Inyanda-Roodeplaat Wind Energy Facility

Inyanda Energy Projects (Pty) Ltd

Final pre-construction bird monitoring report

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Compiled by:

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EXECUTIVE SUMMARY

Inyanda Energy Projects (Pty) Ltd plans to develop the Inyanda-Roodeplaat Wind Energy Facility. This facility will consist of up to approximately 48 turbines and associated infrastructure such as internal access roads, substation, construction compound, batching plant and an operations building. The facility will connect to the Eskom grid near Kirkwood, a grid connection length of approximately 45 kilometres of overhead 132kV power line.

WildSkies Ecological Services (Pty) Ltd was contracted by Inyanda Energy Projects to conduct the pre-construction bird monitoring on site. More recently SRK Consulting have been appointed by IEP to manage the scoping and EIA phases of this project and have therefore managed the submission of this report. Overall, pre-construction bird monitoring consisted of approximately 40 days of field work (covering all four seasons) on site by a skilled team of two observers, several shorter site visits by the specialist, and two comprehensive surveys of breeding raptors on and near the site by contracted ornithologists.

At the outset of the programme, twenty bird species were identified as target species, i.e. those species most likely to be impacted by a development of this type. Eighteen of these species were subsequently recorded on site, out of a total of 134 bird species recorded through the year. Of these 134 species, 7 are Red List and approximately 27 are endemic bird species, several of which are Fynbos specialists associated with the Fynbos on the mountain top. A total of 7 eagle nests were confirmed close to the site, comprising 6 Verreaux's Eagle and 1 Martial Eagle nest. Eleven target bird species were recorded flying on site. These include most importantly: Verreaux's Eagle (33 records); Martial Eagle (7 records); Black Harrier (5 records); Jackal Buzzard (31 records); Booted Eagle (8 records) and Rock Kestrel (19 records). African Crowned Eagle was not recorded during formal monitoring, but was recorded during eagle nest surveys and is suspected to breed south of the site. A collision risk index was calculated for all target species collectively and indicates that the highest collision risk is on the higher ground, either at the top of the main mountain, or on the spurs descending North or South off the mountain top (see Figure 1). Collision risk for Verreaux's Eagle was calculated to be greater closer to the nest site which was within the vantage point survey radius, than in the areas proposed for turbine placement. This may indicate that the risk posed to these birds by the proposed facility is lower the further turbines are placed from the nest. However the species was also recorded flying further from the nests, on the higher ground on which turbines will be placed. Martial Eagle was not recorded flying on site frequently enough for any collision risk patterns to emerge for this species.

Considering all forms of usage of the site, and species' conservation status, the following species are considered to be most at risk at this site should this development proceed as proposed: Verreaux's Eagle; Martial Eagle; African Crowned Eagle; Black Harrier; Rock Kestrel and Jackal Buzzard. In addition, the Blue Crane, Ludwig's Bustard, Secretarybird and Denham's Bustard will be at risk of mortality due to the grid connection power line, which traverses habitat frequented by these species. The Verreaux's and Martial Eagle residing in the area are considered to be at high risk due to the high consequence of any mortality at the site. These species are already highly threatened and need to be protected from any additional unnatural forms of mortality as far as possible. The Martial Eagles is listed as Vulnerable by the "Threatened or Protected Species" listing of NEMA, with the consequent legal protection. Species such as Rock Kestrel and Jackal Buzzard are considered to be at high risk due to their high usage of the site, but the consequence of mortalities of these species is far lower due to their lower conservation status and abundance. The large terrestrial species such as cranes and bustards are unlikely to frequent the turbine area but will be susceptible to collision with the grid connection power line (approximately 45km in length). The majority of the length of this power line is likely to pose a collision risk to these species, since once the line descends off the high ground, the open, flat nature of the alignment is attractive micro habitat for these species.

The primary aim of this report is to present findings on bird abundance and behavior on site, and not formally assess the impacts on birds (as that will be done during the formal Avifaunal Impact Assessment). However given that data collection on site points towards a high risk to avifauna in the development proceeds, we make the following general findings in this regard:

- Disturbance of birds, displacement of birds, and destruction of bird habitat are likely to be of high to very high significance in our opinion. The species most at risk here are the Verreaux's and Martial Eagles, although various other species also utilise the site.
- Collision of birds (particularly Verreaux's and Martial Eagle) with wind turbines once operational is predicted to be of medium to high significance. This is the impact for which there is the most uncertainty and lowest confidence in our ability to mitigate it effectively based on current understanding. The topographic nature of the site provides little opportunity to mitigate this risk by micro siting of turbines. Most turbines in the current layout are situated either on the narrow ridge top or the equally narrow minor spur ridges, with little opportunity to move them.
- Collision and electrocution of birds on the overhead grid connection power line is predicted to be of high significance. In the case of electrocution, this risk is easily mitigated, but in the case of collision, available mitigation is not fully effective.

Three alternative routes for the grid connection power line were provided for assessment. This study recommends the selection of the 'Path 2' corridor for construction, for reasons detailed later in this report.

A construction and post construction bird monitoring framework has been prepared, and is included in this report.

Overall, the study findings indicate that the proposed facility and associated infrastructure poses a high risk to the local avifauna in our opinion. The following are the most important reasons for this statement:

- The facility is situated in a remote, so far relatively un-impacted, area of the country. This makes this area an important refuge for various threatened bird species which require large unspoilt areas for their survival. Several of these species are at risk of being impacted on if the project proceeds, as described in more detail below.

- Seven breeding pairs of eagles are situated within approximately 9 kilometres of proposed turbine positions, and several cliff areas remain incompletely surveyed and could hold more pairs. Six of these nests are used by Verreaux's Eagle, classified as Vulnerable by Taylor (2014) and one is a Martial Eagle, classified as Endangered. Although not recorded on site, the African Crowned Eagle was recorded during the eagle surveys to the south of site and is suspected to breed somewhere in that area as ample suitable habitat exists. This population of eagles represents part of a larger population on the Grootwinterhoekberge. The density of Verreaux's Eagle pairs in this area indicates this habitat may be optimal for this species, which means that this mountain range should be considered an important refuge for them.
- The topography of the general area and the position of the proposed facility in this topography nature of the mountain top turbine layout provides little opportunity for micro siting turbines out of high risk areas for impacts on birds. Almost all turbine positions are in areas indicated likely to be high collision risk based on bird flight data collected on site.
- The facility is a long distance from the existing power grid. An overhead power line of approximately 45 kilometres will be required to connect to the grid. This brings with it additional impacts on avifauna, including several Red Listed species (described elsewhere in this report) which can ill afford additional power line mortality in South Africa. This report has made recommendations as to how these identified impacts can be mitigated as effectively as possible. However, in the case of bird-power line collision particularly, currently available mitigation measures are approximately 60 to 70% effective in reducing the number of collisions. Given that full mitigation is not possible, we are of the opinion that a grid connection power line of this length should be considered a significant risk to avifauna.
- Whilst mitigation measures have been proposed for each identified risk to birds, we cannot say with certainty that these measures will reduce the risk to acceptable levels.
- We are of the opinion that the holistic risk to eagles in particular at this site is 'greater than the sum of its parts'. A piece meal approach to mitigating the risk to each of the seven pairs of breeding eagles, such as through the use of buffer areas (within which no infrastructure is constructed) around each eagle nest will in our view not collectively mitigate the holistic risk adequately. Buffer areas as a mitigation option probably best fits in at the 'minimise' or 'reduce' level of the impact mitigation hierarchy. Minimising or reducing impacts on avifauna is in our view not an acceptable approach in this case where the facility could affect 7 breeding pairs of Red List eagles. In our opinion this is a prime example of where the first step in the mitigation hierarchy, i.e. 'avoid' should be invoked first and foremost.
- There is an inherent value of this site for large eagles particularly, that will undoubtedly be diminished by the construction of such a facility. Furthermore, as apex predators, eagles play an important role in the overall ecology of such an area, and the indirect effects of removing them from an ecosystem such as this, although difficult to quantify, are likely to be significant.

In light of the above findings we believe the appropriate approach in this instance to be the application of the precautionary principle. In other words, based on the level of understanding we have of the site currently, **we believe the overall risk to avifauna to be high and in most cases not easy to mitigate fully**. **We would**

therefore recommend against the construction of this facility. We also note that space and appropriate sites for wind farms is not a limiting factor in South Africa. In our opinion there are likely to be other sites which can be developed to meet the countries energy needs at less risk to avifauna.

If Inyanda Energy Projects still wishes to develop this project in spite of the above findings, we recommend the following steps be taken:

- That additional data be collected on site to complement the data set already collected by 'traditional' human based monitoring. This data would need to again cover a full year in the eagles life history in order to understand if and how the risk posed by the facility to the birds may vary through both the non- breeding and breeding seasons. In particular, a better understanding of the movement and behaviour of the Verreaux's and Martial Eagle on site would be beneficial. Data collection on bird movement to date has sampled approximately 40 days in a year. It would be important to understand what the eagles are doing all day, all week and all year. This would allow a more accurate understanding of how much time the birds spend in the areas of the site where turbines would be built. It is recommended that various technologies such as radar and eagle tracking devices be considered for this purpose. The following two technologies are options to consider, either together or separately:
    - In the case of radar studies, explicit data should be collected for all larger bird species moving on site, with more accurate spatial resolution than human observers. The steep and broken topography on site may pose challenges for the use of radar, but this would need to be confirmed by a suitable radar specialist.
    - Satellite/GSM/GPS transmitters fitted to a number of adult eagles from these breeding sites could yield extremely useful information, and have the advantage of collecting data 24 hours per day for 365 days of the year.
- Additional nest surveys in the south-east of the study area should be conducted to ascertain whether additional pairs of eagles (including possibly African Crowned Eagle) are resident in the area.

This report has made a number of management recommendations in the event that this project be authorised. These recommendations could be added to or altered if additional avifaunal work is done on site.

REPORT REVIEW & TRACKING

Document title	Inyanda Roodeplaat Wind Energy Facility – Avifaunal Impact Assessment	
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SPECIALIST DETAILS

Professional registration

The Natural Scientific Professions Act of 2003 aims to "Provide for the establishment of the South African Council of Natural Scientific Professions (SACNASP) and for the registration of professional, candidate and certified natural scientists; and to provide for matters connected therewith."

"Only a registered person may practice in a consulting capacity" – Natural Scientific Professions Act of 2003 (20(1)-pg 14)

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Professional experience

Jon Smallie has been involved in bird interactions with energy infrastructure for 14 years. During this time he has completed impact assessments for more than 100 projects, at least thirty of which involved wind energy generation. He is a founding member of the Birds and Wind Energy Specialist Group and co-author of the best practice guidelines for wind energy and birds. A full Curriculum Vitae can be supplied on request.

Declaration of Independence

The specialist investigator (WildSkies Ecological Services) declares that:

- We act as independent specialists for this project.
- We consider ourselves bound by the rules and ethics of the South African Council for Natural Scientific Professions.
- We 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, 2006.
- We will not be affected by the outcome of the environmental process, of which this report forms part of.
- We do not have any influence over the decisions made by the governing authorities.
- We 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.
- We 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, 2006.

Terms and Liabilities

- This report is based on four seasons of pre-construction bird monitoring on site, and other available information and data related to the site to be affected.
- The Precautionary Principle has been applied throughout this investigation.
- Additional information may become known or available during a later stage of the process for which no allowance could have been made at the time of this report.
- The specialist investigator reserves the right to amend this report, recommendations and conclusions at any stage should additional information become available.
- Information, recommendations and conclusions in this report cannot be applied to any other area without proper investigation.
- This report, in its entirety or any portion thereof, may not be altered in any manner or form or for any purpose without the specific and written consent of the specialist investigator as specified above.
- Acceptance of this report, in any physical or digital form, serves to confirm acknowledgment of these terms and liabilities.

Assessment philosophy

The specialist has 14 years of experience in bird conservation in South Africa, and is passionate about ensuring the protection of our bird species, particularly outside of protected areas. He also has a sound knowledge of the different forms of energy generation employed to date in SA, and the implications of these choices for our birds. This assessment is therefore conducted with a pragmatic approach founded on the firm belief that in national terms, renewable energy is a positive move for South Africa's environment and birds in the longer term. This does not mean however that renewable energy projects should be exempt from thorough impact assessment or management, but rather that any potential impacts be viewed against the broader implications of continuing on a fossil fuel based energy mix.

Signed in November 2014 by Jon Smallie, in his capacity as avifaunal specialist for this project.

GLOSSARY

AEWA	African-Eurasian Waterbird Agreement
ADU	Animal Demography Unit – University of Cape Town
CAR	Coordinated Avifaunal Roadcount
CBD	Convention on Biological Diversity
CMS	Convention on the Conservation of Migratory Species
EIA	Environmental Impact Assessment
EU	European Union
FS	Focal Site
IBA	Important Bird Area
IEP	Inyanda Energy Projects
IUCN	International Union for Conservation of Nature
MW	Megawatt
Red List species	A species listed by either regional or Global Red Lists – a species of conservation concern
SRK	SRK Consulting
SABAP	Southern African Bird Atlas Project
SACNASP	South African Council for Natural Scientific Professions
Target species	A species believed to be susceptible to wind farm impacts, and/or or conservation concern
TOPS	Threatened or Protected Species List
USA	United States of America
UK	United Kingdom
VP	Vantage Point
VT	Vehicle Transect
WEF	Wind Energy Facility
WT	Walked Transect

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1. INTRODUCTION

Inyanda Energy Projects (Pty) Ltd (hereafter IEP) plans to develop the Inyanda-Roodeplaat wind energy facility (WEF) between the towns of Patensie and Kirkwood within the Sunday's River Valley Municipality in the Eastern Cape Province. The proposed project area will encompass an area of approximately 13 700 hectares, located on 17 property portions. The Inyanda-Roodeplaat WEF will consist of an array of up to 48 turbines and associated infrastructure such as internal access roads, substation, construction compound, batching plant and an operations building covering an area of approximately 60 hectares depending on the final layout design. Each turbine will produce between 1.6 and 6 Megawatts of power.

WildSkies Ecological Services was contracted by Inyanda Energy Projects to conduct the pre-construction bird monitoring, in preparation for the impact assessment. More recently, SRK Consulting (hereafter SRK) have been appointed by IEP as the Environmental Assessment Practitioner (EAP) to manage the environmental impact assessment studies for this development, and hence managed the submission of this report.

Typically a wind energy facility of this nature can be expected to impact on avifauna as follows: disturbance of birds; habitat destruction during construction and maintenance of the facility and associated infrastructure; displacement of birds from the area, or from flying over the area; collision of birds with turbine blades during operation; and collision and electrocution of birds on associated electrical infrastructure. The pre-construction bird monitoring carried out on site over four seasons collected the data required to assess the likelihood and significance of each of these impacts, which this EIA phase report does.

Topographically the site is characterised by the 'Grootwinterhoekberge' and is comprised of a narrow and steep ridge line that runs approximately east-west with slopes facing north and south. Numerous drainage lines of varying sizes drain off the higher ground, and in most cases result in north-south oriented gorges, with extensive cliff substrate. The proposed turbine positions are all located on the higher ground where the vegetation is fairly uniform and classified as "Kouga Grassy Sandstone Fynbos" and "Kouga Sandstone Fynbos". The broader study area (and particularly the lower ground) is comprised of Albany Thicket, which is a very different vegetation type with a different avifaunal community. The low lying area to the north of the site (which will be traversed by the grid connection power line) consists of more open vegetation, and could accommodate large terrestrial species such as bustards, cranes, and Secretarybird. It is however unlikely that these species will frequent the ridge top where the turbines are proposed. An approximate total of 207 bird species could occur in the broader area, based on what has been recorded in the relevant quarter degree square by the first bird atlas project (Harrison *et al* 1997), and in the relevant pentads by the second atlas project (www.sabap2.adu.org.za). This is a relatively good diversity of species, reflecting the diversity of habitats in the broader study area. In total 12 of these species could be considered threatened (Taylor, 2014; IUCN, 2013, including the Peregrine Falcon not listed by Taylor but listed as Least Concern by IUCN). Almost all of the recorded threatened species are important with respect to wind energy facilities. The large terrestrial species such as the Blue Crane *Anthropoides pradiseus*, Denham's Bustard *Neotis denhami,* Ludwig's Bustard Secretarybird *Sagittarius serpentarius,* and raptors such as Martial Eagle *Polemaetus bellicosus* and Verreaux's Eagle *Aquila verreauxii* are all believed to be likely to collide with power lines and wind turbines. The smaller species, in this case including Fynbos specials such as Orange-breasted Sunbird *Anthobaphes violacea* and Cape Grassbird *Sphenoeacus afer*, could most likely be impacted on through disturbance and habitat destruction. Of particular importance at this site is the presence of multiple pairs of breeding eagles.

1.1 Description of the proposed wind energy facility

The proposed Inyanda - Roodeplaat WEF will consist of approximately 48 turbines each generating 1.8 - 6.15 Mega Watts (MW) of power depending on the model and size of turbine selected. The turbine footprints and associated facility infrastructure (internal access roads, substation, construction compound, batching plant and operations building) will potentially cover an area of approximately 60 hectares depending on final layout design should the project proceed. An investigation of the wind regime of the site will decide the model of turbines to be installed. The facility will have a maximum generating output of approximately 140 MW.

At this time there is no alternative site for consideration for the overall wind energy facility. Alternatives exist within the site for the substation, turbine and power line positioning. Figure 1 below shows the location of the proposed site for the Inyanda-Roodeplaat Wind Energy Facility.

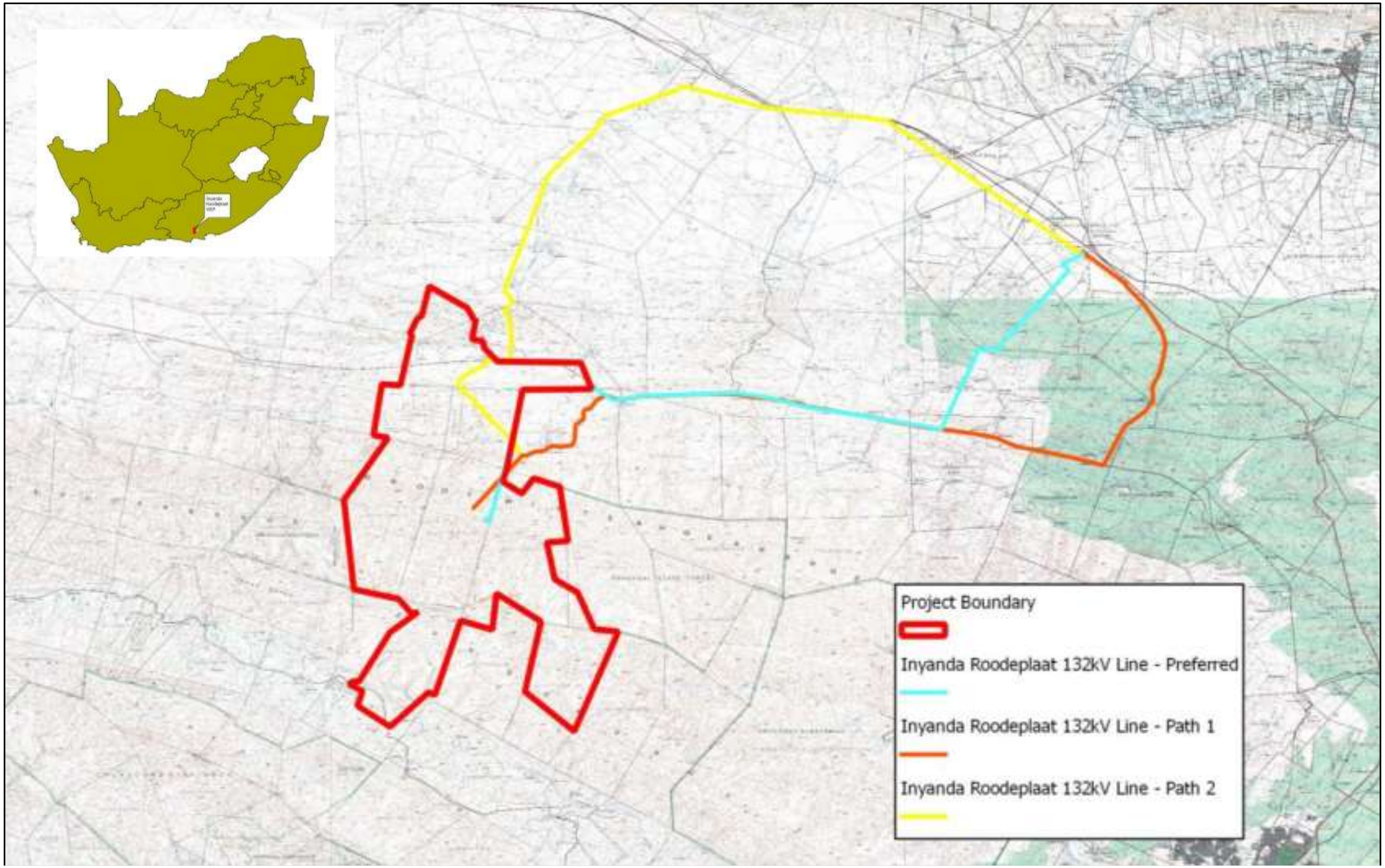

Figure 1. The location of the proposed Inyanda-Roodeplaat Wind Energy Facility.

1.2. Background to wind energy facilities and birds

The South African experience of wind energy generation is limited to date with only eight commercial scale wind turbines having been operational for several years in the country at the time of writing (although a handful of facilities have recently been commissioned and numerous others are currently under construction). The only available post construction bird monitoring results in South Africa are from a monitoring programme at the Klipheuwel demonstration facility (3 turbines) which found two bird collisions equating to an estimated 1 bird/turbine/year fatality rate (Kuyler, 2004). Doty & Martin (2013) monitored one turbine at Port Elizabeth (3 searches per week for 52 weeks) and found one Little Swift *Apus affinis* collision victim over a period of a year. Much of what we know about the interaction between birds and wind energy facilities is therefore learnt from international literature, mostly from the United States, United Kingdom, and Europe. Unfortunately much of this literature is grey literature (not peer reviewed or published in a scientific journal, and therefore potentially less credible), and focuses on the impact of collision. Two important sources used for the below discussion were a review by Rydell *et al* (2012) and assorted information on the "Good Practice Wind" website at www.project-gpwind.eu.

The interaction between birds and wind farms first documented was that of birds killed through collisions with turbines, dating back to the 1970's. Certain sites in particular, such as Altamont Pass – California, and Tarifa – Spain, killed a lot of birds and focused attention on the issue. However it appears that sites such as these are the exception rather than the rule, with most facilities causing low fatality rates (Kingsley & Whittam, 2005). Expressed relative to other anthropogenic mortality factors, wind farms also cause relatively low fatality rates (Erickson *et al*, 2001; Gill *et al*, 2006), although there are some inherent challenges in making these comparisons as explained later in this report.

With time it has become apparent that there are actually three ways in which birds can be affected by wind farms: collisions – which is a direct mortality factor; habitat alteration or destruction (less direct); and displacement and barrier effects (various authors including Rydell *et al* 2012). Whilst the impact of habitat alteration is probably fairly similar to that associated with other forms of development, the displacement and barrier effects are unique to wind energy. It is not yet known whether it is the noise, visual, flicker or shadow effects that may disturb and displace birds. Whatever the cause is, if birds are displaced from the site it is lost as habitat. Without doubt the impact of collision has received the most attention to date amongst researchers, operators, conservationists, and the public.

