INYANDA ROODEPLAAT WIND FARM, EASTERN CAPE: AVIFAUNAL IMPACT ASSESSMENT

REPORT TO SRK CONSULTING

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INYANDA ROODEPLAAT WIND FARM: AVIFAUNAL IMPACT ASSESSMENT

EXECUTIVE SUMMARY

This report provides the specialist avifaunal assessment for the proposed Inyanda Roodeplaat Wind Farm (hereinafter referred to as 'the Development'). It describes and evaluates the current ornithological interest of the Development and its surrounds, and provides an assessment of the likely significant impacts of the proposed Development upon ornithology. The assessment has been undertaken by Dr Steve Percival and draws on a previous assessment undertaken by Jon Smallie and more recent surveys carried out in 2015-16. It uses the SRK Consulting assessment methodology, informed by reference to the other international assessment methodologies. The assessment is based on the current proposed 52-turbine site layout, though it is likely that this will be reduced to 45 turbines. The current assessment would therefore be worst-case with respect to the number of turbines.

The initial baseline ornithological data were collected during a 12-month monitoring campaign in 2013-14 organised by Jon Smallie. A range of surveys were conducted, including a desk study, walked transect surveys for small terrestrial birds, vehicle-based transect surveys for large terrestrial species and raptors, eagle breeding/nest surveys and vantage point surveys to quantify/map key species flight activity. Further field surveys were carried out in 2015-16 focussing on the data gaps (particularly vantage point survey coverage) and ornithological sensitivities already identified, including Verreaux's Eagle and Martial Eagle breeding status and distribution, eagle and other large raptor flight activity within and around the proposed wind farm site and species vulnerable to collision with overhead wires along the proposed grid connection route (particularly Blue Crane, and Ludwig's Bustard).

Up to six pairs of Verreaux's Eagles were breeding within 10km of the Development, mostly successfully in 2013 and 2014, but with widespread breeding failure in 2015. The surveys also found a breeding pair of Martial Eagles (in 2014), and two breeding Black Harriers (in 2015), as well as Booted Eagle, African Harrier-hawk, Jackal Buzzard and Rock Kestrel.

The vantage point surveys showed that the Development site was overflown by a range of raptor species, including regular Verreaux's Eagle, Black Harrier, Jackal Buzzard, Rock Kestrel, and occasional Martial Eagle and Booted Eagle.

Surveys of the grid connection route confirmed the presence of Blue Crane and Ludwig's Bustard, two species considered highly vulnerable to collision with overhead wires.

Five bird species were classed as very high sensitivity, through their listing as 'Endangered' on either the South African or IUCN global red lists; Ludwig's Bustard, Yellow-Billed Stork, Hottentot Buttonquail, Martial Eagle and Black Harrier. An additional five bird species were classed as high sensitivity, through their listing as 'Vulnerable' or 'Near Threatened' on either the South African or IUCN global red lists; Blue Crane, Kori Bustard, Southern Black Korhaan, Black Stork, Secretarybird, Verreaux's Eagle, Knysna Woodpecker, Lanner Falcon and Cape Rockjumper. Five additional species endemics to South Africa were also recorded, and a further 21 near endemics.

Collision risk modelling showed two key species to be at particular risk of collision, Black Harrier and Verreaux's Eagle, with a predicted annual collision rate of 1.5 and 2.6 respectively based on the most recent 2015-16 data. These were the only two species for which the collision risk with the wind turbines was considered to be potentially significant, though for both the change to the existing population mortality would only be small (representing an increase of about 2% over the existing baseline mortality for each regional population).

Mitigation measures are proposed to ensure that no significant collision impacts occur, including on- and off-site habitat management, and the development of a back-up turbine shutdown on demand system.

There are two key raptor species using the wind farm site and breeding within the survey area that make repeated use of traditional nest sites (and hence could be more affected by disturbance), Verreaux's Eagle and Martial Eagle. Operational disturbance could affect two Verreaux's Eagle territories and one Martial Eagle. The loss to one of the Verreaux's Eagle territories would be small (4.7%) and is not considered to be significant. The potential loss to the other would be larger (28%) and there is limited possibility for this territory to expand as it

is bordered to the east and west by other eagle territories. Mitigation measures (particularly off-site habitat management) are recommended to be implemented to avoid any significant impact on this territory.

Martial Eagles have much larger ranges than Verreaux's Eagles, so would be less likely to be vulnerable to range loss through disturbance. The whole of the potential disturbance zone around the wind turbines (taken as a 500m buffer in light of studies of raptor behaviour at existing wind farms) lies with the Martial Eagle range that overlaps the survey area, but even so this would constitute a loss of only 7.1% of the birds' range. Given that this range is largely unconstrained, such a loss would not be considered significant.

There were two Black Harrier nests within the Development site in 2015, so disturbance to breeding harriers does have the potential to be significant (though this species is more variable in its choice of breeding area between years). Mitigation measures are recommended to be implemented to ensure that any net adverse effect on this species is avoided, particularly as it is a species of very high conservation importance, being an IUCN globally vulnerable and a South African endangered red list species.

Mitigation measures will include implementation of a Breeding Bird Protection Plan during construction, off-site and on-site habitat management, together with the development of a turbine shutdown on demand system to provide a back-up response should the post-construction monitoring show that the number of collisions actually approaches the worst-case predictions.

Following mitigation, the residual ornithological effects of the Development will be a non-significant loss of a small amount of habitat to turbine bases and tracks, and a non-significant risk of disturbance and collision. Using evidence from existing wind farms it is considered unlikely that this will have any long term impact on the integrity of the study area's ornithological features or the conservation status of the species found here. Overall, there are not likely to be any significant impacts on ornithology as a result of the Development assuming that the mitigation measures identified in this report are adopted.

The potential collision risk posed by the overhead lines required to connect the wind farm into the grid will also require mitigation. All overhead power lines should be on 'bird friendly' pole design as per Eskom Standard, and that high risk sections to be marked with 'bird flappers'. The 2015-16 surveys have shown that several species prone to collision with overhead wires (including Blue Crane and Ludwig's Bustard) are present in the area through which the overhead lines would pass, and will inform where those measures would need to be applied.

An ornithological monitoring programme is proposed, which should make a significant contribution to the understanding of bird-wind farm interactions in this area and specifically about the key species at risk at this site, Verreaux's Eagle and Black Harrier. It will also inform the need for further mitigation such as the implementation of a turbine shutdown system. A programme of satellite/GPS tagging Verreaux's Eagles and Black Harriers is also recommended to provide further information on how these species behave in and around wind farms.

SPECIALIST DETAILS

Professional experience

Dr Steve Percival has a B.Sc. (Hons) degree in Biological Sciences from the University of Durham, UK (awarded in 1984) and a Ph.D. in Zoology from the University of Glasgow, UK (awarded in 1988).

As principal of his own private practice, Ecology Consulting, he has a wide experience of nature conservation and wind energy issues. His clients have included English Nature, the Wildfowl and Wetlands Trust, Scottish Natural Heritage, the Countryside Agency, the Department of Trade and Industry's Energy Technology Support Unit, the European Bank for Reconstruction and Development and the New Zealand Department of Conservation and numerous wind energy companies. He has been involved in over 350 wind energy projects, including carrying out ecological assessments, preparation of ecological material for environmental statements and giving evidence at public inquiries. He has published papers on the interactions between birds and wind farms and on assessing the potential effects, and given conference papers both within the UK and internationally (including as an invited guest speaker).

He has been studying the conservation ecology of bird populations since 1983. This has included work on population changes of waders in the Outer Hebrides and detailed ecological studies of barnacle geese (including a long-term project extending over 32 years), brent geese, wigeon, golden plover and curlew. His work has been published in major international scientific journals including the Journal of Applied Ecology, Biological Conservation, Ecography and Ibis.

Professional registration

Dr Percival is a member of the UK Chartered Institute for Ecology and Environmental Management, the British Ecological Society and the British Ornithologists' Union.

Declaration of Independence

The specialist investigator, Dr Steve Percival of Ecology Consulting, declares that:

- I act as independent specialist for this project.
- I consider myself bound by the rules and ethics of the UK Chartered Institute for Ecology and Environmental Management.
- I do not have any personal or financial interest in the project except for financial compensation for specialist investigations completed in a professional capacity as specified by the Environmental Impact Assessment Regulations, 2010.
- I will not be affected by the outcome of the environmental process, of which this report forms part of.
- I do not have any influence over the decisions made by the governing authorities.
- I do not object to or endorse the proposed developments, but aim to present facts and our best scientific and professional opinion with regard to the impacts of the development.
- I undertake to disclose to the relevant authorities any information that has or may have the potential to influence its decision or the objectivity of any report, plan, or document required in terms of the Environmental Impact Assessment Regulations, 2010.

Signed in March 2016 by Dr Steve Percival, in his capacity as avifaunal specialist for this project.

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Terms of Reference of the Avifaunal Assessment

1. The Final Scoping Report set out the terms of reference for the avifaunal assessment as follows:

"An avifauna specialist study will be conducted. The assessment will include:

1. A desk-top review of existing literature to seek:

- *Previous means of predicting bird mortality (and other impacts) of wind turbines affecting birds in groups similar to those in the study area;*
- *Accounts of mortality at wind turbines; and*
- *Information on the status of bird groups most likely to be affected.*

2. A site visit to identify species of special concern and assess the likely impacts of the construction and operational phases on the avifauna of the site;

3. Surveys will be conducted on the study area in line with recommended guidelines in this regard. These will be refined for the study area;

4. Conduct a review of international literature and experience relating to operational wind farms; including state of the art plants around the world;

5. Contextualize the literature and experience and relate it to the regional scenario and local avifauna;

6. Map sensitive areas in and around the proposed project site(s);

7. Describe the affected environment and determine the status quo in terms of avifauna;

8. Indicate how an avifaunal resource or community will be affected by the proposed project;

9. Discuss gaps in the baseline data with respect to avifauna and relevant habitats;

10. List and describe the expected impacts;

11. Assess and evaluate the anticipated impacts; and;

12. Make recommendations for relevant mitigation measures which will allow the reduction of negative impacts and the maximization of the benefits associated with any identified positive impacts.

