1) on 20 October 2021 and received a separate EA for Switching Station portion of the on-site substation and 132kV overhead powerline (DFFE Ref: 14/12/16/3/3/1/1814/2) on 20 October 2021. The Environmental Management Programmes (EMPrs) for the WEF, IPP portion of the on-site substation and Eskom portion of the on-site substation, including the 132kV overhead powerline, have been approved by the Department of Forestry, Fisheries and the Environment (DFFE), and will therefore be included within the Final Layout for the WEF for completeness.

The WEF will include the following:

- Up to 25 wind turbines (140MW maximum export capacity), with a hub height up to of 200m and rotor diameter up to 200m
- The wind turbines will be connected to another by means of medium voltage cables
- An internal gravel road network will be constructed to facilitate movement between turbines on site These roads will include drainage and cabling
- A hardstanding laydown area of a maximum of 10 000m² will be constructed
- A temporary site office will be constructed on site for all contractors, this would be approximately 5000m² in size

The proposed IPP portion of the of the on-site substation and associated infrastructure will include the following:

- An IPP portion of the on-site substation
- Laydown area
- Operation & Maintenance Building
- Fencing of the proposed on-site substation
- Battery Energy Storage Infrastructure (BESS)

The proposed Switching Station portion of the on-site substation and powerline will include the following:

- Fencing
- 132kV distribution line from the proposed Sutherland 2 WEF on-site substation to the Acrux third party substation (including tower/pylon infrastructure and foundations)
- Connection to the Acrux third party substation
- Service road below the powerline

The property affected by the 140MW Sutherland 2 WEF and associated infrastructure includes the following:

- Portion 1 of Tonteldoosfontein Farm 152

The properties associated with grid connection infrastructure include the following:

- Portion 1 of Tonteldoosfontein Farm 152
- Portion 2 of Gunsfontein Farm 151
- Portion 1 of Gunsfontein 151
- Portion 1 of Beeren Valley Farm 150

- Remaining Extent of Beeren Valley Farm 150
- Remaining Extent of Nooitgedacht Farm 148

The Sutherland 2 WEF has been selected as a Preferred Bidder project via a private off-taker and construction is expected to commence in early 2023.

Sutherland 2 Wind Farm (Pty) Ltd has commissioned Nala Environmental (Pty) Ltd to undertake the ground truthing and subsequent finalisation of the layout and EMPrs, in terms of the NEMA EIA Regulations, 2014 (as amended). As per the conditions of the EAs, independent specialist walkthrough's have been undertaken to inform the final layout and final EMPr for the authorised WEF and associated infrastructure. Chris van Rooyen Consulting was contracted by Nala Environmental to identify any avifaunal sensitivities to be considered for the final layout of the wind turbines for the authorised Sutherland 2 WEF.

2 METHODOLOGY

A four-day site inspection was conducted in August 2022 to record all avifaunal sensitivities on, and in the immediate vicinity of the project site, which could influence the layout of the wind turbines. Emphasis was placed on confirming the location of priority species nests, particularly species of conservation concern (SCC), which may be impacted by the proposed WEF. The data gathered during the 12-months monitoring, in 2015 -2016, and subsequent nests searches in June and July 2019, and April, November and December 2021, were also taken into account. Priority species were defined as species included on the list of priority species of the Avian Wind Farm Sensitivity Map of South Africa compiled by Birdlife South Africa (Retief *et al.* 2012).

See Figure 1 for the 25 wind turbine layout being proposed for approval.

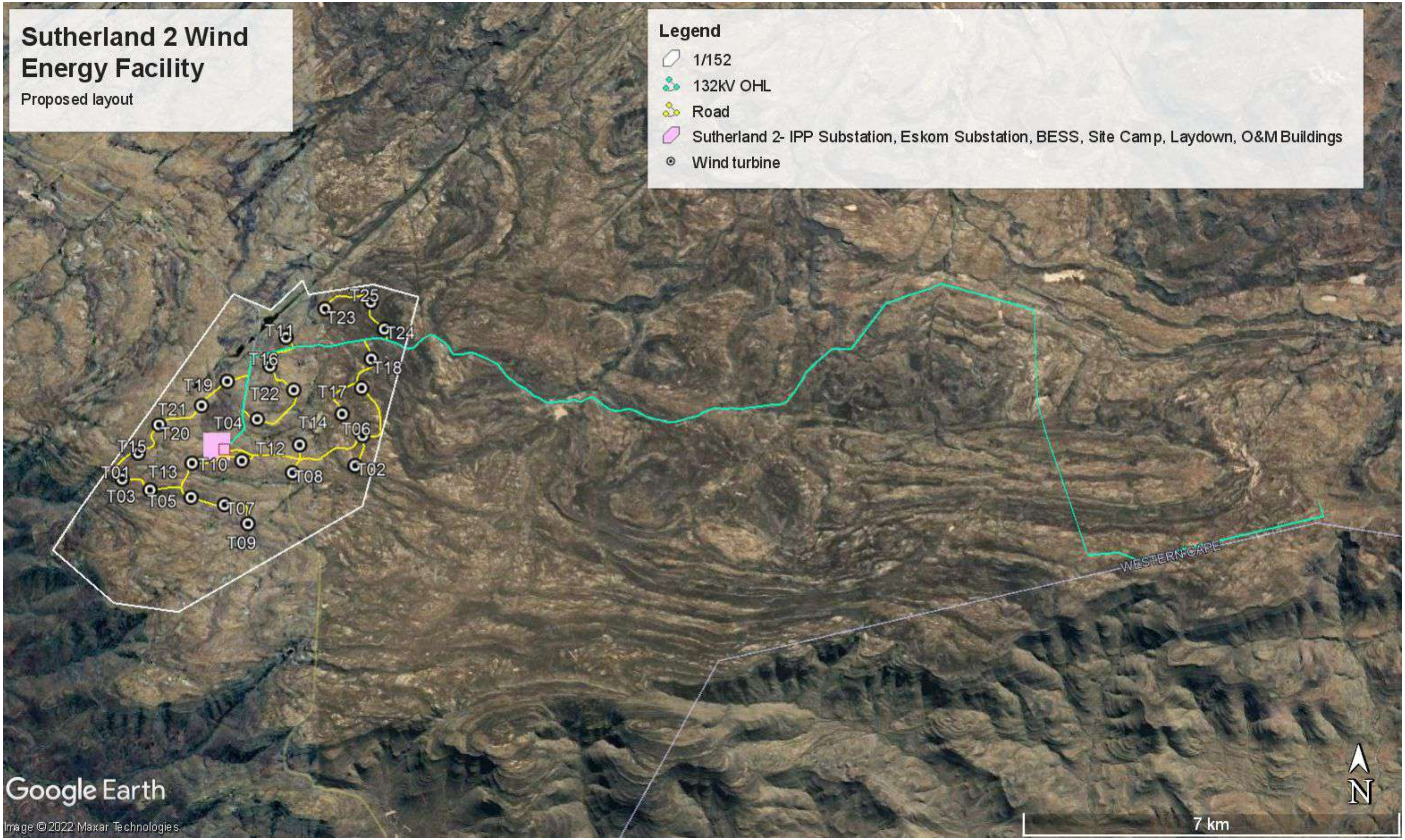

Figure 1: The proposed layout of 25 wind turbines.

3 RECEIVING ENVIRONMENT

3.1 DFFE National Screening Tool

3.1.1 Avian Wind Theme

The project site is classified as **Low, Medium** and **High** sensitivity for avifauna from a wind energy perspective. The Medium and High sensitivity is linked to areas with high topographic relief which is linked to the potential occurrence of a cliff nesting species of conservation concern (SCC) namely Verreaux's Eagle *Aquila verreauxii* (Regionally Vulnerable). The occurrence of Verreaux's Eagle was confirmed during the walk-through exercise in August 2022.

3.1.2 Terrestrial Animal Species Theme

The project site and immediate environment is classified as a mixture of **Medium** and **High** sensitivity for avifauna. The High sensitivity is linked to Southern Black Korhaan *Afrotis afra* (Globally and Regionally Vulnerable), and Verreaux's Eagle. The medium sensitivity is linked to Ludwig's Bustard *Neotis ludwigii* and Verreaux's Eagle.

The project site contains confirmed habitat for species of conservation concern (SCC), as defined in the Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855, 30 October 2020), namely listed on the IUCN Red List of Threatened Species or South Africa's National Red List website as Critically Endangered, Endangered, Vulnerable, Near threatened or Data Deficient. The occurrence of SCC was confirmed during the 12 months pre-construction monitoring in 2015 – 2016, subsequent nests searches in June and July 2019, in April, November and December 2021, and the walk-through exercise in August 2022. Verreaux's Eagle, Black Harrier *Circus maurus* (Globally and Regionally Endangered), Black Stork, Karoo Korhaan *Eupodotis vigorsii* (Regionally Near-threatened), Martial Eagle *Polemaetus bellicosus* (Globally and Regionally Near-threatened), Lanner Falcon, Southern Black Korhaan and Ludwig's Bustard (Globally and Regionally Endangered) were recorded at the project site and immediate environment.

The classification of **High** sensitivity is suggested for the whole site, based on actual conditions recorded on the ground during the site surveys.

See Appendix 1 for the DFFE screening reports.

3.2 Bird habitat

The proposed WEF is located at the junction of the Fynbos and Succulent Karoo biomes, and more specifically, at the interface between the Karoo Renosterveld and Rainshadow Valley Karoo bioregions (Mucina & Rutherford 2006). The site is situated on a plateau at an altitude of between 1600 and 1700 meters above sea-level and partially straddles the escarpment of the Klein-Roggeveld and Komsberg mountain ranges. The dominant vegetation type in the proposed turbine areas is Roggeveld Shale Renosterveld (Mucina & Rutherford 2006). This vegetation type occurs on undulating, plateau landscapes with low hills and broad shallow valleys, supporting mainly moderately tall schrublands dominated by renosterbos, with rich geophytic flora in the wetter and rocky habitats. The climate is quite severe, with about 170 mm of rain per annum, falling mostly in winter, with mean winter minimum and summer maximum temperatures of 0˚C and 29˚C respectively (Mucina & Rutherford 2006). There are several artificial impoundments on the plateau as well as a number of natural, flat depressions which hold water after good rains. There are also a number of drainage lines traversing the plateau with associated wetland areas. The principal land-use is sheep farming.

See Appendix 2 for images of the habitat at the project site.

4 RESULTS AND CONCLUSIONS

4.1 Avifauna

Appendix 3 lists the species Van Rooyen *et al*. (2016) recorded during a year of pre-construction monitoring in 2015 -2016. Table 1 lists the wind priority species that have been recorded at the project site during the walk-through exercises in August 2022.

Table 1: Avifauna recorded during surveys at the project site in August 2022. SCC are shaded.