1.2.1. Collision of birds with turbine blades

That birds collide with human developed infrastructure has been well documented over the years (for e.g. Drewitt & Langston, 2008). Since the first birds were found under wind turbines it has more or less been assumed that the birds collided with turbine blades because they did not see them. Much of the earlier work was therefore based on the assumption that this was a visual problem. The logical consequence then was to develop mitigation measures that made the turbines more visible to birds. It was suggested that the primary reason for birds failing to see turbine blades was the phenomenon of motion smear or retinal blur (Hodos, 2002), whereby an identical image (such as the three turbine blades) passing over the retina repeatedly and fast enough can actually become invisible (such as the propeller of a light aircraft). A suggested solution to this was to paint one blade black so that the images would alternate between white and black thereby reducing the likelihood of retinal blur. Although vision certainly has a lot to do with the collision, more recently it seems likely that various other factors also play a part. In recent research on bird vision (Martin, 2011; Martin & Shaw, 2010) suggest that birds may have reduced visual acuity in front of them when in flight, or in the case of vultures may even be blind for a significant portion of their frontal vision. This would necessitate a different approach to mitigation than has so far been the case.

Fatality rates

It is important to first understand the scale of this effect before delving into the details of factors influencing it. Not surprisingly as soon as dead birds were discovered at wind farms, researchers started to count them. With time the need arose to standardise metrics across multiple sites, countries and continents. The two most common measures used to date are number of birds killed per turbine per year, and number of birds killed per megawatt installed per year. Rydell *et al* (2012) reviewed studies from 31 wind farms in Europe and 28 in North America and found a range between 0 and 60 birds killed per turbine per year, with a median of 2.3. European average bird fatality rates were much higher at 6.5 birds/turbine/year compared to the 1.6 for North America. These figures include adjustment for detection (the efficiency with which monitors detect carcasses in different conditions) and scavenger bias (the rate at which birds are removed by scavengers between searches). These are important biases which must be accounted for in any study of mortality.

Cumulative effects

Even where fatality rates may appear low there should be adequate attention given to the situation. The cumulative effects of several facilities on the same species could be considerable, particularly if these are sited in the same region and impact on the same regional population of the species. Also most long lived slow reproducing Red List species may not be able to sustain any additional mortality factors over and above existing factors.

Bird related factors affecting collision with turbines

Whilst all birds face some inherent risk of collision with wind turbines, certain groups are definitely more susceptible (Jordan & Smallie, 2010; Rydell *et al,* 2012). Taxonomic groups most commonly affected include: Podicipediformes; Pelicaniformes; Ciconiiformes; Anseriformes; Falconiformes; Charadriformes; Strigiformes; Caprimulgiformes; Gruiformes; Galliformes; Psittaciformes; and Passeriformes (Jordan & Smallie, 2010). A number of factors (and various combinations thereof) are believed to be important in determining a bird species susceptibility to collision, described below:

Behavioural factors

The most important behavioural characteristic suggested so far as influencing collision risk is the birds reaction to the presence of turbines (Rydell *et al*, 2012). Certain bird species have been observed to display avoidance behaviour from a significant distance from turbines, thereby ensuring safety, whilst other species appear to be comfortable foraging in amongst turbines. Birds also tend to fly lower during strong headwinds (Richardson, 2000) thereby increasing the risk of collision since turbines are also functioning at a maximum in strong winds (Drewitt & Langston, 2008).

Raptor's susceptibility to collision with turbines is difficult to explain given their apparent excellent eye sight and mostly good maneuverability. It has been suggested that due to these two factors raptors do not avoid obstacles at a far enough distance to ensure safety (in Rydell *et al*, 2012). Obstacles that are moving, such as the three blades of a turbine, need to be avoided at further distances (or earlier) than stationary ones (Martin, 2011)

Morphological factors

Flight prowess and maneuverability have been suggested to be two of the primary morphological factors (Barrios & Rodrigues, 2004; Drewitt & Langston, 2006). This is similar to other forms of collision (such as power lines) where it is believed that large birds (and with high wing loading – the ratio of wing area to mass) may be less able to adjust flight quickly when they perceive an obstacle (Jenkins *et al,* 2010; de Lucas *et al*, 2008). Jenkins *et al* (2010) make a useful distinction between a birds' 'susceptibility' to collision, and its 'exposure'. Susceptibility is determined by factors including: physical size; wing loading; maneuverability; speed of flight; height of flight; open or closed habitat; aerial foraging; aerial displays; frequent flight at night or in low light; and narrow binocular field of vision (Martin & Shaw, 2010). Exposure is determined by how often, far and for how long a bird flies, and whether it flocks. This distinction is relevant to bird-wind turbine collision theory and has been used indirectly to assess risk in Section 5 of this report.

Seasonal factors

According to Drewitt & Langston (2008) bird collisions could be dependent on the season and weather. Raptor fatalities in particular are clumped into certain seasons, perhaps when flight activity is higher due to courtship, nest building, and provisioning of young.

Habituation

Although it has been suggested that birds will get accustomed to a wind energy facility with time and that they will then avoid collisions, there is no evidence to support this (Rydell *et al*, 2012; de Lucas *et al*, 2008; Smallwood & Thelander 2008, Bevanger *et al*, 2010). Likewise with age of bird, young birds do not seem to be disproportionately affected.

Facility related factors affecting collisions with turbines

Turbine size

Several authors have found that taller turbines with longer blades (and hence larger rotor swept area) did not kill more birds (e.g. Barclay *et al,* 2007). As turbine size increases fewer birds are killed when expressed per megawatt, since fewer turbines are required in order to generate the same power.

Lighting

Although it has been suggested previously that lighting at turbines will increase the collision risk (seemingly on the basis of recorded incidents of mass collisions of birds with other lit infrastructure – Erickson, 2001) there does not seem to be any evidence to substantiate this (Rydell *et al,* 2012). It has also been suggested that if flashing or intermittent light is used this may reduce the risk (Drewitt & Langston, 2008).

Size of facility or number of turbines

Rydell *et al* (2012) found that larger wind farms do not necessarily kill more birds per turbine. The absolute number of birds killed by the facility will of course be greater for a larger facility if all other factors are equal. Of course larger facilities would also have greater impacts through habitat destruction and displacement and barrier effects.

There appears to typically be an uneven distribution of collisions across the turbines on a site, with 13% of the 5 000 turbines at Altamont Pass being responsible for all Golden Eagle *Aquila chrysaetos* and Red-tailed Hawk *Buteo jamaicensis* (Curry & Kerlinger, 2000) fatalities, and more than 50% of vulture casualties at Tarifa being on 15% of the turbines (Acha, 1997).

Spacing of turbines

Conflicting information exists on the effect of turbine spacing on collision risk, some authors suggesting that spaces should be left for safe passage of birds (Drewitt & Langston, 2006; 2008), but the same authors also suggest that perhaps birds should be discouraged from flying through a facility and should rather be encouraged to avoid the entre facility. This would clearly result in a greater displacement effect on the species.

Site related factors affecting collision with turbines

Rydell *et al* (2012) conclude from their analysis that the most important factor determining collision risk is the location of turbines relative to bird occurrence, and the surrounding environment. Collision frequency has so far been highest at facilities near wetlands and the coast, and also on the top of ridges or areas with significant variation in topography (such as the Inyanda Roodeplaat site). Certain landscape features may also channel bird flight into flight paths that are used more frequently. In general, high density of birds in an area will mean that the risk of collision is high although studies are conflicting in this regard (Rydell *et al,* 2012). Several authors found that density and activity of birds near wind farms is related to collision risk (Barrios & Rodrigues, 2004; Everaert & Kuijken, 2007; Stienen *et al*, 2008), whilst certain studies found that this is not the case (de Lucas *et al*, 2008; Krijgsveld *et al*, 2009). It seems logical that for collision risk to be high then usage of the site must be high, either by lots of birds or few birds repeatedly. It is also clear that this is not the only factor determining collision risk.

1.2.2. Loss or alteration of habitat during construction

The area of land directly affected by a wind farm and associated infrastructure is relatively small. As a result in most cases, habitat destruction or alteration in its simplest form (removal of natural vegetation) is unlikely to be of much significance. However fragmentation of habitat can be an important factor for some smaller bird species. Construction and operation of a wind farm results in an influx of human activity to areas often previously relatively uninhabited (Kuvlesky *et al* 2007). This disturbance could cause certain birds to avoid the entire site, thereby losing a significant amount of habitat effectively (Langston & Pullan, 2003). In addition to this, birds are aerial species, spending much of their time above the ground. It is therefore simplistic to view the amount of habitat destroyed as the terrestrial land area only. Loss of aerial habitat is discussed in more detail below under displacement and barrier effects.

1.2.3. Disturbance of birds and barrier effects (or displacement)

Disturbance effects can occur at differing levels and have variable levels of effect on bird species, depending on their sensitivity to disturbance and whether they are breeding or not. For smaller bird species, with smaller territories, disturbance may be absolute and the birds may be forced to move away and find alternative territories, with secondary impacts such as increased competition. For larger bird species, many of which are typically the subject of concern for wind farms, larger territories mean that they are less likely to be entirely displaced from their territory. For these birds, disturbance is probably likely to be significant only when breeding.

A barrier effect or displacement occurs when a wind energy facility acts as a barrier for birds in flight, which then avoid the obstacle and fly around it. This can reduce the collision risk, but will also increase the distance that the bird must fly. This has consequences for the birds' energy balance. Obviously the scale of this effect can vary hugely and depends on the scale of the facility, the species territory and movement patterns and the species reaction. This aspect is particularly relevant at Inyanda Roodeplaat, where seven pairs of large threatened eagles breed around the site. Presumably the site itself is important to all of these birds as a foraging area, and the alteration of this site would have some effect on these birds' foraging behaviour and home range. Alternatively if no displacement occurs this would mean that these birds and their young each season would be flying in amongst the turbines, at risk of collision.

Turbine construction has been suggested, but not fully demonstrated, to be a cause of displacement of nesting eagles (Walker *et al*. 2005, Martı´nez *et al*. 2010). We have some limited experience of Martial Eagle at an operational wind farm, which continued to use the wind farm area for foraging post construction (pers. obs.). This suggests that the birds were not completely displaced from the site, although this issue is complex and would require long term detailed data to fully understand. The proposed mitigation for displacement is the use of buffer areas as described for 'Disturbance' above.

1.2.4. Associated infrastructure

Infrastructure associated with wind energy facilities also has the potential to impact on birds, in some cases perhaps more than the turbines themselves. Overhead power lines pose a collision and possibly an electrocution threat to certain bird species (depending on the pole top configuration). Furthermore, the construction and maintenance of the power lines will result in some disturbance and habitat destruction. New access roads, substations and offices constructed will also have a disturbance and habitat destruction impact. Collision with power lines is one of the biggest single threats facing birds in southern Africa (van Rooyen 2004). Most heavily impacted upon are bustards, storks, cranes and various species of water birds. These species are mostly heavy-bodied birds with limited maneuverability, which makes it difficult for them to take the necessary evasive action to avoid colliding with power lines (van Rooyen 2004, Anderson 2001). Unfortunately, many of the collision sensitive species are considered threatened in southern Africa. The Red List species vulnerable to power line collisions are generally long living, slow reproducing species under natural conditions. Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004). The larger bird species are most affected since they are most capable of bridging critical clearances on hardware.

1.2.5. Mitigation

Whilst bird mortalities have been comprehensively documented at numerous sites world-wide, very little has been written about the potential methods of reducing the level of mortalities, perhaps because little mitigation has been implemented post construction. Potential mitigation measures include: alternative turbine designs (such as vertical axis turbines); painting turbine blades (tested only in laboratory conditions to date); anti perching devices; construction of shielding pylons; curtailment of turbines during high risk periods; shutdown of certain high risk turbines; and altering blade height to pose less risk within the birds' preferred height strata. Most of these suggested mitigation measures are either not tested, impractical or unlikely to be implemented by the operator post construction. The primary means of mitigating bird impacts therefore remains correct siting at two levels: 1. - of the entire facility; and 2. - of the individual turbines themselves. This two tiered approach will become relevant later in this report, where it is argued that the position and nature of the Inyanda Roodeplaat site does not allow for effective mitigation at either of these levels. Whichever mitigation measures are identified as necessary, this should be informed by a thorough pre and post construction bird monitoring programme.

1.2.6. Contextualising wind energy impacts on birds

Several authors have compared causes of mortality of birds (American Bird Conservancy, 2012; Sibley Guides, 2012; National Shooting Sports Foundation 2012; Drewitt & Langston 2008) in order to contextualise possible mortality at wind farms. In most of these studies, apart from habitat destruction which is the number one threat to birds (although not a direct mortality factor) the top killers are collision with building windows and cats. Overhead power lines rank fairly high up, and wind turbines only far lower down the ranking. These studies typically cite absolute number of deaths and rarely acknowledge the numerous biases in this data. For example a bird that collides with a high rise building window falls to a pavement and is found by a passer-by, whereas a bird colliding with a wind turbine falls to the ground which is covered in vegetation and seldom passed by anyone. Other biases include: the number of windows; kilometres of power line; or cats which are available to cause the demise of a bird, compared to the number of wind turbines. Biases aside the most important short coming of these studies is a failure to recognise the difference in species affected by the different infrastructure. Species such as those of concern at wind farms in South Africa are unlikely to frequent tall buildings or to be caught by cats. Since many bird species are already struggling to maintain sustainable populations, we should be striving to avoid all additional, new and preventable impacts on these species, and not permitting these impacts simply because they are smaller than those anthropogenic impacts already in existence.

2. METHODOLOGY

2.1 Terms of reference

The avifaunal specialist has conducted this assessment according to the typical terms of reference for a study of this nature. These terms of reference have been added to or amended as this environmental assessment process unfolded. The terms of reference are as follows:

- To provide a description of the environment that may be affected by the activity and the manner in which the environment may be affected by the proposed project.
- To provide a description and evaluation of environmental issues and potential impacts (including direct, indirect and cumulative impacts) that have been identified.
- To provide a statement regarding the potential significance of the identified issues based on the evaluation of the issues or impacts must be made.
- To provide a comparative evaluation of any identified feasible alternatives must be made.
- To identify any potential impacts and to assess their likelihood and significance according the criteria provided by SRK (see Appendix 1).

2.2 Project objectives

The aims of this study are as follows:

1. To estimate the abundance of the priority species within the wind farm affected area. This will be used as a baseline against which to measure potential displacement and disturbance of these species due to the construction and operation of the WEF. This objective is reported on in Section 3.

2. To document patterns of bird movement on site and flight behaviour that is relevant to understanding the risk of collision of these birds with wind turbines once constructed. This objective is achieved in Section 3.

3. To identify potential risks of interaction between avifauna and the facility once constructed. This is achieved in Sections 3, 4, 5 and 6.

4. To develop management recommendations for the mitigation of these risks. This could include providing spatial input into the final design (including the siting of turbines), construction and management strategy of the development. This is presented in Sections 6 and 8.

5. To develop a framework or outline for during construction and operational phase bird monitoring at this site. This is presented in Section 7.

6. More broadly speaking, bird monitoring at WEF's in South Africa aims to develop an understanding of the interactions between birds and WEF's; and to develop means of mitigating impacts where necessary. This

will ensure that individual projects are sustainable once built, and that the overall industry remains sustainable into the future.

2.3 General approach

This study followed the following general steps. The detailed methodology is presented in Section 2.7 and 2.8:

The assessment included:

- A desk-top review of existing literature to assess previous means of predicting bird mortality (and other impacts) of wind turbines affecting birds in groups similar to those in the study area; consider accounts of mortality at wind turbines; and consider information on the status of bird group most likely to be affected.
- Contextualize the literature and experience and relate it to the Eastern Cape scenario and local avifauna;
- 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. In this case a full four seasons of pre-construction bird monitoring was conducted on site in accordance with best practice.
- Surveys conducted on the study area in line with recommended guidelines in this regard. These were refined for the study area.
- Map sensitive areas in and around the proposed project site;
- Describe the affected environment and determine the status quo in terms of avifauna;
- Indicate how an avifaunal resource or community will be affected by the proposed project;
- Discuss gaps in the baseline data with respect to avifauna and relevant habitats;
- List and describe the expected impacts;
- Assess and evaluate the anticipated impacts, and;
- 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.

2.4 Data sources used

Various existing data sources have been used in the design and implementation of this programme, including the following:

- The Southern African Bird Atlas Project data (SABAP1 - Harrison et al, 1997) for the single quarter degree square considered relevant (3325CA - 56 cards and 170 species). The Southern African Bird Atlas Project 2 data was also consulted at http://sabap2.adu.org.za/v1/index.php. The number of cards submitted for the four relevant pentads at the time of writing is as follows: 3330_2500 twelve cards (92 species); 3330_2505 ten cards (116 species); 3335_2500 nine cards (40 species) and 3335_2505 no cards submitted.

- The Important Bird Areas report (IBA - Barnes 1998) was consulted to determine the location of the nearest IBA's and their importance for this study. The closest IBA (SA093 Kouga – Baviaanskloof Complex) is located approximately 16 kilometres west of the proposed site.
- The Co-ordinated Avifaunal Roadcount project (CAR – Young et al, 2003) data was consulted to obtain relevant data on large terrestrial bird report rates in the area where possible. The closest route, EP04 is located approximately 22 kilometres north west of the proposed site.
- The conservation status of all relevant bird species was determined using Taylor (2014) for southern Africa and IUCN (2013) for global status.
- The latest vegetation classification of South Africa (Mucina & Rutherford, 2006) was consulted in order to determine which vegetation types occur on site.
- Google Earth Imagery was used extensively for planning purposes.
- Aerial photography from the Surveyor General was used.
- The recent document "Avian Wind Farm Sensitivity Map for South Africa: Criteria and Procedures Used" by Retief, Diamond, Anderson, Smit, Jenkins & Brooks (2011) was used for the species listing.
- The "BirdLife South Africa/Endangered Wildlife Trust best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa (Jenkins, van Rooyen, Smallie, Harrison, Diamond & Smit, 2012)" was used extensively to guide this project. A revision of this guideline is currently underway and about to be released.
- Various documentation on the Good Practice Wind website was used (www.project-gpwind.eu), particular guidance on assessment of impacts.
- Comments submitted during the scoping phase by interested and affected parties were noted and considered in the design of this programme.
- The Birdlife International "Position statement on wind farms and bird' (2005).
- The Endangered Wildlife Trust and BirdLife South Africa "Position statement on wind farms and birds (2012).
- The BirdLife South Africa "Draft Terms of Reference for Avifaunal Impact Assessment at Wind Energy Facilities" 2013).
- The draft Environmental Scoping Report was consulted for background information on the proposed project.
- As part of the pre-construction bird monitoring programme, two surveys of the breeding eagles in the area were completed, in 2013 and 2014, Barkhuysen and Jenkins et al respectively. Barkhuysen (2013) surveyed the five known Verreaux's Eagle nests on the northern side of the mountain range. Jenkins et al (2014) surveyed the above northern nests and as much as possible of the southern parts of the site for eagle breeding habitat. Parts of the site in the south-east were not accessible in the time available, and may hold breeding pairs of eagles, as there does appear to be suitable habitat (from a distance).

2.5 Relevant legislation

The legislation relevant to this specialist field and development include the following:

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 - 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.

2.6 Limitations and assumptions

Typically a study of avifauna at a site such as this would be heavily dependent on secondary data sources such as those listed above. In this case however, a significant amount of primary data was collected on site – rendering the above data sources useful only for preliminary planning. Limitations of this study then apply more to the primary data collection methods. A potential limitation exists in the quality and skill levels of the observers used. The data obtained can only be as good as those people capturing it. Experience with the observer team used on this project has shown that their bird identification and data capture skills are more than adequate.

At the outset of this programme, road access to the eastern half of the ridge top, and to the areas south of the ridge top watershed was extremely limited, time consuming and damaging to vehicles. As a result the monitoring programme setup was biased in terms of access, a point which was discussed with and agreed upon with the developer at the time. In order to cover the eastern parts, the fourth vantage point (VP4) was situated well off site, with a view up onto the mountain. Later in the programme, new roads were opened up which will improve access significantly, but were too late to influence this monitoring programme. It is believed that since the habitat and topography on site is extremely uniform between the eastern and western parts of the site, extrapolation of results to the inaccessible portions of the site will be acceptable in this case.

Certain biases and challenges are inherent in the methods that have been employed to collect data in this programme. It is not possible to discuss all of them here, and some will only become evident with time, but the following are some of the key points: The presence of the observers on site is certain to have an effect on the behaviour of the birds itself. For example during vantage point counts, it is extremely unlikely that two observers sitting in position for three hours will have no effect on bird flight. Some species may avoid the vantage point position, because there are people there, and others may approach out of curiosity. In almost all data collection methods large bird species will be more easily detected, and their position in the landscape and flight height more easily estimated. This is particularly relevant at the vantage points where a large eagle may be visible several kilometres away, but a smaller Rock Kestrel perhaps only within 800 metres. Similarly birds are spotted more easily closer to the observers. A particularly important challenge is that of estimating the height at which birds fly above the ground. With limited reference points against which to judge this it is exceptionally difficult and subjective. It is for this reason that this data has been treated cautiously by this report, and much of the analysis conducted using flights of all height. With time, and data from multiple sites it will be possible to tease out these relationships and establish indices or measures of these biases.

It is not possible to eliminate all risk of impacts of a proposed facility such as this on avifauna. In our South African landscape a vertical structure of 180 metres is almost unprecedented, multiple such structures even more so. Our best possible efforts can probably not ensure zero impact on birds. Studies such as this attempt to minimise the risk as far as possible, but it is probably unavoidable that the facilities will impact on birds, and perhaps in ways not yet understood.

The questions that one can ask of the data collected by this programme are almost endless. Most of these questions however become far more informative once post construction data has been collected and effects can be observed. For this reason some of the analysis in this report is relatively crude. The raw data has however been collected and will be stored until such time as more detailed analysis is possible and necessary.

An overarching limitation is that since it is early days for wind energy in South Africa we have multiple and often quite different goals for this monitoring. This means that the pre-construction monitoring programme has not been as focused as it would possibly be for a project a few years into the future. Collecting diverse and substantial amounts of data is obviously an advantage on some levels, but perhaps may also dilute the focus somewhat. This is particularly true with hindsight at this site. This monitoring programme was designed and conducted in accordance with best practice, but now that we do the most important avifaunal risk is that of Verreaux's Eagles, we may have structure the programme differently, with more emphasis on eagle flight data.

Since we have little experience with conducting bird monitoring at wind farm sites, it is difficult to judge how much time needs to be invested in a site in order to obtain statistically robust results. This is also extremely site and species dependent.

One of the key features of this site is the presence of multiple pairs of breeding eagles, predominantly Verreaux's Eagle, and one pair of Martial Eagle. Verreaux's Eagle in particular is known to make use of more than one alternate nest site in different seasons. Over the lifespan of a wind farm a pair of eagles may move quite considerably around within its territory. The use of precise nest site locations has been necessary for the purposes of this study but these locations cannot be expected to remain constant for 25 years.

The above limitations need to be stated as part of this study so that the reader fully understands the complexities. However they do not detract from the confidence that this author has in the findings of this study and subsequent management recommendations for this project. It has to be noted that the collection of vast amounts of data through pre-construction monitoring places us in a far better position to assess impacts than was the case 2-3 years ago when only a very short once off site inspection was typically conducted at sites such as this.

2.7 Preparatory analysis

In preparation for this programme, the following steps have been taken by the author:

2.7.1 Definition of the 'inclusive impact zone' (monitoring study area)

Due to their mobility, and the fact that one of the main possible impacts of the wind energy facility, that of bird collision, occurs whilst birds are mobile, the zone within which bird activity is relevant to the WEF is potentially far larger than the WEF itself. An important step in designing a monitoring programme is therefore defining this zone. Ideally monitoring should include the full impact zone. Relevant to this study, the density of Verreaux's

Eagles breeding in the broader area is an aspect which required careful consideration and has influenced the size of the study area.