In addition to the terms of reference recorded above, it is proposed that the further assessment of avifauna impacts during the impact assessment phase should include:

1. Conduct a literature review of the impact of noise on sensitive avifaunal species in the area, with the objective of estimating the significance that increased noise during construction and/or operation will have on these species, either in terms of reducing the size of their habitat by more than the physical footprint of the development, or discouraging them to traverse the site (i.e. contribute to habitat fragmentation by more than the physical footprint of the development);

2. Provide specific comment on the issues raised by the Elands River conservancy regarding avifauna, including the species identified in the vicinity of the site and their vulnerability to turbines, wires of utility structures, and power lines;

3. Collect additional site specific data for Verreaux's, and Martial Eagles, to recognised international good practice standards, in order to perform collision risk modelling with a reasonable degree of confidence (including comment on how extreme weather conditions may affect collision risks);

4. List and describe the expected impacts on sensitive species, including potential impacts from:

- *Wind turbine generators during operation, including collision risk and habitat fragmentation;*
- *Construction activities, with specific reference to identified eagle breeding sites; and*
- *Overhead power lines; and*

5. Recommend practical management and/or mitigation measures."

Introduction and Objectives

2. This report provides the specialist avifaunal assessment for the proposed Inyanda Roodeplaat Wind Farm (hereinafter referred to as 'the Development'). It describes and evaluates the current ornithological interest of the Development and its surrounds, and provides an assessment of the likely significant impacts of the proposed Development upon ornithology. The specific objectives of the ornithological assessment were to:

   - Undertake baseline bird surveys of the proposed wind farm site and its surrounds, to determine the numbers of birds present and their locations;
   - Undertake vantage point observations to quantify the rates of bird movement across the proposed wind farm site and its surrounds through the year;
   - Collate relevant additional information on the area's ornithological interests;
   - Evaluate the ornithological importance of the study area, assess the likely impacts of the Development on the study area's ornithology and recommend mitigation measures if necessary;
   - Evaluate the residual impacts of the Development after mitigation measures are incorporated.

3. This assessment has been undertaken by Dr Steve Percival of Ecology Consulting. It draws on a previous assessment undertaken by Jon Smallie (see Appendix 1) and more recent surveys undertaken by Keith Langdon and Mike Hoit of Ecology Consulting, and local surveyor Adri Barkhuysen. The main elements of the Development considered in this report are:

   - Up to 52 wind turbines with a maximum height from ground level to blade tip of 162.5m (maximum hub height 100m). The assessment is based on the current proposed 52-turbine site layout, though it is likely that this will be reduced to 45 turbines. The current assessment would therefore be worst-case with respect to the number of turbines;
   - Crane hardstandings;
   - Wind monitoring masts (anemometers);
   - Underground electrical cables within the site;
   - Internal access roads;
   - Substation;
   - Construction compound;
   - Batching plant;
   - Operations building; and
   - Overhead grid connection cabling connecting the wind farm to the grid.

4. The Development is located approximately 60km north-west from Port Elizabeth in the Eastern Cape. Baseline surveys have been informed by BirdLife South Africa (BLSA) guidance on bird surveys for wind farm assessments (Jenkins et al. 2012, 2015) that was current at the time of the surveys. The ornithological survey areas were chosen to include areas within the potential zone of ornithological influence of the proposed wind farm.

Relevant Legislation and Planning Policy Guidance

5. The relevant legislation was set out in Jon Smallie's original report (Appendix 1) but is repeated here for completeness:

   "The Convention on Biological Diversity: dedicated to promoting sustainable development. The Convention recognizes that biological diversity is about more than plants, animals and micro-organisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live. It is an international convention signed by 150 leaders at the Rio 1992 Earth Summit. South Africa is a signatory to this convention.

An important principle encompassed by the CBD is the precautionary principle which essentially states that where serious threats to the environment exist, lack of full scientific certainty should not be used a reason for delaying management of these risks. The burden of proof that the impact will not occur lies with the proponent of the activity posing the threat. This principle is particularly relevant to this proposed project, as explained in Sections 5, 6 and 7.

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 117 (as of 1 June 2012) Parties from Africa, Central and South America, Asia, Europe and Oceania. South Africa is a signatory to this convention.

The African-Eurasian Waterbird Agreement. The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is the largest of its kind developed so far under the CMS. The AEWA covers 255 species of birds ecologically dependent on wetlands for at least part of their annual cycle, including many species of divers, grebes, pelicans, cormorants, herons, storks, rails, ibises, spoonbills, flamingos, ducks, swans, geese, cranes, waders, gulls, terns, tropic birds, auks, frigate birds and even the South African penguin. The agreement covers 119 countries and the European Union (EU) from Europe, parts of Asia and Canada, the Middle East and Africa.

The National Environmental Management – Biodiversity Act (10 of 2004) - Threatened or Protected Species list (TOPS). Those species which are relevant to this project and are TOPS listed are presented in Table 1.

The Nature and Environmental Conservation Ordinance (19 of 1974) is relevant in the Eastern Cape, although outdated, and somewhat illogical in the species it protects. Schedule 2 of this ordinance lists protected bird species including, relevant to this site: all crows; Cape Sparrow; Cape Weaver; Cape Bulbul; Red-faced Mousebird and Speckled Mousebird.

The Civil Aviation Authority's regulations are relevant to the issue of lighting of wind energy facilities, and to painting turbine blades, both of which are relevant to bird collisions with turbine blades."

Ornithological Assessment Methods

Assessment and Impact Rating Methodology

6. The assessment of ornithological impacts follows the same assessment methodology as used throughout the wind farm assessment, and is based on the professional judgement of specialists, fieldwork, and desk-top analysis. The significance of potential impacts that may result from the proposed development will be determined in order to assist the Department of Environmental Affairs (DEA) in making a decision.
7. The significance of an impact is defined as a combination of the consequence of the impact occurring and the probability that the impact will occur. The criteria used to determine impact consequences are presented in Table 1 below.

Table 1. Criteria used to determine the Consequence of the Impact

Rating	Definition of Rating	Score
A. Extent– the area over which the impact will be experienced		
None		0
Local	Confined to project or study area or part thereof (e.g. site)	1
Regional	The region, which may be defined in various ways, e.g. cadastral, catchment, topographic	2
(Inter) national	Nationally or beyond	3
B. Intensity– the magnitude of the impact in relation to the sensitivity of the receiving environment		
None		0
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. Duration– the time frame for which the impact will be experienced		
None		0
Short-term	Up to 2 years	1
Medium-term	2 to 15 years	2
Long-term	More than 15 years	3

8. The combined score of these three criteria corresponds to a **Consequence Rating**, as shown in Table 2.

Table 2. Method used to determine the Consequence Score

Combined Score (A+B+C)	0 – 2	3 – 4	5	6	7	8 – 9
Consequence Rating	Not significant	Very low	Low	Medium	High	Very high

9. Once the consequence has been derived, the probability of the impact occurring has been considered using the probability classifications presented in Table 3.

Table 3. Probability Classification

Probability– the likelihood of the impact occurring	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

10. The overall significance of impacts has been determined by considering consequence and probability using the rating system prescribed in the table below.

Table 4. Impact Significance Ratings

Significance Rating	**Possible Impact Combinations**		
	Consequence		**Probability**
Insignificant	Very Low	&	Improbable
	Very Low	&	Possible
Very Low	Very Low	&	Probable
	Very Low	&	Definite
	Low	&	Improbable
	Low	&	Possible
Low	Low	&	Probable
	Low	&	Definite
	Medium	&	Improbable
	Medium	&	Possible
Medium	Medium	&	Probable
	Medium	&	Definite
	High	&	Improbable
	High	&	Possible
High	High	&	Probable
	High	&	Definite
	Very High	&	Improbable
	Very High	&	Possible
Very High	Very High	&	Probable
	Very High	&	Definite

11. Finally, the impacts will also be considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The system for considering impact status and confidence (in assessment) is laid out in Table 5 below.

Table 5. Impact status and confidence classification

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a 'benefit')
	– ve (negative – a 'cost')
Confidence of assessment	
The degree of confidence in predictions based on available information, SRK's judgment and/or specialist knowledge.	Low
	Medium
	High

12. The impact significance rating should be considered by authorities in their decision-making process based on the implications of ratings ascribed below:
    - **Insignificant**: the potential impact is negligible and will not have an influence on the decision regarding the proposed activity/development.
    - **Very Low**: the potential impact is very small and should not have any meaningful influence on the decision regarding the proposed activity/development.
    - **Low**: the potential impact may not have any meaningful influence on the decision regarding the proposed activity/development.
    - **Medium**: the potential impact should influence the decision regarding the proposed activity/development.
    - **High**: the potential impact will affect the decision regarding the proposed activity/development.
    - **Very High**: The proposed activity should only be approved under special circumstances.
13. Practicable mitigation measures have been recommended and impacts rated in the prescribed way both with and without the assumed effective implementation of mitigation measures. Mitigation measures have been classified as either:
    - **Essential**: must be implemented and are non-negotiable; or
    - **Optional**: must be shown to have been considered and sound reasons provided by the proponent, if not implemented.
14. This assessment has also been informed by reference to the other international assessment methodologies produced by Scottish Natural Heritage (2006) for the wider countryside, the UK Institute for Ecological and Environmental Management (2006) and Percival (2007) – an assessment methodology widely used in the wind industry. This has included evaluation of the conservation importance (as defined in Table 6) of the bird populations present in the study area, and the magnitude of the likely effects on those receptors (as described in Table 7).
15. The conservation importance of the bird populations in the study area was assessed by reference to Table 6 and by using the standard 1% criterion method (Holt et al. 2015); >1% national population = nationally important, >1% international population = internationally important. A further category of 'local importance' was used for species that did not reach regional importance but were still of some ecological value.

Table 6. Conservation importance of bird species

Conservation Importance	Definitions
VERY HIGH	Cited interest of an internationally or nationally important statutory protected sites. Cited means mentioned in the citation text for those protected sites as a species for which the site is designated.
HIGH	Other species that contribute to the integrity of an internationally or nationally important statutory protected sites species for which the site is designated. A local population of more than 1% of the national population of a species. Any ecologically sensitive species, e.g. large birds of prey or rare birds (usually taken as <300 breeding pairs in the UK). Species recognised as requiring special conservation measures or otherwise specially protected (in a UK context this includes EU Birds Directive Annex 1, EU Habitats Directive priority habitat/species and/or W&C Act Schedule 1 species. **Note: All of the four raptor species assessed fall into this category**
MEDIUM	Regionally important population of a species, either because of population size or distributional context. Biodiversity Action Plan priority species (if not covered above).
LOW	Any other species of conservation interest.

Table 7. Definition of terms relating to the magnitude of ornithological impacts

Magnitude	Definition
VERY HIGH	Total loss or very major alteration to key elements/ features of the baseline conditions such that post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether. Guide: >80% of population/habitat lost
HIGH	Major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/composition/attributes will be fundamentally changed. Guide: 20-80% of population/habitat lost
MEDIUM	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/ composition/ attributes of baseline will be partially changed. Guide: 5-20% of population/habitat lost
LOW	Minor shift away from baseline conditions. Change arising from the loss/ alteration will be discernible but underlying character/ composition/ attributes of baseline condition will be similar to pre-development circumstances/patterns. Guide: 1-5% of population/habitat lost
NEGLIGIBLE	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation. Guide: <1% of population/habitat lost

16. The SNH (2006) wider countryside assessment guidance defines the key significance test as follows: "*An impact should be judged as of concern where it would adversely affect the favourable conservation status of a species, or stop a recovering species from reaching favourable conservation status, at international or national level or regionally.*"

Survey Methods 2013-14

17. The initial baseline ornithological data were collected during a 12-month monitoring campaign organised by Jon Smallie. This was carried out between July 2013 and May 2014, with an additional breeding eagle survey in July/August 2014.

18. A range of surveys were conducted, including a preliminary desk study, walked transect surveys for small terrestrial birds, vehicle-based transect surveys for large terrestrial species and raptors, eagle breeding/nest surveys and vantage point surveys to quantify/map key species flight activity. Full details are presented in Appendix 1.