Species	Taxonomic name	Global Red Data status IUCN	Regional Red Data status SA
Ant-eating Chat	*Myrmecocichla formicivora*		
Black Harrier	*Circus maurus*	Endangered	Endangered
Black-headed Canary	*Serinus alario*		
Blacksmith Lapwing	*Vanellus armatus*		
Black-winged Stilt	*Himantopus himantopus*		
Bokmakierie	*Telophorus zeylonus*		
Cape Bunting	*Emberiza capensis*		
Cape Clapper Lark	*Mirafra apiata*		
Cape Shoveler	*Anas smithii*		
Cape Teal	*Anas capensis*		
Cape Wagtail	*Motacilla capensis*		
Capped Wheatear	*Oenanthe pileata*		
Crowned Lapwing	*Vanellus coronatus*		
Egyptian Goose	*Alopochen aegyptiaca*		
Familiar Chat	*Oenanthe familiaris*		
Grey Tit	*Melaniparus afer*		
Grey-backed Cisticola	*Cisticola subruficapilla*		
Hadada Ibis	*Bostrychia hagedash*		
House Sparrow	*Passer domesticus*		
Jackal Buzzard	*Buteo rufofuscus*		
Karoo Eremomela	*Eremomela gregalis*		
Karoo Korhaan	*Eupodotis vigorsii*	Near threatened	Least concern
Karoo Lark	*Calendulauda albescens*		
Karoo Long-billed Lark	*Certhilauda subcoronata*		
Karoo Prinia	*Prinia maculosa*		
Karoo Scrub Robin	*Cercotrichas coryphoeus*		
Large-billed Lark	*Galerida magnirostris*		
Layard's Warbler	*Curruca layardi*		
Ludwig's Bustard	*Neotis ludwigii*	Endangered	Endangered
Mountain Wheatear	*Myrmecocichla monticola*		
Pale Chanting Goshawk	*Melierax canorus*		
Pied Avocet	*Recurvirostra avosetta*		
Pied Crow	*Corvus albus*		
Pied Starling	*Lamprotornis bicolor*		
Red-capped Lark	*Calandrella cinerea*		
Ring-necked Dove	*Streptopelia capicola*		
Rock Kestrel	*Falco rupicolus*		
Rufous-eared Warbler	*Malcorus pectoralis*		
Sickle-winged Chat	*Emarginata sinuata*		
South African Shelduck	*Tadorna cana*		
Southern Fiscal	*Lanius collaris*		

Speckled Pigeon	*Columba guinea*		
Spike-heeled Lark	*Chersomanes albofasciata*		
Spotted Eagle-Owl	*Bubo africanus*		
Three-banded Plover	*Charadrius tricollaris*		
Verreaux's Eagle	*Aquila verreauxii*	Vulnerable	Least concern
White-necked Raven	*Corvus albicollis*		
Yellow Canary	*Crithagra flaviventris*		
Yellow-bellied Eremomela	*Eremomela icteropygialis*		
Yellow-billed Duck	*Anas undulata*		

4.2 Nests

The nests of SCC that were recorded during the site surveys are discussed below.

4.2.1 Verreaux's Eagle

- A total of four Verreaux's Eagle nests have been recorded on the escarpment edge in the proximity of the proposed WEF.
- The latest version of the BLSA Verreaux's Eagle (VE) guidelines (November 2021) require that all Verreaux's Eagle nests are buffered regardless of whether the nest is active at the time of the monitoring (i.e. containing an egg of nestling), because the nest is an indication of an occupied territory, or a vacant territory which could be occupied in future.
- The VE guidelines recommend the application of the VERA model in addition to the conventional monitoring, to determine high risk areas that need to be avoided by wind turbines.
- Alternatively, should VERA not be applied, the VE guidelines recommend that a minimum 3.7km **high risk** turbine exclusion zone should be placed around all nests where no turbines should be located. In addition, all turbines in the area >3.7km up to 5.2km should be regarded as **medium-risk** and relocated if possible. Should relocation not be feasible, these turbines should be subject to pro-active mitigation in the form of a proven mitigation method such as Shutdown on Demand (SDoD), using either biomonitors or an automated system such as IdentiFlight.
- In addition, the Verreaux's Eagle guidelines require all areas of high risk such as ridges where high flight activity can be expected, to be designated as a **high-risk** turbine exclusion zones.
- The applicant adjusted the layout in 2019 to accommodate the recommended 3km turbine exclusion zones in the first edition of the Verreaux's Eagle guidelines (Ralston-Patton 2017) by reducing the number of wind turbines to 39 from the original 47 turbines, and shifting the location of turbines.
- The applicant further adjusted and reduced the wind turbine layout to the current 25 turbines to accommodate the proposed avifaunal turbine exclusion zones as far as possible but indicated that the 3.7km turbine exclusion zones required by the second edition (2021) of the Verreaux's Eagle guidelines, cannot be accommodated in totality without compromising the viability of the project. It is noted that the project received EA before any of the Verreaux's Eagle guidelines, or the Verreaux's Eagle Risk Assessment (VERA) model came in to being. This is however not regarded to be a fatal flaw and a 3km turbine exclusion zone around identified nests and 660m along the escarpment have been implemented by the applicant (see below). In addition, appropriate mitigation measures (i.e., shut down on demand and blade painting) have been provided in order to mitigate against any potential impacts in this regard. These must be strictly implemented and adhered to.

See Figure 2 for the location of the Verreaux's Eagle nests, with proposed buffer zones. The buffer zones consist of a combination of the 1st edition of the Verreaux's Eagle guidelines (2017), and the 2nd edition of the Verreaux's Eagle guidelines (2021), as follows:

- **High risk:** Turbine exclusion zone i.e. 3km around identified nests and 660m along the escarpment.
- **Medium-risk:** Turbines to be subject to mitigation such as Shutdown on Demand (SDoD), using either biomonitors or an automated system such a IdentiFlight within the 3 – 5.2km zone around the VE nests.

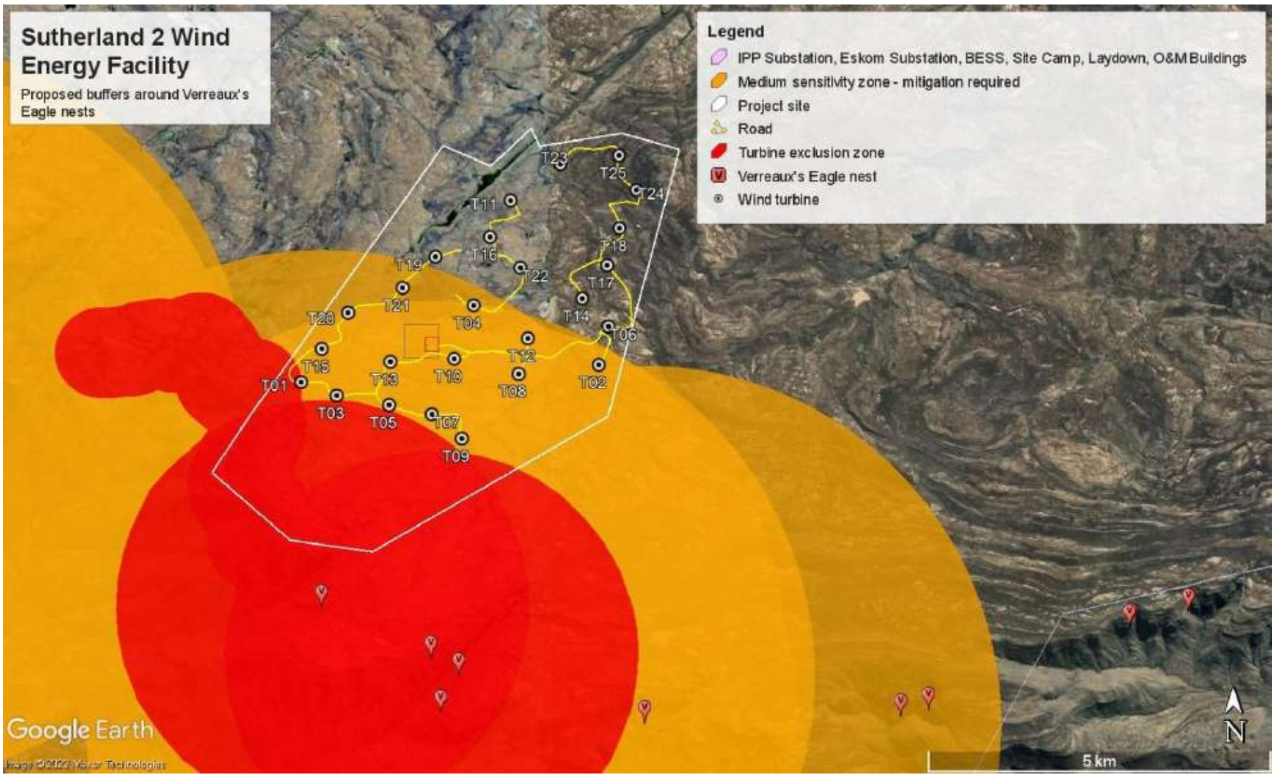

Figure 2: The location of Verreaux's Eagle nests along the escarpment, and the recommended buffer zones.

4.3 Other sensitivities

Surface water (drainage lines and dams) is crucially important for priority avifauna, including all SCC in this dry climate. It is important to leave open space with no obstructions for birds to access and leave the surface water area unhindered. It is therefore required to exclude wind turbines, in this instance the **turbine exclusion zones identified by the bat specialist and those indicated by the aquatic specialist were deemed suitable for avifauna as well** (Figure 3).

5 132kV GRID CONNECTION

The approved EMPrs for the WEF, IPP portion of the on-site substation, Eskom portion of the on-site substation and the 132kV overhead powerline requires that anti-collision devices such as bird flappers must be fitted where the powerline crosses avifaunal corridors, as recommended by the Avifaunal specialist (Condition 33 of the EMPr (DFFE Ref: 14/12/16/3/3/1/1814/2) dated 20 October 2021). The followings sections of the powerline have been identified for the fitting of Bird Flight Diverters (BFDs):

- Sections running between waterbodies
- Sections running through pristine areas where there are no existing powerlines

Figure 4 indicates the sections of power line requiring BFDs.