2.7.2 Description of the study area and bird micro habitat delineation

Vegetation and the micro habitats available to birds on site are important in determining avifaunal abundance and movement on site. The vegetation on site has been described based on the work of Mucina & Rutherford (2006), and micro habitats available to birds were classified based on field work on site and the specialists' experience.

2.7.3 Development of a target species list

Determining the target species for this study, i.e. the most important species to be considered for the impact assessment, is a three step process. The above data represents the first step, i.e. which species occurs or could occur in the area at significant abundances, and the importance of the study area for those species. Secondly, the recent document "A briefing document on best practice for pre-construction assessment of the impacts of onshore wind farms on birds" (Jordan & Smallie, 2010) was consulted to determine which groups of species could possibly be impacted on by wind farms. This document summarises which taxonomic groups of species have been found to be vulnerable to collision with wind turbines in the USA, UK, EU, Australia and Canada. The taxonomic groups that have been found to be vulnerable in two or more of these regions are as follows: Pelicaniformes (pelicans, gannets, cormorants); Ciconiiformes (storks, herons, ibises, spoonbills); Anseriformes (swans, ducks, geese); Falconiformes (birds of prey); Charadriiformes (gulls, terns, waders); Strigiformes (owls); Caprimulgiformes (nightjars); Gruiformes (cranes, bustards, rails); Galliformes (pheasants, grouse, francolins); and Passeriformes (songbirds). The third step is to consider the species conservation status or other reasons for protecting the species. This involved primarily consulting the Red List bird species (Taylor 2014) as in Table 1.

In addition to the above sources of information, the recent document entitled "Avian Wind Farm Sensitivity Map for South Africa: Criteria and procedures used" (Retief, Diamond, Anderson, Smit, Jenkins & Brooks, 2011) combines all three above steps in order to identify sensitive areas of the country. The methods used by this project (Retief *et al*, 2011) are far more thorough and comprehensive than is possible during the scope of an EIA, and although the study was not intended to identify species for consideration in EIA's, it does serve as a useful resource, and in particular includes assessment of non-Red List bird species. The current Inyanda-Roodeplaat study has therefore used the various information sources above to develop a target species list for the project.

2.7.4 Determination of monitoring effort

Two factors were considered in determining the monitoring effort: the facility size (in hectares and turbine number); and the avifaunal sensitivity of the site.

2.8 Sampling activities

2.8.1 Sample counts of small terrestrial species

Although not traditionally the focus of wind farm–bird studies and literature, small terrestrial birds are an important component of this programme. Due to the rarity of many of our threatened bird species, it is anticipated that statistically significant trends in abundance and density may be difficult to observe. More common, similar species could provide early evidence for trends and point towards the need for more detailed future study. Given the large spatial scale of WEF's, these smaller species may also be particularly vulnerable to displacement and habitat level effects. Sampling these species is aimed at establishing indices of abundance for small terrestrial birds in the study area. These counts should be done when conditions are optimal. In this case this means the times when birds are most active and vocal, i.e. early mornings. A total of 12 walked transects (WT) ranging between 268 and 1 186 metres in length were established in areas that are representative of the bird habitats available on the main site. These transects were conducted at first light and all bird species seen or heard, and their position relative to the transect line were recorded. This data collection method was particularly valuable on this site, where Fynbos vegetation elements are present, with associated Fynbos endemic bird species. For more detail on exact methods of conducting Walked Transects see Jenkins *et al* (2012).

2.8.2. Counts of large terrestrial species and raptors

This is a very similar data collection technique to that above, the aim being to establish indices of abundance for large terrestrial species and raptors. These species are relatively easily detected from a vehicle, hence vehicle based transects (VT) were conducted in order to determine the number of birds of relevant species in the study area. Detection of these large species is less dependent on their activity levels and calls, so these counts can be done later in the day. Three VTs counts were established along suitable roads on the site, totalling approximately 20.1 kilometres. These transects were each counted 3-4 times per site visit or season. Due to the steep terrain on and around the Inyanda-Roodeplaat site, roads to the top of the ridge are few and far between, and exceptionally rough. The road to the measuring masts was the only good quality road for most of this programme. This has constrained the layout of the monitoring activities. Access to the easternmost turbine strings was not possible by vehicle, and proved to be prohibitively time consuming to access on foot. The bird monitoring activities were therefore concentrated in the western part of the site. It is believed that since the habitat and topography on site is uniform between the eastern and western parts of the site, extrapolation of results to the inaccessible portions of the site will be acceptable. For more detail on exact methods of conducting Vehicle Based transects see Jenkins *et al* (2012).

2.8.3. Focal site surveys and monitoring

Any particularly sensitive sites such as wetlands, dams, cliffs, and breeding sites are typically identified and monitored on each site visit. At Inyanda-Roodeplaat three such Focal Sites were identified and established for this programme and were surveyed on each site visit. In each case the Focal Site (FS) is a small gorge with suitable nesting substrate for cliff nesting bird species, and Verreaux's Eagle breeding sites. Data collection at these Focal Sites consisted of scanning the identified areas and recording the number of target species individuals and their activities.

This mountain range is home to a high density of breeding Verreaux's Eagles. As discussed elsewhere in this report, this is almost certainly the most important avifaunal aspect for this project. A specific focused survey of the five closest eagle territories and nests was undertaken in the winter of 2013 to assess breeding status as a baseline (Barkhuysen, 2013). During 2014 a similar survey was conducted by Dr Andrew Jenkins of Avisense Consulting (Jenkins & Du Plessis, 2014). Since the turbine layout had by that time expanded further to the south, and a new access road had been built, this survey also included the valleys to the south of the proposed facility. Unfortunately due to time constraints Jenkins et al could not fully survey the south-eastern extremities of the site.

2.8.4. Incidental observations

This monitoring programme comprises a significant amount of field time on site by the observers - much of it spent driving between the above activities. It is important to maximise the benefit from this time on site by recording any other relevant information observed. All other incidental sightings of priority species (and particularly those suggestive of breeding or important feeding or roosting sites or flight paths) within the broader study area were carefully plotted and documented. Species lists were also maintained for each season for the site.

The above efforts allow us to arrive at an estimate of the abundance or density of the relevant species on site. This will allow the identification of any displacement and disturbance effects on these species post construction. However in evaluating the likelihood of these species colliding with turbine blades, their abundance is not sufficient. We also need to understand their flight behaviour. It is the flight behaviour which determines their exposure to collision risk. A bird which seldom flies, or typically flies lower than blade height is presumed to be at lower risk than a frequent flier that typically flies at blade height. In order to gather baseline data on this aspect, direct observations of bird flight behaviour are required. This is the most time consuming and possibly the most important activity to be conducted on site, and is elaborated on below in Section 2.8.5.

2.8.5. Direct observation of bird movements

The aim of direct observation is to record bird flight activity on site. An understanding of this flight behaviour will help explain any future interactions between birds and the WEF. Spatial patterns in bird flight movement may also be detected which will allow for input into turbine placement. Direct observation was conducted through counts at four vantage points (VP) in the study area. Three of these VPs were identified and established to obtain data on the site itself, and overlook potential turbine positions, whilst the fourth was established to the east, overlooking one of the identified Verreaux's Eagle nests (Holbak). The aim at VP4 was to obtain data on the movement of these birds close to the nest, to ascertain whether they in fact move up onto the higher ground where turbines are planned, and to gather data on the eastern parts of the mountain top, which were inaccessible by road. Vantage Points were identified using GIS (Geographic Information Systems), and then fine-tuned during the project setup, based on access and other information. Since these VPs aim at capturing both usage and behavioural data, they are positioned mostly on high ground to maximise visibility. The survey radius for VP counts is two kilometres. VP counts are conducted by two observers, seated at the VP, taking care not to make their presence overtly obvious as to effect bird behaviour. Data should be collected during representative conditions, so the sessions were spread throughout the day, with each VP being counted over 'early to mid-morning', 'mid to late morning', 'early to mid-afternoon', and 'mid-afternoon to evening'. Each session was three hours in duration, resulting in a total of 12 hours of observation being conducted at each vantage point on each site visit. Three hours is believed to be towards the upper limit of observer concentration span, whilst also maximising duration of data capture relative to travel time required to access the VPs. A maximum of two VP sessions are conducted per day, to avoid observer fatigue compromising data quality. For more detail on exact criteria recorded for each flying bird observed, see Jenkins *et al* (2012).

One of the most important attributes of any bird flight event is its height above ground, since this will determine its risk of collision with turbine blades. Since it is possible that the turbine model (and hence the exact height of the rotor swept zone) could still change on this project, actual flight height was estimated rather than assigning flight height to broad bands (such as proposed by Jenkins *et al* 2012). This 'raw' data will allow flexibility in assigning to classes later on depending on final turbine specifications.

The quantitative bird flight data was analysed as follows:

All four VPs were monitored for three hour sessions. For statistical purposes, these three hours were divided into equal 30 minutes time intervals. Statistical Analyses were performed using the STATISTICA 8.0 Package Software (Statsoft 1998). Due to the high variability of data, multiple different analyses were used.

The spatial analysis of the bird flight data was conducted as follows:

A Viewshed Analysis of the two kilometre radius around each Vantage Point was undertaken to identify the areas that can actually be seen by the observers from the Vantage Point. This was done by using 20 metre contours to create a Triangular Irregular Network. Birds in flight above the ground surface can often be seen despite the ground itself not being visible. In order to account for this a point 30 metres above the ground was used to correspond with the approximate (bearing in mind that the turbine model is not finalised) lower edge of the rotor zone. The final viewshed then includes areas where birds 30 metres or more above the ground could be seen. Only data from areas deemed visible were displayed in the final figures. The recorded flight paths within this viewshed were vectorized to create lines for each flight record. A 100 x 100 metre grid was created of the relevant area. Each flight record or line was assigned a collision risk score as follows: The collision risk score for each record equals the flight height score multiplied by flight mode score multiplied by species conservation score, multiplied by number of birds recorded flying. Flight height scores were assigned as follows: 0 – 30 metres above ground = 1; 30 – 180 metres = 2; >180 metres =1. Birds flying at rotor height (approximately 30 to 180 metres) are deemed to be at greater collision risk than those above or below this zone. Scores were assigned for flight mode as follows: direct commuting = 1; soaring or hovering = 2. A conservation score was assigned to each species as follows: common and non-threatened species = 1; 'Near-threatened' species and medium to large raptors = 2; 'Vulnerable' species = 3; and 'Endangered' species = 4. The survey area was divided into a grid of 100m x100m cells, and a collision risk score for each cell was calculated by summing the collision risk scores for all flight records in that cell. The analysis was performed for a) flight records for all species at all heights; b) flight records for Verreaux's Eagle only; and c) flight records for Martial Eagle only. The results of this analysis were superimposed on the latest available turbine layout to determine collision risk at specific turbines.

2.9 Control sites

A suitable control site has been identified to the east of the Inyanda-Roodeplaat site. Activities on the control site consist of a single Vantage Point, one Vehicle Transect and three Walked Transects. Due to the proximity of the control site to a Verreaux's Eagle nest, the data collected will be particularly valuable in the long term.

Figure 2 shows the layout of the above described monitoring activities on the site.

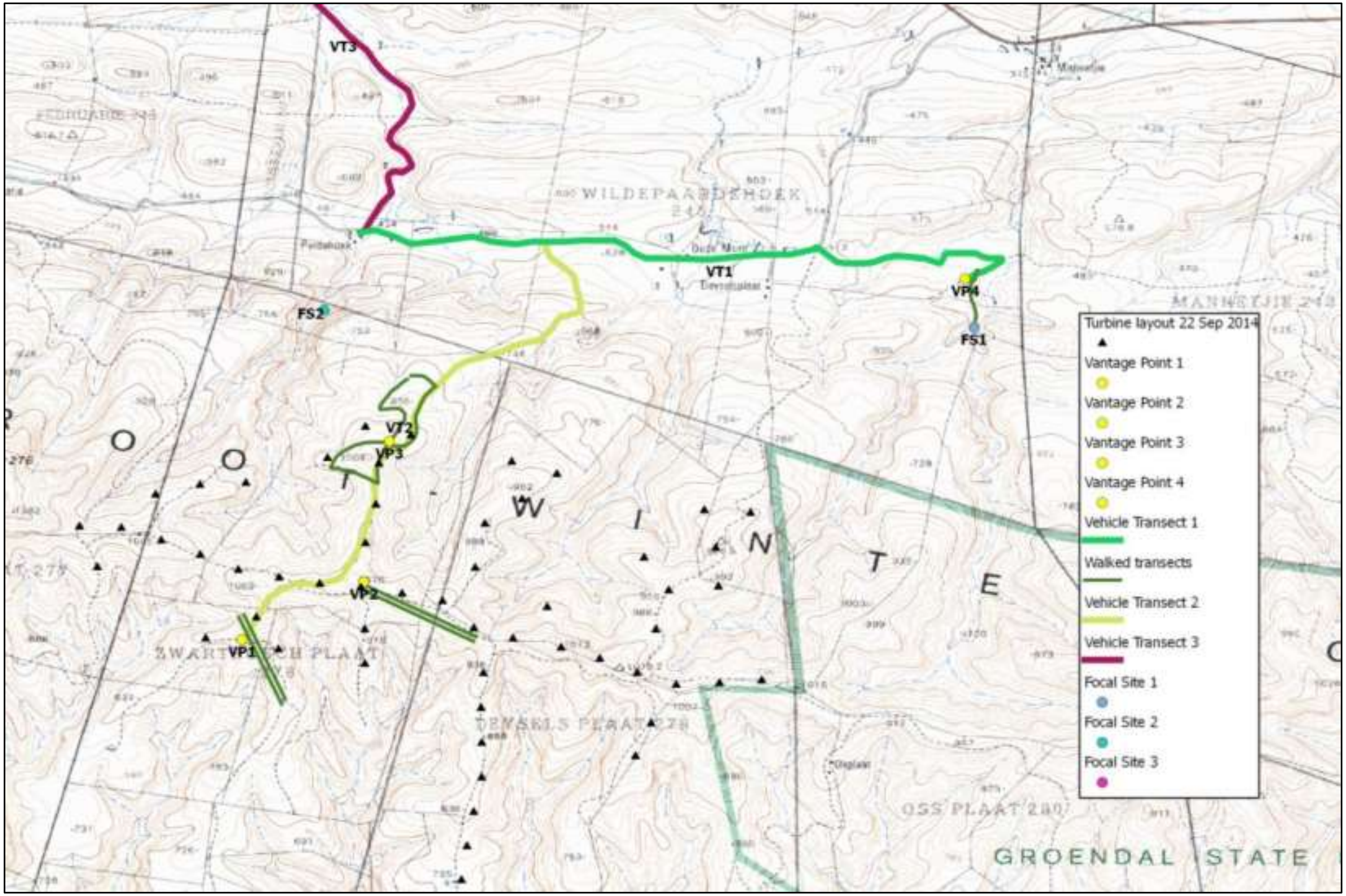

Figure 2. The layout of the various bird monitoring activities described in this report.

3. PRE CONSTRUCTION MONITORING RESULTS & DISCUSSION

The findings from the pre-construction bird monitoring programme have been reported on below.

3.1 Definition of the inclusive impact zone

Ideally this zone would encompass the likely range of all bird species likely to be affected by the WEF. However in the case of large birds of prey, and species such as cranes, bustards and Secretarybird this could be tens of kilometres, and it is not considered feasible to monitor all of this. In this case, the zone has been delineated by buffering the site by approximately two kilometres.

3.2 Description of the study area

Vegetation is one of the primary factors determining bird species distribution and abundance in an area. The following description of the vegetation on the site focuses on the vegetation structure and not species composition. It is widely accepted within ornithological circles that vegetation structure is more important in determining bird species diversity. The classification of vegetation types is from Mucina & Rutherford (2006).

The proposed turbine positions are all located on the higher ground where the vegetation is fairly uniform and classified as “Kouga Grassy Sandstone Fynbos” and “Kouga Sandstone Fynbos” according to Mucina and Rutherford (2006). Various other vegetation types exist to the north, including most prominently “Groot Thicket”, “Sundays Thicket” and “Albany Alluvial Vegetation” (Figure 3). These will be mostly relevant to the grid connection routes, pictured in Figure 1. The main relevance of the vegetation type to avifauna is that it plays a part in determining which bird species are likely to use the site. In this case the elements of Fynbos on site result in a suite of small passerine Fynbos endemics being present, including species such as Orange-breasted Sunbird; Cape Grassbird and others.

The vegetation description partially describes the habitat available and hence the bird species likely to occur in the study area. However, in order to understand exactly where within the study area certain species will occur and how suitable these areas are for the relevant species, a description of the habitats available to birds is useful. The habitats available to birds at a small spatial scale are known as micro habitats. These micro habitats are formed by a combination of factors such as vegetation, land use, anthropogenic factors, topography and others. These micro habitats are typically important for judging the suitability of the site for relevant bird species. The micro habitats identified on the Inyanda-Roodeplaat site include: Fynbos, thicket, rocky ridges, cliffs and gorges, and grassland. Examples of these are shown in Figures 4 and 5, and species likely to utilise each habitat are shown in Table 1.

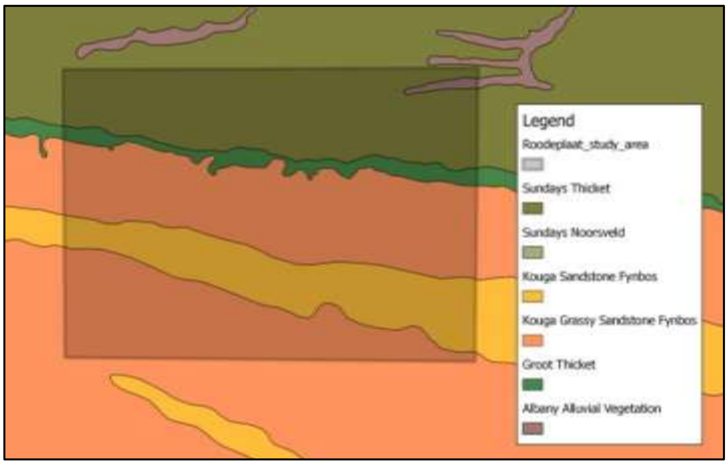

Figure 3. The vegetation composition of the Inyanda-Roodeplaat Wind Energy Facility site (Mucina & Rutherford, 2006).

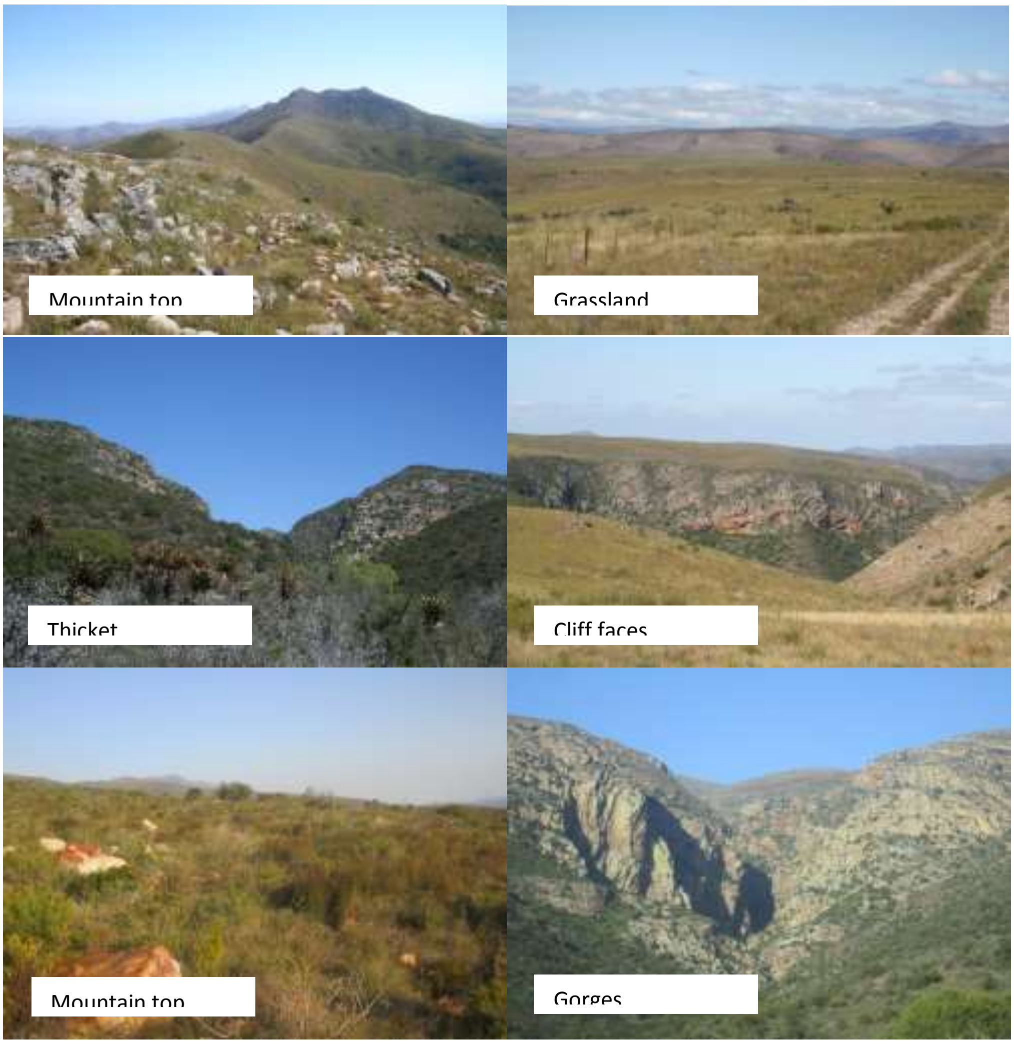

Figure 4. Examples of bird micro habitats available on the Inyanda-Roodeplaat Wind Energy Facility site.

Figure 5. Examples of bird micro habitats available along the grid connection corridors.

3.3 Development of the target species list

A total of 20 target bird species were identified as being of particular relevance on this site (Table 1) and formed the focus of the monitoring programme and this impact assessment. Target species are those which are believed to be most at risk of the proposed facility, and also of conservation concern. Of these target species, the species of most concern at present are the Verreaux's Eagle and the Martial Eagle. In each case the species' regional (Taylor, 2014) and global (IUCN 2013) conservation status is presented, whether it has been confirmed on the site. In the case of Red List species an indication of whether they are believed likely to breed on site is also presented as well as each species' preferred habitat.

