Environmental Impact Assessment for the proposed Banna Ba Pifhu Wind Energy Project near Humansdorp, Eastern Cape: Draft Environmental Impact Assessment Report

Chapter 6:

Impact on Birds

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CHAPTER 6. IMPACT ON BIRDS

6.1 INTRODUCTION

6.1.1 Approach to the study

The investigation of potential impacts on birds caused by wind farms is a new field of study in South Africa, and has only been the focus of much attention since the middle of 2010. The concept of wind energy suddenly and rapidly gained momentum in South Africa in the latter part of 2010, resulted in a plethora of proposed wind farm applications which caught the ornithological community completely by surprise. The pace of new developments is such that both developers and specialist ornithological consultants struggled (and are still struggling) to come to grips with the enormity of the task ahead, namely to ensure that scientifically robust studies are implemented at all proposed development sites to assess the potential impact on avifauna. The basic approach to this study is to present findings and recommendations based on the knowledge which is currently available in a South African context, while acknowledging that there is still much to learn in this field. As the results of pre-and post-construction monitoring programmes which currently are being implemented become available, those results will be applied to future developments in order to predict with increasing confidence what the likely impact of a particular wind farm development will be on avifauna. At present it has to be acknowledged that there is much to be learnt and this situation is likely to continue for some time. In circumstances where there is uncertainty and the precautionary principle may be relevant, evidence, expert opinion, best practice guidance and professional judgement was applied to evaluate what is ornithologically likely to occur if the development is authorised.

The report focuses on the potential site-specific, negative impacts of the development on birds. The benefits to birds at the development site stemming from the contribution made by the wind farm towards countering climate change through renewable energy generation cannot yet be quantified at a local scale. Nevertheless it is clear that a large wind farm will potentially make a beneficial contribution to reducing CO_2 emissions. Climate change is widely perceived to be the single most important long-term threat to the global environment, particularly to birds. Thus, the continued rise in mean global temperatures could ultimately affect the size, distribution, survival and breeding productivity of many bird species (Huntley *et al.* 2007). Therefore, these clearly important beneficial effects have been recognized but are not considered further within this study.

This report presents results of the pre-construction monitoring programme that commenced in March 2011 and is ongoing. The results of this programme will inform the final lay-out of the turbines.

6.1.2 Terms of Reference

The **scope** of the avifaunal assessment report comprises the assessment of the avifaunal impacts associated with the construction and operation of the proposed plant and the provision of appropriate mitigation measures to reduce such potential impacts.

This report is therefore centred on the following specific **terms of reference**:

- Description of the receiving environment (habitat) from an avifaunal perspective;
- Identification of priority avifauna that might be impacted by the proposed facility;
- Identification of potential impacts on priority avifauna;
- The assessment of the potential impacts; and
- The provision of the mitigation measures to reduce the impacts.

The assessment methodology applied in this chapter is fully described in Chapter 4 of the EIR and is therefore not repeated here.

6.1.3 Information sources

The **primary source** of information on bird occurrence, densities, flight patterns and habitat at the development site is a monitoring programme that commenced in March 2011. The objective of the pre-construction programme is to gather baseline data on bird usage of the site. Up to the present, data have been gathered in the following sampling periods:

- Summer: 8-12 March 2011;
- Winter: 28 June, 1-2 July 2011;
- Early spring: 24-27 September 2011; and
- Late spring: 17-20 November 2011

The specific objectives of the monitoring programme are to record the following:

- The abundance and diversity of birds at the turbine site; and
- Flight patterns of priority species at the turbine site.

Monitoring at the turbine site is conducted in the following manner:

- A transect was identified totalling 15 km which covers the majority of the proposed turbine area (see Figure 6.1). This is referred to in the report as the “survey area”, and comprises a 1 km buffer on both sides of the transect.
- Two observers travelling slowly (± 10km/h) in a vehicle record all priority species on both sides of the transect. The observers stop at regular intervals (every 500 m) to scan the environment with binoculars. The transect is counted four times per sampling session (see also 6.1.4 Assumptions and limitations).
- In addition, point counts are conducted every 500 m, where all non-priority species are recorded for a 5 minute period.
- The following variables are recorded:
    - Species;

- Number of birds;
- Date;
- Start time and end time;
- Distance from transect or point (0-50 m, 50-100 m, >100 m);
- Wind direction;
- Wind strength (calm; moderate; strong);
- Weather (sunny; cloudy; partly cloudy; rain; mist);
- Temperature (cold; mild; warm; hot);
- Behaviour (flushed; flying-display; perched; perched-calling; perched-hunting; flying-foraging; flying-commute; foraging on the ground); and
- Co-ordinates (priority species only).

- Two vantage points (VPs) were selected from which the majority of the proposed turbine area can be observed (the “VP area”), to record the flight altitude and patterns of priority species. A total of 18 hours of observations per vantage point per season was conducted. The following variables were recorded:
  - Species;
  - Number of birds;
  - Date;
  - Start time and end time;
  - Wind direction;
  - Wind strength (calm; light; moderate; strong);
  - Weather (sunny; cloudy; partly cloudy; rain; mist);
  - Temperature (cold; mild; warm; hot);
  - Flight altitude (high i.e >150 m; medium i.e. 50-150 m; low i.e. <50 m);
  - Flight mode (soar; flap; glide ; kite; hover); and
  - Flight duration (in 15 second-intervals).

For transect monitoring and data analysis purposes, priority species were identified using the BLSA list of priority species for wind farms (Retief 2011a). The list was updated in September 2011 (Retief 2011b) which added a few additional species, and modified the ranking of the species. In January 2012, a new list was released as part of the Avian Wind Farm Sensitivity Map (Retief *et al.* 2012). This list was used for the analyses in this report.