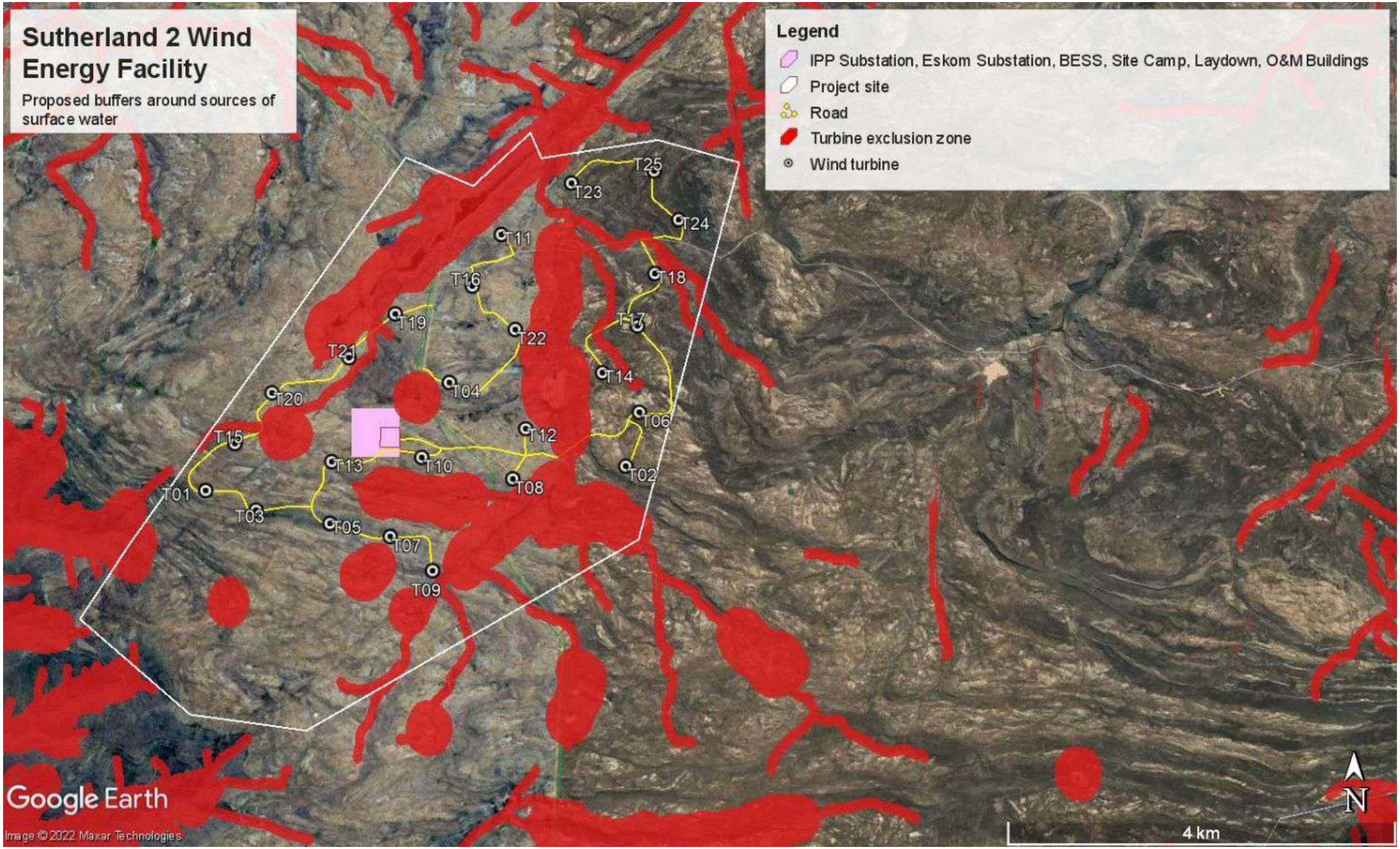

Figure 3: Proposed wind turbine exclusion zones around major drainage lines and waterpoints & dams.

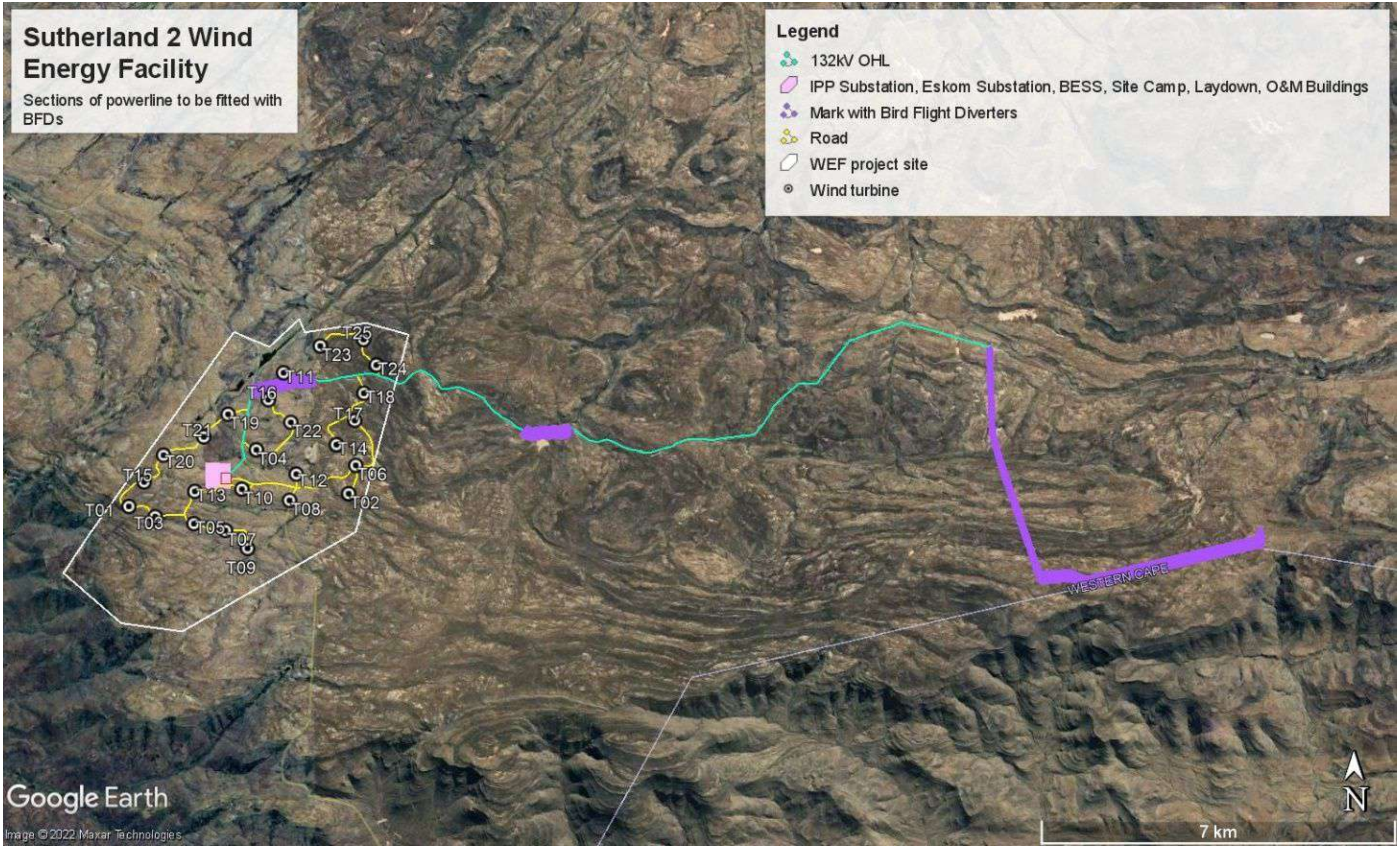

Figure 4: Sections of the 132kV OHL requiring marking with BFDs

6 RECOMMENDATIONS

The recommendations below are put forward for inclusion in the Final EMPr. These recommendations are based on the pre-construction monitoring conducted in 2015-2016 (Van Rooyen *et al*. 2016) and the walk-through exercises and nest inspections in 2019, 2021, and 2022, and **replace the recommendations contained in the original Avian Impact Assessment Report (Jenkins 2011), which are now outdated**:

6.1 Design phase

- A 3km turbine exclusion zone must be implemented around identified Verreaux's Eagle nests, and a 660m turbine exclusion zone along the escarpment (Figure 2).
- A programme of observer-based or automated Shutdown on Demand (SDoD) to reduce potential Verreaux's Eagle turbine collisions must be implemented within the 3 – 5.2km medium-risk buffer zone.
- It is recommended that turbine exclusion zones are implemented around all sources of surface water as indicated by the bat and aquatic specialists, as a pre-cautionary measure against SCC and other priority species collisions (Figure 5).
- All internal 33kV medium voltage cables are to be buried if technically possible.
- Those sections where the 33kV medium voltage cable cannot be trenched due to technical or environmental reasons, but needs to run on overhead poles, the proposed pole designs must be approved by the avifaunal specialist, to ensure that the designs are raptor friendly.
- Bird flight diverters are to be fitted to all internal overhead lines, as well as the sections of the 132kV grid connection as indicated in Figure 4, according to the applicable Eskom Engineering Instruction.
- All wind turbines within the 3 – 5.2km zone must have one blade painted in signal red according to pattern no.4 depicted in Figure (i) below. It is acknowledged that blade painting as a mitigation strategy is still in an experimental phase in South Africa, but research indicates that it has a very good chance of reducing raptor mortality, based on research conducted in Norway (see Simmons *et al*. 2021 (Appendix 5) for an explanation of the science and research behind this mitigation method).

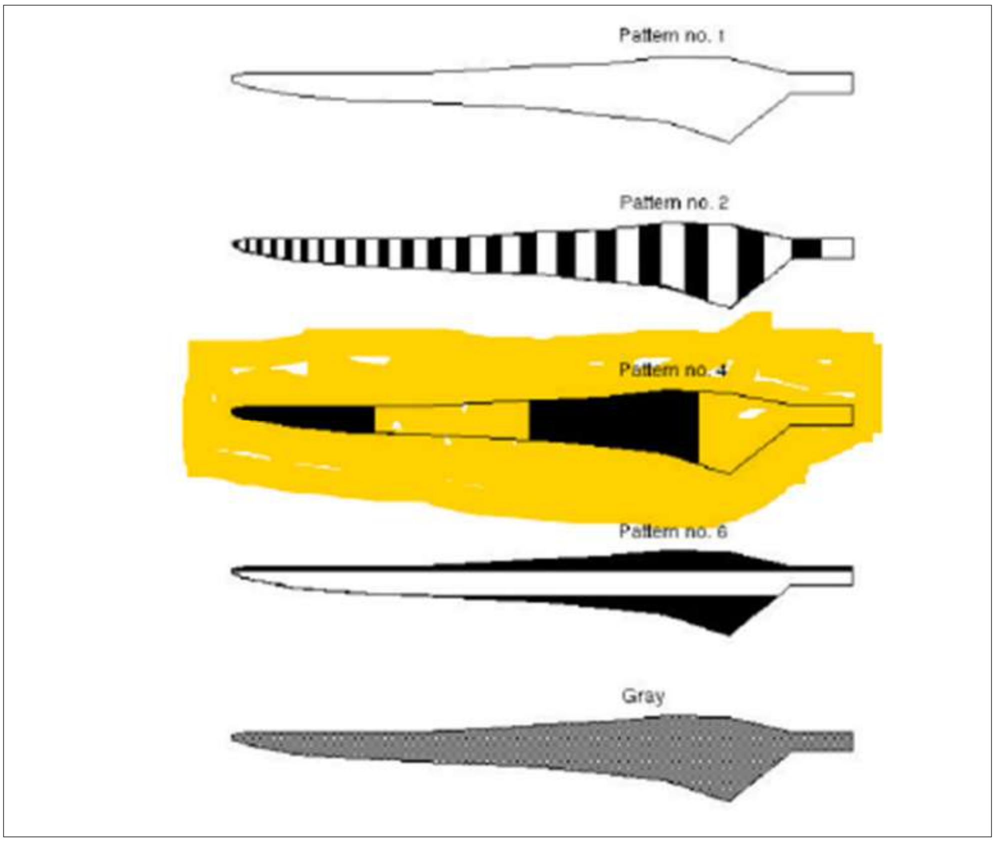

Figure (i): Pattern no.4 is the recommended pattern for blade painting at the WEF

6.2 Construction phase

- 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 strictly controlled to prevent unnecessary disturbance of SCC.
- Removal of vegetation must be restricted to a minimum.
- Construction of new roads should only be considered if existing roads cannot be upgraded.