Table 1. Target species for the Inyanda-Roodeplaat Wind Energy Facility pre-construction bird monitoring programme

Common name	Taxonomic name	Ecological group	Taylor 2014	IUCN 2013	SABA P1	SABA P2	TOPS listed	Presence on site	Preferred micro habitat
African Harrier-Hawk	*Polyboroides typus*	Raptor	-	LC	x	x		Confirmed	Generalist
African Crowned Eagle	*Stephanoaetus coronatus*	Raptor	VU	NT	x	x		Confirmed	Indigenous forest
Black Harrier	*Circus maurus*	Raptor	EN	VU	-	x		Confirmed	Grassland, wetlands,Fynbos
Black-shouldered Kite	*Elanus caeruleus*	Raptor	-	LC	x	x		Possible	Generalist
Booted Eagle	*Aquila pennatus*	Raptor	-	LC	x	x		Confirmed	Mountains with cliffs
Cape Clapper Lark	*Mirafra apiata*	Small terrestrial	-	-	-	x		Confirmed	Fynbos, shrublands
Cape Eagle Owl	*Bubo capensis*	Raptor	-	LC	-	-		Confirmed	Rocky outcrops, cliffs
Grey-winged Francolin	*Scleroptila africanus*	Small terrestrial	-	LC	-	x		Confirmed	Grassland, Fynbos
Jackal Buzzard	*Buteo rufofuscus*	Raptor	-	LC	x	x		Confirmed	Generalist
Lanner Falcon	*Falco biarmicus*	Raptor	VU	LC	-	x		Confirmed	Grassland, arable land
Long-billed Pipit	*Anthus similis*	Small terrestrial	-	-	-	x		Confirmed	Fynbos, shrublands, sparse woodland on rocky slopes
Martial Eagle	*Polemaetus bellicosus*	Raptor	EN	VU	-	x	VU	Confirmed -breeding	Generalist
Orange-breasted Sunbird	*Anthobaphes violacea*	Small terrestrial	-	LC	x	x		Confirmed	Fynbos
Peregrine Falcon	*Falco peregrinus*	Raptor	-	LC	x	x	VU	Confirmed	Grassland, Fynbos, cliffs
Rock Kestrel	*Falco rupicolus*	Raptor	-	-	x	x		Confirmed	Generalist
Southern Pale Chanting Goshawk	*Melierax canorus*	Raptor	-	-	x	x		Confirmed	Arid shrubland
Steppe Buzzard	*Buteo buteo*	Raptor	-	LC	x	x		Confirmed	Generalist
Verreaux's Eagle	*Aquila verreauxii*	Raptor	VU	LC	x	x		Confirmed - breeding	Mountains and rocky areas
Yellow-billed Kite	*Milvus aegyptius*	Raptor	-	-	-	-		Possible	Generalist

EN = Endangered, VU = Vulnerable, NT = Near-threatened, LC = Least Concern

3.4 Sample counts of small terrestrial species

Appendix 2 shows the full data set collected during walked transects. A total of 64 species were recorded on site using this method. A peak in species richness (42 species) was recorded in summer and autumn (40 species), whilst winter recorded only 23 species. The top ten most frequently recorded species are presented in Table 2. The total number of birds, number of birds per kilometre of transect, and number of records are presented. The species recorded most frequently were: Cape Siskin *Crithagra totta*, Wailing Cisticola *Cisticola lais* and Cape Grassbird. Four target species (see Table 1) were recorded on site using this method: Cape Clapper Lark *Mirafra apiata*; Cape Eagle Owl *Bubo capensis*; Grey-winged Francolin; Orange-breasted Sunbird. No Red List species, or species of conservation concern were recorded using this data collection method. At least 27 endemic bird species were recorded on site during this programme, many of which were recorded during walked transects.

3.5 Counts of large terrestrial species and raptors

Table 3 shows a summary of the bird species recorded during the vehicle transects, which totalled approximately 242 kilometres over the full year. In each case the number of birds, number of records, and number of birds per kilometre of transect are presented. A total of 6 target bird species were recorded using this method. By far the most frequently recorded species was the Rock Kestrel *Falco rupicolus*, followed by Southern Pale Chanting Goshawk *Melierax canorus*. Verreaux's Eagle was the third most frequently recorded species, but was only recorded 3 times in the year. The most species (4) were recorded during winter and summer, with spring and autumn recording 2 and 1 species respectively. It must be noted that this terrain is not ideal for vehicle transects. The hilly topography means that visibility of anything other than raptors high in the air is reasonably poor, and the drivers' attention is taken up by the poor road quality, resulting in only one effective observer.

3.6 Focal sites

The results of monitoring at Focal Sites 1 to 3 are shown in Table 4. However the findings by Barkhuysen (2013) and Jenkins *et al* (2014), which are summarised in Table 5, are more informative. During the 2013 winter raptor breeding season, Barkhuysen visited the 5 closest known Verreaux's Eagle nests: Guntia; Holbak; Perdehoek; February; and Tygerberg. These nests are all situated on the northern side of the mountain. At this point of the monitoring programme, the turbine layout provided to the specialist did not extend far south of the watershed and this coupled with poor road access mean that the southern areas were not surveyed for sensitive breeding bird species. All five of these nest sites were active at that point. It is important to note at this point that eagle nest sites would typically be considered sensitive for a study of this nature whether recently active or not, provided that there is no evidence of nest abandonment. Most eagle species utilise alternate nesting sites over the years, and during the lifespan of the proposed facility one could expect eagle nest sites to be occupied at some point.

During 2014, Jenkins *et al* visited four of the five northern Verreaux's Eagle nest sites, and surveyed a large amount of suitable cliff nesting habitat to the south of the site. During this survey his team found an addition Verreaux's Eagle nest (named Tiptree) and importantly a Martial Eagle nest. At each of the cliff nesting sites various other breeding species were also recorded. A number of lesser cliffs which did not hold eagle pairs were also surveyed, but the results of the less important breeding species are not presented in Table 5.

To summarise the situation with regard to eagle breeding: A total of 6 Verreaux's and 1 Martial Eagle nests have been confirmed within approximately 9 kilometres of proposed turbine positions at the Inyanda Roodeplaat site. These nests were all confirmed as active in either or both of the 2013 and 2014 breeding seasons. In addition, some areas have not yet been comprehensively surveyed and it is believed possible that they hold another pair of Verreaux's Eagle, and a pair of African Crowned Eagle. The position of the confirmed nest sites is shown in Figure 6.

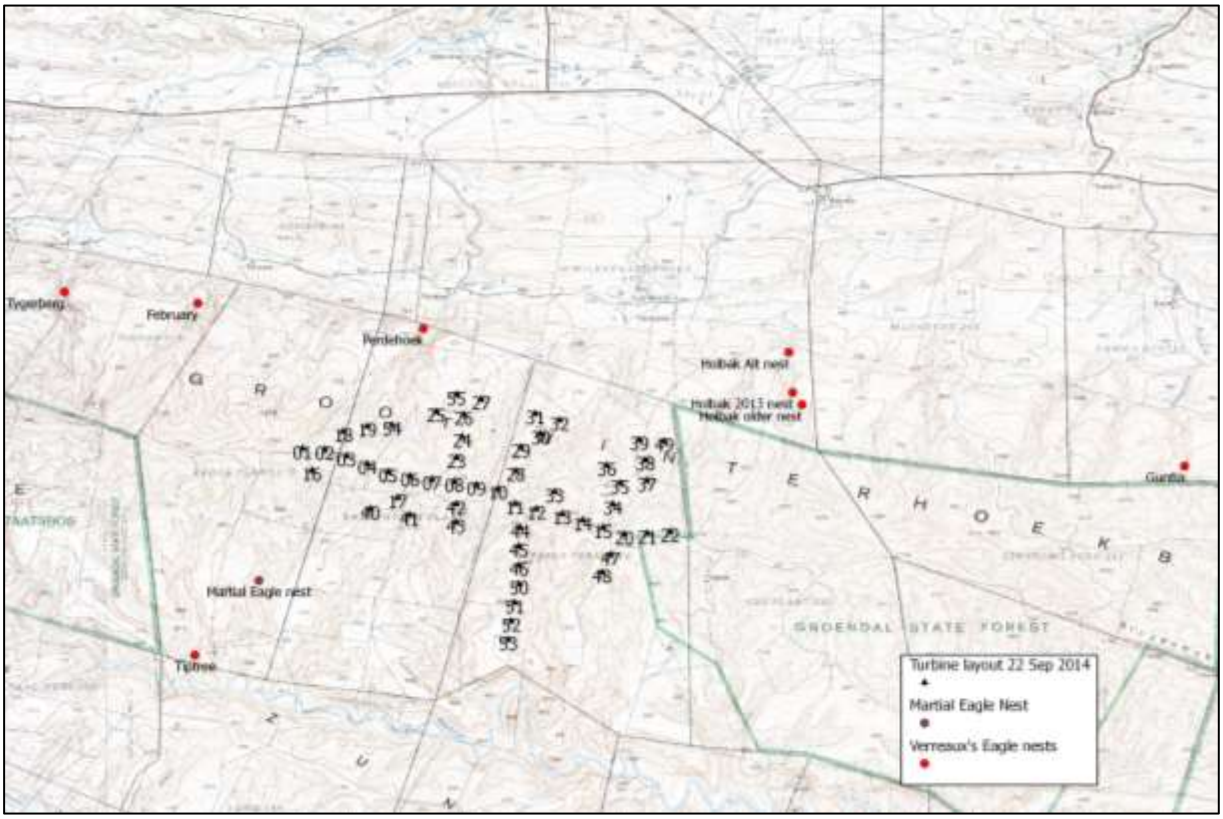

Figure 6. The position of the 6 confirmed Verreaux's Eagle and 1 Martial Eagle nests.

Table 2. Summary statistics and top ten most frequently recorded bird species during walked transects on the Inyanda-Roodeplaat site.

	Total for year			Winter			Spring			Summer			Autumn		
Number of species	64			23			38			42			40		
	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km
Cape Siskin	94	11	2.73	0	0	0.00	90	7	10.45	2	2	0.23	2	2	0.23
Wailing Cisticola	61	52	1.77	13	11	1.51	12	11	1.39	23	21	2.67	13	9	1.51
Cape Grassbird	55	50	1.60	9	8	1.04	20	20	2.32	14	13	1.63	12	9	1.39
Red-winged Starling	54	12	1.57	0	0	0.00	44	6	5.11	5	4	0.58	5	2	0.58
Sombre Greenbul	47	32	1.36	2	2	0.23	16	10	1.86	17	11	1.97	12	9	1.39
Bokmakierie	30	15	0.87	2	1	0.23	14	7	1.63	10	5	1.16	4	2	0.46
Speckled Mousebird	30	11	0.87	2	1	0.23	0	0	0.00	14	5	1.63	14	5	1.63
Southern Boubou	29	18	0.84	4	2	0.46	15	8	1.74	3	2	0.35	7	6	0.81
Long-billed Pipit	28	16	0.81	1	1	0.12	22	11	2.55	4	3	0.46	1	1	0.12
Orange-breasted Sunbird	26	22	0.75	7	6	0.81	2	2	0.23	9	8	1.04	8	6	0.93

Table 3. Summary statistics and species recorded during vehicle transects on the Inyanda-Roodeplaat site.

	Total for year			Winter			Spring			Summer			Autumn		
Number of species	6			4			2			4			1		
	# Birds	# Records	# birds/km	# Birds	# Records	# birds/km	# Birds	# Records	# birds/km	# Birds	# Records	# birds/km	# Birds	# Records	# birds/km
Rock Kestrel	12	10	0.05	7	5	0.12	2	2	0.08	3	3	0.22	0	0	0.00
Southern Pale Chanting Goshawk	9	9	0.04	2	2	0.03	4	4	0.16	3	3	0.22	0	0	0.00
Verreaux's Eagle	6	3	0.02	0	0	0.00	0	0	0.00	0	0	0.00	6	3	0.11
Jackal Buzzard	4	4	0.02	3	3	0.05	0	0	0.00	1	1	0.07	0	0	0.00
Rufous-chested Sparrowhawk	1	1	0.00	1	1	0.02	0	0	0.00	0	0	0.00	0	0	0.00
Steppe (Common) Buzzard	1	1	0.00	0	0	0.00	0	0	0.00	1	1	0.07	0	0	0.00

Table 4. Summary of observations of Verreaux's Eagle breeding at Focal sites 1 to 3.

	Winter	Spring	Summer	Autumn
Holbak -Focal site 1	No birds seen near nest	4 adults seen near nest area	No birds see	No birds seen
Perdehoek - Focal site 2	2 adults seen in nest area	Nests burnt out	No birds seen	3 birds seen in area
Tygerberg - Focal site 3	Adult seen on nest	2 adults & 1 juvenile on nest	No birds see	No birds seen

Table 5. Summary of observations of Verreaux's Eagle and other relevant species in 2013 and 2014.

Name	2013 result (Barkhuysen) - Verreaux's Eagles	2014 Result (Jenkins *et al*) - Eagles	2014 Result (Jenkins *et al*) other species
Guntia	9-11 week chick on nest	Not surveyed	
Holbak	11-13 week chick on nest	2 adults seen, nest looked active	Probable 1 breeding pair White-necked Raven
Perdehoek	Near fledging chick on nest	Adults seen copulating & displaying	Probable 1 breeding pair Jackal Buzzard, Possible 2-3 breeding pairs Rock Kestrel, Probable 1 breeding pair White-necked Raven
February	2 eggs on nest	2 smallish downy chicks on nest	Probable 1 breeding pair Jackal Buzzard, Possible 2-3 breeding pairs Rock Kestrel, Probable 1 breeding pair White-necked Raven
Tygerberg	Large downy chick on nest	2 adults present, no active nests seen	Possible Jackal Buzzard & White-necked Raven breeding pairs
Tiptree	Not surveyed	Adult incubating on nest	
Martial Eagle	Not surveyed	Martial Eagle active nest, likely chick	

3.7 Incidental observations

A total of ten species were recorded incidentally, nine of which were target species. The additional species considered relevant to record despite not being target species was Rufous-chested Sparrowhawk *Accipiter rufiventris* (recorded once in winter). The most frequently recorded species was Vereaux's Eagle (13 records), followed by Southern Pale Chanting Goshawk and Rock Kestrel (with 7 records each) and Jackal Buzzard (6 records). Martial Eagle was recorded three times. Figure 7 shows the location of all incidental observations during the programme. Care must be taken not to attach too much importance to these sightings as they are not the product of systematic sampling and various biases exist in the data. For example, certain areas of the site were frequented more than others, and would therefore result in a higher likelihood of incidental observations. It is however interesting to note that most sightings were made in the lower areas towards the north of the site.

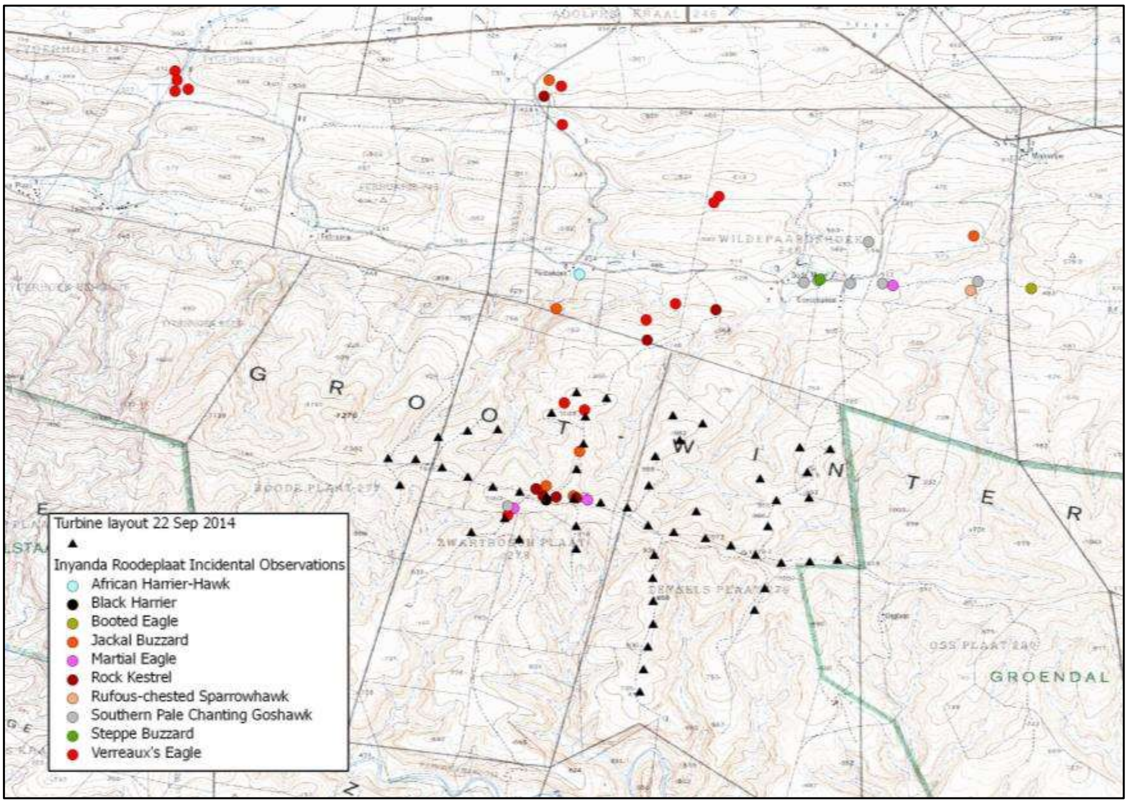

Figure 7. Incidental observations of target bird species during pre-construction bird monitoring.

In addition to incidental sightings of target species, species check lists were compiled each season for all bird species seen on or close to the site. In total 134 bird species were recorded by this monitoring programme, comprising: 93 in winter; 117 in spring; 78 in summer; and 78 in autumn. Of these species, 18 were target species and 7 of these are Red Listed species (Taylor, 2014). At least 27 of these bird species were endemic (Appendix 3). The full species lists for each season are presented in Appendix 3.

3.8 Direct observation of bird movements

3.8.1 Quantitative data analysis

Table 6 lists the 11 target bird species recorded flying on site during vantage point counts. There are 109 records of 11 species mostly raptors (98% - 9 species) but two species: the Verreaux's and Martial eagles, account for 33 (30%) and 7 (6.5%) respectively, overall 37%. The most frequently recorded species was the Verreaux's Eagle, followed by Jackal Buzzard and Rock Kestrel. The top 6 most frequently recorded species all flew for the majority of their flight duration at approximate rotor height (30 to 180m above ground, outside boundaries of various turbine model options supplied by IEP).

Table 6. Summary flight data for target species recorded flying on the Inyanda-Roodeplaat WEF site.

Species	Group	n	Mean flight height	Total flight duration	Mean flight duration	% of flight duration below rotor	% of flight duration within rotor	% of flight duration above rotor
Verreaux's Eagle	Raptor	33	57.27	01:27:00	00:02:38	6	94	0
Jackal Buzzard	Raptor	31	46.45	01:00:50	00:01:58	33	67	0
Rock Kestrel	Raptor	19	38.42	01:32:30	00:04:52	49	51	0
Booted Eagle	Raptor	8	68.75	01:30:00	00:11:15	0	100	0
Martial Eagle	Raptor	7	56.67	00:06:00	00:00:51	8	92	0
Black Harrier	Raptor	5	55.50	00:14:00	00:02:48	43	57	0
African Harrier-Hawk	Raptor	1	5.00	00:01:00	00:01:00	100	0	0
Black Stork	Large terrestrial	1	80.00	00:02:00	00:02:00	0	100	0
Peregrine Falcon	Raptor	1	50.00	00:00:30	00:00:30	0	100	0
Southern Pale Chanting Goshawk	Raptor	1	50.00	00:02:00	00:02:00	0	100	0
Yellow-billed Stork	Large terrestrial	1	40.00	00:01:00	00:01:00	0	100	0

Activity of Verreaux's Eagles has been measured as birds per hour of observation. Without any experience from constructed wind farms, it is difficult to interpret the data and understand what the numbers mean for the risk to the birds. In order to provide perspective we have included the activity levels from another two proposed wind energy sites we have worked at with this species (Figure 8). Results show that the Inyanda Roodeplaat project area has a much higher use by the birds (Kruskal-Wallis test: H (2, N= 1169) =15,43073 p < 0.001). The average number of flights per 10 hours is 2 birds at Inyanda-Roodeplaat as compared to 1 and 0.32 respectively for the other WEF's.

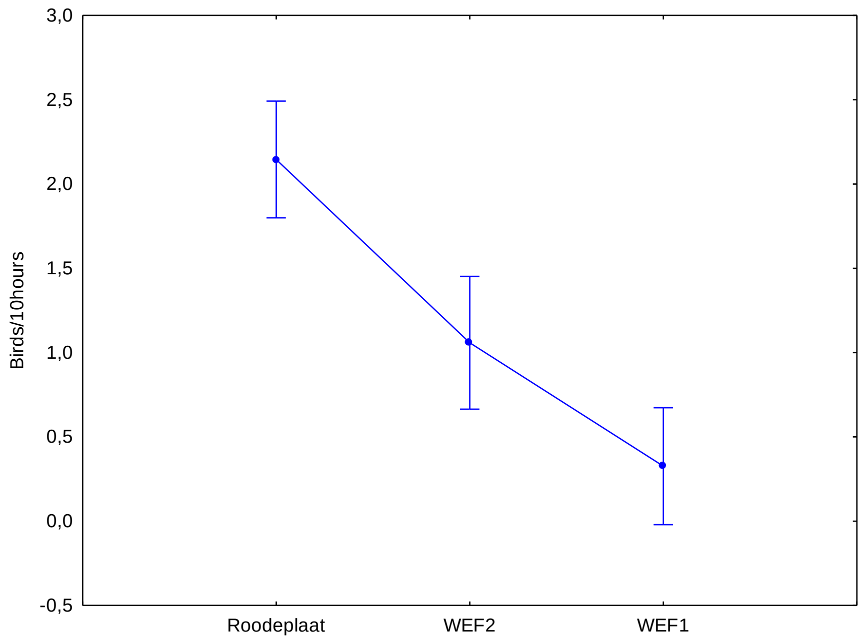

Figure 8. Verreaux's Eagle flight activity at Inyanda Roodeplaat, as compared to two other sites.

Figure 9 shows that the activity of the eagles is significantly higher in winter (four flights per day per vantage point) (Kruskal-Wallis test: H (3, N= 422) =10.78 $p < 0.05$). This increased activity is likely due to the beginning of the breeding season when adult birds are re-building the nest and mating.

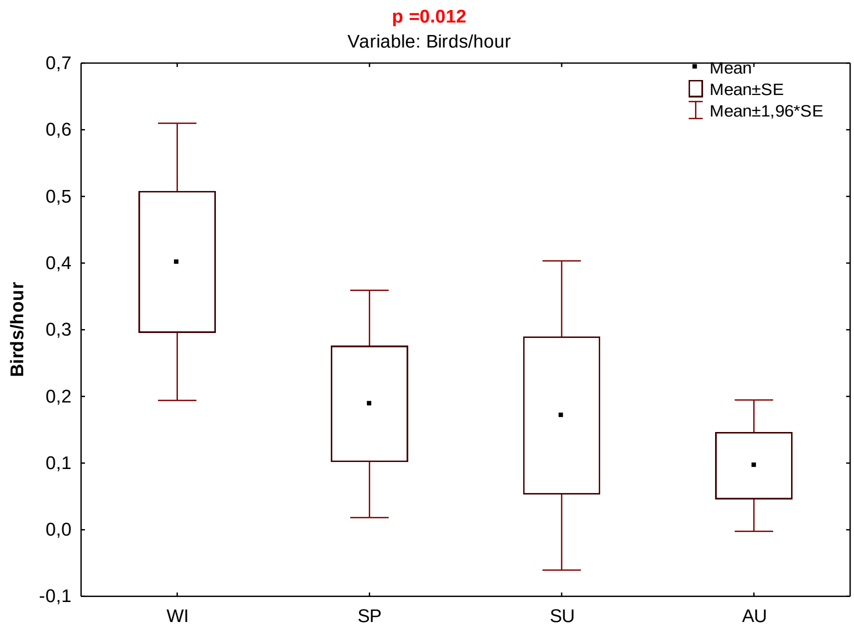

Figure 9. Verreaux's Eagle flight activity per season.

Over the remainder of the year, i.e. spring to autumn, the activity of birds is almost constant with average values of 0.10-0.18 birds per hour, which means a range of 1-2 flights per day and per vantage point. The high number of breeding pairs means that multiple birds are present in the area, resulting in the high passage rates over the area.

These activity rates are also evenly distributed over the different daylight hours as Figure 10 shows (Kruskal-Wallis test: H (2, N= 422) =7.12 p > 0.05). This illustrates that the eagles are moving around throughout the day, without any significant temporal peak in flight activity.