The following information sources were also consulted for this report, as **background information**:

- Bird distribution data of the Southern African Bird Atlas Project (SABAP1 – Harrison *et al.,* 1997) obtained from the Animal Demography Unit of the University of Cape Town, as a means to ascertain which species occur within the study area. A data set was obtained for the QDGCs (quarter degree grid cells) within which the development will take place, namely 3424BA and 3424BB. A QDGC corresponds to the area shown on a 1:50 000 map (15' x 15') and is approximately 27 km long (north-south) and 23 km wide (east-west).
- The SABAP1 data were supplemented with SABAP2 data for the relevant QDGCs. These data are much more recent, as SABAP2 was only launched in May 2007, and should therefore be more representative. For SABAP1, QDGCs were the geographical sampling units. For SABAP2 the sampling unit has been reduced in size to pentad grid cells (or pentads); these cover 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is

approximately 8 × 7.6 km. This finer scale has been selected for SABAP2 to obtain more detailed information on the occurrence of species and to give a clearer and better understanding of bird distributions. There are nine pentads in a QDGC.

- Additional information on large terrestrial avifauna and habitat use was obtained from the Coordinated Avifaunal Roadcounts (CAR) project of the Animal Demography Unit (ADU) of the University of Cape Town (Young 2003; 2008; 2009a; 2009b; 2010a; 2010b).
- The conservation status of all bird species occurring in the aforementioned QDGCs was determined with the use of the *Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland* (Barnes 2000) and the most recent and comprehensive summary of southern African bird biology “Roberts VII”(Hockey *et al.* 2005).
- A classification of the vegetation types in the QDGC from an avifaunal perspective was obtained from SABAP1.
- Detailed satellite imagery from Google Earth was used in order to view the study area on a landscape level and to help identify bird habitat on the ground.
- Information on the micro habitat level was obtained before the monitoring commenced through several site visits in the course of 2010 and 2011. An attempt was made to investigate the total study area as far as was practically possible, and to visit potentially sensitive areas identified from the Google Earth imagery.
- Supplementary data on avifaunal diversity was obtained from the St Francis Bay Bird Club (Langlands 2012a; Langlands & Craig 2012b).

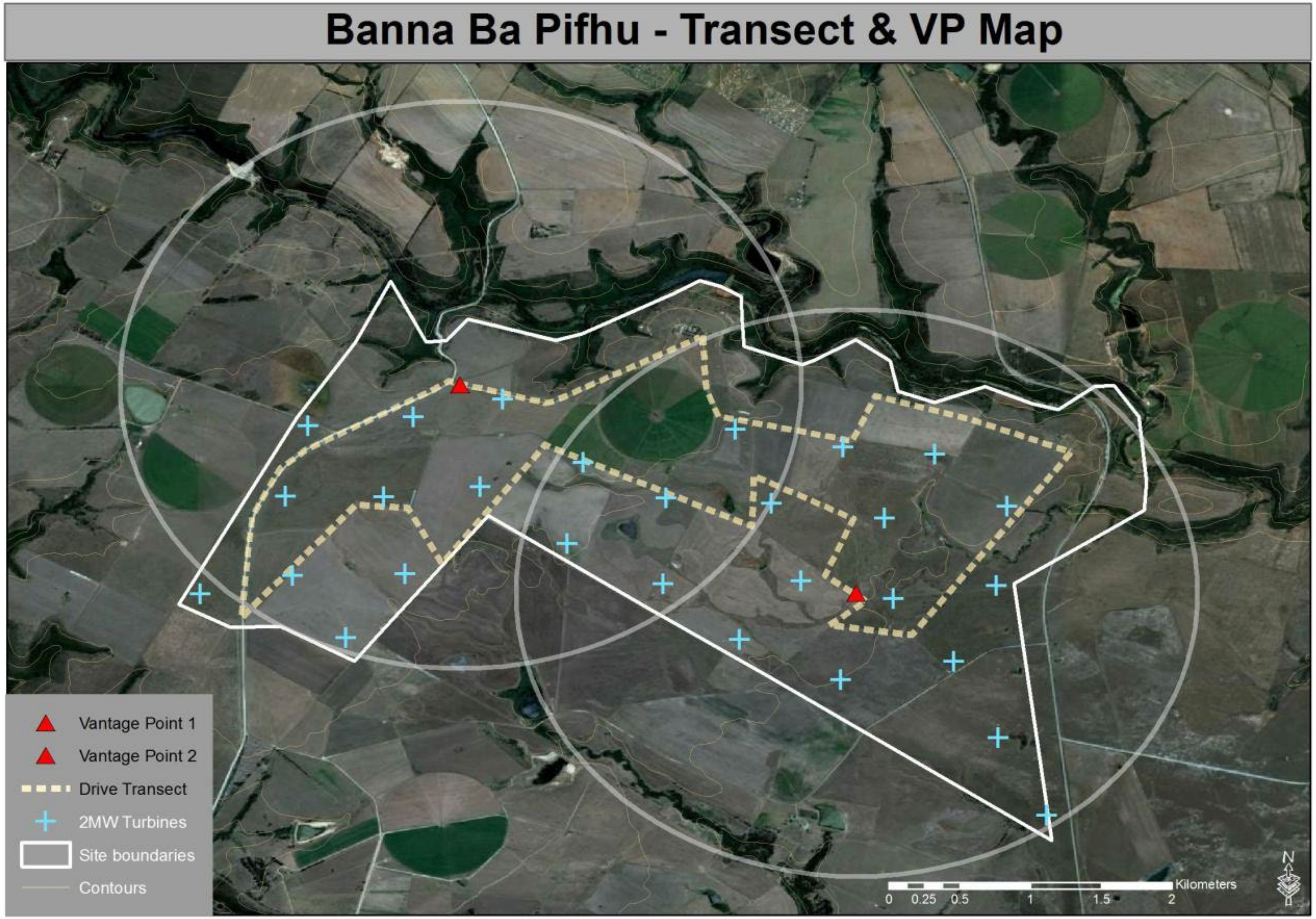

Figure 6.1: The 15 km transect and vantage points that are used to record birds in the study area, overlaid on the proposed turbine locations lay-out.