6.3 Operational phase

- Vehicle and pedestrian access to the site should be controlled and restricted to access roads to prevent unnecessary disturbance of SCC.
- Formal monitoring should be resumed once the wind turbines have been constructed, as per the most recent edition (2015) of the best practice guidelines (Jenkins *et al.* 2011). The exact time when post-construction monitoring should commence, will depend on the construction schedule, and will be agreed upon with the site operator once these timelines and a commercial operational date have been finalised.
- As a 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 for the operational life-time of the facility. The exact scope and nature of the post-construction monitoring will be determined on an ongoing basis by the results of the monitoring through a process of adaptive management.
- Depending on the results of the carcass searches, a range of mitigation measures will have to be considered if mortality levels exceed mortality thresholds as determined by the avifaunal specialist at the time, in consultation with relevant experts, which may include measures such as expanding the SDoD beyond the current zones, selective curtailment of turbines during specific high-risk conditions or any other practical and effective mitigation.

7 IMPACT STATEMENT

The proposed layout was reduced by 46%, from the original 47 wind turbines to the current 25 wind turbines, and **avoids all the recommended avifaunal buffer zones**. The proposed WEF layout is therefore deemed acceptable from an avifauna perspective, and it is recommended that the layout is approved, subject to the implementation of the mitigation measures as detailed in the final EMPr.

8 REFERENCES

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- Mucina. L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.
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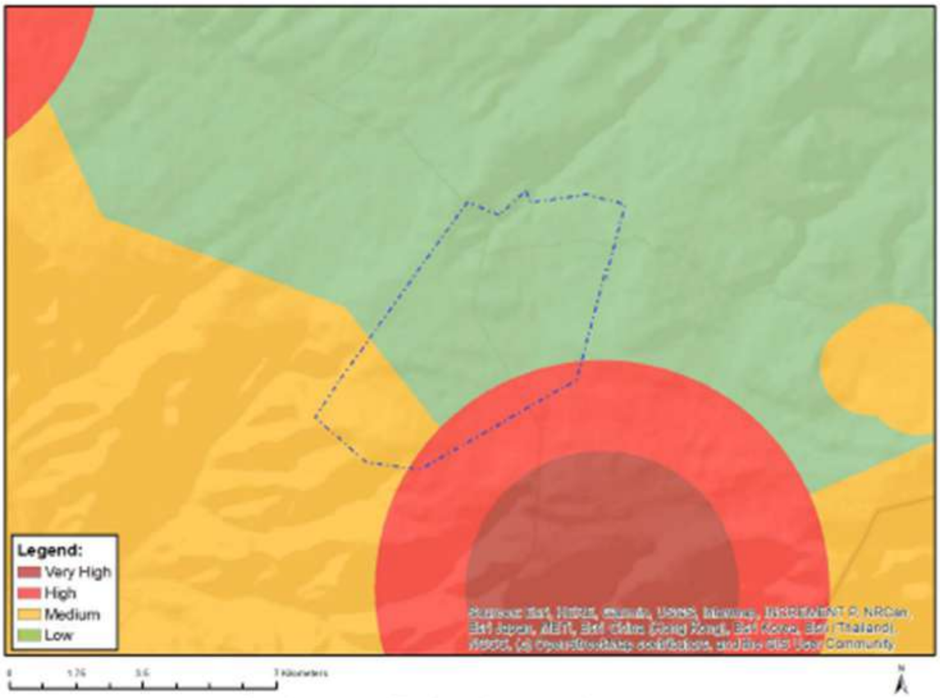
- Ralston-Patton, S. 2017. Verreaux's Eagles and Wind Farms. Guidelines for impact assessment, monitoring, and mitigation. Birdlife South Africa.
- Retief E.F., Diamond M, Anderson M.D., Smit, H.A., Jenkins, A & M. Brooks. 2012. Avian Wind Farm Sensitivity Map. Birdlife South Africa http://www.birdlife.org.za/conservation/birds-and-wind-energy/windmap.
- Simmons, R. E., Martins, M & May, R. 2021. Coloured-blade mitigation at Africa's wind farms to reduce eagle deaths: implementation, challenges and solutions. Unpublished note. Birds & Bats Unlimited.
- Van Rooyen, C., Froneman, A & Laubscher, N. 2016. Avifaunal pre-construction monitoring at three proposed Sutherland Wind Energy Facilities. Unpublished report to Mainstream Renewable Power, August 2016.

APPENDIX 1: DFFE SCREENING REPORTS

MAP OF RELATIVE AVIAN (WIND) THEME SENSITIVITY

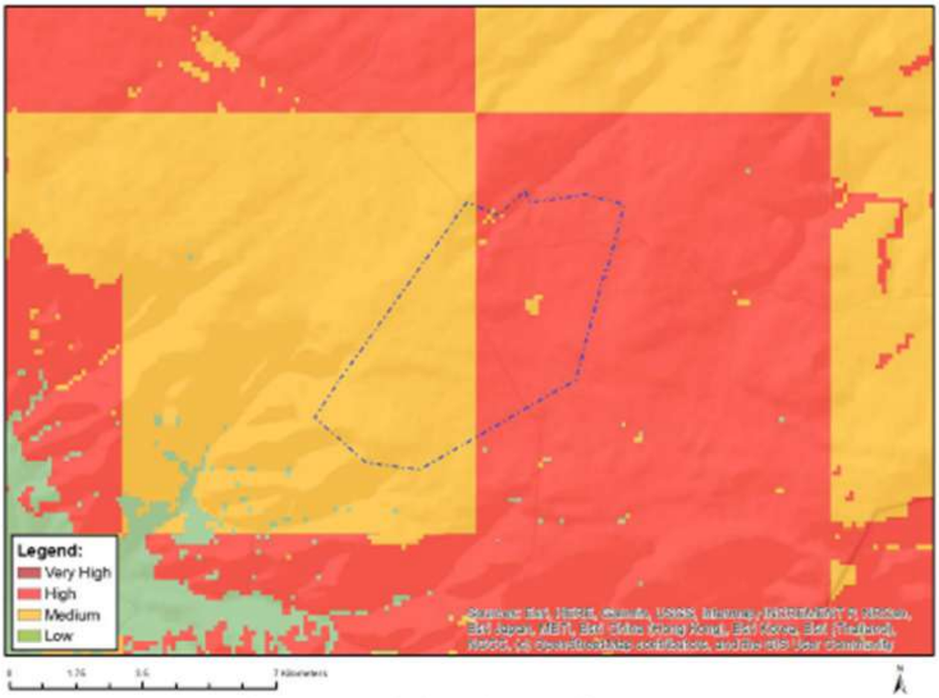


Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Between 3 and 5 km from Verreaux's Eagle nests
High	only areas with high topographic relief;Between 3 and 5 km from Verreaux's Eagle nests
Low	Area Outside Sensitivities
Medium	only areas with high topographic relief

MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



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

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Aves-Neotis ludwigii
High	Aves-Aquila verreauxii
Medium	Aves-Neotis ludwigii
Medium	Aves-Afrotis afra
Medium	Aves-Aquila verreauxii
Medium	Mammalia-Bunolagus monticularis
Medium	Reptilia-Chersobius boulengeri

APPENDIX 2: BIRD HABITAT

Figure 1: Typical Roggeveld Shale Renosterveld vegetation on the plateau above the Komsberg mountains at the project site.

Figure 2: A drainage line on the plateau at the project site

Figure 3: South-facing cliffs along the escarpment at the project site.

Figure 4: A dam on the plateau at the project site.

APPENDIX 3: SPECIES LIST PRE-CONSTRUCTION MONITORING 2015 – 2016

Priority Species	**Scientific Name**	**Turbine**	**Control**	**VP**	**Ctrl VP**	**Incidental**	
Black Harrier	*Circus maurus*	*		*		*	
Black Stork	*Ciconia nigra*					*	
Black-chested Snake-Eagle	*Circaetus pectoralis*		*	*	*	*	
Booted Eagle	*Aquila pennatus*	*		*		*	
Cape Eagle-Owl	*Bubo capensis*					*	
Greater Flamingo	*Phoenicopterus ruber*		*				
Grey-winged Francolin	*Scleroptila africanus*	*	*			*	
Jackal Buzzard	*Buteo rufofuscus*	*	*	*	*	*	
Karoo Korhaan	*Eupodotis vigorsii*	*		*		*	
Lanner Falcon	*Falco biarmicus*		*	*			
Ludwig's Bustard	*Neotis ludwigii*	*		*		*	
Martial Eagle	*Polemaetus bellicosus*		*	*		*	
Peregrine Falcon	*Falco peregrinus*			*			
Sclater's Lark	*Spizocorys sclateri*		*				
Southern Black Korhaan	*Afrotis afra*					*	
Southern Pale Chanting Goshawk	*Melierax canorus*	*	*	*		*	
Spotted Eagle-Owl	*Bubo africanus*					*	
Steppe Buzzard	*Buteo vulpinus*	*		*			
Verreaux's Eagle	*Aquila verreauxii*		*	*	*	*	
19	**Total:**	**8**	**9**	**12**	**3**	**14**	
Non-Priority Species		**Turbine**	**Control**	**VP**	**Ctrl VP**	**Incidental**	**Focal points**
African Black Duck	*Anas sparsa*	*					
African Pipit	*Anthus cinnamomeus*	*	*				
Barn Swallow	*Hirundo rustica*	*	*				
Black-eared Sparrowlark	*Eremopterix australis*	*					
Black-headed Canary	*Serinus alario*	*	*				
Black-headed Heron	*Ardea melanocephala*	*	*				
Blacksmith Lapwing	*Vanellus armatus*	*	*				*
Bokmakierie	*Telophorus zeylonus*	*	*				
Cape Bulbul	*Pycnonotus capensis*	*					
Cape Bunting	*Emberiza capensis*	*	*				
Cape Clapper Lark	*Mirafra apiata*	*	*				
Cape Crow	*Corvus capensis*	*					
Cape Penduline-Tit	*Anthoscopus minutus*	*	*				
Cape Shoveler	*Anas smithii*		*				
Cape Sparrow	*Passer melanurus*	*	*				
Cape Spurfowl	*Pternistis capensis*	*	*				
Cape Teal	*Anas capensis*		*				
Cape Turtle-Dove	*Streptopelia capicola*	*	*				
Cape Wagtail	*Motacilla capensis*	*	*				*
Capped Wheatear	*Oenanthe pileata*	*	*				
Cinnamon-breasted Bunting	*Emberiza tahapisi*	*					
Common Fiscal	*Lanius collaris*	*	*				
Common Greenshank	*Tringa nebularia*						*
Common Starling	*Sturnus vulgaris*		*				
Common Swift	*Apus apus*	*	*				
Common Waxbill	*Estrilda astrild*	*					
Crowned Lapwing	*Vanellus coronatus*	*	*				
Dusky Sunbird	*Cinnyris fuscus*	*					
Egyptian Goose	*Alopochen aegyptiaca*	*	*				*
European Roller	*Coracias garrulus*		*				
Fairy Flycatcher	*Stenostira scita*	*	*				
Familiar Chat	*Cercomela familiaris*	*	*				
Glossy Ibis	*Plegadis falcinellus*		*				
Greater Striped Swallow	*Hirundo cucullata*	*	*				
Grey Heron	*Ardea cinerea*						*
Grey Tit	*Parus afer*	*	*				