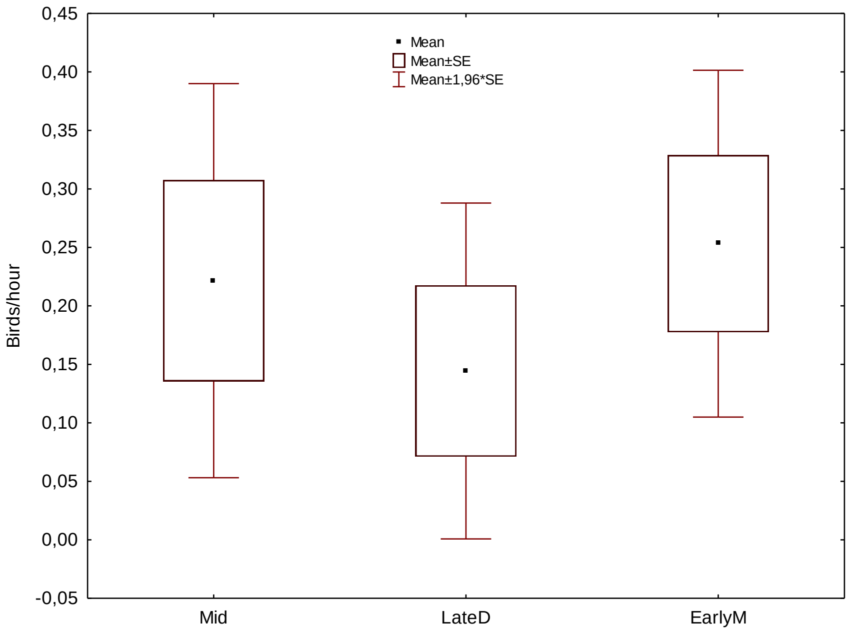

Figure 10. Verreaux's Eagle flight activity through the day (Mid = midday; LateD = Afternoon to evening; EarlyM = early morning).

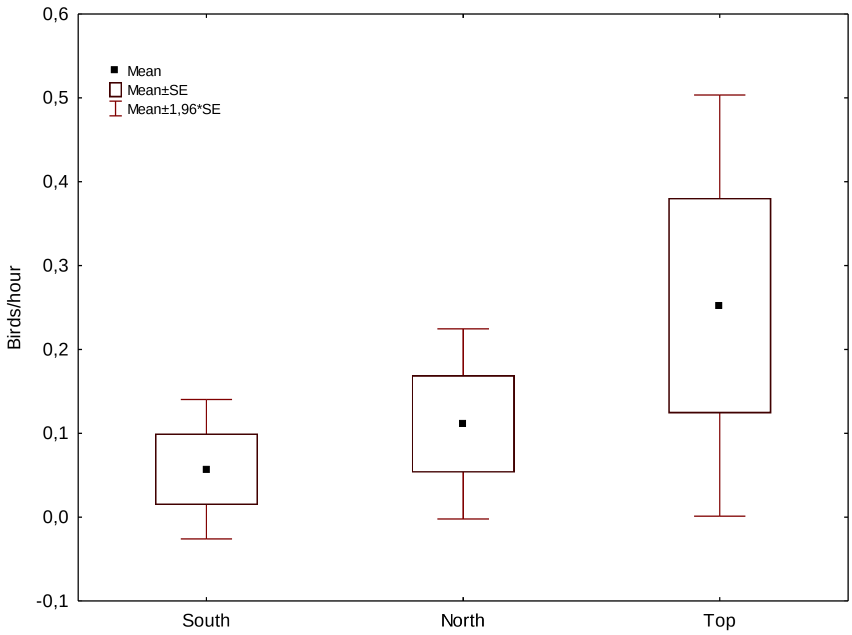

Figure 11. Verreaux's Eagle flight activity in different parts of the site: 'south', 'north' and 'top'.

In order to examine the Verreaux's Eagle flight activity across different parts of the site, the data was split into that from the southern vantage point (VP2), the northern vantage point (VP3) and the central vantage point on the top of the mountain (VP1) (Figure 11). Although no statistically significant difference between these three areas was found, it is evident that more flight activity was recorded at the top, and that there that was a high level of variance in this flight activity (Kruskal-Wallis test: $H (2, N= 320) =2.03$ $p > 0.05$). Some days several flights were recorded, and some days none were recorded.

The Verreaux's Eagle flight data was tested for any association with wind direction, time of day and weather conditions (as assessed by the field team: poor, good or fair). No such association was found (Kruskal-Wallis tests: $H (6, N= 320) =9.22$ and $(3, N= 320) =1.14$ respectively; $p > 0.05$ in both cases). This means that, based on this data set, the eagles do not appear to favour flying in any particular conditions.

Figure 12 presents the flight data with respect to both season and slope (north, south or the top of the project area) together with the passage rates (eagles per ten hours of observation). The darker red colours demonstrate higher passage rates, whilst dark green shows lowest passage rates. As can be seen, the highest passage rates occurred during winter at all locations and also at the top of the mountain range in spring and summer.

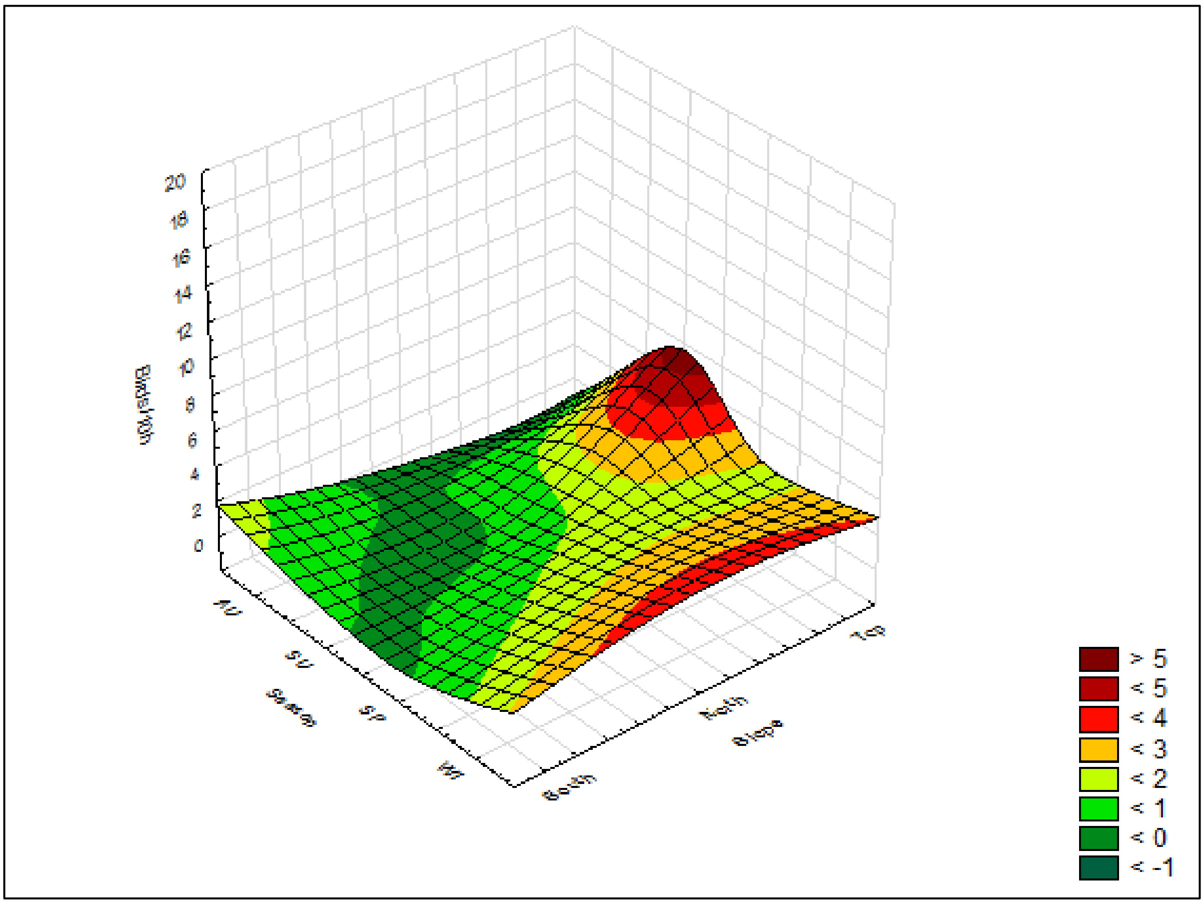

Figure 12. Verreaux's Eagle flight activity related to season and slope.

For the Martial Eagle, probably because of the large home range this species requires, data are non-consistent between seasons or vantage points and no strong patterns emerge. This is a solitary species with a passing rate over the project area of around 1 bird every ten days.

For the remaining species, Table 7 presents a summary of the number of crossing flights per 10 hours of observation. The most important season in terms of species richness was spring (7 species).

Table 7. Seasonal summary of the remaining bird species recorded flying on site.

	Winter	Spring	Summer	Autumn
Black Harrier	2.09±0.00 (n=1)	2.29±0.04 (n=3)	-	2.10±0.16 (n=2)
African Harrier-Hawk	1.20±0.00 (n=1)	-	-	-
Southern Pale Chanting Goshawk	-	1.27+0.00 (n=1)	-	-
Booted Eagle	-	1.47±0.03 (n=3)	1.76±0.28 (n=4)	1.43±0.00 (n=1)
Yellow-billed Stork	-	0.83±0.00 (n=1)	-	-
Black Stork	-	1.10±0.00 (n=1)	-	-
Rock Kestrel	1.46±0.11 (n=8)	1.65±0.214 (n=3)	1.50±0.12 (n=7)	1.43±0.00 (n=1)
Peregrine Falcon	-	-	-	1.44+0.00 (n=1)
Jackal Buzzard	1.67±0.09 (n=8)	1.35±0.18 (n=6)	1.82±0.11 (n=11)	1.55±0.14 (n=6)
#Species /season	**4**	**7**	**3**	**5**

4.8.2 Spatial data analysis

The position of the four vantage points on site has been shown in Figure 13. Figure 13 shows the rasterised collision risk index for all target bird species at each vantage point. Each grid cell has been categorised and coloured according to the collision risk index for that cell. Figure 13 includes data for all bird species, whilst Figures 14 and 15 show only Verreaux's Eagle and Martial Eagle respectively. In these figures darker colours represent greater collision risk.

Vantage Point 1 is situated on the southern slopes of the mountain range, with a viewshed predominantly southwards, although birds flying directly above the top of the mountain would also be visible. At this point a higher collision risk has been identified on the small spur running southwards (darker red colours in Figure 13. Two current turbine positions are situated within this risk area, T40 and T17. It would be preferable if these turbines could be shifted to areas of lower risk or discarded.

Vantage Point 2 is on the highest point on site (near the met mast), and faces predominantly north, east and south. High collision risk has been identified in the immediate vicinity of this vantage point. Three current turbine positions are within this high risk area, T07, T08, and T09. It would be preferable if these turbines could be shifted to areas of lower risk or discarded.

Vantage Point 3 is on the north facing slope and faces west, north and eastwards. At this vantage point no strong patterns of collision risk have emerged, and no turbine positions appear at risk.

Vantage Point 4 is off site to the north-east. It was positioned here in order to capture data on the eastern half of the site which was inaccessible, and also to capture data closer to a Verreaux's Eagle nest. As is evident in Figure 13, far higher collision risk was recorded at VP4 than at the other VP's. Comparison of Figure 13 and 14 (which presents the Verreaux's Eagle specific collision risk index) shows that most of the flight activity at VP4 was Verreaux's Eagle, as expected due to the presence of the nest. This may indicate a higher collision risk for this species closer to nest.

Figures 14 and 15 show the collision risk index calculated for only the Verreaux's and Martial Eagles respectively. Figure 14 demonstrates that Verreaux's Eagle collision risk is far higher in the lower areas and closer to the eagles nest, based on data collected at Vantage Point 4 (close to the 'Holbak' nest site). This species was recorded flying far less frequently on the site itself, i.e. on the higher ground where turbines will be positioned. The most obvious explanation for this would be that the birds spend more of their time closer to the nest. This would fit nicely with the use of buffer areas as mitigation measures for these eagles, as described elsewhere in this report. However this may be an overly simplistic finding. Greater understanding is required of other confounding factors such as: the influence of weather conditions on where the birds fly; topography and its influence on where birds fly; and many others. It is also important to recognise that with human collected data, certain biases may exist. For example, visibility in this topography is far from ideal. This makes detection of birds in flight challenging, particularly against dark backgrounds such as would be the case when looking down from the higher three vantage points (1,2 and 3), but not from the lower vantage point 4, where many birds would be viewed against the lighter background of the sky. Another bias is that by being situated closer to the nest, observers are able to more easily locate birds at the outset of an observation session, and then keep track of where the birds are for longer periods, thereby resulting in more flight activity being recorded. At other locations where birds are not easily initially located, the observers would rely more on their ability to detect them from a distance. Figure 15 is useful only to demonstrate that Martial Eagle was recorded flying through the site several times. No patterns in usage are evident.

Since the placement of vantage points aimed to sample the site and does not provide an absolute coverage (see also the earlier discussion of access constraints on site), it is important to apply the principles learnt at these four vantage points to the rest of the site. The two higher collision risk areas (for all target species) discussed above are the higher ground at the top of the mountain range, and the high ground on the smaller spur line which descends southwards off the main mountain. These findings have the following consequences for the project:

- All turbine positions in the current layout are potentially in high risk areas, as they are either in the main turbine string on the main mountain top, or on north or south running spur lines.
- The narrow, knife edge like nature of the mountain top and spurs means that there is little room to move turbines away from the edge of the slopes either side.
- The narrow nature of the mountain also means that birds using up lift generated by either generally northern (north-west, north, north-east) or generally southern (south-west, south, south-east) winds would be exploiting areas in close proximity to turbine positions.

The extrapolation of collision risk patterns identified in small areas within the vantage point view sheds to the entire remainder of the site could justifiably be questioned. However we believe that even if not extrapolated, the indications based on data collected to date are of high risk in certain places on site. The likelihood of more such high risk sections of the site being determined with more data collection is high in our view. We believe that in light of this identified risk, the onus would be on the developer to collect sufficient data to either disprove this risk or develop suitable mitigation measures, in accordance with the precautionary principle. As recommended later in this report, we believe that such data, and confidence therein, can probably only be collected using satellite/GPS tracking of birds and/or radar studies.

The Scottish Natural Heritage (SNH) has written a guidance note on calculating theoretical collision rates for situations such as this (www.project-gpwind.eu). The SNH Collision Risk Model (also sometimes known as the Band model) makes several significant assumptions with respect to factors such as the speed that the bird flies at, the width of the turbine blade, and the dimensions of the turbine and the bird. At this stage in South Africa, at the very beginning of the learning curve, this author is of the opinion that calculations such as this would have limited use. A central factor to this calculation is the avoidance rate of the bird. That is, not every bird flight recorded through the rotor swept zone prior to construction will result in a collision with a turbine post construction. Birds take avoidance behaviour, either well before entering the facility or even at the last moment. SNH has published a set of avoidance rates and also advised that for species for which no avoidance rate is available (all species in South Africa currently) a rate of 99% should be used. This recommendation is based upon multiple sources. It is this authors' opinion that in addition to the multiple tenuous assumptions involved in this calculation of collision rate, the fact that our entire calculation would represent only 1% of the true answer (given the 99% avoidance rate) this exercise would have little value. The type of qualitative interpretation of data presented elsewhere in this report is believed to be far more important for assessing the risk of the project.

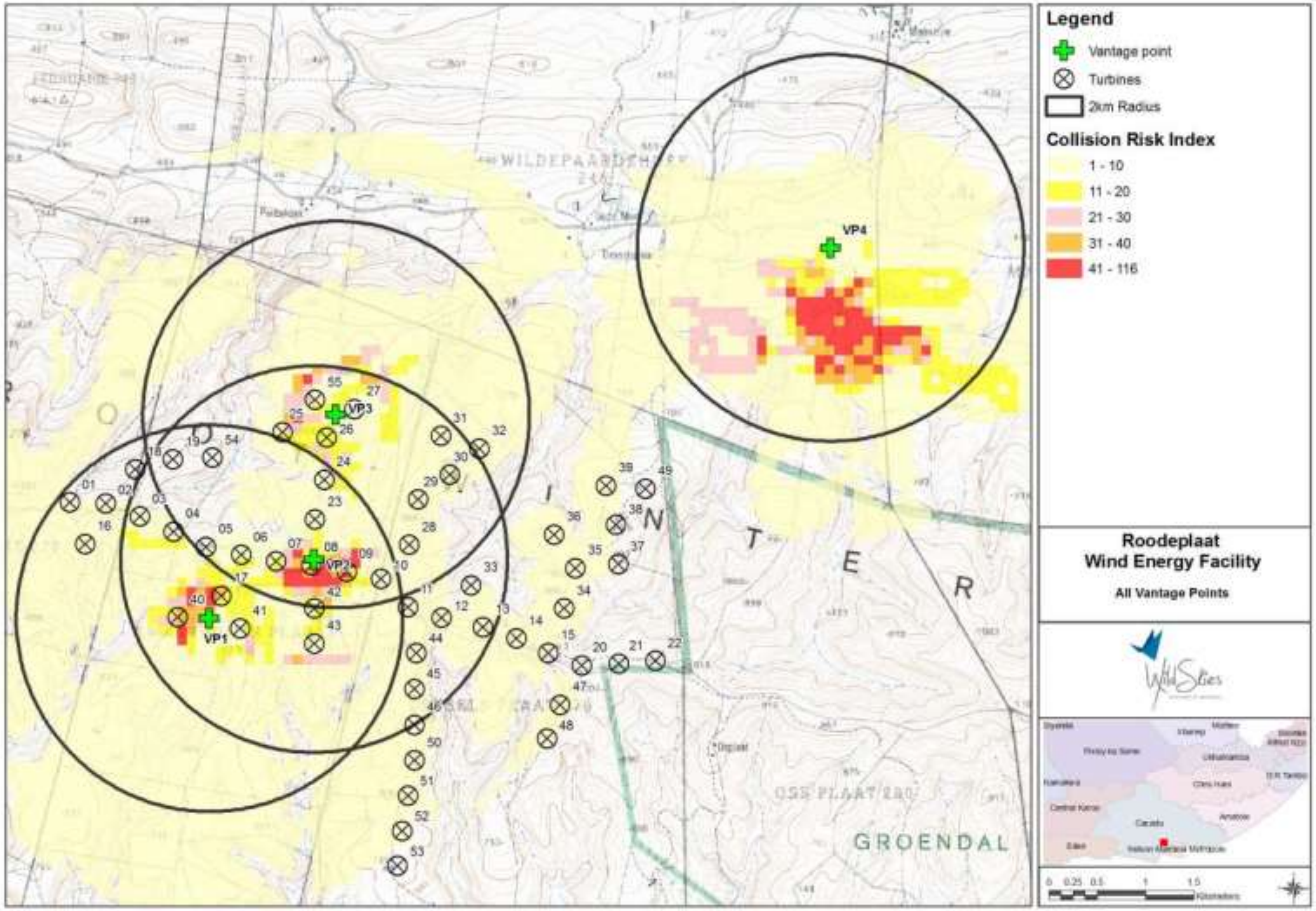

Figure 13. Collision risk index for all target bird species.

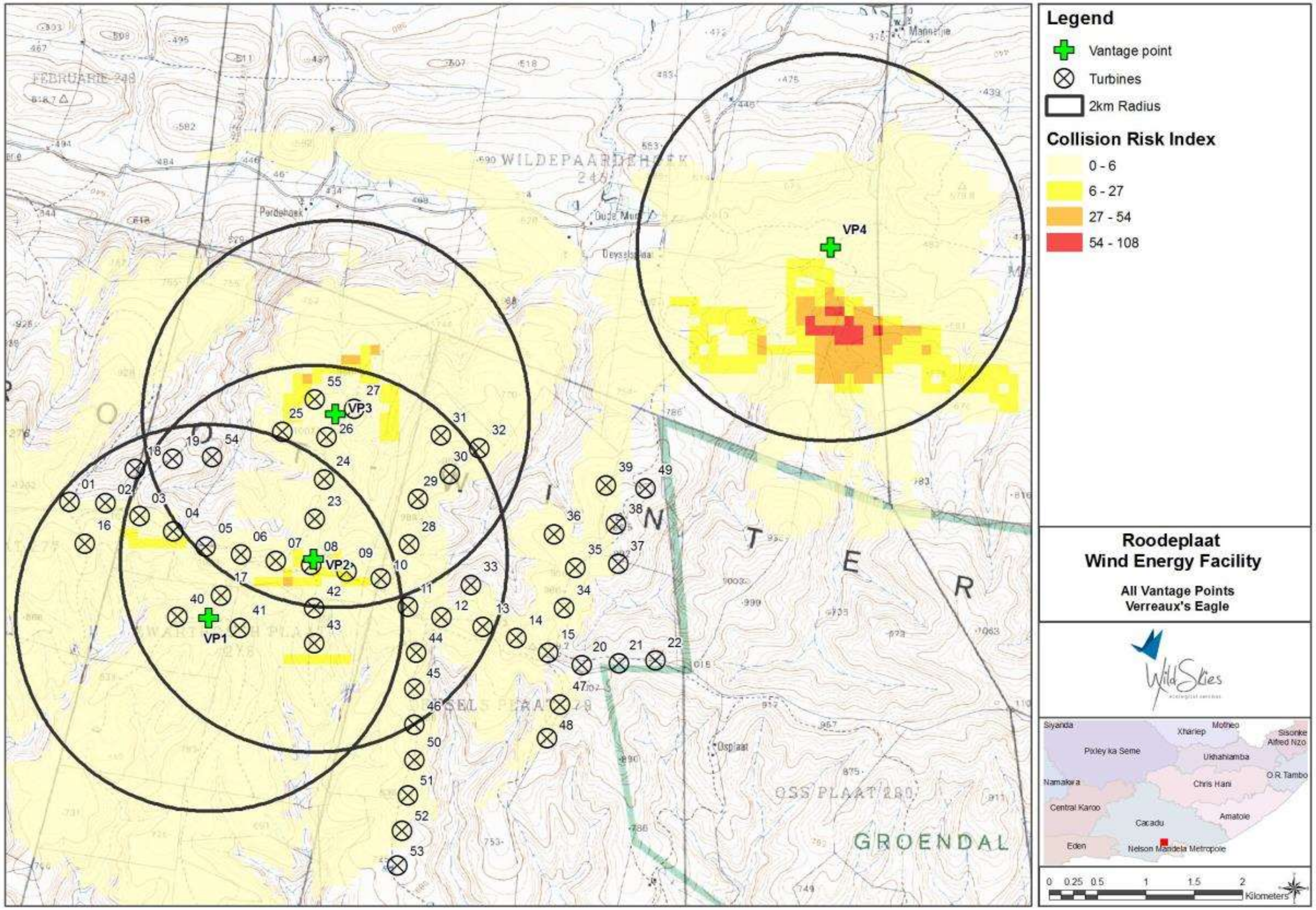

Figure 14. Collision risk index for the Verreaux's Eagle.