6.1.4 Assumptions and limitations

The basic assumption made in this study is that the sources of information used are reliable. However, it must be noted that there are certain limitations:

- Since the avifaunal impact studies commenced on this site in 2010, a number of important developments have taken place. The most important development from an avifaunal impact perspective is the publication of *"Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa"* (Jenkins *et al.* 2011) by the Endangered Wildlife Trust (EWT) and BirdLife South Africa (BLSA). Version 1 of this document was placed in the public domain on 31 March 2011, and was slightly amended in August 2011. This document is attached as Appendix 6.1. The guidelines propose a much expanded survey for wind farm developments, including a pre-construction period that should cover a minimum of 12 months and should include all major periods of bird usage in that period, as well as a compulsory post-construction component. The monitoring protocol used in this study was designed and commenced with before the existence of any South African best practice guidelines, and originally (Nov 2010) with the available knowledge at the time and after consulting other avifaunal specialists, two sampling periods were planned. After the guidelines were released, additional sampling periods were added.
- It is inevitable that observations at vantage points will be biased towards those species that are more visible (i.e. larger species), and flights that are closer to the observer. It must therefore be accepted that the chances of a bird being missed increases with the distance from the observer. This means that information on flight paths gathered during vantage point watches must be interpreted with caution.
- The analyses of the data in this report should be viewed as descriptive and preliminary. The final report will include an in depth statistical analyses of the final dataset.
- Originally, it was planned to complete a full sampling cycle in mid-winter (July). This was commenced with, but unfortunately, vehicle access to the site became impossible during the winter due to ongoing heavy rains, which resulted in the survey track becoming undrivable (even with a quad bike). The site only became accessible again in early spring, when the monitoring was resumed. This is not regarded as a major problem from an avifaunal perspective, as the conditions in early spring were not significantly different to those in winter, especially as far as temporary wetland areas were concerned – these areas were still waterlogged when early spring monitoring were carried out.
- With certain classes of birds, particularly cranes and bustards, very little research has been conducted on potential impacts with wind facilities worldwide. The precautionary principle was therefore applied throughout. The World Charter for Nature, which was adopted by the UN General Assembly in 1982, was the first international endorsement of the precautionary principle. The principle was implemented in an international treaty as early as the 1987 Montreal Protocol and, among other international treaties and declarations, is reflected in the 1992 Rio Declaration on Environment and Development. Principle 15 of the 1992 Rio Declaration states that: "in order to protect the environment, the precautionary approach

shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage**, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation."**

- No comprehensive studies, and published, peer-reviewed scientific papers, are available on the impacts wind farms have on birds in South Africa. It is therefore inevitable that, because of the lack of any research on this topic in South Africa, strong reliance had to be placed on professional opinion.

6.2 DESCRIPTION OF AFFECTED ENVIRONMENT

The natural vegetation in the survey area consists of Humansdorp Shale Renosterveld and Gamtoos Thicket (Mucina & Rutherford 2006). Vegetation structure is more critical in determining bird habitat than actual plant composition (Harrison *et.al.* 1997). Therefore, the description of the habitat presented in this study concentrates on factors relevant to birds, and does not give an exhaustive list of plant species which occur in the study area (please consult the Ecological Specialist Report for a detailed discussion of vegetation types).

The proposed development site is situated within the Fynbos biome (Harrison *et.al*. 1997). The Fynbos biome is characterized by a high diversity of plant species and a high level of endemism. This diversity is not paralleled in its avifaunal composition, and fynbos is regarded as relatively poor in avifaunal diversity compared with other southern African biomes. However, whilst some of the distribution and abundance of the bird species in the study area is related to the occurrence of natural fynbos, it is more important to examine the micro-habitats available to birds, most of which are the result of human-induced transformation. These are generally evident at a much smaller spatial scale than the natural vegetation communities.

The following bird habitat classes were defined within the survey area (see Figure 6.2 and Appendix 6.2):

- Agriculture: The majority of the sites consist of agricultural land, and mostly comprises of pastures (cattle), both irrigated and dry-land, structurally resembling short grassland;
- Thicket: Very dense, in places impenetrable, shrub present in steep valleys along drainage lines. Small trees are also present;
- Wetlands: Includes both man-made dams and natural seasonal wetlands which, when dry, consist of short grassland virtually indistinguishable from the surrounding pastures. In the rainy season, depending on the amount of rainfall, some of the wetlands contain standing water for weeks up to several months ; and
- Scrub: A mixture of grassland and scattered shrubs.