19. A review of that work was undertaken by the author of this report, and is included as Appendix 2. It identified some issues with coverage for the vantage point (VP) surveys and reporting of eagle nest locations from the breeding eagle surveys, and made recommendations for further data collection to assist in the assessment process on the key issues identified in the initial 2013-14 surveys.

Survey Methods 2015-16

20. This work was commissioned to undertake baseline bird survey work at the Development site, updating the previous 2013-14 bird survey work to address concerns with the existing data. Its purpose was not to undertake a full baseline survey but rather to focus on the key issues, data gaps and ornithological sensitivities already identified, specifically:

    - Eagle breeding status and distribution (particularly Verreaux's Eagle and Martial Eagle).
    - Eagle and other large raptor flight activity within and around the proposed wind farm site (particularly Verreaux's Eagle and Martial Eagle).
    - Species vulnerable to collision with overhead wires along the proposed grid connection route (particularly Blue Crane, and Ludwig's and Denham's Bustards)

21. The surveys were designed to take into account BirdLife South Africa emerging guidance (Jenkins et al. 2015) and other international guidance on bird surveys for wind farms (including Natural England, Drewitt 2010 and Scottish Natural Heritage, SNH 2014). The initial August surveys were undertaken by Mike Hoit and Keith Langdon, during which the local surveyor, Adri Barkhuysen (a local raptor expert) was trained to Ecology Consulting wind farm survey standards. Adri Barkhuysen then undertook the September to January surveys, with all of the data checking and processing undertaken by Ecology Consulting, who have also carried out all of the data analysis and reporting. The surveys will continue until July 2016 to complete a full 12 months.

22. Full details of the survey methods are given in Appendix 3.

Information Gaps

23. The review of the 2013-14 surveys identified a number of issues with those baseline data, including the following:

    - Coverage gaps – there were substantial parts of the wind farm (25 of the 52 proposed turbine locations) that fell outside the effective viewing area, as a result of access issues. This required assumptions to be made about flight activity in these areas for input into the collision modelling, adding uncertainty to the initial collision risk assessment, but the further 2015-16 data have enabled that uncertainty to be reduced.
    - Potential incomplete recording of flight lines – many of the flight lines are short and terminate in areas where eagles would have been expected to still be visible from the VP.
    - Viewing distances – it was reported in the survey methodology that a 2km maximum viewing distance was adopted. However, examination of the raw plotted flight lines suggested that flights were recorded much less frequently in the 1-2km zone from the VPs than within 1km. Further analysis of the data (presented in Appendix 2), indicated that the effective coverage from the survey VPs was

dependent on the viewing area. Raptors were being detected at approximately 1km when viewed against the ground and at approximately 2km when seen against the sky, so this assumption was incorporated into the initial collision risk assessment.

24. The 2015-16 surveys that have been completed to date have extended the spatial coverage of the VP surveys to address concerns with the previous data, and it is planned that these will continue for a full year. However, the data currently available cover the period August 2015 – January 2016, so do not yet have full temporal coverage of the year. Assumptions have therefore needed to be made on flight activity outside this period, but this has been possible by reference back to the 2013-14 data.

25. The 2015-16 breeding season was a very poor one for the local Verreaux's Eagles, with no successful nests within the survey area. This could potentially have affected the birds' flight behaviour (and hence collision risk), but comparison with the previous flight activity in 2013-14 did not indicate any major behavioural differences, so it is not considered that this had any material effect on the assessment for this species.

26. The 2015-16 grid connection transect data cover the main part of each potential route where access for the surveys was possible and where the surveys could be carried out safely. This did not include the full route but did cover a representative range of the habitats through which the route would pass.

27. Inevitably with any ornithological survey it cannot be guaranteed to detect all target species/individuals and surveys cannot be fully representative of all conditions (e.g. severely reduced visibility, including in fog/mist and at night). It was assumed in the assessment that the surveys were representative of flight activity throughout daylight hours (there was no *a priori* ecological reason to suppose that it would be any higher), and no suggestion that the site was likely to be important for any nocturnal species that could be vulnerable to the development. It was, therefore, concluded that the baseline surveys provide a robust data set on which to carry out the assessment. None of the limitations are considered likely to have materially affected the conclusions of this assessment.

Baseline Ornithological Conditions and Receptors

Desk Study

28. A desk study was undertaken to provide information on the ornithological interest of the study area and its surrounds, including the locations of any relevant statutory protected sites, and is reported in Appendix 1.

Walked transects surveys 2013-14

29. A total of 64 species were recorded on site during the walked transect surveys, including 27 endemic bird species. Details are given in Appendix 1. The species recorded most frequently were Cape Siskin, Wailing Cisticola and Cape Grassbird, with Red-winged Starling, Sombre Greenbul, Bokmakierie, Speckled Mousebird, Southern Boubou, Long-billed Pipit and Orange-breasted Sunbird also seen regularly. Species richness was higher in summer (42 species) and autumn (40 species) than in winter (when only 23 species were recorded).

Vehicle-based transect surveys 2013-14

30. A total of 6 target species were recorded during the vehicle-based transect surveys. Rock kestrel was the most frequently recorded species, followed by Pale Chanting Goshawk. Verreaux's Eagle was the third most frequently recorded species, but was only recorded 3 times in the year. Other species recorded comprised Jackal Buzzard, Rufous-breasted Sparrowhawk and Steppe (Common) Buzzard. The observers did not consider these surveys to be particularly effective as a result of the terrain and survey technique.

Eagle breeding/nest surveys 2013-14 and 2015-16

31. The results of the Verreaux's Eagle breeding surveys are summarised in Table 8. The breeding site locations are shown in Appendix 3 Figure 1. Whilst 2013 and 2014 were highly successful breeding years, 2015-16 was a very poor breeding year for this species, with no successful nesting at any of these sites.

Table 8. Verreaux's Eagle nest site baseline survey results, 2013-14 and 2015-16

Range (see Appendix 3 Figure 1)	Distance from proposed wind farm in km (52T layout)	Use in 2013-14	Use in 2015-16
Perdehoek	1.4	Successful nest in 2013; near fledging chick seen on nest. Active in 2014; Adults seen copulating and displaying.	Pair seen daily flying in vicinity of nest kloof during August visit, showing territory occupied. No sign of breeding success – failure confirmed on September visit. Pair seen over nest site during October VP survey, and in January.
Holbak	2.3	Successful nest in 2013; 11-13 week chick on nest. Active in 2014; pair seen.	Breeding failure confirmed on September survey. Single seen 3.6km N from site on 22/9/15.
February	3.3	Nesting in 2013 and 2014; 2 eggs on nest seen in 2013, 2 smallish downy chicks seen on nest in 2014.	Breeding failure confirmed on September survey.
Tiptree	4.0	Not visited in 2013. Nesting in 2014; adult seen incubating on nest.	Pair seen flying in vicinity of nest site during August VP survey. Nest site located on a cliff facing SW in the Kwazunga River valley on October survey. No eagles were seen then and no chick on the nest, but it appeared to have been active (from the white defecation marks and greenery that was laid some time ago).
Tygerberg	5.0	Nesting in 2013; large downy chick seen on nest. Active in 2014; 2 adults present, but no active nest seen.	Pair flying around the nest kloof during September visit but no sign of active nest
Guntia	8.5	Successful nest in 2013; 9-11 week chick on nest. Not surveyed in 2014.	No chick was seen on either nest during the October survey, and no adults were seen. Some white defecation marks on the smaller nest but no greenery could be seen.
Krompoort	12	Not visited in either year.	No chick on the nest and no adult eagles were seen during the October visit. This nest had active white defecation marks but otherwise it appeared inactive. Single seen near the site on 27/9/15.

32. The records obtained of other breeding raptors during the baseline surveys are summarised below:

- **Martial Eagle** – evidence of breeding behaviour was observed in 2014. The nest site was not confirmed but the adults' behaviour suggested a nest with young in a wooded gorge 2.6km SW from proposed wind farm. No evidence was found of breeding there in 2015-16, with the only records of this species in those surveys being occasional over-flying birds seen during the VP surveys and a single incidental sighting near Perdehoek in August 2015.
- **Booted Eagle** - a pale phase bird was seen twice in the Perdehoek kloof during the September 2015 surveys.

- **African Harrier-hawk** – seen in the February kloof during the September 2015 survey.
- **Black Harrier** – this species was confirmed nesting within the proposed wind farm site in 2015-16, above and very close to the track near the higher of the two meteorological masts. There were a minimum of three adults present, likely to have been a polygamous male with two females (two nests). Breeding was successful, with sightings of fledged juveniles during October and November 2015. Two sightings in the Kwazunga valley suggested potential nesting there too in 2015.
- **Jackal Buzzard** – probable breeding pairs noted at Perdehoek and February, and a possible at Tygerberg in 2014.
- **Rock Kestrel** – possible 2-3 pairs breeding at Perdehoek and another 2-3 pairs at February in 2014.

Vantage point surveys

33. Full details of the VP survey results area given in Appendices 1, 2 and 3 (which also include maps of all of the recorded key species flights). The more recent data have been used as the primary baseline for the assessment presented here, as they covered a wider viewing area over the site, with more vantage points and a greater effective viewing distance.
34. **Martial Eagles** were seen only occasionally (on only five occasions in 2015-16, three of which involved flights through the collision risk zone). No areas of more concentrated flight activity were apparent.
35. **Verreaux's Eagles** were recorded widely but at relatively low frequency over most of the survey area, in both 2013-14 and 2015-16. As for the previous species, no areas of more concentrated flight activity were apparent (other than in the immediate vicinity of an active nest site at Holbak in the 2013-14 surveys). The two 2015-16 VPs over-looking the two closest breeding sites did not reveal any specific connectivity with or use of the wind farm site.
36. **Booted Eagle** was only occasionally recorded (with only six flights in total in 2015-16). No areas of more concentrated flight activity were apparent.
37. **Black Harrier** was the most frequently observed target species in 2015-16, with a total of 144 flights logged in total. Activity was greatest around the nesting sites near to the upper met mast, but also further to the east and west along the main ridge running through the wind farm site, and over the ridge south from the nesting area. Activity declined markedly after October (as found in the previous 2013-14 surveys). Much lower flight activity of this species was recorded in 2013-14.
38. **Jackal Buzzard** was frequently recorded in both 2013-14 and 2015-16 surveys, particularly along the main ridge running east-west through the wind farm site (especially at its western end). This species was less frequently seen over the lower ground.
39. **Rock Kestrel** was seen widely over the survey area, with several scattered areas of more concentrated activity.

Grid Connection Corridor Surveys 2015-16

40. Full details of the results of the grid connection corridor surveys that were undertaken in 2015-16 are included in Appendix 3, which includes maps of all records of key species.
41. Of the key species, Blue Cranes were widely distributed over the more open habitat along the grid connection survey transects, particularly at the western end of the main grid connection route (transect 1). That area was also where most of the Ludwig's Bustards were seen, as well as further to the north along the Glen Connor Road (transect 2).
42. The most frequently recorded raptor species was Pale Chanting-goshawk. It was seen mainly along the central part of the main grid connection route (transect 1) and along the Glen Connor Road.
43. Less frequently-encountered raptors included African Harrier-hawk, Verreaux's Eagle, Booted Eagle, Black Harrier, Rufous-breasted Sparrowhawk, Jackal Buzzard, Forest Buzzard, Steppe Buzzard, Lesser Kestrel, Rock Kestrel, Lanner Falcon and Peregrine Falcon.