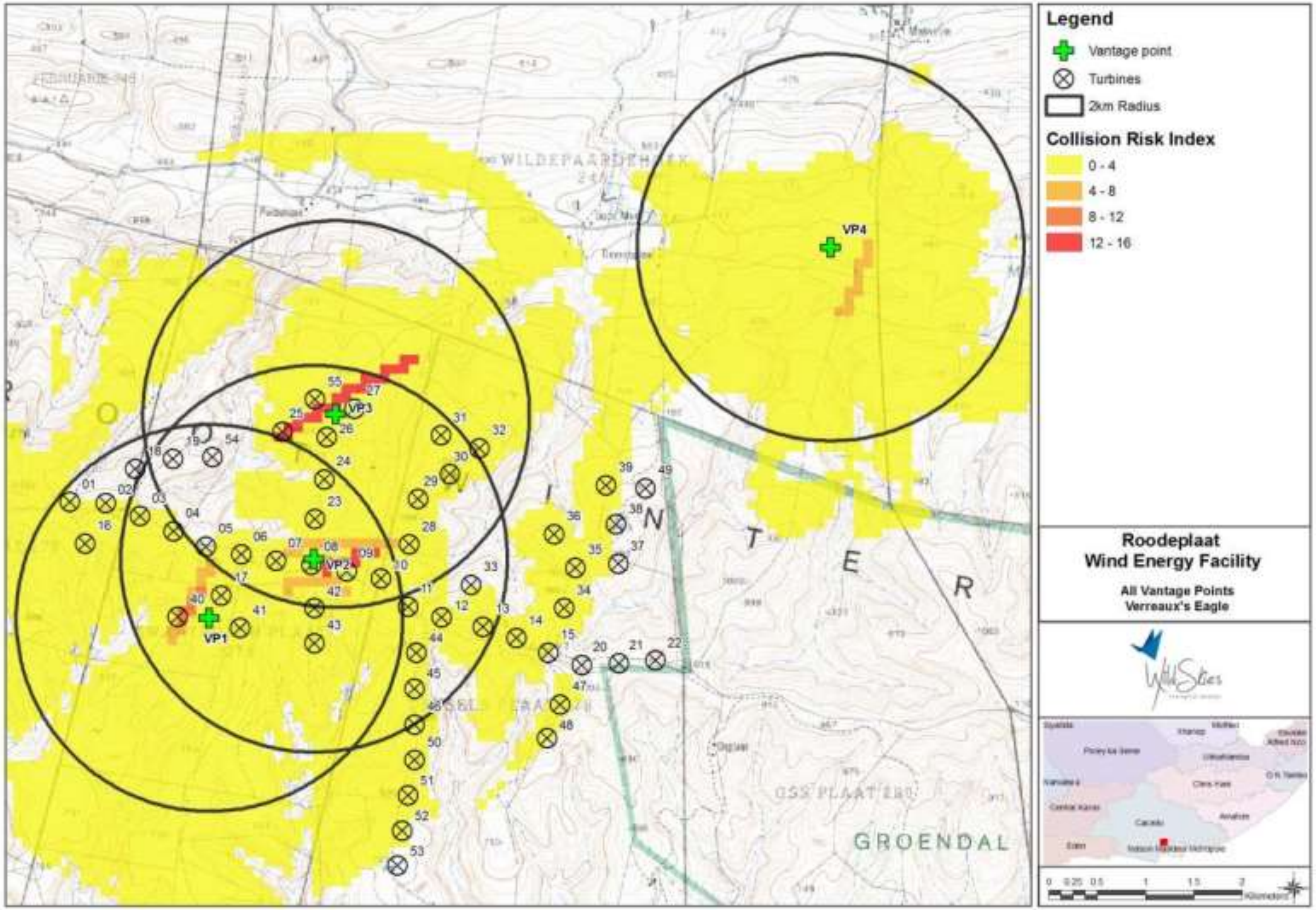

Figure 15. Collision risk index for the Martial Eagle.

4. ASSESSMENT OF RISK OF INTERACTION

In order to assess the risk of birds interacting with the proposed wind energy facility a risk matrix has been utilised (after Allan, 2006; Smallie, 2011), whereby the following equation is used:

Risk of interaction = Probability of interaction x Severity of interaction

In this case the probability of interaction is in simple terms the outcomes of this monitoring programme combined with general knowledge and understanding of the species and its likelihood of interacting with the facility. Useful sources in making this assessment include: Jordan & Smallie (2010) and Retief *et al* (2011). Jordan and Smallie (2010) examined literature on the families of species affected elsewhere in the world by wind farms in order to identify families of birds which could be affected in South Africa. Retief *et al* scored a suite of South Africa bird species for a number of factors believed to be relevant to the species risk of interaction with wind farms, such as behavioural and morphological factors. Combining these scores they arrived at a final risk score per species and a list of 105 species believed most at risk.

The severity of interaction is the importance of the species involved, i.e. what are the implications of impacting on these species. This is based largely on the species conservation status (Taylor, 2014; IUCN 2013). These aspects are described in more detail below:

4.1 Probability of interaction

Based on the data emanating from the above described monitoring programme it is possible to now make an informed qualitative assessment of the importance of this site for the target species in order to narrow our focus down to species and interactions that are of most importance for this project. This is achieved through assessing each species in terms of how it utilises the site and how it could interact with the proposed facility.

4.1.1 Form of utilisation of site

Birds can utilise a site such as this in five ways: breeding, perching, roosting, foraging and overflying. Each of these is explained in more detail below:

Breeding

This is one of the most important forms of utilisation. Breeding is often the aspect of birds life history that they are most specialised in, requiring certain substrate and other conditions to be correct in order to breed. As a result, breeding habitat is probably the form of habitat most under threat for most threatened bird species in South Africa. The breeding phase is also a time when birds are particularly susceptible to disturbance, and any number of factors could result in failed breeding attempt. Once young birds are hatched they are also susceptible to impacts, particularly when recently fledged as their inexperience in flight renders them more at risk of collision with obstacles. This is particularly relevant for large eagles at the Inyanda Roodeplaat site.

Perching

Raptors in particular spend a fair proportion of their time perching on various substrate such as trees, poles, fences, rocks, and any others suitable. Certain species hunt from the perch, whilst others merely rest on perches. Perch availability is therefore an important factor determining the distribution of various bird species.

Roosting

Most bird species roost at night in trees, cliffs or in the shallows of dams – all in an attempt to escape predation. Most large raptors roost at their nest site typically, whilst smaller gregarious raptors roost communally in trees or on overhead cables. Communal roosting is an important feature in determining the sensitivity of a site for birds since the congregation of numerous birds increases the likelihood of impacts occurring. Also – roosts are typically entered and exited in poor light conditions at the start and the end of the day, when the risk of collision with obstacles is greatest.

Foraging

Due to their energy needs, most birds spend most of their time foraging. This is done in a number of different ways by different groups of birds. The likelihood of bird species foraging over an area depends on the presence of their food source or prey in that area and the favourability of other factors such as topography and water availability.

Commuting

Of course almost all birds can and do fly. In the context of this project though we mean those species recorded flying for long durations, in large numbers or frequently, i.e. those species at risk of collision with obstacles on site. On certain sites birds may commute across the site, without actually utilising the site itself for anything else, and would still therefore be at risk of collision.

4.1.2 Form of interaction with facility

The likely interactions between birds and the proposed facility include: habitat destruction as a result of construction of wind turbines, roads, substations and power lines; disturbance of birds as a result of these activities and operation of the facility; displacement of birds from the site; collision and electrocution of birds with/on overhead power lines; and collision of birds with wind turbine blades. Each of these is discussed in more detail below:

Habitat destruction

Any destruction or alteration of natural habitat will have some negative effect on the various bird species present. However, many species will tolerate this and there will be little impact, so for many of the target species this is not considered to be significant. For species that may be breeding on site (i.e. the site provides breeding habitat in addition to foraging) this could be far more serious. These species have been identified in Table 8.

Disturbance

The situation with respect to this interaction is almost identical to that above for habitat destruction. Once again the species most likely to be affected in this regard are the species that breed on site.

Displacement of birds from site

Displacement refers to the scenario whereby a bird is forced to stop using a site or traversing it. This may result in a loss of habitat, or if the species was merely commuting across the site and now has to fly further around the site this may come with energetic costs to the bird. Important species in this regard are probably the large raptors and breeding species again. Breeding birds need to provide food for their young and are therefore already under pressure in terms of their energy balance. Any added travel distance could compromise the adults well-being or its care for its young.

Collision and electrocution of birds with/on overhead power lines

Collisions are a significant threat posed to many bird species by overhead power lines. A collision occurs when a bird in flight does not see the cables, or sees them too late for effective evasive action. The bird is typically killed by the impact with the cable, or the subsequent impact with the ground. Most heavily impacted upon are bustards, storks, cranes and various species of water birds. These species are mostly heavy-bodied birds with limited manoeuvrability which makes it difficult for them to take the necessary evasive action to avoid colliding with power lines (van Rooyen 2004, Anderson 2001).

Electrocutions of birds on overhead lines are an important cause of unnatural mortality of raptors and storks. It has attracted plenty of attention in Europe, USA and South Africa (APLIC 1994; Alonso & Alonso 1999; van Rooyen & Ledger 1999). Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004). Most at risk are the physically larger species such as eagles and vultures, which have more chance of bridging these clearances.

Collision of birds with wind turbines

Bird collisions with human developed infrastructure such as wind turbines have been well documented over the years (for e.g. Drewitt & Langston, 2008). Since the first birds were found under wind turbines it has more or less been assumed that the birds collided with turbine blades because they did not see them. Although vision certainly has a lot to do with the collision, it seems likely that various other factors also play a part. In recent research on bird vision (Martin, 2011; Martin & Shaw, 2010) suggest that birds may have reduced visual acuity in front of them when in flight, or in the case of vultures even be blind for a significant portion of their frontal vision.

Once again Table 8 presents the assessment results for each species. A final probability score of 1 to 5 is assigned to each species based on the above information.

4.2 Severity of interaction

Conservation status (Taylor 2014, IUCN 2013) was taken as the primary index of severity of interaction, the assumption being that impacting on a threatened species is more severe than impacting on a common species. Although not all Red Listed currently, it is generally agreed in ornithological circles that almost all raptors (in particular the larger ones) require as much protection as possible. Scores were assigned to species as follows: Common and non-threatened species = 1; Most large to medium raptors, species protected under the Bonn Convention, certain korhaans and Near-threatened species = 2; Vulnerable species = 3; and Endangered = 4 (Taylor 2014).

4.3 Risk of interaction

The final risk score was obtained by multiplying the probability (1 to 5) and severity scores (1 to 3) to give a final risk score ranging between 0 and 15 (see final column in Table 8). These scores were then classed into High (10-15); Medium (5-9) and Low (0-4), or red, orange and yellow. Those species in the High category are most at risk of impact from the proposed facility. Two such species have been identified, the Verreaux's and Martial Eagle. Four species are identified as being at Medium risk, the African Crowned Eagle, Black Harrier, Jackal Buzzard and Rock Kestrel. These species are all described in more detail below:

In addition to these species, several additional species stand out as being at particularly high risk of interaction only with the grid connection power line. These include Blue Crane, Denham's Bustard, and Ludwig's Bustard.

Table 8. Target bird species for the Inyanda-Roodeplaat site and their form of utilisation of the site, likely interactions between each species and the facility, and final risk score for the species is presented.

	Species name	Ecological group	Severity score	Data collection method					Form of utilisation of site	Likely interactions	Probability score	Final risk score
				Walked Transect	Driven Transect	Focal Site	Incid. Obs.	Vantage Point				
Common name	*Species*											
African Harrier-Hawk	*Polyboroides typus*	Raptor	2	√	-	√	√	√	Foraging, commuting, perching	C, D, HD, DISPL	2	4
African Crowned Eagle	*Stephanoaetus coronatus*	Raptor	3	-	-	-	-	-	Not recorded during this study, although Jenkins *et al* recorded it, and suspected breeding	C, E, D, HD, DISPL	2	6
Black Harrier	*Circus maurus*	Raptor	4	-	-	-	√	√	Foraging, commuting	C, D, HD, DISPL	2	8
Black-shouldered Kite	*Elanus caeruleus*	Raptor	1	-	-	-	-	-	-	C, D, HD, DISPL	1	1
Booted Eagle	*Aquila pennatus*	Raptor	2	-	-	-	√	√	Foraging, commuting, perching,	C, E, D, HD, DISPL	2	4
Cape Clapper Lark	*Mirafra apiata*	Small terrestrial	1	√	-	-	-	-	Foraging	D, HD, DISPL	1	1
Cape Eagle Owl	*Bubo capensis*	Raptor	2	√	-	-	-	-	Foraging, roosting	C, E, D, HD, DISPL	1	2
Grey-winged Francolin	*Scleroptila africanus*	Small terrestrial	1	√	-	-	-	-	Foraging	D, HD, DISPL	1	1
Jackal Buzzard	*Buteo rufofuscus*	Raptor	2	√	√	-	√	√	Foraging, commuting, perching, likely breeding	C, E, D, HD, DISPL	4	8
Lanner Falcon	*Falco biarmicus*	Raptor	3	-	-	-	-	-	-	C, D, HD, DISPL	1	3
Long-billed Pipit	*Anthus similis*	Small terrestrial	1	√	-	-	-	-	Foraging	D, HD, DISPL	1	1
Martial Eagle	*Polemaetus bellicosus*	Raptor	4	√	-	-	√	√	Foraging, commuting, breeding	C, E, D, HD, DISPL	3	12
Orange-breasted Sunbird	*Anthobaphes violacea*	Small terrestrial	1	√	-	-	-	-	Foraging	D, HD, DISPL	1	1
Peregrine Falcon	*Falco peregrinus*	Raptor	2	-	-	-	-	√	Foraging,	C, D, HD, DISPL	1	3

									commuting			
Rock Kestrel	*Falco rupicolus*	Raptor	2	√	√	-	√	√	Foraging, commuting, perching	C, D, HD	3	6
Southern Pale Chanting Goshawk	*Melierax canorus*	Raptor	2	√	√	-	√	√	Foraging, commuting, perching	C, E	2	4
Steppe Buzzard	*Buteo buteo*	Raptor	2	-	√	-	√	-	Foraging, commuting, perching	C, E, D, HD, DISPL	1	2
Verreaux's Eagle	*Aquila verreauxii*	Raptor	3	√	√	√	√	-	Foraging, commuting, perching, breeding	C, E, D, HD, DISPL	4	12
Yellow-billed Kite	*Milvus aegyptius*	Raptor	2	-	-	-	-	-	-	C, E, D, HD, DISPL	1	2

C = collision with either turbines or power lines, E = electrocution on power lines, D = disturbance, HD = habitat destruction, DISPL = displacement

Verreaux's Eagle & Martial Eagle (High)

The Verreaux's Eagle has recently been up listed in conservation status to Vulnerable (Taylor, 2014) in recognition of the threats it is facing. It is ranked at 22 on the list developed by Retief *et al* (2011). These eagles can exist at quite high density compared to other eagle species, with some territories as small as 10km² (Davies, 2010). They also tend to occupy remote mountainous areas largely unaffected by development (until the advent of wind energy in SA that is). Davies recognizes wind farms as a 'new and worrying' threat, although the main threat to the species to date is considered to be the loss of prey populations (Rock Hyrax). Davies recorded home ranges of 10 to 50km², with an average of 24km². The furthest recorded flight from the nest for food was 7 kilometres, although it is almost certain that they will fly further when required (Davies, 2010). Juveniles disperse from their home ranges 4 months after fledging and are not allowed to return to these territories by the adults. There is a suspected high mortality rate amongst juveniles due to the difficult in finding suitable territories.

There are an estimated 12-13 breeding pairs of Verreaux's Eagles on the Grootwinterhoekberge between Uitenhage and Cockscomb (Barkhuysen, 2013). This equates to a nest every 4 to 5 kilometres on average. This is an extremely high density of eagles and suggests that the habitat is optimal on this mountain range for this species. Five of these known breeding sites are within 9 kilometres of planned turbine positions for this project, and a sixth previously unknown nest has been found south of the escarpment.

The Martial Eagle is classified as Endangered by Taylor (2014) and was rated as fifth highest species in terms of risk from wind farms (Retief *et al*, 2011). One breeding pair has been identified to the south of the Grootwinterhoekberge. This is a far ranging species, with a likely far larger home range than Verreaux's Eagle.

Eagles in general are one of the groups of birds most affected by wind farms, with Golden Eagle *Aquila chrysaetos* (most closely related to Verreaux's*)*; White-tailed Sea Eagle *Haliaeetus albicilla*; Bald Eagle *Haliaeetus leucocephalus*; Wedge-tailed Eagle *Aquila audax*; and White-bellied Sea Eagle *Haliaeetus leucogaster* all having been documented as colliding with turbines around the world (various authors). Large, heavy bird species such as eagles, which spend time soaring are considered to be particularly at risk of collision with wind turbines. Their slow breeding and long lifespan also make them susceptible to mortality factors such as wind turbines (Drewitt & Langston 2008, Herera Alsina *et al* 2013). It certainly appears then that we should expect large eagles to be susceptible to collision with wind turbines on the proposed site. This risk may be amplified by the nature of the site itself. The site is positioned on a large mountain range, with almost all turbine positions on high ground within the site. The presence of proposed turbine positions on both the northern and southern slopes of the mountain, and on thin north-south running spurs, means that in almost any wind, raptors are likely to be foraging and utilising air currents in areas occupied by turbines.

To summarise, there are 7 known pairs of eagles breeding in the vicinity of the proposed Inyanda Roodeplaat turbine layout, 6 pairs of Verreaux's Eagles, and one pair of Martial Eagle. The risk that the proposed facility poses to these birds can be classed into six types: destruction of habitat; disturbance of the birds; displacement of the birds from the area affected by the facility, shown below in Table 9. Table 10 presents a subjective rating of the extent to which each impact can be successfully mitigated in our opinion. The impacts of habitat destruction, disturbance and displacement can in our opinion be mitigated to a large degree with the application of appropriate buffer areas around the eagle nest sites although the size of these buffers is highly speculative at this stage. Collision of eagles with wind turbines remains the most challenging risk to mitigate, and the aspect over which we have the lowest confidence.

African Crowned Eagle (Medium)

The African Crowned Eagle is ranked at 35th on the list developed by Retief *et al* (2011). This is an uncommon eagle species in South Africa, with no real population estimate to our knowledge. It's a resident species, with adults remaining less than 10 kilometres from their nest time most of the time (Tuer & Tuer, 1974). In the Eastern Cape the inter nest distance was established to be 6 kilometres (sample of 21 nests – Vernon, 1984). Most breeding displays were recorded within 4 – 8 kilometres of the nest site, with the male bird returning directly to the nest after displaying.

The formal pre-construction bird monitoring programme did not record this species on site. This is probably due to the poor access to the southern valleys which appear more suited to this species. Jenkins et al (2014) recorded the species in their survey and suspected them to be breeding. Other anecdotal information from various birding sources and interested and affected parties indicates that the valleys to the south of the site may be important for multiple pairs of this species.

Black Harrier (Medium)

Black Harrier has been recorded flying 5 times on site with a mean height above ground of 55.5 metres. This is the most range restricted continental raptor in the world. It is classified as Vulnerable globally and Endangered in South Africa (Taylor, 2014). Only an estimated 500 to 1000 breeding pairs remain. Although these birds typically spend most of their time flying below rotor height, they do aerial display and 'sky dance' at greater heights around their breeding sites. The Black Harrier is ranked at No 5 by Retief *et al* (2011) because of its aerial displays, its propensity to fly at night, its long-distance foraging and its Red List status.

Jackal Buzzard (Medium)

The Jackal Buzzard is a fairly common species throughout South Africa which tends to be resident in a particular area, as is the case on this site where at least one pair probably resides in the broader area. It is a generalist in terms of habitat, although does favour shorter vegetation. It hunts mostly in flight, meaning that a large proportion of its time is spent flying, and thereby at some risk of collision with vertical obstacles. On this site this species has been recorded frequently by all data collection methods and is suspected to breed somewhere close by. This species is ranked at 42 on Retief's list. It is believed that this species will be susceptible to collision with wind turbines. Due to its relatively common status this anticipated risk does not carry as much significance as it would if the species were Red Listed.

Rock Kestrel (Medium)

Rock Kestrel is a relatively common species throughout most of South Africa. It can forage over most open habitat types but breeds in cliff terrain, although it has also been recorded breeding on man-made structures.

This species has been recorded flying frequently and for long durations on the Inyanda Roodeplaat site. Its flight behaviour, alternating hovering with soaring makes it theoretically highly susceptible to collision with turbines. It is considered likely to breed on or near the site.

In addition to the above species, a suite of species has been identified that are at high risk of impact from the proposed grid connection power line. These include the following species:

Blue Crane (High risk – power line only)

The Blue Crane is globally Vulnerable, and regionally Near-threatened (Taylor 2014, BirdLife International 2013). Near-endemic to South Africa, the population had decreased from at least 100,000 birds to some 20,765 birds by 1993 (Hockey *et al.* 2005). This is a bird which is highly vulnerable to collision with power lines so it is important to consider in the context of the proposed grid connection power line. The Blue Crane is a flocking species, particularly in the non-breeding season (winter) and birds roost in the shallows of dams at night, sometimes in large numbers (up to 3,000 at one site; Hockey *et al.* 2005), often arriving after dark and leaving at first light. These are the periods when visibility is lowest, which contributes to the risk of colliding with obstacles. The Blue Crane is by far the species reported killed most frequently on Eskom power lines (Eskom-EWT 2012), with some 12% of the Overberg population estimated to die in collisions annually (Shaw *et al.* 2010). At the Inyanda Roodeplaat site Blue Crane is known to occur in the lower lying areas, including the route for the proposed grid connection power line. This species is therefore considered to be at some risk of collision with the proposed power line. It is not considered likely to visit the wind energy facility site itself very frequently and is therefore not considered at high risk of collision with the wind turbines.

Denham's and Ludwig's Bustard (High risk – power line only)

These physically large species are highly vulnerable to collision with overhead power lines, and are also likely to be affected by disturbance and habitat destruction. Ludwig's Bustard is a wide-ranging bird endemic to the south-western region of Africa (Hockey *et al.* 2005). This species was listed as globally Endangered in 2010 because of potentially unsustainable power line collision mortality, exacerbated by the current lack of proven mitigation and the rapidly expanding power grid (Jenkins *et al.* 2011, BirdLife International 2013). Ludwig's Bustards are both partially nomadic and migratory (Allan 1994, Shaw 2013), with a large proportion of the population moving west in the winter months to the Succulent Karoo. In the arid and semi-arid Karoo environment, bustards are also thought to move in response to rainfall, so the presence and abundance of bustards in any one area are not predictable. Therefore, collisions are also largely unpredictable, and vary greatly between seasons and years (Shaw 2013). While there is no evidence yet of population-level declines resulting from power line collision mortality, detailed range-wide power line surveys estimate that tens of thousands of bustards (from a total South African population of approximately 114,000 birds) die annually on the existing power grid in this country, which is of grave concern given that they are likely to be long-lived and slow to reproduce. It seems likely that there will be a threshold power line load at which population declines will become apparent, but it is not possible to accurately predict what this will be, and such effects will probably only be noticed when it is too late to do anything about it (Shaw 2013). Therefore, extreme caution is necessary in the planning of any new power lines and other infrastructure in the range of this species. Denham's Bustard is classified as Vulnerable by Taylor (2014) and its population and range has decreased over the last few decades due to habitat destruction and disturbance. Allan & Anderson (2010) adjudged the Denham's Bustard to be the topmost priority amongst bustards for conservation attention, on account of it facing the widest range of known threats. This classification was too early to consider wind turbines as a threat. The southern African population of this species is estimated at < 5 000 birds (Allan 2003, in Hockey *et al*, 2005). In 1984 the Eastern Cape population was estimated at 100-200 birds (Brooke, 1984) and there does not appear to be a more recent estimate. This species is typically seen in higher densities in transformed habitats towards the west of the country, rather than in the natural grassland more prevalent in the east of South Africa. In the Inyanda Roodeplaat project area this species could occur on the low lying ground traversed by the grid connection power line.

It is noted that the lower lying areas of the Inyanda Roodeplaat project area are on the margin between Ludwig's and Denham's Bustard occurrence, with both species occurring here (and even Kori Bustard being an occasional visitor). Both are equally susceptible to power line collision. Mitigation measures proposed by this report will fortunately address the risk to all three species.