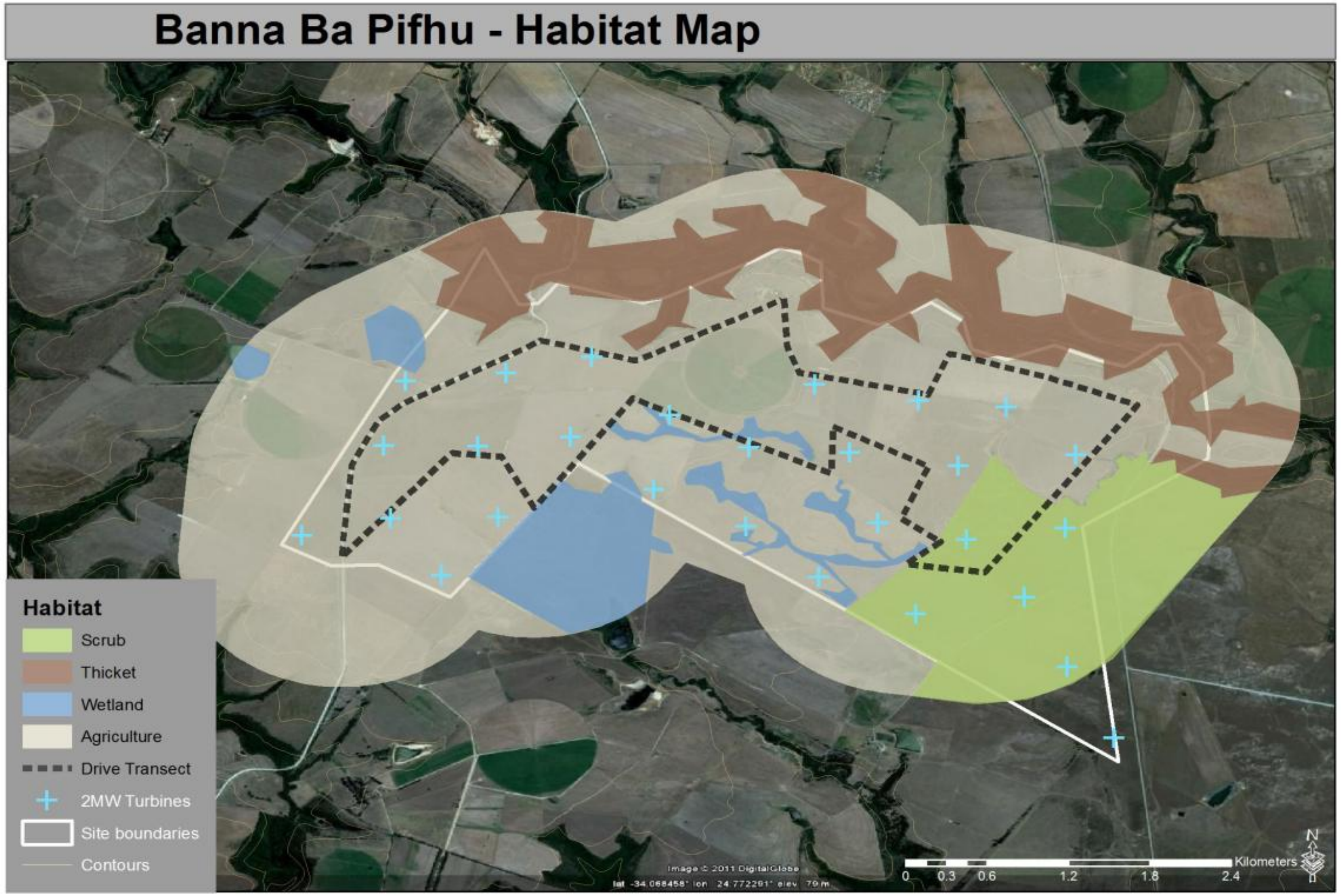

Figure 6.2: The bird habitat classes in the survey area, together with proposed turbine lay-out.

Within the survey area approximately 7% of the bird habitat is classified as wetland, 15% as thicket, 13% as scrub and 65% as agriculture. These are estimates and may change depending on the rainfall pattern in any given year, but for purposes of the analyses, these ratios were assumed to be an accurate estimate to work with.

The priority bird species (Retief *et al.* 2012) that have been recorded on the site are displayed in Figure 6.3 below.

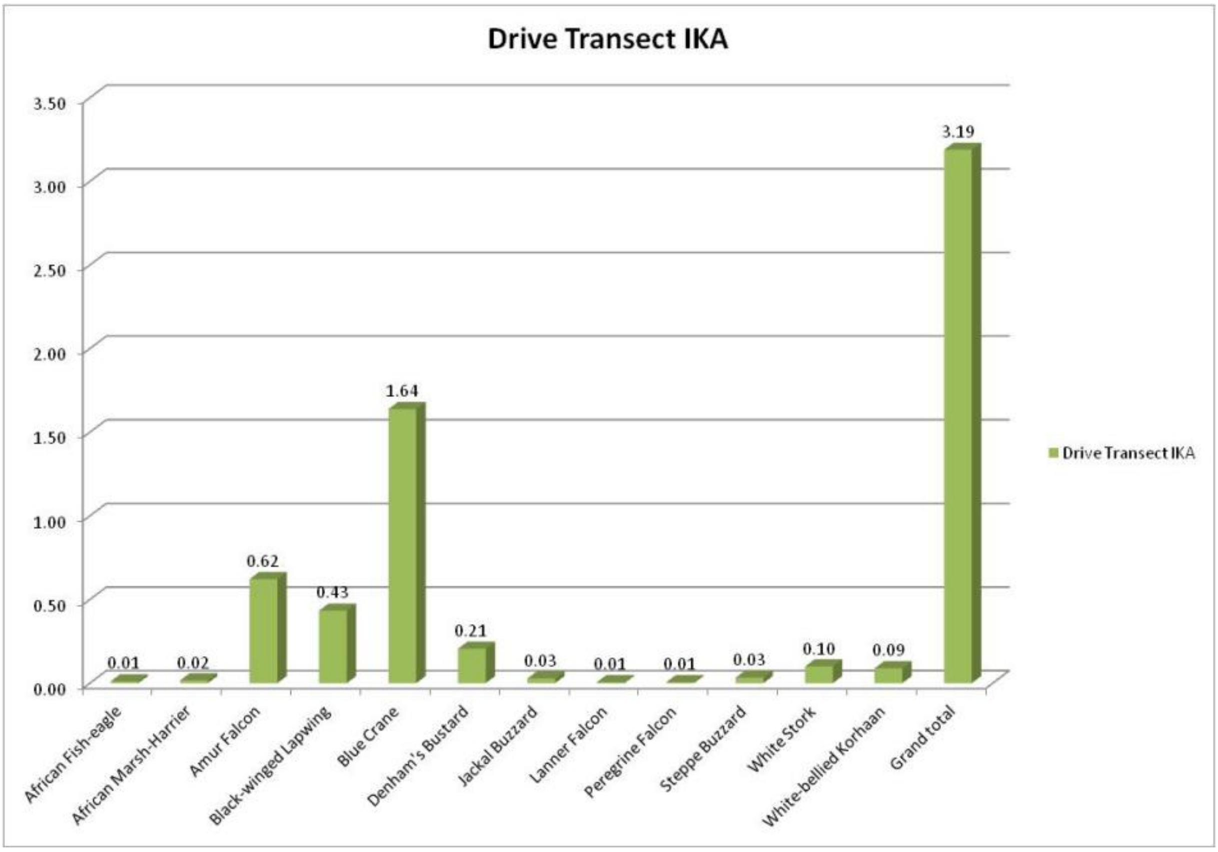

Figure 6.3: Index of kilometric abundance (IKA) for priority bird species recorded during transect surveys (summer, early spring and late spring)

6.3 IDENTIFICATION OF ISSUES AND IMPACTS

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

- Mortality due to collision with the wind turbines;

- Displacement due to disturbance;
- Habitat loss due to the footprint of the wind farm; and
- Mortalities due to collision with associated power line infrastructure.