44. Other species potentially at risk of collision with overhead wires seen during these surveys included Southern Black Korhaan, Kori Bustard, Secretarybird, African Wood-owl, Barn Owl and Spotted Eagle-owl.

Conservation Importance of Bird Populations

45. The conservation importance of the bird populations seen during the 2013-14 and 2015-16 baseline surveys is summarised in Table 9. This Table includes all the species noted during the surveys that have low or greater sensitivity (i.e. all of those that are red-data listed for South Africa or globally, or area South African endemics/near endemics). A full species list and evaluation of conservation importance is given in Appendix 4.

Table 9. Conservation evaluation of the bird populations in the Inyanda Roodeplaat survey area, 2013-14 and 2015-16.

Species	Scientific name	Red Data Status South Africa	Red Data Status Global	Endemic sp	Conservation Importance (using Table 6)
Grey-winged Francolin	*Scleroptila afra*	LC	LC	SLS	Low
Blue Crane	*Anthropoides paradiseus*	NT	VU		High
Ludwig's Bustard	*Neotis ludwigii*	EN	EN		Very high
Kori Bustard	*Ardeotis kori*	NT	NT		High
Southern Black Korhaan	*Afrotis afra*	VU	VU	*	High
Knysna Turaco	*Tauraco corythaix*	LC	LC	SLS	Low
Yellow-billed Stork	*Mycteria ibis*	EN	LC		Very high
Black Stork	*Ciconia nigra*	VU	LC		High
Hottentot Buttonquail	*Turnix hottentottus*	EN	EN	*	Very high
Secretarybird	*Sagittarius serpentarius*	VU	VU		High
Martial Eagle	*Polemaetus bellicosus*	EN	VU		Very high
Verreaux's Eagle	*Aquila verreauxii*	VU	LC		High
Black Harrier	*Circus maurus*	EN	VU	(*)	Very high
Jackal Buzzard	*Buteo rufofuscus*	LC	LC	(*)	Low
Forest Buzzard	*Buteo trizonatus*	LC	LC	SLS	Low
Ground Woodpecker	*Geocolaptes olivaceus*	LC	LC	SLS	Low
Knysna Woodpecker	*Campethera notata*	NT	NT	*	High
Lanner Falcon	*Falco biarmicus*	VU	LC		High
Southern Tchagra	*Tchagra tchagra*	LC	LC	(*)	Low
Grey Tit	*Parus afer*	LC	LC	(*)	Low
South African Cliff Swallow	*Petrochelidon spilodera*	LC	LC	BSLS	Low
Cape Clapper Lark	*Mirafra apiata*	LC	LC	(*)	Low
Karoo Prinia	*Prinia maculosa*	LC	LC	(*)	Low
Cape Bulbul	*Pycnonotus capensis*	LC	LC	*	Medium
Victorin's Warbler	*Cryptillas victorini*	LC	LC	*	Medium
Cape Grassbird	*Sphenoeacus afer*	LC	LC	(*)	Low
Cape White-eye	*Zosterops virens*	LC	LC	(*)	Low
Pied Starling	*Lamprotornis bicolor*	LC	LC	SLS	Low
Cape Rockjumper	*Chaetops frenatus*	NT	LC	*	High
Cape Rock Thrush	*Monticola rupestris*	LC	LC	SLS	Low
Sentinel Rock Thrush	*Monticola explorator*	LC	LC	SLS	Low
Fiscal Flycatcher	*Sigelus silens*	LC	LC	(*)	Low
Fairy Flycatcher	*Stenostira scita*	LC	LC	(*)	Low

Species	Scientific name	Red Data Status South Africa	Red Data Status Global	Endemic sp	Conservation Importance (using Table 6)
Orange-breasted Sunbird	*Anthobaphes violacea*	LC	LC	*	Medium
Southern Double-collared Sunbird	*Cinnyris chalybeus*	LC	LC	(*)	Low
Greater Double-collared Sunbird	*Cinnyris afer*	LC	LC	SLS	Low
Cape Sugarbird	*Promerops cafer*	LC	LC	*	Medium
Cape Weaver	*Ploceus capensis*	LC	LC	(*)	Low
Swee Waxbill	*Coccopygia melanotis*	LC	LC	(*)	Low
Cape Siskin	*Crithagra totta*	LC	LC	*	Medium

*Note: Red Data Stats: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern, South African endemics: * = endemic; SLS = endemic to South Africa, Lesotho and Swaziland; (*) = near endemic (i.e. ~70% or more of population in RSA); BSLS = breeding South Africa, Lesotho and Swaziland endemic*

46. Five species were classed as very high sensitivity, through their listing as 'Endangered' on either the South African and/or IUCN global red lists; Ludwig's Bustard, Yellow-Billed Stork, Hottentot Buttonquail, Martial Eagle and Black Harrier.

47. Five species were classed as high sensitivity, through their listing as 'Vulnerable' or 'Near Threatened' on either the South African or IUCN global red lists; Blue Crane, Kori Bustard, Southern Black Korhaan, Black Stork, Secretarybird, Verreaux's Eagle, Knysna Woodpecker, Lanner Falcon and Cape Rockjumper.

48. A further five species were classed as medium sensitivity (South Africa endemic species), and a further 21 as low sensitivity (near endemics).

49. The Ornithological Impact Assessment presented in this report has focused on the key species of conservation importance that could be adversely affected by the Development, including all of the very high and high value species, and those that could be vulnerable to wind farm construction and operation.

Potential Ornithological Impacts

Structure of the Impact Assessment

50. Direct and indirect environmental effects of the wind farm's construction, operational and decommissioning phases, based on the project description in Chapter 4, are evaluated for each aspect of the ornithological studies in the following section. Mitigation for identified negative effects is presented below.

Effects on birds

51. The main potential effects of wind farms on birds are considered to be direct loss of breeding or feeding habitat, potential collision risk and indirect loss of habitat from disturbance (either temporary during construction or more permanent from operating turbines) (Percival 2005, Drewitt and Langston 2006). Each of these is considered in turn in the following sections.

Direct effects (1): loss of habitat

52. This would be an effect of low/negligible magnitude, with only a very small area taken up by the turbine bases and access tracks. Use of existing tracks and the careful selection of routes for the access tracks and turbine locations, alongside use of proven construction techniques would ensure that such effects on birds would be of low/negligible magnitude (even in a local context), and would not be significant. In addition, the developer has committed to the production of a Construction Method Statement to the satisfaction of BLSA and other relevant stakeholders, before construction commences, and would follow industry best practice.

Direct effects (2): collision risk

53. There have been a number of wind farms that have caused bird mortalities through collision but their

characteristics are very different to those at the proposed Inyanda Roodeplaat site. Most notably, at Altamont Pass in California and Tarifa in southern Spain, large numbers of raptors have been killed (Orloff and Flannery 1992, Janss 1998, Thelander et al. 2003). Such problems have occurred where large numbers of sensitive species occur in close proximity to very large numbers (hundreds/thousands) of turbines, and usually also where the wind farm area provides a particularly attractive feeding resource. At Altamont, for example, the wind turbine bases provided an attractive shelter for ground squirrels which themselves provided an attractive raptor foraging resource (Thelander et al 2003).

54. A specific problem has been identified for old world vultures, which have much the highest numbers of reported raptor collisions (Hotker et al. 2004, Illner 2011). Martin et al. (2012) reported that these species have large blind areas in their field of vision above, below and behind the head, such that with the head positions typically adopted by foraging vultures, they will often be blind in the direction of travel. This would make them particularly vulnerable to collision with wind turbines and the studies that have been undertaken bare out this conclusion (Janss 1998, Lucas et al. 2012). Vultures also have a high wind loading, reducing their maneuverability which also increases their vulnerability to collision (Janss 2000, Barrios and Rodríguez, 2004; Lucas et al., 2008). In addition to this wind farms have been located in areas of high vulture food resource and several of their populations are vulnerable to additional mortality (Carrete et al. 2009).

55. Another species clearly more vulnerable to collision with wind turbines is the White-Tailed Eagle. Small numbers of collisions have been reported at several wind farms including in Germany and Poland, but at one particular site rather more fatalities have occurred, Smøla in NW Norway (an average of 8 collisions per year, May et al. 2010). In Australia White-Bellied Sea Eagle and Wedge-Tailed Eagle have also both been demonstrated to be vulnerable to collision (Hull and Muir 2013).

56. Outside the UK, Golden Eagles have been reported as collision victims at wind farms, but generally at a low rate in comparison with vultures and White-Tailed Eagles. Whitfield (2009) reviewed the avoidance rates that this species has exhibited and reported estimates varying between 98.64 % and 99.89 % depending on site and uncertainty associated with observed mortality rates before and after adjustment for potential biases. An overall 'worst case' estimate weighted by the scale of study was 99.33 % and the mean unweighted 'worst case' (lowest) avoidance rate for the four wind farms was 99.19 %, and adoption of a precautionary value of 99.0 % was advised for use in wind farm assessments (and adopted by SNH in their guidance, Urquhart 2010).

57. Collision risk of raptors has been shown to be affected by wind conditions (Johnston et al., 2014). That study found that Golden Eagles migrating over a wind farm in the Rocky Mountains experienced lower collision risk with increased wind speed and increased risk under head- and tailwinds when compared with crosswinds.

58. In wind farm sites in the UK, with similar large raptor flight densities to Inyanda Roodeplaat, collision rates have generally been very low and are not considered to be significant (Meek et al. 1993, Tyler 1995, Dulas 1995, EAS 1997, Bioscan 2001, Percival et al. 2008, Percival et al. 2009a). There have been no Golden Eagle collisions at all reported to date in the UK, despite their presence at several operational sites. A study of this species at Beinn an Tuirc (Walker et al. 2005) has shown them to largely avoid the wind farm site after construction, with a resultant reduction in collision risk. Marsh Harrier, too, has been found to show a similar avoidance of the proximity of wind turbines, with flight density post-construction reduced by 94% within 200m of turbines (Percival et al. 2009a, Percival et al. 2009b). Again no collisions at all of this species have been reported in the UK. Studies of Red Kite and Hen Harrier in the UK have found they too have exhibited high rates of avoidance of collision (Whitfield and Madders 2006a and 2006b).

59. Sites where higher numbers of raptor collisions have occurred generally have supported a high density of flight activity that has been maintained post-construction, often associated with attractive ecological resource within the wind farm site, resulting in attraction into the wind farm rather than avoidance. The key risk features can be summarised as:

- High turbine numbers
- Turbine design – older design lattice towers can provide a perching resource
- High bird density within the wind farm – particularly where there is a rich food resource within the wind farm, or attractive breeding sites

- Source of distraction in close proximity to turbines, e.g. food resource in turbine bases, breeding displays.
- Vultures have a specific issue with their limited field of vision, and a high wing loading that reduces their maneuverability
- Particular vulnerability of populations to additional mortality (e.g. Egyptian vulture – where wind farms have been implicated in population decline often where acting in combination with other factors, Carrete et al. 2009).