Grey-backed Cisticola	*Cisticola subruficapilla*	*	*				
Ground Woodpecker	*Geocolaptes olivaceus*	*					
Hadeda Ibis	*Bostrychia hagedash*	*	*				
Helmeted Guineafowl	*Numida meleagris*	*					
Horus Swift	*Apus horus*	*					
Common House-martin	*Delichon urbicum*		*				
House Sparrow	*Passer domesticus*	*					
Karoo Chat	*Cercomela schlegelii*		*				
Karoo Eremomela	*Eremomela gregalis*	*	*				
Karoo Lark	*Calendulauda albescens*	*	*				
Karoo Long-billed Lark	*Certhilauda subcoronata*	*	*				
Karoo Prinia	*Prinia maculosa*	*	*				
Karoo Scrub-Robin	*Cercotrichas coryphoeus*	*	*				
Kittlitz's Plover	*Charadrius pecuarius*	*	*				*
Large-billed Lark	*Galerida magnirostris*	*	*				
Lark-like Bunting	*Emberiza impetuani*	*	*				
Layard's Tit-Babbler	*Parisoma layardi*	*	*				
Levaillant's Cisticola	*Cisticola tinniens*	*					
Little Stint	*Calidris minuta*						*
Little Swift	*Apus affinis*	*	*				
Long-billed Crombec	*Sylvietta rufescens*	*					
Malachite Sunbird	*Nectarinia famosa*	*					
Mountain Wheatear	*Oenanthe monticola*	*	*				
Namaqua Sandgrouse	*Pterocles namaqua*	*	*				
Pied Crow	*Corvus albus*	*	*				
Pied Starling	*Spreo bicolor*	*	*				
Red-billed Teal	*Anas erythrorhyncha*		*				
Red-capped Lark	*Calandrella cinerea*	*	*				
Red-eyed Dove	*Streptopelia semitorquata*	*	*				
Red-winged Starling	*Onychognathus morio*	*					
Rock Kestrel	*Falco rupicolus*	*	*				
Rock Martin	*Hirundo fuligula*	*	*				
Rufous-eared Warbler	*Malcorus pectoralis*	*	*				
Sickle-winged Chat	*Cercomela sinuata*	*	*				
South African Shelduck	*Tadorna cana*	*	*				*
Southern Double-collared Sunbird	*Cinnyris chalybeus*	*					
Southern Masked-Weaver	*Ploceus velatus*	*					
Speckled Pigeon	*Columba guinea*	*	*				
Spike-heeled Lark	*Chersomanes albofasciata*	*	*				
Spur-winged Goose	*Plectropterus gambensis*		*				*
Three-banded Plover	*Charadrius tricollaris*	*	*				*
White-necked Raven	*Corvus albicollis*	*	*				
White-rumped Swift	*Apus caffer*	*	*				
White-throated Canary	*Crithagra albogularis*	*	*				
Wood Sandpiper	*Tringa glareola*						*
Yellow Canary	*Crithagra flaviventris*	*	*				
Yellow-bellied Eremomela	*Eremomela icteropygialis*	*	*				
Yellow-billed Duck	*Anas undulata*		*				*
84	**Total:**	**70**	**63**				**12**
Grand Total		**78**	**72**	**12**	**3**	**14**	**12**

APPENDIX 4: CURRICULUM VITAE

Expertise of Specialist

Curriculum vitae: Chris van Rooyen

Profession/Specialisation	:	Avifaunal Specialist
Highest Qualification	:	BA LLB
Nationality	:	South African
Years of experience	:	26 years

Key Experience

Chris van Rooyen has 26 years' experience in the assessment of avifaunal interactions with industrial infrastructure. He was employed by the Endangered Wildlife Trust as head of the Eskom-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 consulted in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. He also has extensive project management experience and he has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author and/or co-author of 17 conference papers, co-author of two book chapters, several research reports and the current best practice guidelines for avifaunal monitoring at wind farm sites. He has completed around 130 power line assessments; and has to date been employed as specialist avifaunal consultant on more than 50 renewable energy generation projects. He has also conducted numerous risk assessments on existing power lines infrastructure. He also works outside the electricity industry and he has done a wide range of bird impact assessment studies associated with various residential and industrial developments. He serves on the Birds and Wind Energy Specialist Group which was formed in 2011 to serve as a liaison body between the ornithological community and the wind industry.

Key Project Experience

Bird Impact Assessment Studies and avifaunal monitoring for wind-powered generation facilities:

1. Eskom Klipheuwel Experimental Wind Power Facility, Western Cape
2. Mainstream Wind Facility Jeffreys Bay, Eastern Cape (EIA and monitoring)
3. Biotherm, Swellendam, (Excelsior), Western Cape (EIA and monitoring)
4. Biotherm, Napier, (Matjieskloof), Western Cape (pre-feasibility)
5. Windcurrent SA, Jeffreys Bay, Eastern Cape (2 sites) (EIA and monitoring)
6. Caledon Wind, Caledon, Western Cape (EIA)
7. Innowind (4 sites), Western Cape (EIA)
8. Renewable Energy Systems (RES) Oyster Bay, Eastern Cape (EIA and monitoring)
9. Oelsner Group (Kerriefontein), Western Cape (EIA)
10. Oelsner Group (Langefontein), Western Cape (EIA)
11. InCa Energy, Vredendal Wind Energy Facility Western Cape (EIA)
12. Mainstream Loeriesfontein Wind Energy Facility (EIA and monitoring)
13. Mainstream Noupoort Wind Energy Facility (EIA and monitoring)
14. Biotherm Port Nolloth Wind Energy Facility (Monitoring)
15. Biotherm Laingsburg Wind Energy Facility (EIA and monitoring)
16. Langhoogte Wind Energy Facility (EIA)
17. Vleesbaai Wind Energy Facility (EIA and monitoring)
18. St. Helena Bay Wind Energy Facility (EIA and monitoring)
19. Electrawind, St Helena Bay Wind Energy Facility (EIA and monitoring)
20. Electrawind, Vredendal Wind Energy Facility (EIA)
21. SAGIT, Langhoogte and Wolseley Wind Energy facilities
22. Renosterberg Wind Energy Project – 12-month preconstruction avifaunal monitoring project
23. De Aar – North (Mulilo) Wind Energy Project – 12-month preconstruction avifaunal monitoring project
24. De Aar – South (Mulilo) Wind Energy Project – 12-month bird monitoring
25. Namies – Aggenys Wind Energy Project – 12-month bird monitoring
26. Pofadder - Wind Energy Project – 12-month bird monitoring
27. Dwarsrug Loeriesfontein - Wind Energy Project – 12-month bird monitoring
28. Waaihoek – Utrecht Wind Energy Project – 12-month bird monitoring
29. Amathole – Butterworth Utrecht Wind Energy Project – 12-month bird monitoring & EIA specialist
30. PhezukomEmaya and San Kraal Wind Energy Projects 12-month bird monitoring & EIA specialist study (Innowind)
31. Sutherland Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
32. Leeuwdraai Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mainstream)
33. Sutherland Wind Energy Facility 12-month bird monitoring (Mainstream)
34. Maralla Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
35. Esizayo Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
36. Humansdorp Wind Energy Facility 12-month bird monitoring & EIA specialist study (Cennergi)
37. Aletta Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
38. Eureka Wind Energy Facility 12-month bird monitoring & EIA specialist study (Biotherm)
39. Makambako Wind Energy Facilty (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
40. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
41. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
42. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
43. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
44. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
45. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
46. Dassieklip Wind Energy Facility 3 years post-construction monitoring (Biotherm)
47. Loeriesfontein 2 Wind Energy Facility 2 years post-construction monitoring (Mainstream)
48. Khobab Wind Energy Facility 2 years post-construction monitoring (Mainstream)
49. Excelsior Wind Energy Facility 18 months construction phase monitoring (Biotherm)

50. Boesmansberg Wind Energy Facility 12-months pre-construction bird monitoring (juwi)
51. Mañhica Wind Energy Facility, Mozambique, 12-months pre-construction monitoring (Windlab)
52. Kwagga Wind Energy Facility, Sutherland, 12-months pre-construction monitoring (ABO)
53. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment Studies for Solar Energy Plants:

1. Concentrated Solar Power Plant, Upington, Northern Cape.
2. Globeleq De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
3. JUWI Kronos PV project, Copperton, Northern Cape
4. Sand Draai CSP project, Groblershoop, Northern Cape
5. Biotherm Helena PV Project, Copperton, Northern Cape
6. Biotherm Letsiao CSP Project, Aggeneys, Northern Cape
7. Biotherm Enamandla PV Project, Aggeneys, Northern Cape
8. Biotherm Sendawo PV Project, Vryburg, North-West
9. Biotherm Tlisitseng PV Project, Lichtenburg, North-West
10. JUWI Hotazel Solar Park Project, Hotazel, Northern Cape
11. Veld Solar One Project, Aggeneys, Northern Cape
12. Brypaal Solar Power Project, Kakamas, Northern Cape
13. ABO Vryburg 1,2,3 Solar PV Project, Vryburg, North-West
14. NamPower CSP Facility near Arandis, Namibia
15. Dayson Klip PV Facility near Upington, Northern Cape
16. Geelkop PV Facility near Upington, Northern Cape

Bird Impact Assessment Studies for the following overhead line projects:

1. Chobe 33kV Distribution line
2. Athene - Umfolozi 400kV
3. Beta-Delphi 400kV
4. Cape Strengthening Scheme 765kV
5. Flurian-Louis-Trichardt 132kV
6. Ghanzi 132kV (Botswana)
7. Ikaros 400kV
8. Matimba-Witkop 400kV
9. Naboomspruit 132kV
10. Tabor-Flurian 132kV
11. Windhoek - Walvisbaai 220 kV (Namibia)
12. Witkop-Overyssel 132kV
13. Breyten 88kV
14. Adis-Phoebus 400kV
15. Dhuva-Janus 400kV
16. Perseus-Mercury 400kV
17. Gravelotte 132kV
18. Ikaros 400 kV
19. Khanye 132kV (Botswana)
20. Moropule – Thamaga 220 kV (Botswana)
21. Parys 132kV
22. Simplon –Everest 132kV
23. Tutuka-Alpha 400kV
24. Simplon-Der Brochen 132kV
25. Big Tree 132kV
26. Mercury-Ferrum-Garona 400kV
27. Zeus-Perseus 765kV
28. Matimba B Integration Project
29. Caprivi 350kV DC (Namibia)
30. Gerus-Mururani Gate 350kV DC (Namibia)
31. Mmamabula 220kV (Botswana)
32. Steenberg-Der Brochen 132kV
33. Venetia-Paradise T 132kV
34. Burgersfort 132kV
35. Majuba-Umfolozi 765kV
36. Delta 765kV Substation
37. Braamhoek 22kV
38. Steelpoort Merensky 400kV
39. Mmamabula Delta 400kV
40. Delta Epsilon 765kV
41. Gerus-Zambezi 350kV DC Interconnector: Review of proposed avian mitigation measures for the Okavango and Kwando River crossings
42. Giyani 22kV Distribution line
43. Liqhobong-Kao 132/11kV distribution power line, Lesotho
44. 132kV Leslie – Wildebeest distribution line
45. A proposed new 50 kV Spoornet feeder line between Sishen and Saldanha
46. Cairns 132kv substation extension and associated power lines
47. Pimlico 132kv substation extension and associated power lines
48. Gyani 22kV
49. Matafin 132kV
50. Nkomazi_Fig Tree 132kV
51. Pebble Rock 132kV
52. Reddersburg 132kV