6.3.1 Mortalities from collisions with wind turbines

Internationally, it is widely accepted that bird mortalities from collisions with wind turbines contribute a relatively small proportion of the total mortality from all causes. The US National Wind Coordinating Committee (NWCC) conducted a comparison of wind farm bird mortality with that caused by other man-made structures in the USA (Anon. (b) 2000). The NWCC did not conduct its own study, but analysed all of the research done to date on various causes of avian mortality, including commercial wind farm turbines. It reports that "data collected outside California indicate an average of 1.83 avian fatalities per turbine (for all species combined), and 0.006 raptor fatalities per turbine per year. Based on current projections of 3,500 operational wind turbines in the US by the end of 2001, excluding California, the total annual mortality was estimated at approximately 6,400 bird fatalities per year for all species combined". The NWCC report states that its intent is to "put avian mortality associated with windpower development into perspective with other significant sources of avian collision mortality across the United States". It further reports that: "Based on current estimates, windplant related avian collision fatalities probably represent from 0.01% to 0.02% (i.e. 1 out of every 5,000 to 10,000) of the annual avian collision fatalities in the United States". That is, commercial wind turbines cause the direct deaths of only 0.01% to 0.02% of all of the birds killed by collisions with man-made structures and activities in the USA.

Also in the USA, a Western EcoSystems Technology Inc. study found a range of between 100 million to 1 billion bird fatalities due to collisions with artificial structures such as vehicles, buildings and windows, power lines and communication towers, in comparison to 33,000 fatalities attributed to wind turbines. The study (see Anon. (a) 2003) reports that “windplant-related avian collision fatalities probably represent from 0.01% to 0.02% (i.e. one out of every 5,000 to 10,000 avian fatalities) of the annual avian collision fatalities in the United States, while some may perceive this level of mortality as small, all efforts to reduce avian mortality are important”. A Finnish study reported 10 bird fatalities from turbines, and 820,000 birds killed annually from colliding with other structures such as buildings, electricity pylons and lines, telephone and television masts, lighthouses and floodlights (Anon (a) 2003). Many of the studies of buildings, communication towers, and powerlines were conducted in response to known or perceived problems with avian collisions, and therefore may not be representative of all structures in the United States. As a consequence, using averages of these estimates to project total avian fatalities in the U.S. would be biased high. The estimates provided for the sources of avian mortality listed above, except wind generation facilities, are based on subjective models and are very speculative.

The majority of studies on collisions caused by wind turbines have recorded relatively low mortality levels (Madders & Whitfield 2006). This is perhaps largely a reflection of the fact that many of the studied wind farms are located away from large concentrations of birds. It is also important to note that many records are based only on finding corpses, with no correction for corpses that are overlooked or removed by scavengers (Drewitt & Langston, 2006). Relatively high collision mortality rates have been recorded at several large, poorly-sited wind farms in areas where large concentrations of birds are present (including Important Bird Areas (IBAs)), especially among migrating birds, large raptors or other large soaring species, e.g. in the

Altamont Pass in California, USA (Thelander & Smallwood 2007), and in Tarifa and Navarra in Spain (Barrios & Rodrigues 2004). In these cases actual deaths resulting from collision are high, notably of Golden Eagle *Aquila chrysaetos* and Eurasian Griffon *Gyps fulvus*, respectively.

In a study in Spain, it was found that the distribution of collisions with wind turbines was clearly associated with the frequencies at which soaring birds flew close to rotating blades (Barrios & Rodriguez 2004). Patterns of risky flights and mortality included a temporal component (deaths concentrated in some seasons), a spatial component (deaths aggregated in space), a taxonomic component (a few species suffered most losses), and a migration component (resident populations were more vulnerable). Clearly, the risk is likely to be greater on or near areas regularly used by large numbers of feeding or roosting birds, or on migratory flyways or local flight paths, especially where these are intercepted by the turbines. Risk also changes with weather conditions, with evidence from some studies showing that more birds collide with structures when visibility is poor due to fog or rain, although this effect may to some extent be offset by lower levels of flight activity in such conditions (Madders & Whitfield 2005). Strong headwinds also affect collision rates and migrating birds in particular tend to fly lower when flying into the wind (Drewitt & Langston 2006). The same applies for Blue Cranes flying between roosting and foraging areas (pers. obs.).

Accepting that many wind farms may only cause low levels of mortality, even these levels of additional mortality may be significant for long-lived species with low productivity and slow maturation rates, especially when rarer species of conservation concern are affected (e.g. Denham's Bustard, Blue Crane and African Marsh-Harrier). In such cases there could be significant effects at the population level (locally, regionally or, in the case of rare and restricted species, nationally), particularly in situations where cumulative mortality takes place as a result of multiple installations (Carette *et. al.* 2009).

Large birds with poor manoeuvrability (such as cranes, korhaans, bustards and Secretarybirds) are generally at greater risk of collision with structures (Jenkins *et al.* 2010), and species that habitually fly at dawn and dusk or at night are perhaps less likely to detect and avoid turbines (e.g. cranes arriving at a roost site after sunset, or flamingos flying at night). Collision risk may also vary for a particular species, depending on age, behaviour and stage of annual cycle (Drewitt & Langston 2006). While the flight characteristics of cranes, flamingos and bustards make them obvious candidates for collisions with power lines (Jenkins *et al.* 2010), it is noted that these classes of birds (unlike raptors) do not feature prominently in literature as wind turbine collision victims. It may be that they avoid wind farms entirely, resulting in lower collision risks. However, this can only be verified through on-site post-construction monitoring.

The precise location of a wind farm site can be critical. Soaring species may use particular topographic features for lift (Barrios & Rodriguez 2004; De Lucas *et al.* 2008) or such features can result in large numbers of birds being funnelled through an area of turbines (Drewitt & Langston 2006). For example, absence of thermals on cold, overcast days may force larger, soaring species (e.g. Martial Eagle and Secretarybird) to use slopes for lift, which may increase their exposure to turbines. Gentle slopes may also pose a bigger risk than steep slopes for large soaring species, as updrafts from gentle slopes are weaker than those from steeper slopes, so turbines situated on the tops of gentle slopes should pose a bigger risk to these birds than those situated atop steep slopes (De Lucas *et al.* 2008) Birds also lower their flight height in some locations, for example when following the coastline or crossing a ridge (Smallwood pers.comm;

Smallwood is the head of the Scientific Review Committee of Altamont Pass Wind Resource Area and is based in California), which might place them at greater risk of collision with rotors.