60. The mitigation of collision risk has been recently reviewed by Marques et al (2014). This publication outlined a range of measures that have been implemented at existing wind farms in order to reduce collision risk. It includes details of several highly successful schemes, including:

    - Turbine shutdown on demand - Lucas et al. (2012) showed that wind turbine shutdown on demand halved Griffon Vulture fatalities in Andalusia, Spain, with only a marginal (0.07%) reduction in energy production. This study used human observers but automated (radar and video-based) systems are also now becoming available (Collier et al. 2011; Desholm et al. 2006).
    - Restriction of turbine operation – this involves avoiding operation of the turbines at key risk times. This has been very effective for bats (Arnett et al. 2010), where reducing turbine operation during periods of low wind speeds reduced bat mortality by 44% - 93%, with marginal annual power loss (<1% of total annual output). For birds (including at the Inyanda Roodeplaat site) it is less likely to be such a useful tool as defining the higher risk periods is more difficult and it is unlikely that such a large reduction would be achievable without a much greater loss in power output.
    - Habitat management – these schemes are usually implemented to reduce the attractiveness of the wind farm site for foraging (e.g. removal of carcasses for carrion feeding species) whilst at the same time increasing food availability elsewhere (to draw birds away from the wind farm and at the same time offset lost foraging opportunity) (Walker et al. 2005).
    - Increasing turbine visibility – laboratory experiments have shown this to be a potentially effective tool but there have not yet been any field trials that have demonstrated a major benefit of such measures. Its applicability remains to be proven.
    - Deterrents – bioacoustic or other scaring devices might have the potential to deter birds from flying in close proximity to wind turbines. Smith et al. (2011) showed that use of an acoustic deterrent (Long Range Acoustic Device) elicited strong reactions from 60% of Griffon Vultures but its efficacy depended on the distance from the bird, altitude and flock size. Deterrents also have the potential to be activated by automated real-time surveillance systems as an initial mitigation step and prior to blade curtailment (May et al., 2012; Smith et al., 2011). A possible problem with this mitigation though, as noted by Marques et al. (2014), is that the deterrent may have an unpredictable effect on the flight path and may not always deflect the bird in the desired direction.
    - Compensation – these include measures to deliver a wider benefit to the populations that could be affected by the wind farm, including habitat expansion, creation or restoration, predator control and supplementary feeding.

Indirect effects: disturbance

61. Disturbance could potentially affect a rather greater area than direct habitat loss. Disturbance itself can result from several factors associated with the wind farm, including operational noise, the visibility of tall structures and increased human presence through maintenance activities, as well as the construction works prior to operation. Published studies have only been able to look at all of these factors acting together, so it is not possible to separate out the different aspects of disturbance when assessing the potential effects.

62. The maximum distance that wind turbines have been shown to affect birds is 800m (Percival 2005; Pearce-Higgins et al. 2009), though most reliable studies have not reported effects further than 600m from turbines (Drewitt and Langston 2006) and displacement is usually partial rather than complete (i.e. a reduction in use not complete exclusion). Displacement has generally been more widely reported and over a greater distance outside the breeding season.

63. Several of the studies referred to above (e.g. Walker et al. 2005, Percival et al. 2009a, Percival et al. 2009b, Whitfield et al. 2006) have noted some displacement of raptors from a zone around wind turbines. This has typically been reported over a distance of 1-200m of turbines, though Fielding and Haworth (2013) found evidence of displacement of golden eagle up to 500m. Displacement effects have also been reported for White-tailed Eagles at Smøla, in Norway (May et al. 2013). Campedelli et al (2013) found significant reductions in a range of raptor species at a wind farm in Italy. Though disturbance would reduce collision risk it does mean that the development of a wind farm could result in effective loss of habitat if birds are dissuaded from using the area in proximity to turbines. Any impact on the population would be dependent on importance of that area from which displaced and the availability of alternative areas, but any assessment should take into account the possibility of such small-scale displacement.

64. The most effective way to mitigate any such losses would be through the provision of alternative resources nearby (but outside the potential impact zone of the wind farm). Such measures have been successfully implemented at several wind farms, including for golden eagles (Walker et al. 2005), and have been agreed (though not yet implemented) for Verreaux's Eagle in South Africa (for the Witberg wind farm).

65. Disturbance is likely to be highest during construction owing to the activities being carried out. Pearce-Higgins et al. (2012) found that Red Grouse, Snipe and Curlew densities all declined on wind farms during construction, whilst densities of skylark and stonechat increased. Construction also involves the presence of work personnel on site which itself can be an important source of potential disturbance. Even at this time displacement from a zone around the wind turbines is likely to be only partial. Pearce-Higgins et al. (2012) for example reported decreases in curlew density during construction of 40% and snipe by 53%.

66. A further potential disturbance effect could be disruption to important flight lines (barrier effect; Percival 2005, Drewitt and Langston 2006). Birds may see the wind farm and change their route to fly around (rather than through) it. This would reduce the risk of collision but could possibly have other effects, for example potentially making important feeding areas less attractive (by acting as a barrier to the birds reaching them) and (if diversions were of a sufficient scale) resulting in increased energy consumption.

67. The distance needed to divert around the Inyanda Roodeplaat WEF would be relatively small and would not be expected to act as a major barrier to movements. Accordingly, the ecological consequences of any such changes in flight lines would be of negligible magnitude and not significant.

Ornithological Impact Assessment Results

Collision Risk Modelling

68. One of the main potential ornithological impacts of concern for the Inyanda Roodeplaat wind farm is collision with the operational turbines. Collision risk modelling (CRM) was undertaken for a previous report (Percival et al. 2015), following the method of Band et al. (2007), as extensively used in the UK. Details of the original SNH guidance on this model (Band 2000) are available from the SNH web site at <www.snh.gov.uk/docs/C205425.pdf>. The model runs as a two-stage process. Firstly, the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.

69. The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action, as has been shown to occur in all studies of birds at existing wind farms (Urquhart 2010[1]). Discussion as to the most appropriate avoidance rates to apply is included in the following section.

[1] See SNH web site: www.snh.gov.uk/docs/B721137.pdf

70. The CRM was carried out on the four key raptor species of concern that were observed flying within the collision risk zone at rotor height; Verreaux's Eagle, Booted Eagle, Martial Eagle and Black Harrier, as detailed in Appendices 2 and 3.

71. The collision model requires data on bird body size and flight speed. Body sizes and baseline mortality rates were taken from Roberts Birds of South Africa (Hockey et al. 2005). Flight speeds were taken from Alerstam et al. (2007) for ecologically similar species, as none were available for any of the four key species (Golden Eagle for Verreaux's Eagle, the mean of all of the available *Aquila* eagle species for Martial Eagle, the mean of all of the available *Buteo* species for the smaller Booted Eagle and the mean of all *Circus* harrier species for Black Harrier). The data used in the collision risk modelling are shown in Table 10.

Table 10. Key species body size and flight speed data used in the collision risk modelling

Species	Body length (m)	Wing span (m)	Flight speed (m/s)
Verreaux's Eagle	0.88	2.4	11.9
Booted Eagle	0.50	1.23	11.5
Martial Eagle	0.81	2.15	10.4
Black Harrier	0.51	1.0	9.7

72. The collision modelling requires a range of input data on the wind turbine specifications, which were provided by the client and the turbine manufacturers (Table 11). This modelling has taken a reasonable worst-case approach, running the model for the turbine likely to give the highest collision risk of the options being considered. The model was run for this report on the current proposed 52-turbine layout being assessed for the EIA. It is likely that the number of turbines will be reduced further, but this has been assessed as a worst case at this stage.

Table 11. Wind turbine data used in the collision risk modelling.

Specification	52-turbine input data
Number of turbines	52
Hub height	85m
Rotor diameter	130m
Height to blade tip	150m
Minimum height of blade above ground	20m
Rotational speed (variable – mean of range used)	9.5 rpm
Blade maximum chord	4.2m
Blade pitch (variable – mean value used)	6°
Turbine operation time (when not constrained by	90%

Specification	52-turbine input data
high/low wind speed or maintenance activity)	

73. Data from the VP surveys were used to determine the proportion of flights at rotor height, with all flights between 16m and 180m treated (conservatively to take into account the difficulty of accurately estimating flight heights) as being at rotor height.

74. The collision risk zone was defined, as per Band et al (2007) and SNH guidance (Whitfield et al. 2010) as a 500m zone around the proposed wind turbine locations.

75. The improved VP survey protocol enabled viewing to 2km and, in combination with more VPs, enabled a high coverage of this zone (including viewing of the full risk volume of 46 of the 52 turbine locations, in comparison with only 27 turbines within the effective viewing zone in the previous analysis).

76. As more recent data are only currently available for the six months of August-January (though a full year's surveys are in progress to be completed in July 2016), some assumptions were needed to convert the modelling output to a full year and compare with the previous results. For the three species resident in the area year-round, Verreaux's Eagle, Martial Eagle and Booted Eagle, it was assumed that the same level of flight activity in the collision risk zone will occur through the remainder of the year, so the August-January flight activity was doubled to give an annual estimate. Black Harrier, however, was only present in the survey area during the breeding period in the previous 2013-14 surveys, so it has been assumed that there would not be any further flight activity of this species in the February-July period.

77. The results of any collision risk modelling using the Band et al. (2007) approach is highly sensitive to the avoidance rate used (Chamberlain et al. 2006). Application of an appropriate rate is therefore of fundamental importance in undertaking such modelling. However, there are very few studies at existing wind farm where avoidance rates have been fully determined, comparing pre-construction flight activity with the actual numbers of collisions post-construction (Urquhart 2010). The approach generally used to address this is to apply a precautionary rate based on the available data, such that any collision prediction is unlikely to be exceeded (i.e. represents a reasonable worst case). Where data on actual avoidance rates of particular species/groups have been established, then this has usually enabled a higher rate to be safely applied. For example, SNH has recently recommended a move from a 99% rate to 99.8% for geese based on recent research (Douse 2013). SNH now recommends using a value of 99.8% as an avoidance rate for geese (Douse 2013), 99% for several birds of prey (including Golden Eagle and Hen Harrier), and 98% for most other species (Urquhart 2010).