53. Thaba Combine 132kV
54. Nkomati 132kV
55. Louis Trichardt – Musina 132kV
56. Endicot 44kV
57. Apollo Lepini 400kV
58. Tarlton-Spring Farms 132kV
59. Kuschke 132kV substation
60. Bendstore 66kV Substation and associated lines
61. Kuiseb 400kV (Namibia)
62. Gyani-Malamulele 132kV
63. Watershed 132kV
64. Bakone 132kV substation
65. Eerstegoud 132kV LILO lines
66. Kumba Iron Ore: SWEP - Relocation of Infrastructure
67. Kudu Gas Power Station: Associated power lines
68. Steenberg Booysendal 132kV
69. Toulon Pumps 33kV
70. Thabatshipi 132kV
71. Witkop-Silica 132kV
72. Bakubung 132kV
73. Nelsriver 132kV
74. Rethabiseng 132kV
75. Tilburg 132kV
76. GaKgapane 66kV
77. Knobel Gilead 132kV
78. Bochum Knobel 132kV
79. Madibeng 132kV
80. Witbank Railway Line and associated infrastructure
81. Spencer NDP phase 2 (5 lines)
82. Akanani 132kV
83. Hermes-Dominion Reefs 132kV
84. Cape Pensinsula Strengthening Project 400kV
85. Magalakwena 132kV
86. Benficosa 132kV
87. Dithabaneng 132kV
88. Taunus Diepkloof 132kV
89. Taunus Doornkop 132kV
90. Tweedracht 132kV
91. Jane Furse 132kV
92. Majeje Sub 132kV
93. Tabor Louis Trichardt 132kV
94. Riversong 88kV
95. Mamatsekele 132kV
96. Kabokweni 132kV
97. MDPP 400kV Botswana
98. Marble Hall NDP 132kV
99. Bokmakiere 132kV Substation and LILO lines
100. Styldrift 132kV
101. Taunus – Diepkloof 132kV
102. Bighorn NDP 132kV
103. Waterkloof 88kV
104. Camden – Theta 765kV
105. Dhuva – Minerva 400kV Diversion
106. Lesedi –Grootpan 132kV
107. Waterberg NDP
108. Bulgerivier – Dorset 132kV
109. Bulgerivier – Toulon 132kV
110. Nokeng-Fluorspar 132kV
111. Mantsole 132kV
112. Tshilamba 132kV
113. Thabamoopo - Tshebela – Nhlovuko 132kV
114. Arthurseat 132kV
115. Borutho 132kV MTS
116. Volspruit - Potgietersrus 132kV
117. Neotel Optic Fibre Cable Installation Project: Western Cape
117. Matla-Glockner 400kV
118. Delmas North 44kV
119. Houwhoek 11kV Refurbishment
120. Clau-Clau 132kV
121. Ngwedi-Silwerkrans 134kV
122. Nieuwehoop 400kV walk-through
123. Booysendal 132kV Switching Station
124. Tarlton 132kV
125. Medupi - Witkop 400kV walk-through
126. Germiston Industries Substation
127. Sekgame 132kV
128. Botswana – South Africa 400kV Transfrontier Interconnector
129. Syferkuil – Rampheri 132kV
130. Queens Substation and associated 132kV powerlines
131. Oranjemond 400kV Transmission line
132. Aries – Helios – Juno walk-down

133. Kuruman Phase 1 and 2 Wind Energy facilities 132kV Grid connection
134. Transnet

Bird Impact Assessment Studies for the following residential and industrial developments:

1. Lizard Point Golf Estate
2. Lever Creek Estates
3. Leloko Lifestyle Estates
4. Vaaloewers Residential Development
5. Clearwater Estates Grass Owl Impact Study
6. Sommerset Ext. Grass Owl Study
7. Proposed Three Diamonds Trading Mining Project (Portion 9 and 15 of the Farm Blesbokfontein)
8. N17 Section: Springs To Leandra –“Borrow Pit 12 And Access Road On (Section 9, 6 And 28 Of The Farm Winterhoek 314 Ir)
9. South African Police Services Gauteng Radio Communication System: Portion 136 Of The Farm 528 Jq, Lindley.
10. Report for the proposed upgrade and extension of the Zeekoegat Wastewater Treatment Works, Gauteng.
11. Bird Impact Assessment for Portion 265 (a portion of Portion 163) of the farm Rietfontein 189-JR, Gauteng.
12. Bird Impact Assessment Study for Portions 54 and 55 of the Farm Zwartkop 525 JQ, Gauteng.
13. Bird Impact Assessment Study Portions 8 and 36 of the Farm Nooitgedacht 534 JQ, Gauteng.
14. Shumba’s Rest Bird Impact Assessment Study
15. Randfontein Golf Estate Bird Impact Assessment Study
16. Zilkaatsnek Wildlife Estate
17. Regenstein Communications Tower (Namibia)
18. Avifaunal Input into Richards Bay Comparative Risk Assessment Study
19. Maquasa West Open Cast Coal Mine
20. Glen Erasmia Residential Development, Kempton Park, Gauteng
21. Bird Impact Assessment Study, Weltevreden Mine, Mpumalanga
22. Bird Impact Assessment Study, Olifantsvlei Cemetery, Johannesburg
23. Camden Ash Disposal Facility, Mpumalanga
24. Lindley Estate, Lanseria, Gauteng
25. Proposed open cast iron ore mine on the farm Lylyveld 545, Northern Cape
26. Avifaunal monitoring for the Sishen Mine in the Northern Cape as part of the EMPr requirements
27. Steelpoort CNC Bird Impact Assessment Study

Professional affiliations

I work under the supervision of and in association with Albert Froneman (MSc Conservation Biology) (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003.

Chris van Rooyen
17 November 2022

Expertise of Specialist

Curriculum vitae: Albert Froneman (Pr.Sci.Nat Registration no: 400177/09)

Profession/Specialisation : Avifaunal Specialist
Highest Qualification : MSc (Conservation Biology)
Nationality : South African
Years of experience : 24 years

Key Qualifications

Albert Froneman **(**Pr.Sci.Nat) has more than 24 years' experience in the management of avifaunal interactions with industrial infrastructure. He holds a M.Sc. degree in Conservation Biology from the University of Cape Town. He managed the Airports Company South Africa (ACSA) – Endangered Wildlife Trust Strategic Partnership from 1999 to 2008 which has been internationally recognized for its achievements in addressing airport wildlife hazards in an environmentally sensitive manner at ACSA's airports across South Africa. Albert is recognized worldwide as an expert in the field of bird hazard management on airports and has worked in South Africa, Swaziland, Botswana, Namibia, Kenya, Israel, and the USA. He has served as the vice chairman of the International Bird Strike Committee and has presented various papers at international conferences and workshops. At present he is consulting to ACSA with wildlife hazard management on all their airports. He also an accomplished specialist ornithological consultant outside the aviation industry and has completed a wide range of bird impact assessment studies. He has co-authored many avifaunal specialist studies and pre-construction monitoring reports for proposed renewable energy developments across South Africa. He also has vast experience in using Geographic Information Systems to analyse and interpret avifaunal data spatially and derive meaningful conclusions. Since 2009 Albert has been a registered Professional Natural Scientist (reg. nr 400177/09) with The South African Council for Natural Scientific Professions, specialising in Zoological Science.

Key Project Experience

Renewable Energy Facilities –avifaunal monitoring projects in association with Chris van Rooyen Consulting

1. Jeffrey's Bay Wind Farm – 12-months preconstruction avifaunal monitoring project
2. Oysterbay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
3. Ubuntu Wind Energy Project near Jeffrey's Bay – 12-months preconstruction avifaunal monitoring project
4. Bana-ba-Pifu Wind Energy Project near Humansdorp – 12-months preconstruction avifaunal monitoring project
5. Excelsior Wind Energy Project near Caledon – 12-months preconstruction avifaunal monitoring project
6. Laingsburg Spitskopvlakte Wind Energy Project – 12-months preconstruction avifaunal monitoring project
7. Loeriesfontein Wind Energy Project Phase 1, 2 & 3 – 12-months preconstruction avifaunal monitoring project
8. Noupoort Wind Energy Project – 12-months preconstruction avifaunal monitoring project
9. Vleesbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
10. Port Nolloth Wind Energy Project – 12-months preconstruction avifaunal monitoring project
11. Langhoogte Caledon Wind Energy Project – 12-months preconstruction avifaunal monitoring project
12. Lunsklip – Stilbaai Wind Energy Project – 12-months preconstruction avifaunal monitoring project
13. Indwe Wind Energy Project – 12-months preconstruction avifaunal monitoring project
14. Zeeland St Helena bay Wind Energy Project – 12-months preconstruction avifaunal monitoring project
15. Wolseley Wind Energy Project – 12-months preconstruction avifaunal monitoring project
16. Renosterberg Wind Energy Project – 12-months preconstruction avifaunal monitoring project
17. De Aar – North (Mulilo) Wind Energy Project – 12-months preconstruction avifaunal monitoring project (2014)
18. De Aar – South (Mulilo) Wind Energy Project – 12-months bird monitoring
19. Namies – Aggenys Wind Energy Project – 12-months bird monitoring
20. Pofadder - Wind Energy Project – 12-months bird monitoring
21. Dwarsrug Loeriesfontein - Wind Energy Project – 12-months bird monitoring
22. Waaihoek – Utrecht Wind Energy Project – 12-months bird monitoring
23. Amathole – Butterworth Utrecht Wind Energy Project – 12-months bird monitoring & EIA specialist study
24. De Aar and Droogfontein Solar PV Pre- and Post-construction avifaunal monitoring
25. Makambako Wind Energy Faclity (Tanzania) 12-month bird monitoring & EIA specialist study (Windlab)
26. R355 Wind Energy Facility 12-month bird monitoring (Mainstream)
27. Groenekloof Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
28. Tsitsikamma Wind Energy Facility 24-months post-construction monitoring (Cennergi)
29. Noupoort Wind Energy Facility 24-months post-construction monitoring (Mainstream)
30. Kokerboom Wind Energy Facility 12-month bird monitoring & EIA specialist study (Business Venture Investments)
31. Kuruman Wind Energy Facility 12-month bird monitoring & EIA specialist study (Mulilo)
32. Mañhica Wind Energy Facility 12-month bird monitoring & EIA specialist study (Windlab)
33. Kwagga Wind Energy Facility, Sutherland, 12-months pre-construction monitoring (ABO)
34. Pienaarspoort Wind Energy Facility, Touws River, Western Cape, 12-months pre-construction monitoring (ABO).