The size and alignment of turbines and rotor speed are likely to influence collision risk; however, physical structure is probably only significant in combination with other factors, especially wind speed, with moderate winds resulting in the highest risk (Barrios & Rodriguez 2004; Stewart *et. al.* 2007) as there is less lift for birds to clear the turbines. Lattice towers are generally regarded as more dangerous than tubular towers because many raptors use them for perching and occasionally for nesting; however Barrios & Rodriguez (2004) found tower structure to have no effect on mortality, and that mortality may be directly related to abundance for certain species (e.g. Common Kestrel *Falco tinnunculus*). De Lucas *et. al.* (2008) found that turbine height and higher elevations may heighten the risk (taller/higher = higher risk), but that abundance was not directly related to collision risk, at least for Eurasian Griffon Vulture *Gyps fulvus*.

A review of the available literature indicates that, where collisions have been recorded, the rates per turbine are highly variable with averages ranging from 0.01 to 23 bird collisions annually (the highest figure is the value, following correction for scavenger removal, for a coastal site in Belgium and relates to gulls, terns and ducks among other species) (Drewitt & Langston 2006). Although providing a helpful and standardised indication of collision rates, average rates per turbine must be viewed with some caution as they are often cited without variance and can mask significantly higher (or lower) rates for individual turbines or groups of turbines (Everaert *et. al.* 2001 as cited by Drewitt & Langston 2006).

Some of the highest mortality levels have been for raptors in the Altamont Pass in California (Howell & DiDonato 1991, Orloff & Flannery 1992 as cited by Drewitt & Langston 2006) and at Tarifa and Navarre in Spain (Barrios & Rodriguez unpublished data as cited by Drewitt & Langston 2006). These cases are of particular concern because they affect relatively rare and long-lived species such as Griffon Vulture *Gyps fulvus* and Golden Eagle *Aquila chrysaetos* that have low reproductive rates and are vulnerable to additive mortality. Golden Eagles congregate in Altamont Pass to feed on super-abundant prey which supports very high densities of breeding birds. In the Spanish cases, extensive wind farms were built in topographical bottlenecks where large numbers of migrating and local birds fly through a relatively confined area due to the nature of the surrounding landscape, for example through mountain passes, or use rising winds to gain lift over ridges (Barrios & Rodriguez 2004). Although the average numbers of annual fatalities per turbine (ranging from 0.02 to 0.15 collisions/turbine) were generally low in the Altamont Pass and at Tarifa, overall collision rates were high because of the large numbers of turbines involved (over 7 000 in the case of Altamont). At Navarre, corrected annual estimates ranging from 3.6 to 64.3 mortalities/turbine were obtained for birds and bats (unpublished data). Thus, a minimum of 75 Golden Eagles are killed annually in Altamont and over 400 Griffon Vultures are estimated (following the application of correction factors) to have collided with turbines at Navarre. Work on Golden Eagles in the Altamont Pass indicated that the population was declining in this area thought to be due, at least in part, to collision mortality (Hunt *et. al.* 1999, Hunt 2001 as cited by Drewitt & Langston 2006).

The effects of night-time illumination in increasing the risk of collisions with the turbines has not been adequately tested, and the results of studies are contradictory (Johnson *et al.* 2007). Studies involving lighted objects or towers indicate that lights may attract birds, rather than disorient or repel them, resulting in collision mortality (Cochran & Graber 1958; Herbert 1970; Weir 1976; Crockford 1992; APLIC 1994; Johnson *et al* 2007). This is mostly a problem for nocturnal migrants (primarily passerines) during poor visibility conditions. Different colour lights vary in their attractiveness to birds and their effect on orientation. Several studies have shown that intermittent lights have less of an effect on birds than constant lights, with reduced rates of mortality (Weir 1976; Jaroslow 1979; EPRI 1985; APLIC 1994). In addition, some studies suggest that replacing white lights with red lights may reduce mortality by up to 80%. This may be due to the change in light intensity rather than the change in wavelength (Weir 1976). However, Ugoretz (2001) suggest that birds are more sensitive to red lights and may be attracted to them. Quickly flashing white strobe lights appear to be less attractive. The issue is however far from settled - a study at Buffalo Ridge, Minnesota, where most of the collision fatalities were classified as nocturnal migrants, found little difference between lighted and unlighted turbines (Johnson *et al.* 2000).The consensus among researchers is to avoid lighting the turbines if possible, but that is against civil aviation regulations (Civil Aviation Regulations 1997). Lighting may also indirectly contribute to avian collision risks in that it may attract insects which in turn attract nocturnal bird activity.

6.3.2 Displacement due to disturbance

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

Unfortunately, few studies of displacement due to disturbance are conclusive, often because of the lack of before-and-after and control-impact (BACI) assessments. Onshore, disturbance distances (in other words the distance from wind farms up to which birds are absent or less abundant than expected) up to 800 m (including zero) have been recorded for wintering waterfowl (Pedersen & Poulsen 1991 as cited by Drewitt & Langston 2006), though 600 m is widely accepted as the maximum reliably recorded distance (Drewitt & Langston 2006). The variability of displacement distances is illustrated by one study which found lower post-construction densities of feeding European White-fronted Geese *Anser albifrons* within 600 m of the turbines at a wind farm in Rheiderland, Germany (Kruckenberg & Jaene 1999 as cited by Drewitt & Langston 2006), while another showed displacement of Pink-footed Geese *Anser brachyrhynchus* up to only 100–200 m from turbines at a wind farm in Denmark (Larsen & Madsen 2000 as cited by Drewitt & Langston 2006). Indications are that Great Bustard *Otis tarda* (a species related to the Ludwig's Bustard) are displaced by wind farms within one kilometre of the facility (Langgemach 2008).