5. ASSESSMENT OF IMPACTS

The primary aim of this report is to present findings on bird abundance and behavior on site, and not formally assess the impacts on birds (as that will be done during the formal Avifaunal Impact Assessment). However given that data collection on site points towards a high risk to avifauna in the development proceeds, we make the following general findings in this regard:

- Disturbance of birds, displacement of birds, and destruction of bird habitat are likely to be of high to very high significance in our opinion. The species most at risk here are the Verreaux's and Martial Eagles, although various other species also utilise the site.
- Collision of birds (particularly Verreaux's and Martial Eagle) with wind turbines once operational, is predicted to be of medium to high significance. The relevant species are threatened, long lived raptors, with low breeding productivity (a maximum of 1 young bird raised per year, although often only every second year). Mortality of such species has a high consequence for the local and national populations of the species. This study has found Verreaux's and Martial Eagles to be flying through the area where turbines will be built. Although these flights do not appear frequent at face value, with these species, even low numbers of mortalities could be significant for the species. As described elsewhere in this report, the buffer areas recommended by this report do not fully cover the eagles' home range and therefore do not fully mitigate this risk. This is the impact for which there is the most uncertainty and lowest confidence in our ability to mitigate it effectively based on current understanding. The topographic nature of the site provides little opportunity to mitigate this risk by micro siting of turbines. Most turbines in the current layout are situated either on the narrow ridge top or the equally narrow minor spur ridges, with little opportunity to move them.
- Collision and electrocution of birds on the overhead grid connection power line is predicted to be of high significance. In the case of electrocution, this risk is easily mitigated, but in the case of collision, available mitigation is not fully effective.

Table 9 below provides insight into the confidence in our assessment of each of these risks, and our predicted ability to mitigate these risks.

Table 9. Summary of the potential impacts of the proposed facility on eagles.

Risk	Effect on birds	Suggested mitigation measure	Estimated contribution mitigation makes to reducing risk	Degree of confidence in assessment
Destruction of habitat	Indirect effect whereby less available habitat compromises birds ability to meet its needs for foraging, breeding and other activities	No infrastructure to be built within appropriate buffer	60-70% - the identified buffers could conceivably encompass up to 70% of the eagles range. This would need to be established more accurately by data collected through eagle tracking studies.	Low to medium
Disturbance of birds	Indirect effect whereby birds may be less successful in their breeding attempts, or unsuccessful or not even attempt to breed. These outcomes all reduce the recruitment of new young birds to the local population.	No infrastructure to be built within appropriate buffer, and within 'line of sight' of nests during breeding season	80%	High
Displacement of birds	Birds may be displaced from foraging over and within the wind farm, thereby losing this area or needing to fly longer distances commuting around the area in order to avoid the wind farm, with consequent greater pressures on their energy budget, and possible lower breeding success.	No infrastructure to be built within appropriate buffer	60-70%	Low to medium
Collision with turbine blades	Birds killed - likely to affect adults of the closest breeding pairs as well as young birds produced each season. If juveniles killed this reduces recruitment to population. If adults killed it reduces breeding and could result in a 'sink' situation whereby 'replacement' birds are continually drawn into the area only to be killed.	No infrastructure to be built within appropriate buffer or in identified sensitive positions in the landscape. Unfortunately in our view this entire facility is within a high risk area.	50-60% - we anticipate that up to 60% of eagle flight activity will be within the identified buffers and hence safe from collision if no turbines are built in these areas. However, this statement is based on speculation, and incomplete understanding of the birds behavior on this site. It is conceivable that birds territorial display/defence behavior would place birds particularly at risk at the outer extremities of their home ranges, which likely will not be encompassed by buffers. Watson (2010) found the following: "Distant ridgelines away from	Low

			nests that create eagle view sheds may be significant focal locations for interactions with adjacent nesting eagles (e.g., undulating flight displays, sentinel perching, tail chases), dictate the shape of territories, and act as density-dependent constraints on range size.	
Electrocution on power lines	Same as above.	No infrastructure to be built within appropriate buffer All on site power line to be underground All overhead power line to be on bird friendly pole design as per Eskom Standard	100% - mitigation is complete	High
Collision with power lines	Same as above	No infrastructure to be built within appropriate buffer All on site power line to be underground Grid connection to be built on optimal route and high risk sections to be marked with bird flappers	60% - collision mitigation marking devices installed on lines typically reduces collision by up to 60%. If other mitigation measures recommended in left hand column are implemented these could conceivably increase the contribution	Medium

6. AVIFAUNAL SENSITIVITY ANALYSIS

The primary means of minimising the potential impacts identified for a wind energy facility is typically the optimal placement of the proposed infrastructure. In order to achieve this, a sensitivity analysis is typically prepared for the site. This has been presented below in Figures 16 and 17.

Avifaunal sensitivity for a project of this nature may be viewed at several spatial levels:

6.1. National & regional level

At the national level two bird conservation initiatives are particularly relevant to this exercise: the BirdLife South Africa-Endangered Wildlife Trust "Avian wind farm sensitivity map for South Africa" (Retief *et al*, 2011); and the Important Bird Areas programme of BirdLife South Africa (Barnes, 1998). The sensitivity map (Retief *et al*, 2011) consolidated multiple avifaunal spatial data sources for a list of priority species in order to categorise pentads (9 x 9 kilometre grid cells – as shown in Figure 16) across South Africa according to their risk of bird-wind farm interactions. The darker grid cells indicate higher risk and the lighter coloured cells indicate lower risk. It is clear from Figure 16 that parts of the proposed site (in the south where the turbines are mostly proposed) are classed in one of the higher sensitivity categories (Retief *et al*, 2011). It should be noted that since the primary data sources used to develop this map were the SABAP1 and 2, the map is affected by how well the areas of the country were covered by atlasing effort. It is therefore possible that areas of seemingly low sensitivity are actually data deficient. Exercises such as this map will certainly be over ruled by actual data collected by pre-construction monitoring on site, but are useful to provide perspective at this level. The closest Important Bird Area (IBA) is the Kouga Baviaanskloof Complex – SA093, which is approximately 17 kilometres to the west of the proposed site.

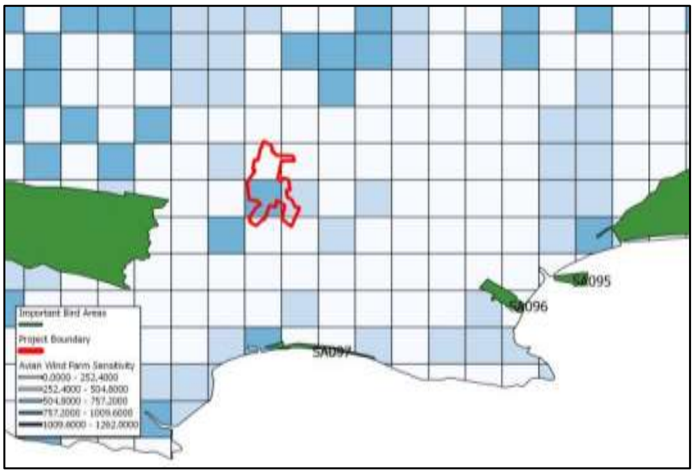

Figure 16. The proposed Inyanda-Roodeplaat Wind Energy Facility site (red polygon) relative to the Avian Wind Farm Sensitivity Map (Retief *et al*, 2011). Dark colours indicate higher sensitivity or risk and light colours indicate lower sensitivity. The position of Important Bird Areas is also shown.

Based on these two information sources it is concluded that the site is of medium sensitivity at a regional scale.

6.2 Local on- site level sensitivity

A number of factors could be considered in determining on site sensitivity. These include: drainage lines and streams; areas of higher topographic relief, ridge edges, the 'collision risk index' presented in Section 3; and the buffer areas identified around the known Verreaux's and Martial Eagle nests. At this point it is believed that other specialists such as the ecologist and botanist would have identified the drainage lines as sensitive, and there is no need to repeat that information. Almost the entire site is close to ridge edges, and turbines are mostly proposed for the higher ground. This is one of the reasons that we make the finding that this site is highly sensitive for avifauna. Mapping these areas is therefore not particularly informative for micro siting of turbines. The two most important factors considered below are therefore the eagle buffer areas, and the collision risk index.

6.2.1. Buffer zones at eagle nest sites

Large eagles such as the Verreaux's, Martial, and possibly African Crowned Eagle present at the Inyanda Roodeplaat site are often protected against wind farm impacts internationally through the use of buffers. The radius of these buffers is typically determined by the measured or estimated core foraging ranges of the affected birds (Martinéz *et al*. 2010). At Inyanda Roodeplaat we do not yet know what the core foraging or home range is of any of the relevant pairs of eagles. In such cases, a theoretical buffer area may be imposed to provide protection for the birds. A survey of international literature available pertaining to eagle buffer sizes for various forms of development revealed a range of recommended buffers from as little as 400 metres to as much as 12.8 kilometres (DeLong, 2008; Martinéz *et al*. 2010; Ruddock & Whitfield 2007; Marja-Liisa Kaisanlahti-Jokimäki, *et al*. 2008; Colorado Division of Wildlife 2008; Rydell *et al*, 2012; US Fish & Wildlife Service 2013, Watson, Duff & Davies, 2014). Most of these studies dealt with the Golden Eagle *Aquila chrysaetos*, an eagle quite similar to Verreaux's Eagle in behaviour. One of the most recent sources, the US Fish & Wildlife Service (2013), recommended a buffer radius equal to half the mean inter nest distance for the species in the area. Some of this literature also points towards the importance of 'line of sight' in determining buffer size. The assumption is that if adult birds are able to see the proposed development (and presumably construction activities) from the nest this may disturb them or alter their breeding behaviour. Informal discussion with other avifaunal specialists practising in SA reveals a range of buffers of between 1.3 and 2.5 kilometres for Verreaux's Eagle and slightly larger buffers for Martial Eagle (pers. Comm). At Inyanda Roodeplaat, Jenkins *et al* (2014) recommended 2.5km buffers for Verreaux's and 5km for Martial Eagles. This is based on a mean inter nest distance of 5.1km for Verreaux's Eagle and an estimated 15km for Martial Eagle in the Karoo. Unfortunately since the wind energy industry is so young in South Africa we do not know of published data on buffer sizes and their ultimate effectiveness in providing protection to breeding eagles. We have therefore made use of the available international literature, and our own work at Inyanda Roodeplaat to make an informed professional judgement on an appropriate sixe for buffer areas.

In calculating a recommended buffer size for Verreaux's Eagle we have used only the northern 5 Verreaux's Eagle nests to calculate the mean inter nest distance (since the southern portions of the site were incompletely surveyed and would bias the results). We calculated an approximate mean inter nest distance between the five northernmost Verreaux's Eagle nests in this area of 4.1 kilometres. This implies a theoretical buffer size of 2 kilometres if the US Fish & Wildlife Service guidance is utilised. In the case of the Martial Eagle we are not aware of any other pairs in the area from which to calculate a mean inter nest distance, and so we suggest that a buffer of 2.5 kilometres as our first estimate in this instance. Although we agree that this is a far ranging species, and large buffers would be better, in our opinion 2.5km is a reasonable compromise between being cautious and practical. Figure 17 presents these proposed buffer areas relative to the proposed turbine layout. No new infrastructure should be built within these buffer areas. Currently 5 turbines are within 2km of the Perdehoek nest site, and 2 turbines within 2.5km of the Martial Eagle nest site. The remaining buffers do not impact on the current turbine layout.

The uncertainty around the mitigation of the collision risk to these eagles, coupled with our so far poor understanding of these birds home range sizes and requirements (hence buffer size) are the main reason for the recommendation made in Sections 5, 6 and 7, that the significance of impacts on avifauna as determined by this assessment is likely to be high.

In addition, although each eagle pair could possibly be buffered by an appropriate distance, this piece meal approach does not do justice to the holistic effect that the facility could have on these eagles and their mountain refuge. It is our opinion that this type of wilderness area has an intrinsic value for species such as this, and that a holistic view needs to be taken of the sensitivity of the site.

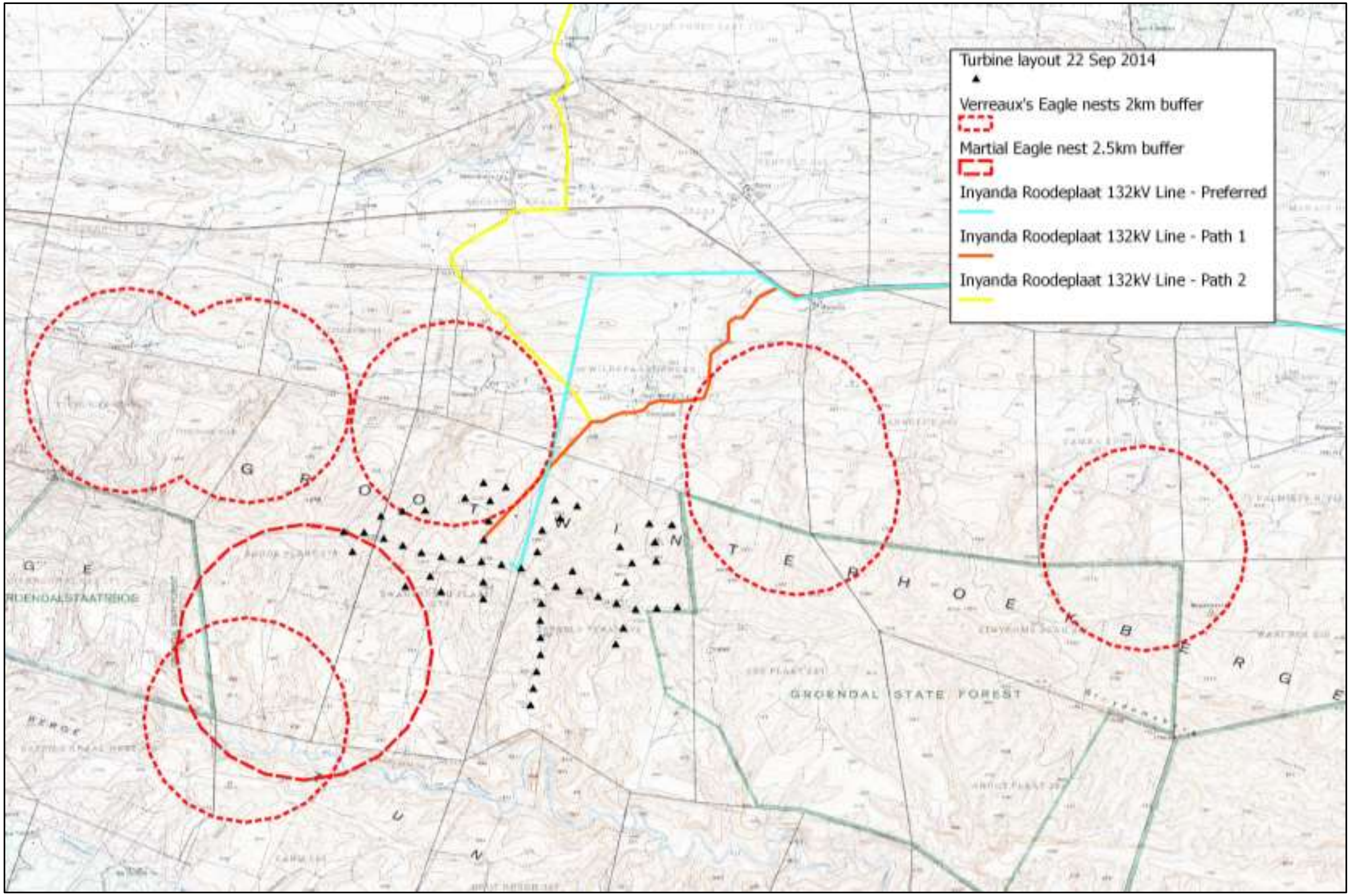

Figure 17. Avifaunal sensitivity analysis for the Inyanda-Roodeplaat Wind Energy Facility.

6.2.2. Collision risk index

As described earlier in this report, based on the collision risk index calculated to date, we would identify the top of the main mountain and the tops of each of the north-south spurs as sensitive areas. This would eliminate almost all current turbine positions, and does not seem productive to map at this stage.

6.3 Power line grid connection corridors

Three corridor options for the 132kV overhead power line connection to the grid have been proposed. These are pictured in Figure 18 below. Whichever option is utilized, this is a relatively long grid connection (approximately 45 kilometres), compared to most projects this author has worked on. Since overhead power lines present a significant risk to avifauna (in some cases it can be argued that they pose more risk than wind farms themselves) this has to be viewed as a significant risk posed by the proposed project to avifauna. Having said that the most optimal corridor from an avifaunal perspective is 'Path 2' in Figure 18 below, for the following reasons:

- Path 2 is adjacent to an existing high voltage power line (see Figure 18) for approximately half of its route, and a medium voltage line for part of the remainder of its route. Placing new power lines adjacent to existing lines is believed to be advantageous for reducing the bird collision risk, since more cables in close proximity may be more visible (APLIC 1994, 2012) and because resident birds may already be aware of the risk in that vicinity. Grouping linear infrastructure also reduces the need for additional access and maintenance roads and various other factors.
- Path 2 is adjacent to the main tar road between Kirkwood and Jansenville for approximately half of its route, and adjacent to a district gravel road for much of the remainder. As described above this is believed to be advantageous for avifauna.
- Path 2 passes through less remote areas than the 'Preferred' and 'Path 1' corridors (in the far east of Figure 18).

It is recommended that the 'Preferred' and 'Path 1' options not be considered further.

In addition to route selection, it will be important to correctly mitigate for the risk of bird collision and electrocution on the power line. This has been described in more detail in Section 5.

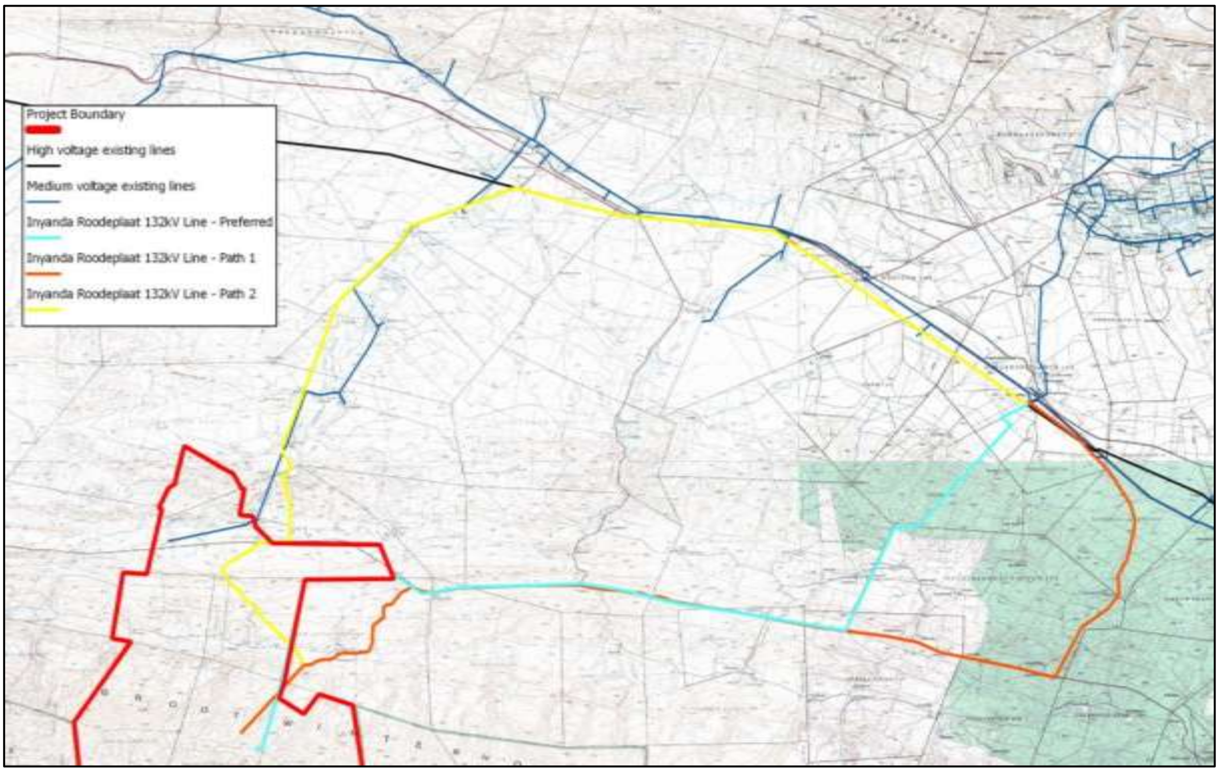

Figure 18. The 132kV power line grid connection corridors for the Inyanda-Roodeplaat Wind Energy Facility.

7. CONSTRUCTION & POST CONSTRUCTION BIRD MONITORING FRAMEWORK

The bird monitoring work done to date on the Inyanda-Roodeplaat WEF site has established a baseline understanding of the distribution, abundance and movement of important bird species on and near the site. However this baseline data should be compared to post construction data once the facility is constructed. In addition, certain of the anticipated impacts, disturbance of breeding eagles for example, require an on-going presence on the site before and during construction in order to fully understand the impact. The following programme has therefore been developed to meet these needs. It is recommended that this programme be implemented by the developer.

7.1 During construction bird monitoring

It is envisaged that movement of ornithologists on site may be restricted for safety reasons during certain components of the construction process. The following is therefore a 'minimal input' programme designed to provide at least some insight into the reaction of important bird species to the construction activities on site:

- Eagle breeding site visits. These are the most important aspect of this phase of the programme, as they will provide insight into the effects of construction on these birds, and hence the effectiveness of the mitigation measures implemented. The 7 known eagle breeding sites should be visited at least twice during each breeding season (June to December) during which construction takes place. These activities should comprise approximately 5 days per site visit, by a suitably qualified avifaunal specialist.

7.2 Post construction monitoring

The intention with post construction bird monitoring is to repeat as closely as possible the methods and activities used to collect data pre-construction. One very important additional component needs to be added, namely mortality estimates through carcass searches. The following programme has therefore been developed to meet these needs, and should start as soon as possible after the construction of the first phase of turbines (not later than 3 months):

Live bird monitoring

The twelve walked transects that have been done during pre-construction monitoring should be continued, as should the three vehicle based road count routes. The focal sites already established as well as any new focal sites identified by the 'during construction monitoring' should be monitored. All other incidental sightings of priority species (and particularly those suggestive of breeding or important feeding or roosting sites or flight paths) within the broader study area will be carefully plotted and documented. The four Vantage Points already established should be used to continue data collection post construction. The exact positioning of these may need to be refined based on the presence of new turbines and roads. A total of 12 hours of observation will be conducted at each vantage point on each site visit, resulting in a total of 48 hours direct observation on site per site visit. The activities at the control site should be continued, i.e. one Vantage Point, one Vehicle Transect, and 3 Walked Transects. It is estimated that these activities will require 10-12 days on site for four site visits in a 12 month period.

This component of the monitoring should be conducted for at least one year or for as long as is recommended by the most recent version of the best practice guidelines at that time.