Bird Impact Assessment studies and / or GIS analysis:

1. Aviation Bird Hazard Assessment Study for the proposed Madiba Bay Leisure Park adjacent to Port Elizabeth Airport.
2. Extension of Runway and Provision of Parallel Taxiway at Sir Seretse Khama Airport, Botswana Bird / Wildlife Hazard Management Specialist Study
3. Maun Airport Improvements Bird / Wildlife Hazard Management Specialist Study
4. Bird Impact Assesment Study - Bird Helicopter Interaction – The Bitou River, Western Cape Province South Africa
5. Proposed La Mercy Airport – Bird Aircraft interaction specialists study using bird detection radar to assess swallow flocking behaviour
6. KwaZulu Natal Power Line Vulture Mitigation Project – GIS analysis
7. Perseus-Zeus Powerline EIA – GIS Analysis
8. Southern Region Pro-active GIS Blue Crane Collision Project.
9. Specialist advisor ~ Implementation of a bird detection radar system and development of an airport wildlife hazard management and operational environmental management plan for the King Shaka International Airport
10. Matsapha International Airport – bird hazard assessment study with management recommendations
11. Evaluation of aviation bird strike risk at candidate solid waste disposal sites in the Ekurhuleni Metropolitan Municipality

12. Gateway Airport Authority Limited – Gateway International Airport, Polokwane: Bird hazard assessment; Compile a bird hazard management plan for the airport
13. Bird Specialist Study - Evaluation of aviation bird strike risk at the Mwakirunge Landfill site near Mombasa Kenya
14. Bird Impact Assessment Study - Proposed Weltevreden Open Cast Coal Mine Belfast, Mpumalanga
15. Avian biodiversity assessment for the Mafube Colliery Coal mine near Middelburg Mpumalanga
16. Avifaunal Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
17. Avifaunal Impact Assessment Study (with specific reference to African Grass Owls and other Red List species) Stone Rivers Arch
18. Airport bird and wildlife hazard management plan and training to Swaziland Civil Aviation Authority (SWACAA) for Matsapha and Sikhupe International Airports
19. Avifaunal Impact Scoping & EIA Study - Renosterberg Wind Farm and Solar PV site
20. Bird Impact Assessment Study - Proposed 60 year Ash Disposal Facility near to the Kusile Power Station
21. Avifaunal pre-feasibility assessment for the proposed Montrose dam, Mpumalanga
22. Bird Impact Assessment Study – Proposed ESKOM Phantom Substation near Knysna, Western Cape
23. Habitat sensitivity map for Denham's Bustard, Blue Crane and White-bellied Korhaan in the Kouga Municipal area of the Eastern Cape Province
24. Swaziland Civil Aviation Authority – Sikhuphe International Airport – Bird hazard management assessment
25. Avifaunal monitoring – extension of Specialist Study - SRVM Volspruit Mining project – Mokopane Limpopo Province
26. Avifaunal Specialist Study – Rooikat Hydro Electric Dam – Hope Town, Northern Cape
27. The Stewards Pan Reclamation Project – Bird Impact Assessment study
28. Airports Company South Africa – Avifaunal Specialist Consultant – Airport Bird and Wildlife Hazard Mitigation

Geographic Information System analysis & maps

1. ESKOM Power line Makgalakwena EIA – GIS specialist & map production
2. ESKOM Power line Benficosa EIA – GIS specialist & map production
3. ESKOM Power line Riversong EIA – GIS specialist & map production
4. ESKOM Power line Waterberg NDP EIA – GIS specialist & map production
5. ESKOM Power line Bulge Toulon EIA – GIS specialist & map production
6. ESKOM Power line Bulge DORSET EIA – GIS specialist & map production
7. ESKOM Power lines Marblehall EIA – GIS specialist & map production
8. ESKOM Power line Grootpan Lesedi EIA – GIS specialist & map production
9. ESKOM Power line Tanga EIA – GIS specialist & map production
10. ESKOM Power line Bokmakierie EIA – GIS specialist & map production
11. ESKOM Power line Rietfontein EIA – GIS specialist & map production
12. Power line Anglo Coal EIA – GIS specialist & map production
13. ESKOM Power line Camcoll Jericho EIA – GIS specialist & map production
14. Hartbeespoort Residential Development – GIS specialist & map production
15. ESKOM Power line Mantsole EIA – GIS specialist & map production
16. ESKOM Power line Nokeng Flourspar EIA – GIS specialist & map production
17. ESKOM Power line Greenview EIA – GIS specialist & map production
18. Derdepoort Residential Development – GIS specialist & map production
19. ESKOM Power line Boynton EIA – GIS specialist & map production
20. ESKOM Power line United EIA – GIS specialist & map production
21. ESKOM Power line Gutshwa & Malelane EIA – GIS specialist & map production
22. ESKOM Power line Origstad EIA – GIS specialist & map production
23. Zilkaatsnek Development Public Participation –map production
24. Belfast – Paarde Power line - GIS specialist & map production
25. Solar Park Solar Park Integration Project Bird Impact Assessment Study – avifaunal GIS analysis.
26. Kappa-Omega-Aurora 765kV Bird Impact Assessment Report – Avifaunal GIS analysis.
27. Gamma – Kappa 2nd 765kV – Bird Impact Assessment Report – Avifaunal GIS analysis.
28. ESKOM Power line Kudu-Dorstfontein Amendment EIA – GIS specialist & map production.
29. Proposed Heilbron filling station EIA – GIS specialist & map production
30. ESKOM Lebatlhane EIA – GIS specialist & map production
31. ESKOM Pienaars River CNC EIA – GIS specialist & map production
32. ESKOM Lemara Phiring Ohrigstad EIA – GIS specialist & map production
33. ESKOM Pelly-Warmbad EIA – GIS specialist & map production
34. ESKOM Rosco-Bracken EIA – GIS specialist & map production
35. ESKOM Ermelo-Uitkoms EIA – GIS specialist & map production
36. ESKOM Wisani bridge EIA – GIS specialist & map production
37. City of Tswane – New bulkfeeder pipeline projects x3 Map production
38. ESKOM Lebohang Substation and 132kV Distribution Power Line Project Amendment GIS specialist & map production
39. ESKOM Geluk Rural Powerline GIS & Mapping
40. Eskom Kimberley Strengthening Phase 4 Project GIS & Mapping
41. ESKOM Kwaggafontein - Amandla Amendment Project GIS & Mapping
42. ESKOM Lephalale CNC – GIS Specialist & Mapping
43. ESKOM Marken CNC – GIS Specialist & Mapping
44. ESKOM Lethabong substation and powerlines – GIS Specialist & Mapping
45. ESKOM Magopela- Pitsong 132kV line and new substation – GIS Specialist & Mapping

Professional affiliations

South African Council for Natural Scientific Professions (SACNASP) registered Professional Natural Scientist (reg. nr 400177/09) – specialist field: Zoological Science. Registered since 2009.

Signature of the Specialist

Albert Froneman
17 November 2022

APPENDIX 5: BLADE PAINTING AS MITIAGTION STRATEGY

Coloured-blade mitigation at Africa's wind farms to reduce eagle deaths: implementation, challenges and solutions

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Introduction

The recent publication of the ground-breaking experimental study of black-blade mitigation at an operational wind farms in Norway (May et al. 2020) has opened up a new and exciting method that could reduce avian fatalities at wind farms in other, more biologically diverse area of the world where renewable energies are being rolled out. This contribution :

- Explains what black/coloured-blade mitigation is
- Outlines the theory behind the black-blade mitigation
- Outlines the field test of the idea
- Summarises the challenges for rolling it out in Africa
- Assesses what it could mean for reducing raptor fatalities in Africa

Figure 1: The single black-blade in the process of being painted in situ, at the Smøla Wind Farm. Painting white blades black after they are erected is more expensive than producing them at source.

Rationale

Research around the world has shown that avian populations are declining due to climate change effects arising from increasing temperature and decreased rainfall in arid areas (www.ipcc.ch/, Thomas et al. 2004, Simmons et al. 2004, Phipps et al. 2017). In the USA, non-renewable fossil fuel energy sources are estimated to kill ~14.5 million birds annually, whereas green wind energy kills about 234 000 birds per year (Sovacool 2013, Loss et al. 2013). That is a 62-fold difference and a powerful environmental argument in support of renewable energy for our future needs. But while wind farms have many positive effects, they also pose some environmental challenges, particularly where wind farms are poorly positioned (on migration corridors for example Smallwood references).

In Africa two data sets on avian fatalities indicate that an average of 2.0 bird (adjusted) fatalities occur per MW per year in South Africa (Perold et al. 2020), and at one farm 1 raptor per month is killed of which 17% are breeding red data raptors (Simmons and Martins 2018). With about 2294 MW already being produced by 27 operational farms here in 2019 (energy.org.za), the cumulative impacts of South African wind farms alone are in excess of 4500 birds annually. If about 36% (>1600 birds per annum) are predicted to be raptors (Ralston-Paton et al. 2017) and about 17% (Simmons and Martins 2018) are known to be red data species, then an estimated 280 red data raptors are likely to be killed per year in South Africa in 2020. Since taller and longer-bladed turbines kill significantly more birds (Loss et al. 2013) and bats (Barclay et al. 2007) then Africa's threatened birds face increasing risks.

The need for urgent mitigations to reduce these costs is at a premium. Enter the coloured-blade mitigation.

What is coloured-blade mitigation?

This is a new mitigation technique in which one of the three white blades on a wind turbine are painted black (figure 1). About two thirds of the blade to the tip is painted this way. This is designed to increase visibility and decrease avian impacts (May et al. 2020). Since Civil Aviation in South Africa does not allow black but does allow "Signal Red" we propose that this is used in experiments here in South Africa. The amount of paint required can also be reduced by using the two-strip patterning shown in the experiments of McIsaac (see below).

Why black-blade mitigation?

Several innovative mitigation measures have recently been proposed for wind farms (flashing UV lights, automated shut-down-on demand, habitat management: May et al. 2017) and in a few cases have reduced collisions. However, developers are reticent to implement these.

The idea for **Black-blade mitigation** arose from work by Hodos (2003) who argued that a bird's retina views moving objects differently at different distances and as the bird gets close to a fast-moving object, the retinal image is moving so fast that the birds' brain can no longer process it. This was dubbed "motion smear" and means that birds approaching a fast-moving object no longer see it, with disastrous consequences. He suggested that a single coloured-blade may break up the motion smear. This is supported by recent work from Sweden (Potier et al. 2018) who show that raptors, despite their very high visual acuity, have very poor contrast abilities (poorer than humans). So, a coloured blade may be even better than a black one. So, a light (white) blade against a bright background is unlikely to be seen. But a black or coloured one is.

What is the evidence that it works?

Black-blade mitigation was field-tested by May et al. (2020) at the Smøla wind farm in 2013 in Norway over 3.5 years. On Smøla, White-tailed Eagles *Haliaeetus albicilla* are being killed at a very high rate by collision with the turbine blades. Four turbines were painted with a single black-painted blade in summer 2013. The black-painted turbines killed (i) 71% fewer total birds and (ii) 100% fewer eagles relative to unpainted blades.

Even more exciting in 2020 still no eagles have been killed at the coloured-blade turbines since 2013. In other words, no more eagles were killed in the 11-year experiment (starting 7.5 years before painting (2006-2013) and in situ 3.5 years after painting (2013-2016) (May et al.

2020). This despite 45-50 territorial pairs present on the island of Smøla (Dahl et al. 2012). The white-bladed turbines, however, are still killing birds at an average of 6 eagles per year (B. Iuell in litt.).

We see little reason why coloured blade – in the form of **Signal-red**, approved by Civil Aviation, would not work as well. This is because raptors see well in the colour spectrum (i.e. with the cones in the retina as opposed to the rods which see in black and white).

What are the visual impacts?

Discussions with wind farm managers in South Africa and Kenya suggest that visual effects are among the possible negative perceptions. We, therefore, requested the Smøla managers to supply us with images and videos of the turning blades to determine the effects.

Figure 1: The black-blade set up on a cloudy day in Norway is shown left. The black-blade (far turbine) is little different to the shadow cast by the all-white blades in the foreground © Bjorn Iuell.

The effect can be seen in the video kindly provided by Arild Soleim at www.birds-and-bats.com/specialist-studies. This shows little to no visual flicker or intrusion on the landscape from a single coloured-blade, and this concern is largely negated for all but the most sensitive human observer. It also has the effect of making the blade appear slower as one follows the black blade itself.