Studies of breeding birds are also largely inconclusive or suggest lower disturbance distances, though this apparent lack of effect may be due to the high site fidelity and long life-span of the breeding species studied. This might mean that the true impacts of disturbance on breeding birds will only be evident in the longer term, when new recruits replace existing breeding birds. Few studies have considered the possibility of displacement for short-lived passerines (such as larks), although Leddy *et al.* (1999) found increased densities of breeding grassland passerines with increased distance from wind turbines, and higher densities in the reference area than within 80 m of the turbines, indicating that displacement did occur at least in this case. The consequences of displacement for breeding productivity and survival are crucial to whether or not there is likely to be a significant impact on population size. A recent comparative study of nine wind farms in Scotland (Pearce-Higgens *et al.* 2009) found unequivocal evidence of displacement: Seven of the 12 species studied exhibited significantly lower frequencies of occurrence close to the turbines, after accounting for habitat variation, with equivocal evidence of turbine avoidance in a further two. No species were more likely to occur close to the turbines. Levels of turbine avoidance suggest breeding bird densities may be reduced within a 500-m buffer of the turbines by 15–53%, with Common Buzzard *Buteo buteo*, Hen Harrier *Circus cyaneus*, Golden Plover *Pluvialis apricaria*, Snipe *Gallinago gallinago*, Curlew *Numenius arquata* and Wheatear *Oenanthe oenanthe* most affected.

Studies show that the scale of disturbance caused by wind farms varies greatly. This variation is likely to depend on a wide range of factors including seasonal and diurnal patterns of use by birds, location with respect to important habitats, availability of alternative habitats and perhaps also turbine and wind farm specifications. Behavioural responses vary not only between different species, but between individuals of the same species, depending on such factors as stage of life cycle (wintering, moulting, breeding), flock size and degree of habituation. The possibility that wintering birds in particular might habituate to the presence of turbines has been raised (Langston & Pullin 2003), though it is acknowledged that there is little evidence and few studies of long enough duration to show this, and at least one study has found that habituation may not happen (Altamont Pass Avian Monitoring Team 2008). A systematic review of the effects of wind turbines on bird abundance has shown that increasing time since operations commenced resulted in greater declines in bird abundance (Stewart *et al*. 2004 as cited by Drewitt & Langston 2006). This evidence that impacts are likely to persist or worsen with time suggests that habituation is unlikely, at least in some cases (Drewitt & Langston 2006, Altamont Pass Avian Monitoring Team 2008).

The effect of birds altering their migration flyways or local flight paths to avoid a wind farm is also a form of displacement. This effect is of concern because of the possibility of increased energy expenditure when birds have to fly further, as a result of avoiding a large array of turbines, and the potential disruption of linkages between distant feeding, roosting, moulting and breeding areas otherwise unaffected by the wind farm. The effect depends on species, type of bird movement, flight height, distance to turbines, the layout and operational status of turbines, time of day and wind force and direction, and can be highly variable, ranging from a slight 'check' in flight direction, height or speed, through to significant diversions which may reduce the numbers of birds using areas beyond the wind farm (Drewitt & Langston 2006).

A review of the literature suggests that none of the barrier effects identified so far have significant impacts on populations (Drewitt & Langston 2006). However, there are circumstances where the barrier effect might lead indirectly to population level impacts; for example where a wind farm effectively blocks a regularly used flight line between nesting and foraging areas, or where several wind farms interact cumulatively to create an extensive barrier which could lead to diversions of many tens of kilometres, thereby incurring increased energy costs.

6.3.3 Habitat change and loss

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

6.3.4 Collision mortality with associate power lines

Because of their size and prominence, components of electrical infrastructure constitute an important interface between wildlife and man. Negative interactions between wildlife and electricity structures take many forms, but two common problems in southern Africa are electrocution of birds (and other animals) and birds colliding with power lines (Ledger & Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs & Ledger 1986a; Hobbs & Ledger 1986b; Ledger *et.al.* 1992; Kruger & Van Rooyen 1998; Van Rooyen 1998; Kruger 1999; Van Rooyen 1999; Van Rooyen 2000). Electrocutions are not envisaged to be a problem on the proposed electricity line. Collisions, on the other hand, could be a major potential problem.

Collisions probably kill far more birds annually in southern Africa than electrocutions (Van Rooyen 2007). 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 (Jenkins *et al.* 2010; van Rooyen 2004, Anderson 2001). Unfortunately, many of the collision sensitive species are considered threatened in southern Africa - of the 2369 avian mortalities on distribution lines recorded by the Endangered Wildlife Trust since August 1996, 1512 (63.8%) were Red Data species (Van Rooyen 2007).

In the Overberg region of the Western Cape power line collisions have long been recorded as a major source of avian mortality (Van Rooyen 2007). Most numerous amongst power line collision victims are Blue Crane and Denham's Bustard (Shaw 2009). It has been estimated that as many as 10% of the Blue Crane population in the Overberg are killed annually on power lines, and figure for Denham's Bustard might be as high as 30% of the Overberg population (Shaw 2009). These figures are extremely concerning, as it represents a possible unsustainable source of unnatural mortality.

6.4 PERMIT REQUIREMENTS

No specific legal requirements are applicable that pertain to avifauna.

From an international perspective, the Convention on Biological Diversity (CBD), is applicable. The overall objective of the CBD is the "…conservation of biological diversity, [and] the sustainable use of its components and the fair and equitable sharing of the benefits …".

The Convention on the Conservation of Migratory Species of Wild Animals (http://www.unep-aewa.org) is also applicable. This Convention, commonly referred to as the Bonn Convention, (after the German city where it was concluded in 1979), came into force in 1983. This Convention's goal is to provide conservation for migratory terrestrial, marine and avian species throughout their entire range. This is very important, because failure to conserve these species at any particular stage of their life cycle could adversely affect any conservation efforts elsewhere. The fundamental principle of the Bonn Convention, therefore, is that the Parties to the Bonn Convention acknowledge the importance of migratory species being conserved and of Range States agreeing to take action to this end whenever possible and appropriate, paying special attention to those migratory species whose conservation status is unfavourable, and individually, or in co-operation taking appropriate and necessary steps to conserve such species and their habitat. Parties acknowledge the need to take action to avoid any migratory species becoming endangered.