78. There is a lack of specific avoidance rate data from South Africa and on the species of concern at Inyanda Roodeplaat. As collision avoidance rates are not yet known for the species of concern, suitable overseas species have been used as proxies, following the same assumptions as made for the previous CRM. The selection of appropriate rates followed SNH guidance and with reference to the bird-wind farm literature. As recommended in SNH guidance, a precautionary 98% was adopted as the default value (Urquhart 2010) but the work has also explored whether particular species exhibit similar behaviour to more vulnerable species such as White-tailed Sea Eagle and Kestrel, or such behaviour that would reduce risk (and hence allow higher rates to be used as is recommended by SNH for Golden Eagle and Hen Harrier for example). The collision risk modelling results have been presented for each layout for a range of avoidance rates to inform the assessment but the most appropriate rate to apply in each specific case is also indicated. Most weight has been given to the precautionary SNH position of applying a 98%, though Verreaux's Eagle in particular shares an ecological similarity with Golden Eagle (albeit at a generally higher breeding density), for which SNH recommends a 99% avoidance rate, so applying that rate could be justified (particularly in relation to adult birds). The Golden Eagle is recognised as the Verreaux's Eagle's closest relative (Wink and Sauer-Gürth 2000). However, a more precautionary approach has been adopted in this assessment, as previously. Given that the Inyanda Roodeplaat eagles occur at a much lower density (approximately 2.4/100km^2) than the white-tailed eagles at Smøla where a density of 73/100km^2 has been recorded with 13 pairs of white-tailed eagle nesting in the wind farm which extends over 17.3km^2, Bevanger et al. 2009) and that the eagle core ranges have been buffered, it is not considered appropriate to apply as low a rate as 95% to the Verreaux's Eagle or for any other modelled species at Inyanda Roodeplaat.

Collision Modelling Results

79. The results of the collision risk modelling for the proposed 52-turbine layout for each of the four key species are summarised in Table 12. The results from the previous CRM (based on baseline data from 2013-14, but updated for the current turbine specification as set out in Table 11) are given in Table 13 for comparison. These Tables the number of collisions predicted per year based on a range of avoidance rates (95% - 99%). Verreaux's and Martial Eagle are both large non-colonial eagles, and the area in proximity to their nest sites has been avoided in the design process (so 'riskier' display flights and early juvenile flights would be less likely to occur in the wind farm). As a result, 99% should be a suitable precautionary avoidance rate to apply (as is used in the UK for Golden Eagle, an ecologically similar species), though as discussed above a more precautionary 98% has been adopted for the purpose of this assessment. Booted Eagle is more ecologically similar to buzzard species, so on the basis of the information currently available, the possibility of lower avoidance cannot be excluded so the SNH default 98% value has been applied. SNH has recommended the use of 99% avoidance rate for harriers, so that value is the primary one used for Black Harriers.

Table 12. Collision risk modelling predictions based on Aug 2015-Jan 2016 data (adjusted for a full year as set out above) for the Inyanda Roodeplaat wind farm 52-turbine layout, applying a range of avoidance rates. Predictions in bold represent the precautionary result used in the further assessment.

Species	**Precautionary predicted number of collisions per year**			
Avoidance Rate	**95%**	**98%**	**99%**	**99.5%**
Verreaux's Eagle	6.59	**2.64**	1.32	0.66
Martial Eagle	0.72	**0.29**	0.14	0.07
Booted Eagle	0.52	**0.21**	0.10	0.05
Black Harrier	7.36	2.94	**1.47**	0.74

Table 13. Collision risk modelling predictions for the Inyanda Roodeplaat wind farm 52-turbine layout based on 2013-14 data, applying a range of avoidance rates. Predictions in bold represent the precautionary result used in the further assessment.

Species	**Precautionary predicted number of collisions per year**			
Avoidance Rate	**95%**	**98%**	**99%**	**99.5%**
Verreaux's Eagle	4.30	**1.72**	0.86	0.43
Martial Eagle	0.53	**0.21**	0.11	0.05
Booted Eagle	0.20	**0.08**	0.04	0.02
Black Harrier	0.83	0.33	**0.17**	0.08

80. The predicted risks for all three eagle species using the recent data were broadly similar to those produced previously, with no major differences from the previous assessment apparent at this stage. The collision risk for Black Harrier, though was considerably higher than the previous prediction, as a result of much-increased flight activity of this species in 2015-16 (when two nests were active within the wind farm

site – see above).

Collision Modelling Interpretation

81. Whilst the Band collision model produces a quantitative estimate of the numbers of birds that might collide with the wind turbines, those numbers need to be put into the context of the existing mortality to enable their significance to be assessed. The same level of additional mortality on a population that has a low level of background mortality could potentially have a much more important effect than on a population with a higher level of existing mortality. The collision mortality needs to be assessed in the context of each species population dynamics. In the UK a 1% increase over the baseline mortality is now frequently being used as an initial filter threshold above which they may be a concern with the predicted collision mortality (and hence requiring further investigation). Collision risks below this level are usually considered not to be significant.

82. In the context of the Inyanda Roodeplaat site, the predicted collision mortality has been set against the regional background mortality for each of the four key species at risk of collision. The population data used in this analysis are summarised in Table 14. The region has been taken as the Karoo biome (Mucina and Rutherford 2006, and with reference to the WWF Karoo eco-region).

Table 14. Background population data for Verreaux's Eagle, Booted Eagle and Martial Eagle. Source: Roberts VII (Hockey et al. 2005) and Gargett (1990).

Species	Regional population	Adult mortality rate	Immature mortality rate	Annual productivity (chicks/pair /year)	Age at first breeding	Baseline annual mortality
Verreaux's Eagle	940 pairs	5%	20%	0.5	5	94 (adult)
Martial Eagle	300 pairs	7%	20%	0.6	5	150
Booted Eagle	700 pairs	10%	20%	1.0	3	500
Black Harrier	150 pairs	20%	50%	1.9	2	330 (all) 60 (adult)

83. The Verreaux's Eagle baseline population has been estimated in the same way as the previous report. This gave a conservative estimate of 600 pairs of Verreaux's Eagle for the Karoo escarpment (Roggeveld, Nuweveld, Sneeuberge and Winterberge) plus a further 100 pairs for the smaller inselbergs outside of the main mountain ranges was produced by Rob Simmons for the Witberg wind farm project (Percival 2013). These numbers were derived primarily from information collected by Rob Davies for his PhD work (together with other published population density estimates; Simmons in Hockey et al. 2005) and since then the population is thought to have declined by about 15% on the basis of recent field surveys carried out by Rob Davies. This would therefore give a current populations estimate for the escarpment plus the inselbergs of about 600 pairs. The area on which this estimate is based does not include approximately 24,000km^2 of other Karoo mountain ranges that would provide suitable habitat Verreaux's Eagle habitat. Using a very conservative nesting density of 1 pair per 60km^2 (the lowest recorded according to Davies 1994, densities at the Karoo National Park and around the Inyanda Roodeplaat site are considerably higher than this) over this entire area, this gives a further 400 pairs over this area. That too should be scaled down from the 1994 density by 15%, giving an estimated 340 additional pairs, and hence a more realistic total of about 940 pairs for the Karoo.

84. Tables 15 and 16 show the predicted collision risk (for the 2015-16 and 2013-14 data respectively) and associated impact significance for each of the four species in the context of their background mortality and the % increase over the baseline that each risk represents, for each of the two layouts. For Verreaux's

Eagle, the assessment summarised in this Table assesses the collision risk against the adult population, as the large majority of records from the site related to adult birds.

Table 15. Collision risk for Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on Aug 2015-Jan 2016 data (adjusted for full year prediction).

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect
Verreaux's Eagle	98%	2.64	2.8%	Low
Martial Eagle	98%	0.29	0.19%	Negligible
Booted Eagle	98%	0.21	0.04%	Negligible
Black Harrier	99%	1.47	0.45% (all) 2.5% (adult only)	Negligible/Low

Table 16. Collision risk for Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on 2013-14 data.

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect
Verreaux's Eagle	98%	1.72	1.8%	Low
Martial Eagle	98%	0.21	0.14%	Negligible
Booted Eagle	98%	0.08	0.02%	Negligible
Black Harrier	99%	0.17	0.05%	Negligible

85. For Martial Eagle and Booted Eagle, the predicted collision risks from the 2015-16 data continued as previously to be very small both numerically and in a population context. Those increases were considerably less than 1% when assessing the collision risk against the regional population. With such a negligible magnitude risk there would not be likely to be any regionally significant population impact for either of these species for any of the layouts.

86. For Verreaux's Eagle, the predicted collision risk of 2.6 collisions per year was, as previously, assessed as a low magnitude effect, which would be considered to be of low significance on a high sensitivity species, and hence strictly not a significant impact. However, it is above the 1% increase in the baseline mortality, and therefore requires careful consideration as to whether on the information currently available a significant effect on Verreaux's Eagle can be ruled out.

87. It was recommended previously that mitigation measures should be implemented to reduce the collision risk to Verreaux's Eagle, and this remains the case from the new 2015-16 data. As previously, it should be noted that the collision risk results presented here are from a precautionary assessment, not the most likely outcome. The analysis has adopted a precautionary approach, including:

- Use of a precautionary 98% avoidance rate rather than the more evidence-based 99% for the closely related Golden Eagle;

- Use of a conservative regional population estimate against which to assess the predicted wind farm mortality;
- Assessment of mortality has been made against only the existing adult mortality rather than the usual assessment against all of the predicted mortality;
- Assuming that flight activity through the wind farm will continue at the same rate after construction. Given that mitigation measures will be implemented to improve the food resource within nest buffers away from the wind farm (see next section) and the observed behavior of Golden Eagles at existing wind farms (e.g. Walker et al. 2005), some reduction in risky flight activity is more likely;
- The assessment is based on the current proposed 52-turbine site layout, though it is likely that this will be reduced to 45 turbines.

88. The predicted collision risk for Black Harriers (1.5 collisions per year) is higher than that predicted from the 2013-14 data (0.2 per year), reflecting this species' higher use of the wind farm site in August 2015-January 2016 than had been recorded previously (including two nests). Set against the overall regional mortality this would be an increase of only about 0.5% over the existing baseline mortality, which would be a negligible magnitude effect (and not significant). However, focusing on adult mortality (most of the flights within the risk zone were of adult birds) this increases to a 2.5% increase over the baseline, a low magnitude effect. This species is globally 'vulnerable' (on the 2015 IUCN red list) and is listed as 'endangered' on the BirdLife South Africa red list and is a near-endemic to South Africa (SA holds >70% world population), so that has the potential to be a significant impact. Mitigation measures for this species will be implemented, to ensure that this species is not adversely affected by the development.

89. In summary with regard to collision risk, the initial undertaken by Jon Smallie (Appendix 1) concluded that a significant impact on Verreaux's Eagle could not be ruled out, but that assessment was largely qualitative and did not assess the mortality in the context of the regional population. A quantitative collision risk assessment and new survey data have reduced the uncertainty of the assessment, but there still remains the potential for a significant collision risk to this species, and, on the basis of the new 2015-16 data, to Black Harrier as well. Mitigation measures are therefore proposed to ensure that no significant collision impacts occur, including on- and off-site habitat management, and development of a back-up turbine shutdown on demand system (see Mitigation section below).