We argue that the benefits (no eagles killed) far outweigh the costs (initial costs to produce the coloured-blades). And once the blades are installed there will be no further costs as there are with competing mitigations (DT bird, or observer-operated shut-downs).

Black blade and Civil Aviation – white blades are not the most conspicuous

South African Civil Aviation state that white is "to provide the maximum daytime conspicuousness" However this statement was tested by McIsaac (2003) and he found that white is NOT the most conspicuous colour for either a moving blade or a stationary one

Embedded in the experiments undertaken by McIsaac's (2003) on kestrels is this very revealing graphic showing how human observers perceive the same patterns (including pure white).

Raptor Acuity and Wind-Turbine Blade Conspicuity

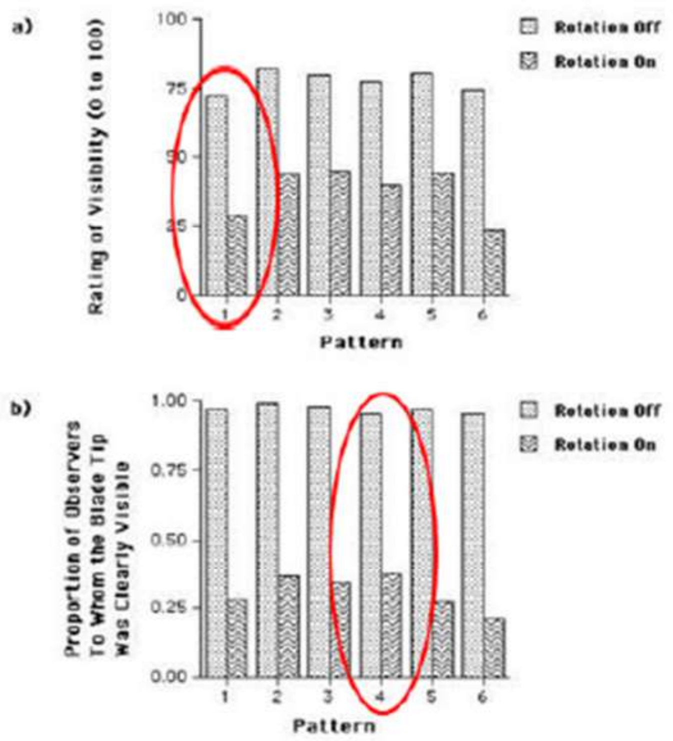

FIGURE 10. Human-perceived blade-pattern conspicuity: two-factor interactions of pattern and rotation. *These diagrams show the relationship between blade-pattern conspicuity and the effects of rotation. Illustrations of the blade patterns are presented in Fig. 9. Both blade pattern and rotation significantly affected conspicuity. Two ratings of pattern conspicuity are presented, a) full-blade visibility ratings, b) blade-tip visibility ratings.*

- **The pure white blade [pattern 1] was perceived as <u>less visible</u> by human observers than 5 of the other 6 patterns used whether the blades were spinning or not (top graph)**
- The <u>tip</u> of the pure white blade [pattern 1] was also perceived as less visible by human observers than 4 of the other 6 patterns used whether the blades were spinning or not (bottom graph)
- Like the Kestrels being tested, human observers saw patterned blades (patterns 2,3,4,5,6) better than pure white [pattern 1].

So, the CAA assumption that white is the most conspicuous colour for humans is not supported by experimentation with either raptorial birds or humans.

Patterned blades are better for both humans and raptors.

It is very important the South African Civil Aviation Authority is aware of these findings. Why? Because their guiding documents on painting of tall structures (**139.01.30 OBSTACLE LIMITATIONS AND MARKINGS OUTSIDE AERODROME OR HELIPORT (effective 1 August 2012)**) makes the following statement under section in **1.14. Wind turbine generators (Windfarms)**

- (4) Windfarm Markings (page 12 of 16)
  Wind turbines shall be painted bright white to provide the maximum daytime conspicuousness. The colours grey, blue and darker shades of white should be avoided altogether. If such colours have been used, the wind turbines shall be supplemented with daytime lighting, as required.

While this assumption that "bright white" would be most obvious to pilots and others, the experiments of McIsaac (2001) indicate that this is a false assumption. The pure white blade performed very poorly in the experiments of McIsaac (2001) and the patterned blade (No. 4 below) performed best of all.

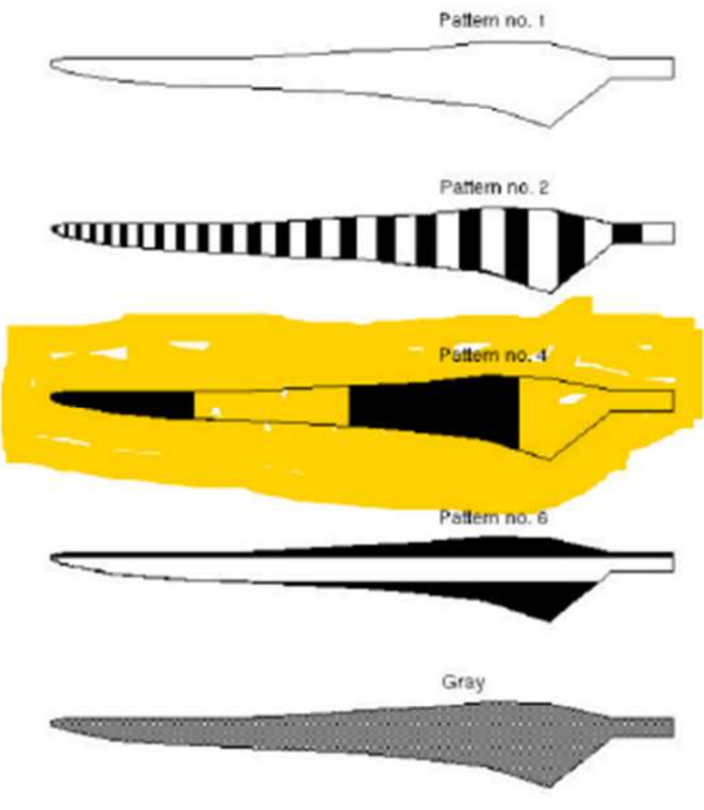

FIGURE 12. Kestrel-perceived blade-pattern conspicuity: stimulus blade patterns. *Depicted are the four black-and-white test patterns and the gray control pattern that were used to determine pattern conspicuity as perceived by a kestrel.*

Can it be applied in an African setting?

Given that eagles and raptors the world over probably see the landscape in similar ways there is a high probability that African eagles will see coloured-blades similarly well. Recent research on other raptors shows that despite their high visual acuity they see contrast more poorly than do humans (Potier, Milbus & Kelber 2019). This nicely explains why raptors take no avoiding action and are struck by white blades in the first place, and second why painting a blade black (increasing the contrast) increases the avoidance of those blades by eagles.

It also breaks up the "motion smear" researched by Hodos (2003) because he predicted a single black or coloured blade would increase the ability of birds to see movement in a set of fast-moving blade (the same effect can be seen by pilots of prop-driven planes, where one blade is painted differently). In an African setting the same can be seen on farmers' metal windmills where a blade is missing or painted on the rapidly spinning blades. Both increase the visual contrast and effect of movement.

The coloured-blade mitigation has yet to be rolled out in Africa – where it is urgently needed, given that we have over 100 species of raptors – more than any other continent (Clark and Davies 2018). Red blade tips have, however, already been used at the Ysterfontein Wind farm in the Western Cape, setting a precedent for their use elsewhere in South Africa.

Figure 2: Red-tipped turbine-blades on turbines at the Ysterfontein wind farm north west of Clanwilliam in the Western Cape (S 32° 9'23.42" E 18°49'7.10"). While these mitigations are not used in the correct single-blade configuration used by the Norwegians, they set a precedent for turbine blades to be red-painted in South Africa © RE Simmons

We have been informed that this mitigation is indeed being rolled out at the Kobe wind farm site in Japan. And there are plans for testing it in the Netherlands (Arjen Schultinga of Innogy, to Iuell Bjorn, Senior Environmental Advisor at Smøla Wind farm.)

This suggests that General Electric Renewables (GE), a manufacture of wind turbine blades, are already in the market for coloured blades. Attempts to engage with GE Renewables through the internet have proven unsuccessful despite contact with officials there.

We as avian specialist recommend the coloured-blade version of the black blade mitigation because (i) it is likely to be seen even more clearly by raptors than black, (ii) South African Civil Aviation (Lizell Stroh) in correspondence with Birdlife SA and Birds & Bats Unlimited have suggested that "signal red" would be preferable to black as it already used for marking structures such as towers, and is approved by them and (iii) the red paint may heat up less than a black blade in an African environment.

Four more aspects to consider from experience at the Smøla wind farm:

(i) It will cost a fraction to paint while the rotor blades are still on the ground instead of installed at the hub. At Smøla the painting was done with the blades up on the tower in situ and proved quite costly. The cost of painting one blade (with the crane lift and specialised personnel) was K55,000 ($5900). For all four blades and all fees and disbursements included over 2 weeks (due mainly to inclement weather) the total cost was c. K750 000 ($79 000). This would have been negligible had the blades been painted on the ground or come pre-painted (B. Iuell pers comm).

(ii) Although not an issue at Smøla, potentially a black blade may increase the blade temperature with potential consequences for blade quality and operation. We noticed that the temperature in the turbine tower at ground level with a painted tower base was high in summer (Stokke et al. 2020); there the surface area is large and more localized, and, of course, is not moving. No such effect was noticed for the black-painted turbine blades and there was no effect of any imbalance of the blades from differential heating of the black blade.

(iii) Smøla wind farm was not allowed to paint turbines which were constructed in the second construction stage due to insurance issues. Thus, guarantees with the blade manufacturers must be secured before the painting takes places – and preferably come pre-manufactured with a blade already painted red or black.

(iv) Each blade weighed 9 tonnes and the blade were painted with Carboline Windmastic TopCoat HSX. Two coats were applied and weighed approximately 60 kg. This is about 0.66% the weight of the blade and no mechanical effects were apparent. On inspection of the paint there was no wear or cracking apparent (B Iuell pers comm).

It is for influential players such as those in the South African Wind Energy Association and other wind farm developers, their governing bodies and avian conservation organisations to lobby the main players such as General Electric and Siemens to roll out this form of mitigation to reduce to a minimum the thousands of raptors deaths likely in future years. Without black or coloured blades on Africa's turbines we will continue to see the high fatality rates already apparent at some wind farms in South Africa (Simmons and Martins 2018, Perold et al. 2020).

With black-blade mitigation now shown to be highly effective in reducing eagle deaths in Norway, there is a great incentive for wind farm developers elsewhere to enact the coloured blade mitigation to reduce raptor deaths, particularly since it has no operational costs once installed.

Acknowledgments

Grateful thanks to Bjorn Iuell (Environmental Advisor to Smøla wind farm) for answering our numerous questions and providing extra information and photographs on Smøla's black blade project. Also to Arild Soleim at Smøla for the video clip of the moving blades, and to Lizell Stroh of SA Civil Aviation for valuable inputs.

Figure 3: A 4-year old Martial Eagle, struck by a white-bladed turbine, plummets to the earth at an Eastern Cape wind farm. Deaths like this could be reduced or avoided with black/coloured blade mitigation . © RE Simmons

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