Mortality estimates

This is a new component of the methodology that only applies once the facility is built. The following description is from Jenkins *et al* (2012), but the most recent version of this guidance should be used to design the monitoring programme once it is required. The area surrounding the base of turbines should be searched for collision victims. As an absolute minimum, the search area should be defined by a radius equal to 75% of the turbine height (ground to blade-tip). The area around each turbine should searched using transects no greater than 10 meters apart, this width should be reduced where groundcover reduces visibility. Transects should be walked at a slow pace and carefully and methodically searched for any sign of a bird collision incident (carcasses, dismembered body parts, scattered feathers, injured birds). The period between searching individual turbines, the search interval, should be informed by assessments of scavenge and decomposition rates conducted in the initial stages of the monitoring period. Ideally the search interval should be shorter than the average carcass removal time. As a rule of thumb, a search interval of two weeks could be expected; however the primary objective of fatality searches could also influence the search interval. Bearing this in mind, it may be necessary to have two different approaches to sampling, and two different search intervals: 1) intensive, regular sampling of a subset of turbines and 2) extensive, less frequent sampling for large bodied bird carcasses. While this approach is not ideal for determining average fatality rates (Smallwood 2013), it does represent a compromise where significant mortalities of large birds at a particular turbine, or group of turbines, can be identified with limited resources.

Any suspected collision casualties should be comprehensively documented (for more detail see Jenkins *et al*, 2012). The number of turbines sampled should be informed by the objectives of the monitoring, as well as the spatial variation in fatality rates. It is therefore recommended that all turbines at each wind farm are surveyed, if necessary using the two different survey methods (intervals) as described above. No less than 30% or 20 turbines (whichever is greater) should be surveyed using the more rigorous (intensive) sampling methods. It is also important that associated infrastructure such as power lines and wind masts be searched for collision victims according to similar methods.

It is important that in addition to searching for carcasses under turbines, an estimate of the detection (the success rate that monitors achieve in finding carcasses) and scavenging rates (the rate at which carcasses are removed and hence not available for detection) is also obtained (Jenkins *et al*, 2012).

Both of these aspects can be measured using a sample of carcasses of birds placed out in the field randomly. The rate at which these carcasses are detected as well as the rate at which they decay or are removed by scavengers should be measured. It is important that at least 20 carcasses are used, and that this is done twice in a 12 month period, in summer and in winter. Although it is important to try to use carcasses similar in size and other factors to the target species for the site, this is unlikely to be achievable in practice. It is more likely that a readily obtainable species will be used, such as ducks or geese.

Since the mortality searches need to be done more frequently than the other monitoring), this will require a separate team with different skills and hopefully based closer to the site. This should be discussed with the specialist as soon as the project is confirmed as going ahead.

At this stage the time required for this component of monitoring is difficult to determine since it will also be dependent on the exact methods, i.e. dogs and other options. This should be discussed more with the developer as the time approaches.

This component should be continued for at least 3 years, and repeated in years 5, 10, 15 etc, or in accordance with the latest available best practice guidelines at the time.

8. CONCLUSION & RECOMMENDATIONS

The proposed facility and associated infrastructure poses a high risk to the local avifauna in our opinion. Although various reasons for this opinion have been described in this report, the following are key and are worthy of repetition here:

- The proposed site is situated in a remote, so far relatively un-impacted, area of the country, and between two protected areas. These factors make this area an important refuge for various threatened bird species which require large unspoilt areas for their survival.
- Testimony to the above point is the fact that 7 breeding sites of highly threatened eagles are situated within approximately 9 kilometres of proposed turbine positions. Six of these nests are used by Verreaux's Eagle, classified as Vulnerable by Taylor (2014) and one is a Martial Eagle, classified as Endangered. This population of eagles represents part of a larger population on the Grootwinterhoekberge.
- The nature of the mountain top turbine layout provides little opportunity for micro siting turbines out of high risk areas, the entire site being relatively high risk.
- The facility is a long distance from the existing power grid. An overhead power line of approximately 45 kilometres will be required to connect to the grid. This brings with it additional impacts on avifauna.
- Whilst mitigation measures have been proposed for each identified risk to birds, we cannot say with certainty that these measures will reduce the risk to acceptable levels.
- We are of the opinion that the holistic risk to avifauna at this site is greater than the sum of its parts. A piece meal approach to mitigating each impact, and in particular the use of buffers around each eagle nest will in our view not collectively mitigate the holistic risk.
- There is an inherent value of this site for large eagles particularly, that will undoubtedly be diminished by the construction of such a facility.

In light of the above findings we believe the appropriate approach in this instance to be the application of the precautionary principle. In other words, based on the level of understanding we have of the site currently, **we believe the overall risk to avifauna to be high and in most cases not easy to mitigate fully**. **We would therefore recommend against the construction of this facility.** We also note that space and appropriate sites for wind farms is not a limiting factor in South Africa. In our opinion there are likely to be other sites which can be developed to meet the countries energy needs at less risk to avifauna.

- That additional data be collected on site to complement the data set already collected by 'traditional' human based monitoring. In particular, a better understanding of the movement and behaviour of the Verreaux's and Martial Eagle on site would be beneficial. Data collection on bird movement to date has sampled approximately 40 days in a year. It would be far more useful to understand what the eagles are doing all day, all week and all year. This would allow an understanding of how much time the birds spend in the areas of the site where turbines would be built. It is recommended that various technologies such as radar, and bird tracking devices be considered for this purpose.

- In the case of radar studies, explicit data could be collected for all larger bird species moving on site, with more accurate spatial resolution than human observers. The steep and broken topography on site may pose challenges for the use of radar, but this would need to be confirmed by a suitable radar specialist.
- Satellite/GSM/GPS based transmitters fitted to a number of resident eagles could yield extremely useful information, and have the advantage of collecting data 24 hours per day for 365 days of the year.
- Additional nest surveys in the south-east of the study area will be required to ascertain whether any additional pairs of eagles are resident there, including possibly African Crowned Eagle.

The following management recommendations are made in order to manage the risk posed to birds by the proposed facility should it be authorised:

- All power line linking the turbines and linking turbine strings to the on-site substation should be placed underground where possible. Where not possible this should be discussed with the specialist and a compromise reached that provides acceptable protection for birds.

- The power line linking the site to the Eskom grid will be above ground but must conform to all Eskom standards in terms of bird friendly pole monopole structures with Bird Perches on every pole top (to mitigate for bird electrocution), and anti-bird collision line marking devices (to mitigate for bird collision). It is particularly important that the collision mitigation devices used are durable and remain in place on the line for the full lifespan of the power line. It will be Eskom's responsibility to maintain these devices in effective condition for this period. Systematic patrols of this power line should be conducted during post construction bird monitoring for the wind energy facility, in order to monitor the impacts, the effectiveness of mitigation, and the durability of the mitigation measures.

- A final avifaunal walk through should be conducted prior to construction to ensure that all the above aspects have been adequately managed and to ground truth the final layout of all infrastructure. This will most likely be done as part of the site specific Environmental Management Plan. This will also allow the development of specific management actions for the Environmental Control Officer during construction, and training for relevant on site personnel if necessary.

- The 'during' and post-construction bird monitoring programme outlined by this report should be implemented by a suitably qualified avifaunal specialist. In particular the post construction monitoring should be conducted for at least 3 years after the commissioning of the facility and should include carcass searches and all the associated studies in order to measure the impact of the turbines through collision. This monitoring should be done in accordance with the latest available best practice guidelines in this regard. As mentioned above this monitoring should include the grid connection power line.

- The findings of post-construction monitoring should be used to measure the effects of this facility on birds. If significant impacts are identified the wind farm operator will have to identify and implement suitable mitigation measures. It is likely that post construction these mitigation measures would have to consist of selective curtailment of turbines identified as having unacceptable levels of impact on target bird species.

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APPENDIX 1. Method of assessing the significance of potential environmental impacts

This section outlines the proposed method for assessing the significance of the potential environmental impacts outlined above. As indicated, these include both operational and construction phase impacts.

For each impact, the EXTENT (spatial scale), MAGNITUDE and DURATION (time scale) would be described. These criteria would be used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. The mitigation described in the EIAR would represent the full range of plausible and pragmatic measures but does not necessarily imply that they would be implemented.[1]

The tables on the following pages show the scale used to assess these variables, and defines each of the rating categories.

Table 1: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	**Regional**	Beyond a 10 km radius of the candidate site.
	Local	Within a 10 km radius of the candidate site.
	Site specific	On site or within 100 m of the candidate site.
Magnitude of impact (at the indicated spatial scale)	**High**	Natural and/ or social functions and/ or processes are *severely* altered
	Medium	Natural and/ or social functions and/ or processes are *notably* altered
	Low	Natural and/ or social functions and/ or processes are *slightly* altered
	Very Low	Natural and/ or social functions and/ or processes are *negligibly* altered
	Zero	Natural and/ or social functions and/ or processes remain *unaltered*
Duration of impact	**Construction period**	Up to 3 years
	Short Term	Up to 5 years after construction
	Medium Term	5-15 years after construction
	Long Term	More than 15 years after construction

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in **Table 2.**

Table 2: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED

High	• High magnitude with a regional extent and long term duration • High magnitude with either a regional extent and medium term duration or a local extent and long term duration • Medium magnitude with a regional extent and long term duration
Medium	• High magnitude with a local extent and medium term duration • High magnitude with a regional extent and construction period or a site specific extent and long term duration • High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration • Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Low magnitude with a regional extent and long term duration
Low	• High magnitude with a site specific extent and construction period duration • Medium magnitude with a site specific extent and construction period duration • Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Very low magnitude with a regional extent and long term duration
Very low	• Low magnitude with a site specific extent and construction period duration • Very low magnitude with any combination of extent and duration except regional and long term
Neutral	• Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact, would be determined using the rating systems outlined in **Table 3** and **Table 4** respectively. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring. Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in **Table 5**.

Table 3: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95 % chance of the impact occurring.
Probable	Estimated 5 to 95 % chance of the impact occurring.
Unlikely	Estimated less than 5 % chance of the impact occurring.

Table 4: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Table 5: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is in all practical terms permanent.
Reversible	The impact is reversible within 2 years after the cause or stress is removed.

APPENDIX 2. BIRD SPECIES RECORDED ON THE INYANDA-ROODEPLAAT WIND ENERGY FACILITY SITE DURING WALKED TRANSECTS

	Total for year			Winter			Spring			Summer			Autumn		
Number of species	64			23			38			42			40		
	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km	# Birds	# Records	# Birds/km
Cape Siskin	94	11	2.73	0	0	0.00	90	7	10.45	2	2	0.23	2	2	0.23
Wailing Cisticola	61	52	1.77	13	11	1.51	12	11	1.39	23	21	2.67	13	9	1.51
Cape Grassbird	55	50	1.60	9	8	1.04	20	20	2.32	14	13	1.63	12	9	1.39
Red-winged Starling	54	12	1.57	0	0	0.00	44	6	5.11	5	4	0.58	5	2	0.58
Sombre Greenbul	47	32	1.36	2	2	0.23	16	10	1.86	17	11	1.97	12	9	1.39
Bokmakierie	30	15	0.87	2	1	0.23	14	7	1.63	10	5	1.16	4	2	0.46
Speckled Mousebird	30	11	0.87	2	1	0.23	0	0	0.00	14	5	1.63	14	5	1.63
Southern Boubou	29	18	0.84	4	2	0.46	15	8	1.74	3	2	0.35	7	6	0.81
Long-billed Pipit	28	16	0.81	1	1	0.12	22	11	2.55	4	3	0.46	1	1	0.12
Orange-breasted Sunbird	26	22	0.75	7	6	0.81	2	2	0.23	9	8	1.04	8	6	0.93
Bar-throated Apalis	22	15	0.64	4	2	0.46	7	4	0.81	6	5	0.70	5	4	0.58
Karoo Scrub-Robin	18	11	0.52	5	3	0.58	5	3	0.58	5	3	0.58	3	2	0.35
Cape Canary	14	8	0.41	1	1	0.12	13	7	1.51	0	0	0.00	0	0	0.00
Cape Turtle-Dove	14	10	0.41	1	1	0.12	8	5	0.93	0	0	0.00	5	4	0.58
Familiar Chat	14	9	0.41	1	1	0.12	5	3	0.58	5	2	0.58	3	3	0.35
Southern Double-collared Sunbird	14	12	0.41	1	1	0.12	4	3	0.46	5	5	0.58	4	3	0.46
Cape Rock-Thrush	10	6	0.29	0	0	0.00	3	2	0.35	6	3	0.70	1	1	0.12
Karoo Prinia	10	8	0.29	0	0	0.00	3	2	0.35	6	5	0.70	1	1	0.12
Cape Bulbul	9	8	0.26	2	1	0.23	0	0	0.00	2	2	0.23	5	5	0.58
Neddicky	9	7	0.26	1	1	0.12	3	2	0.35	1	1	0.12	4	3	0.46
Cape Bunting	8	7	0.23	0	0	0.00	3	2	0.35	0	0	0.00	5	5	0.58
Cape White-eye	8	6	0.23	0	0	0.00	0	0	0.00	3	3	0.35	5	3	0.58

Cape Robin-Chat	7	5	0.20	0	0	0.00	0	0	0.00	2	1	0.23	5	4	0.58
Chestnut-vented Tit-Babbler	7	7	0.20	0	0	0.00	1	1	0.12	4	4	0.46	2	2	0.23
Rock Martin	7	4	0.20	0	0	0.00	2	1	0.23	4	2	0.46	1	1	0.12
Common Fiscal	6	6	0.17	0	0	0.00	0	0	0.00	4	4	0.46	2	2	0.23
Emerald-spotted Wood-Dove	6	5	0.17	1	1	0.12	4	3	0.46	1	1	0.12	0	0	0.00
Grey-backed Cisticola	6	6	0.17	0	0	0.00	0	0	0.00	3	3	0.35	3	3	0.35
Streaky-headed Seedeater	6	3	0.17	0	0	0.00	2	1	0.23	3	1	0.35	1	1	0.12
Egyptian Goose	5	2	0.15	0	0	0.00	1	1	0.12	4	1	0.46	0	0	0.00
Greater Double-collared Sunbird	5	4	0.15	0	0	0.00	1	1	0.12	1	1	0.12	3	2	0.35
African Hoopoe	4	4	0.12	2	2	0.23	2	2	0.23	0	0	0.00	0	0	0.00
Cape Clapper Lark	4	3	0.12	1	1	0.12	0	0	0.00	3	2	0.35	0	0	0.00
Cape Sugarbird	4	3	0.12	0	0	0.00	0	0	0.00	2	1	0.23	2	2	0.23
Cinnamon-breasted Bunting	4	1	0.12	0	0	0.00	0	0	0.00	4	1	0.46	0	0	0.00
Fork-tailed Drongo	4	4	0.12	0	0	0.00	0	0	0.00	2	2	0.23	2	2	0.23
Knysna Woodpecker	3	3	0.09	0	0	0.00	0	0	0.00	1	1	0.12	2	2	0.23
Red-winged Francolin	3	2	0.09	0	0	0.00	0	0	0.00	3	2	0.35	0	0	0.00
Victorin's Warbler	3	3	0.09	0	0	0.00	1	1	0.12	1	1	0.12	1	1	0.12
Acacia Pied Barbet	2	2	0.06	0	0	0.00	0	0	0.00	1	1	0.12	1	1	0.12
Cape Rock-jumper	2	1	0.06	0	0	0.00	2	1	0.23	0	0	0.00	0	0	0.00
Fiscal Flycatcher	2	2	0.06	0	0	0.00	1	1	0.12	1	1	0.12	0	0	0.00
Grey-winged Francolin	2	2	0.06	1	1	0.12	1	1	0.12	0	0	0.00	0	0	0.00
Red-faced Mousebird	2	2	0.06	0	0	0.00	1	1	0.12	1	1	0.12	0	0	0.00
Red-fronted Tinkerbird	2	2	0.06	0	0	0.00	0	0	0.00	0	0	0.00	2	2	0.23
Red-throated Wryneck	2	2	0.06	0	0	0.00	1	1	0.12	1	1	0.12	0	0	0.00
South African Cliff-Swallow	2	1	0.06	0	0	0.00	2	1	0.23	0	0	0.00	0	0	0.00
South African Shelduck	2	1	0.06	0	0	0.00	0	0	0.00	0	0	0.00	2	1	0.23
Southern Tchagra	2	2	0.06	0	0	0.00	0	0	0.00	0	0	0.00	2	2	0.23
White-browed Scrub-Robin	2	2	0.06	0	0	0.00	0	0	0.00	0	0	0.00	2	2	0.23
African Black Duck	1	1	0.03	1	1	0.12	0	0	0.00	0	0	0.00	0	0	0.00

Amethyst Sunbird	1	1	0.03	0	0	0.00	1	1	0.12	0	0	0.00	0	0	0.00
Cape Eagle-Owl	1	1	0.03	0	0	0.00	0	0	0.00	1	1	0.12	0	0	0.00
Cape Sparrow	1	1	0.03	1	1	0.12	0	0	0.00	0	0	0.00	0	0	0.00
Cardinal Woodpecker	1	1	0.03	0	0	0.00	0	0	0.00	0	0	0.00	1	1	0.12
Hottentot Buttonquail	1	1	0.03	0	0	0.00	1	1	0.12	0	0	0.00	0	0	0.00
Lesser Striped Swallow	1	1	0.03	0	0	0.00	1	1	0.12	0	0	0.00	0	0	0.00
Long-billed Crombec	1	1	0.03	0	0	0.00	0	0	0.00	0	0	0.00	1	1	0.12
Malachite Sunbird	1	1	0.03	0	0	0.00	0	0	0.00	0	0	0.00	1	1	0.12
Mocking Cliff-Chat	1	1	0.03	1	1	0.12	0	0	0.00	0	0	0.00	0	0	0.00
Olive Woodpecker	1	1	0.03	0	0	0.00	1	1	0.12	0	0	0.00	0	0	0.00
Red-necked Francolin	1	1	0.03	0	0	0.00	1	1	0.12	0	0	0.00	0	0	0.00
Swee Waxbill	1	1	0.03	0	0	0.00	0	0	0.00	1	1	0.12	0	0	0.00
White-throated Canary	1	1	0.03	0	0	0.00	0	0	0.00	1	1	0.12	0	0	0.00

APPENDIX 3. SEASONAL BIRD SPECIES LISTS FOR THE INYANDA-ROODEPLAAT WIND ENERGY FACILITY SITE

Target species are shown with **bold** and Red List species with **red.** '1' denotes presence, not abundance

	Endemic	Winter	Spring	Summer	Autumn
Acacia Pied Barbet		1	1	1	1
African Black Duck		1	1		
African Harrier-Hawk		**1**	**1**		
African Hoopoe		1	1		
African Paradise Flycatcher			1	1	
African Pipit		1	1		
African Sacred Ibis		1	1		
African Spoonbill		1	1		
African Stonechat		1	1		1
Amethyst Sunbird			1	1	
Anteating Chat	Yes	1	1		
Alpine Swift			1	1	
Banded Martin		1	1		
Barn Swallow				1	
Bar-throated Apalis		1	1	1	1
Black Harrier	**Yes**	**1**	**1**		**1**
Black Stork			**1**	**1**	
Black-collared Barbet		1	1	1	1
Black-headed Heron		1	1		
Black-headed Oriole				1	1
Blacksmith Lapwing				1	
Bokmakierie	Yes	1	1	1	1
Booted Eagle			**1**	**1**	**1**
Brimstone Canary			1		
Bronze Mannikin		1	1		
Brown-hooded Kingfisher		1	1	1	1
Brown-throated Martin		1	1		
Cape Batis		1	1		1
Cape Bulbul	Yes	1	1	1	1
Cape Bunting		1	1		1
Cape Canary		1	1	1	
Cape Clapper Lark	**Yes**	**1**	**1**	**1**	**1**
Cape Crow		1	1	1	1
Cape Eagle-Owl				**1**	
Cape Glossy Starling	Yes	1	1	1	1
Cape Grassbird	Yes	1	1	1	1
Cape Robin-Chat		1	1	1	1
Cape Rock-jumper		1	1	1	1
Cape Rock-Thrush		1	1	1	1
Cape Siskin	Yes	1	1	1	1
Cape Sparrow	Yes	1	1		1
Cape Sugarbird	Yes		1	1	1
Cape Turtle-Dove		1	1	1	1
Cape Wagtail		1	1	1	1
Cape Weaver		1	1		1
Cape White-eye		1	1	1	1
Cardinal Woodpecker		1	1		1
Chestnut-vented Tit-Babbler	Yes	1	1	1	1
Cinnamon-breasted Bunting				1	1
Common Fiscal		1	1	1	1

Common Waxbill		1	1		1
Dark-capped Bulbul				1	1
Egyptian Goose		1	1	1	1
Emerald-spotted Wood-Dove		1	1	1	
Fairy Flycatcher		1	1		
Familiar Chat		1	1	1	1
Fiery-necked Nightjar		1	1		1
Fiscal Flycatcher	Yes	1	1	1	1
Fork-tailed Drongo		1	1	1	1
Golden-breasted Bunting		1	1		
Greater Double-collared Sunbird	Yes	1	1	1	1
Greater-striped Swallow	Yes		1	1	
Green Woodhoopoe		1	1		
Grey Heron		1	1		
Grey Tit			1		1
Grey-backed Cisticola	Yes	1	1	1	1
Grey-winged Francolin	**Yes**	**1**	**1**		
Ground Woodpecker		1	1		
Hadeda Ibis		1	1	1	1
Helmeted Guineafowl		1	1	1	1
Hottentot Buttonquail			1		
Jackal Buzzard	**Yes**	**1**	**1**	**1**	**1**
Karoo Prinia		1	1	1	1
Karoo Scrub-Robin		1	1	1	1
Knysna Turaco	Yes	1	1		
Knysna Woodpecker	Yes		1	1	1
Kurrichane Thrush			1		
Lanner Falcon			**1**		
Larklike Bunting				1	
Laughing Dove		1	1		
Lazy Cisticola				1	
Lesser Honeyguide		1	1		
Lesser Striped Swallow			1		
Long-billed Crombec		1	1		1
Long-billed Pipit		**1**	**1**	**1**	**1**
Malachite Kingfisher			1		
Malachite Sunbird		1	1	1	1
Martial Eagle		**1**	**1**		**1**
Mocking Cliff-Chat		1	1		
Mountain Wheatear					1
Neddicky		1	1	1	1
Olive Woodpecker			1	1	1
Orange-breasted Sunbird	**Yes**	**1**	**1**	**1**	**1**
Pearl-breasted Swallow			1	1	
Peregrine Falcon					**1**
Pied Crow			1	1	1
Pied Starling	Yes	1	1		
Pririt Batis			1		
Red-faced Mousebird		1	1	1	1
Red-fronted Tinkerbird		1	1	1	1
Red-necked Francolin			1		
Red-throated Wryneck		1	1	1	1
Red-winged Francolin				1	1
Red-winged Starling		1	1	1	1
Rock Kestrel		**1**	**1**	**1**	**1**
Rock Martin			1	1	1
Rufous-chested Sparrowhawk		1	1		
Sentinel Rock-Thrush		1	1		
Sombre Greenbul		1	1	1	1

South African Cliff-Swallow	Yes		1		
South African Shelduck	Yes	1	1		1
Southern Black Tit	Yes	1	1		
Southern Boubou	Yes	1	1	1	1
Southern Double-collared Sunbird	Yes	1	1	1	1
Southern Masked Weaver			1		
Southern Pale Chanting Goshawk	**Yes**	**1**	**1**	**1**	**1**
Southern Tchagra		1			1
Speckled Mousebird		1	1	1	1
Speckled Pigeon		1	1	1	1
Spectacled Weaver		1	1		
Spotted Eagle Owl				1	
Steppe Buzzard				**1**	
Streaky-headed Seedeater		1	1	1	1
Swee Waxbill		1	1	1	
Verreaux's Eagle		**1**	**1**	**1**	**1**
Victorin's Warbler			1	1	1
Wailing Cisticola		1	1	1	1
White-browed Scrub-Robin					1
White-necked Raven		1	1	1	1
White-rumped Swift				1	
White-throated Canary		1	1	1	
White-throated Robin-Chat					1
Yellow-billed Duck		1	1		
Yellow-billed Stork			**1**		
Total		93	117	78	78