Disturbance Effects

90. The implementation of the recommended buffers from known eagle nest sites that were put in place primarily to reduce collision risk (1.5km for Verreaux's Eagle and 2.5km for Martial Eagle), also removes possibility of disturbance to these eagle nest sites. The main residual disturbance issue would therefore be the loss of foraging habitat around the wind farm as a result of displacement. From experience at existing wind farms, birds are likely to avoid the close proximity of the wind turbines. There is uncertainty as to the precise extent of such an effect, but would be reasonable in the assessment to assume that it could occur. Given results from post-construction studies of other raptor species, particularly Golden Eagle (e.g. Walker et al. 2005), it has been considered that these raptors at this site might have reduced flight activity within 500m of the wind farm (as a reasonable worst case). A 500m buffer has therefore been used in this assessment as a precautionary distance over which disturbance to eagles might reasonably occur. The assessment also considered a smaller potential disturbance zone of 250m around the wind turbines, as the area in which disturbance (and hence displacement of foraging eagles) was more likely to occur (though the assessment focused primarily on the more precautionary 500m buffer).

91. There are two key raptor species using the wind farm site and breeding within the survey area that make repeated use of traditional nest sites (and hence could be more affected by disturbance), **Verreaux's Eagle** and **Martial Eagle**. In order to inform the assessment, range analyses have been carried out for these two species, following the process set out by McGrady et al (1997) developed for Golden Eagle:

    - Determination of range centre – taken as the active nest location for both species. Where more than one nest location was known for a territory the one closest to the wind farm was used (as a worst case). Where the precise nest location had not been determined the best estimate was used.
    - Determination of territory boundaries with neighboring eagles – (i) draw a straight line joining the two range centres, (ii) find a point on this line half-way between centres, (iii) draw a line through the half-way point at right angles to the first line.

- Determination of territory boundaries without neighbouring eagles – draw a curved line at 2.9 km (Verreaux's Eagle) or 9.4km (Martial Eagle) radius from the range centre to connect adjacent boundary lines drawn in Step 2. These distances were derived from reported territory sizes for these species (26km^2 for Verreaux's Eagle, from Davies 1994, and 280km^2 for Martial Eagle (Brown 1991).

92. There is likely to be further altitude constraint on both eagle species' ranges, but both species have been recorded across the full altitudinal range of the Inyanda Roodeplaat survey area, so it was not considered appropriate to include any such constraint at this site. Observed flight data (Appendix 3 Figure 12) would suggest though that there is more Verreaux's Eagle flight activity within the lower altitude parts of the survey area, where the eagle nest sites were located, rather than over the higher ground where the wind farm would be sited.

93. Range loss was predicted by overlaying a 500m and a 250m buffer around the proposed wind turbines onto the estimated ranges and measuring the percentage of each range that could be lost through displacement. The results of this range analysis are summarised in Table 17.

94. For Verreaux's Eagle, there would be no range loss for the February, Tygerberg, Tiptree and Guntia territories. There would be a 4.7% loss from the Holbak territory and a 27.9% loss from the Perdehoek territory if there were complete displacement to 500m for the 52-turbine layout.

95. For Martial Eagle, there would be a 7.1% loss from the single territory within the survey area for complete displacement to 500m for the 52-turbine layout, and a 3.3% loss assuming complete displacement to 250m from the turbines.

Table 17. Predicted Verreaux's Eagle and Martial Eagle range loss for the proposed 52-turbine wind farm, assuming complete displacement of both species to 500m from turbines.

Species	Range	Area of range within 250m of proposed turbines (km^2)	% range loss if displaced 250m from turbines	Area of range within 500m of proposed turbines (km^2)	% range loss if displaced 500m from turbines
Verreaux's Eagle	February	0	0%	0	0%
	Perdehoek	2.48	10.6%	6.54	27.9%
	Holbak	0.59	2.2%	1.23	4.7%
	Tygerberg	0	0%	0	0%
	Guntia	0	0%	0	0%
	Tiptree (new 2014)	0	0%	0	0%
Martial Eagle	New 2014	9.13	3.3%	19.7	7.1%

96. The magnitude of these disturbance impacts (and hence significance of effect) relates to the ecological consequences of any range loss. Ranges of golden eagles have been reported as being abandoned following a 40% loss of habitat (Watson et al. 1987) and reduced productivity associated with a 10-15% loss (Whitfield et al. 2001), though not in all cases and the effects of habitat loss generally can be complex. For a heavily constrained range (for example by a close neighbour or reduced availability of suitable habitat in the wider area), any additional loss is likely to be more ecologically important that an unconstrained range (Whitfield et al. 2001, 2007).

97. Focussing on the two specific Verreaux's Eagle territories that would be most affected, the area within the Holbak territory that would be affected is on the south-western edge of the range, on higher ground 2-3km from the closest nest site. Given the relative low use of the higher ground observed during the VP surveys and the wide availability of alternative foraging areas of similar habitat and elevation close nearby, the predicted 4.7% loss is not considered to be significant. This conclusion is reinforced when the benefits of the proposed mitigation measures discussed above area also implemented.

98. The predicted loss to the Perdehoek territory is much the greatest of the displacement impacts on Verreaux's Eagle, with 27.9% of that range falling within 500m of the proposed wind turbine locations.

This is below the 40% threshold at which golden eagle range abandonment occurred, but could still be a substantial loss. There is also limited possibility for this territory to expand as it is bordered to the east and west by other eagle territories. The vantage point surveys (both in 2013-14 and 2015-16) did cover most of this area, however, and did not indicate that it formed an important part of the range, suggesting that the actual impact may be somewhat reduced. It will though still be important to ensure that the recommended mitigation measures discussed above (particularly the off-site habitat management) are implemented to avoid any significant impact on this territory.

99. Martial Eagles have much larger ranges than Verreaux's Eagles, so would be predicted to be less vulnerable to range loss. The whole of the wind turbine 500m buffer lies with the Martial Eagle range that overlaps the survey area, but even so this would constitute a loss of only 7.1% of the birds' range. Given that this range is largely unconstrained, such a loss would not be considered significant (especially as this species would also benefit from off-site habitat management).

100. In conclusion with regard to disturbance to these species, disturbance impacts on Verreaux's Eagle have the potential to be significant, but mitigation measures have the potential to enable these to be managed so that they remain below the significance threshold.

101. The 2015-16 data have shown that the wind farm site can be important for **Black Harrier**, with breeding birds nesting there and a high level of use of the site for foraging as well. This was in contrast to previous surveys, which had shown that this species made only occasional use of the site. Population fluctuations in this species are though well-documented (Simmons et al. in Hockey et al. 2005), so the breeding as in 2015-16 is not an event that is certain to be repeated in future years. As noted above in the discussion of collision risk, Black Harrier is a species of particular conservation importance, being an IUCN globally vulnerable and a South African endangered red list species. With two nests within the wind farm site, disturbance to breeding birds does have the potential to be significant, so mitigation measures will be developed to ensure that any net adverse effect on this species is avoided.

Effects of the Decommissioning Phase

102. The ornithological effects that are likely to occur during decommissioning will be similar to those during construction, though given the reduced time required, and the presence of existing infrastructure, they would be of a lower magnitude. Significant effects are not likely but precautionary mitigation measures will be implemented to ensure this, as detailed below.

Summary of Effects

103. The assessment of the potential effects of the proposed wind farm on the features of ornithological interest are summarised in Table 18.

104. In the absence of mitigation, significant wind turbine collision risk and disturbance effects cannot be ruled out for Verreaux's Eagle and Black Harrier, nor for collision risk to Blue Crane and Ludwig's Bustard from the grid connection overhead wires. Mitigation measures to address these are presented in the following section.

Mitigation

Design Mitigation

105. It is usual practice when designing a wind farm to use the baseline ornithological data to inform that design to minimize any ornithological impacts. Where key species (such as eagles) use traditional nest sites over many years, it is possible to avoid locating turbines in proximity to known nest sites. For most species it would be expected that flight activity (and hence collision risk) would be higher in closer proximity to nest sites, so leaving a turbine-free buffer around nest sites should reduce collision impacts. At the same time, it should also remove any disturbance impacts on eagles at the nest, and reduce any displacement of birds from more important (closer to the nest site) foraging areas.

106. The optimal extent of buffer zones for each of the two eagle species recorded breeding in the survey area (Verreaux's Eagle and Martial Eagle) has been discussed in detail above, where it was concluded, on the basis of field data from the site and expert opinion from other wind farms developments, that a 2.5km buffer for Martial Eagle and a 1.5km buffer for Verreaux's Eagle should be applied.

107. Both collision risk and disturbance related to number of turbines, so overall magnitude of impacts will be strongly influenced by the number of turbines, so further reductions in turbine numbers, should they be implemented, would be another way in which to mitigate the ornithological impacts of the Development.

Mitigation of the Construction Phase

108. The developer has committed to the production of a Construction Method Statement to the satisfaction of BLSA and other relevant stakeholders, before construction commences, and would follow industry best practice.

109. Designated working areas, storage areas and access routes would be identified at the commencement of the construction phase. The proposed works will be phased so that access tracks are constructed early in the construction programme. Vehicular access would be restricted to designated routes throughout construction and operation as far as possible, thereby minimising potential disturbance of birds.

110. Several key species potentially vulnerable to construction disturbance were recorded during the surveys, including Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier. These should not be disturbed at the nest site during breeding, particularly during the construction phase of the wind farm. Further surveys for these will therefore be undertaken immediately prior to construction if construction were planned for the relevant breeding periods. If any were found then potentially disturbing activities would be suspended until the breeding had been completed within an appropriate zone (dependent on the location of the birds and the species involved, to be agreed with BLSA). This would form part of a Breeding Bird Protection Plan.

111. Measures should also be implemented to deter birds from nesting in those areas that will be affected by the construction works. It is proposed to remove the vegetation within the footprint for the Development, i.e. turbine foundations, access tracks etc., outside of the bird breeding period.

112. Where a disturbance impact on nesting birds is possible, site ground-works (i.e. laying of site tracks, laying out of the temporary construction compound and excavation of the turbine foundations and footings for the substation and meteorological mast) will be scheduled to take place where possible outside the breeding period. Where works affecting habitats that could be used by nesting birds must take place during the breeding season, they will only be carried out following an on-site check for nesting birds by an experienced ecologist. If this indicates that no nesting birds are likely to be harmed by the works, then the works will proceed.

113. If nesting birds are found to be present, work will not take place in that area until the adult birds and young have left the nest. A protection zone will be clearly marked around the nest site to prevent accidental disturbance or damage.

114. It is proposed to clearly mark the extent of the working area to minimise the risk of machinery encroaching onto adjacent habitat. It is important to protect habitats adjacent to the working area, since they might be used by nesting birds.

Mitigation of the Operational Phase

115. Jon Smallie was dismissive of operational mitigation at this site, stating that "*the position and nature of the Inyanda Roodeplaat site does not allow for effective mitigation at either of these levels*" [the 'levels' being the entire facility and individual turbines] (see Appendix 1). However, the Smallie report and assessment did not fully consider all of the available mitigation options. A recent review of wind farm mitigation for birds discussed in Section 4 of Appendix 2 set out possible options, including (a) specific turbine shutdown on demand when risk of collision is imminent, (b) wider restriction of turbine operation in certain seasons/times of days associated with higher risks, (c) habitat management, (d) increasing turbine visibility, (e) use of deterrents and (f) compensation.

116. Of these, (b), (d) and (e) are considered unlikely to provide a deliverable solution at Inyanda Roodeplaat. With regards to (b), there are not any specific periods/seasons to which risk is restricted, so an economically viable scheme would be unlikely. Options (d) and (e) are not widely proven techniques and still in the developmental phase, so could not currently be relied upon. Each of the other three are discussed below:

    - *Turbine shutdown on demand*

117. Curtailment of the operation of wind turbines could potentially be a useful mitigation measure to reduce collision risk, but is often uneconomic. Recent developments of schemes that have very limited shutdown over short periods has made the implementation of such schemes more viable, and there are now several in operation globally (mainly in southern Europe). These rely either on direct human observers at key risk periods and/or automated detection systems based on radar or video monitoring. Such a system should be implemented at Inyanda Roodeplaat, if required, to provide a back-up response should the number of collisions actually approach the worst-case predictions.

- *Habitat Management (on-site)*

118. The raptor food resource must not become more attractive within the wind farm site, drawing foraging birds into the site, as this would increase collision risk. For instance, during access track construction, there may be periods of time where imported or excavated aggregate is stockpiled forming potentially attractive habitat for Rock Hyrax. During construction of the wind farm all mounds of aggregate or rocks which could serve as hyrax habitat should be removed prior to the commencement of operation of the turbines and through the operational phase of the wind farm.

119. In addition, the proposed turbine bases should not serve as a refuge for small mammals, and thus the turbines themselves will not create attractive habitat for potential prey species such a hyrax.

120. As none of key species are predominantly carrion-feeders it is not considered necessary to have a programme of carrion removal from the wind farm site, though this should be reviewed in light of the results of the post-construction monitoring programme.

- *Habitat management (off-site)*

121. A management programme will be implemented within the Verreaux's Eagle nest buffers to enhance the food resources away from the wind farm, and hence reduce eagle flight activity within the wind farm.

122. The wind farm landowner plans to put 16,000 ha within his ownership into stewardship as part of the mitigation programme. This will include management measures that could improve raptor prey populations and habitat over a large area that, if managed appropriately, could deliver a net gain to the local raptor populations. A specific management plan will be drawn up and implemented to integrate the ecological requirements of the local raptors into the management of this area.

123. All of the proposed mitigation measures are summarised in Table 19 below.

Mitigation of the Decommissioning Phase

124. In order to ensure that none of the decommissioning effects on the site's ornithological interest are significant, the same mitigation measures will be implemented as for the construction phase of the development.

Assessment of Residual Effects

125. The assessment of the potential effects of the proposed wind farm on the features of ornithological interest after the implementation of the proposed mitigation are summarised in Table 20. Following mitigation, the residual ornithological effects of the Development will be a non-significant loss of a small amount of habitat to turbine bases and tracks, and a non-significant risk of disturbance and collision.

126. Using evidence from existing wind farms it is considered unlikely that the residual impacts will have any long term impact on the integrity of the study area's ornithological features or the conservation status of the species found here.

127. Overall, there are not likely to be any significant impacts on ornithology as a result of the Development assuming that the mitigation measures referred to in this report are adopted.

Grid Connection

128. The potential collision risk posed by the overhead lines required to connect the wind farm into the grid was identified by Jon Smallie as an impact that would require mitigation. He advised that all overhead power line should be on 'bird friendly' pole design as per Eskom Standard, and that high risk sections to be marked with 'bird flappers'. There was though no field survey as part of that work to enable those higher risk sections to be defined.

129. Three possible options are being considered for the grid connection. The second alternative route (Figure 3) runs adjacent to an existing line and road, and passes through less remote areas than other options, which lowers its potential ornithological sensitivity. However, the transect surveys have shown that this route holds similar densities of the two key species at risk of collision (Blue Crane and Ludwig's Bustard), indicating little difference between the ornithological sensitivity of the different routes, and emphasising the need to implement the mitigation measures set out above whichever route is finally selected.

130. The 2015-16 surveys have shown that several species prone to collision with overhead wires (including Blue Crane and Ludwig's Bustard) are present in the area through which the overhead lines would pass. It will be important therefore to ensure that suitable mitigation is put in place. The 2015-16 surveys are also informing where those species occur and hence the higher collision risk areas where those measures would need to be applied. It was not possible to obtain access to survey the full routes of all three possible grid connection routes (and the results currently available cover only the August-January period), so a further survey should be undertaken once the final route is confirmed to identify the locations where these measures will be needed (in combination with the 2015-16 data).

Proposed Ornithological Monitoring Programme

Pre-Construction Monitoring

131. The monitoring programme for the wind farm should include continuation of the pre-construction baseline surveys (raptor surveys and vantage point surveys) for a full year, continuing with the improved survey methodology to increase detection distance and a better spread of vantage points to cover the whole site.

Post-Construction Monitoring

132. Post-construction bird monitoring should be undertaken to better understand the impacts that actually occur and inform future wind farm design. This has the potential to make a significant contribution to the understanding of bird-wind farm interactions in this area and specifically about the key species at risk at this site, Verreaux's Eagle and Black Harrier.

133. The post-construction bird monitoring should include continuation, for a period of at least three years, of the raptor surveys and vantage point surveys, to compare bird distribution, abundance and behaviour before and after construction, and a programme to monitor the actual collisions that occur.

134. The operational phase collision monitoring should follow the standard methodology developed for this purpose in the United States (Morrison 1998). A core area of 100m radius around each turbine should be carefully searched on foot. The 100m distance has been set conservatively as bird fatalities have rarely been documented over 70m from turbines at other wind farms (Johnson et al. 2000). Sectors around the turbine should be slowly searched, taking particular care to search any taller clumps of vegetation, rocks and openings of animal burrows. In addition, a further area 250m around each turbine should be checked for larger bird carcasses by scanning the ground with binoculars. The precise location of any dead birds found should be recorded and mapped (by reference to the distance and direction to the nearest wind turbine, and using a GPS). All carcasses should be photographed as found then placed in a plastic bag, labelled as to the location and date (turbine number, distance and direction from turbine base), and preserved (refrigerated or frozen) until identified. Feather spots (e.g., a group of feathers attached to skin) and body parts should also be collected. For all casualties found, data recorded should include species, sex, age, date and time collected, location, distance and direction (degrees) to nearest turbine, condition, and any comments regarding possible causes of death. The condition of each carcass found

should be recorded using the following condition categories:

- Intact - carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- Scavenged - entire carcass that shows signs of being fed upon by a predator or scavenger or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, legs, pieces of skin, etc.).
- Feather Spot - 10 or more feathers at one location indicating predation or scavenging.

135. A sample of 50 dead birds (e.g. dark-feathered chickens) should be obtained in order to study the rate of carcass removal and to test observer search efficiency. These should be placed within the search area at intervals through the study by someone independent of the carcass searcher, at precise recorded locations (mapped in relation to distance and direction from the wind turbines), and marked appropriately (e.g. with coloured tape) to identify them as experimental birds. They should then be recorded by the observer on all subsequent visits, noting their precise location (distance and direction from nearest wind turbine) and condition, and left in place on site until they disappear. The amount of scavenger activity should inform the survey frequency, but an initial programme of weekly visits is recommended as a starting point.

136. A programme of tagging Verreaux's Eagles and Black Harriers is also recommended to provide further information on how these species behave in and around wind farms. Sample individuals (ideally young and adult birds) from the local population should be tagged with GPS/satellite tags to enable their detailed movement patterns to be determined. The VP surveys provide data on the use of the wind farm site but the tagging would provide more comprehensive data on how these birds are using their whole ranges and on how they respond to the presence of the wind turbines. Data from such a study could also be used to inform range modelling for this species (similar to that undertaken for the golden eagle in the UK, McLeod et al 2002, which has been widely applied to better assess the effects of wind farms on this species). Funding of a project that combines tagging and range modelling could make a significant contribution to the future conservation management of these species.

Table 18. Summary of effects of the Inyanda Roodeplaat Wind Farm on birds in the absence of mitigation

Impact	Key species	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Collision mortality from wind turbines	Black Harrier	Regional (2)	Medium (2)	Long-term (3)	High	Possible	Medium	Negative	High
	Verreaux's Eagle	Regional (2)	Medium (2)	Long-term (3)	High	Possible	Medium	Negative	High
	Martial Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Booted Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
Disturbance from foraging/nesting areas	Black Harrier	Regional (2)	Medium (2)	Long-term (3)	High	Possible	Medium	Negative	High
	Verreaux's Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Possible	Low	Negative	High
	Martial Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Possible	Low	Negative	High
	Booted Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Possible	Low	Negative	High
Collison mortality from overhead wires (grid connection)	Blue Crane	Regional (2)	Medium (2)	Long-term (3)	High	Probable	High	Negative	High
	Ludwig's Bustard	Regional (2)	Medium (2)	Long-term (3)	High	Probable	High	Negative	High

Table 19. Proposed Ornithological Mitigation for the Inyanda Roodeplaat Wind Farm

Potentially Significant Impact	Key species affected	Mitigation proposed	Requirement	Residual Impact
Disturbance during construction	Verreaux's Eagle, Martial Eagle, Booted Eagle and Black Harrier	Avoid potentially disturbing works near active nests, as part of Breeding Bird Protection Plan (to form part of Construction Method Statement).	Optional, requirement to be informed by pre-construction surveys	Not significant
Nest destruction during construction	All ground-nesting birds	Breeding Bird Protection Plan to form part of Construction Method Statement	Optional	Not significant
Collision mortality from operational wind turbines	Black Harrier, Verreaux's Eagle	On-site habitat management	Essential	Not significant
		Off-site habitat management	Essential	Not significant
		Turbine shutdown on demand	Optional, requirement to be informed by post-construction monitoring	Not significant
Disturbance from foraging/nesting areas by operational wind turbines	Black Harrier, Verreaux's Eagle	On-site habitat management	Essential	Not significant
		Off-site habitat management	Essential	Not significant
Collison with overhead wires of grid connection	Blue Crane, Ludwig's Bustard	All overhead power line to be on 'bird friendly' pole design as per Eskom Standard, and high risk sections to be marked with 'bird flappers'	Essential	Not significant

Table 20. Summary of effects of the Inyanda Roodeplaat Wind Farm on birds after applying mitigation measures

Impact	Key species	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Collision mortality from wind turbines	Black Harrier	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Verreaux's Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Martial Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Booted Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
Disturbance from foraging/nesting areas	Black Harrier	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Verreaux's Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Martial Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
	Booted Eagle	Regional (2)	Low (1)	Long-term (3)	Medium	Improbable	Low	Negative	High
Collison mortality from overhead wires (grid connection)	Blue Crane	Regional (2)	Low (1)	Long-term (3)	Medium	Possible	Low	Negative	High
	Ludwig's Bustard	Regional (2)	Low (1)	Long-term (3)	Medium	Possible	Low	Negative	High

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Appendix 1: Final pre-construction bird monitoring report (Jon Smallie, Nov 2014)

Appendix 2: Ornithological review and assessment update: final report (Steve Percival, June 2015)

Appendix 3: Bird surveys August 2015 – January 2016 (Steve Percival, February 2016)

Appendix 4: Baseline survey species list and evaluation of conservation importance (Steve Percival, March 2016)