The most important guidance document from an avifaunal impact perspective that is currently applicable to wind energy development is the *"Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa"* (Jenkins *et al* 2011). This document was published by the Endangered Wildlife Trust (EWT) and Birdlife South Africa (BLSA) on 31 March 2011 and is attached as Appendix 6.1. This protocol prescribes a pre-construction period that stretches over a minimum of 12 months and includes all major periods of bird usage in that period, as well as a post-construction component. This document is not legally binding on developers, but has the full support of the South African Wind Energy Association (SAWEA).

6.5 ASSESSMENT OF IMPACTS AND IDENTIFICATION OF MANAGEMENT ACTIONS

6.5.1 Mortalities from collisions with wind turbines

A total of 108 hours of vantage point watches (summer = 36 hours, winter = 18 hours, early spring = 18 hours, late spring = 36 hours) has been completed to date in order to record flight patterns and altitudes of priority species. For purposes of this report, the combined area taken up by the two vantage points is termed "the VP area" (see Figure 6.1).

In the three sampling periods, priority species were recorded flying over the VP area for a total of 7 hours 4 minutes and 45 seconds. A total of 744 individual birds were recorded. Of these, 347 birds flew at low altitude (below rotor height), 277 flew at medium altitude (i.e. approximately within rotor height) and 120 flew at high altitude (above rotor height). The passage rate for recorded flights of priority species over the VP area (all heights) was 6.88 birds/hour. For medium altitude flights only, the passage rate was 2.56 birds/hour.

Figures 6.4 – 6.6 below provide a breakdown of the species and flight heights recorded during the three sampling periods, in various wind conditions. In addition to species specific analyses, it was decided to group species with similar flight characteristics in the following manner (see Figures 6.7 – 6.9):

- *Medium to large terrestrial species*: Medium to large birds that spend most of the time foraging on the ground. They are generally reluctant to fly and generally fly short distances at low to medium altitude, usually powered flight. Some species undertake longer distance flights at higher altitudes, when commuting between foraging and roosting areas. At the wind farm site, cranes, bustards, lapwings and korhaans are included in this category.
- *Soaring species*: Species that spend a significant time on the wing in a variety of flight modes including soaring, kiting, hovering and gliding at medium to high altitudes. At the wind farm site, these are mostly raptors and storks, but medium and high gliding and soaring flights of Blue Cranes are also included in this category.

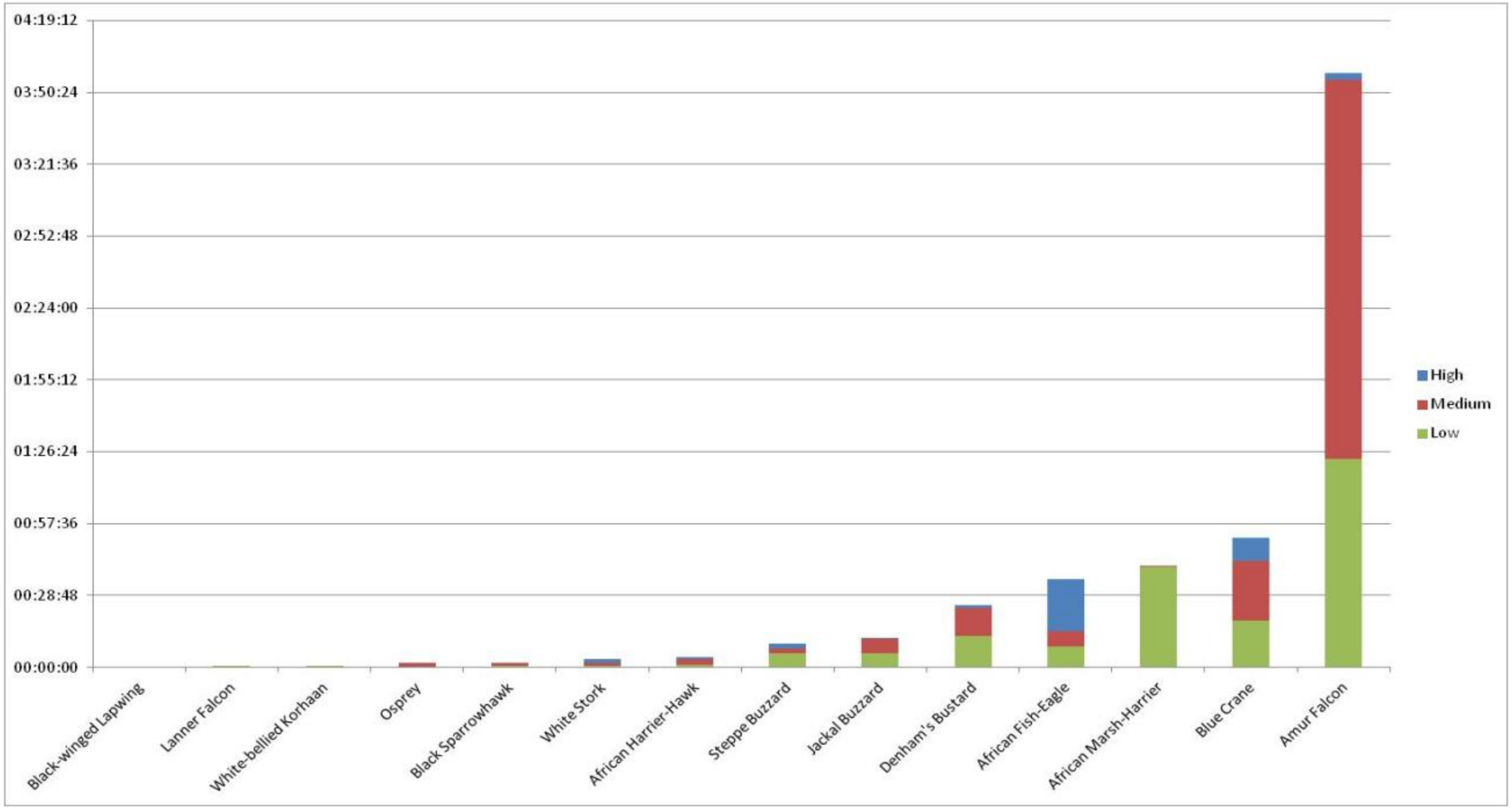

Figure 6.4: Breakdown of priority species vantage point observations (all flight heights). Time is hours: minutes: seconds.

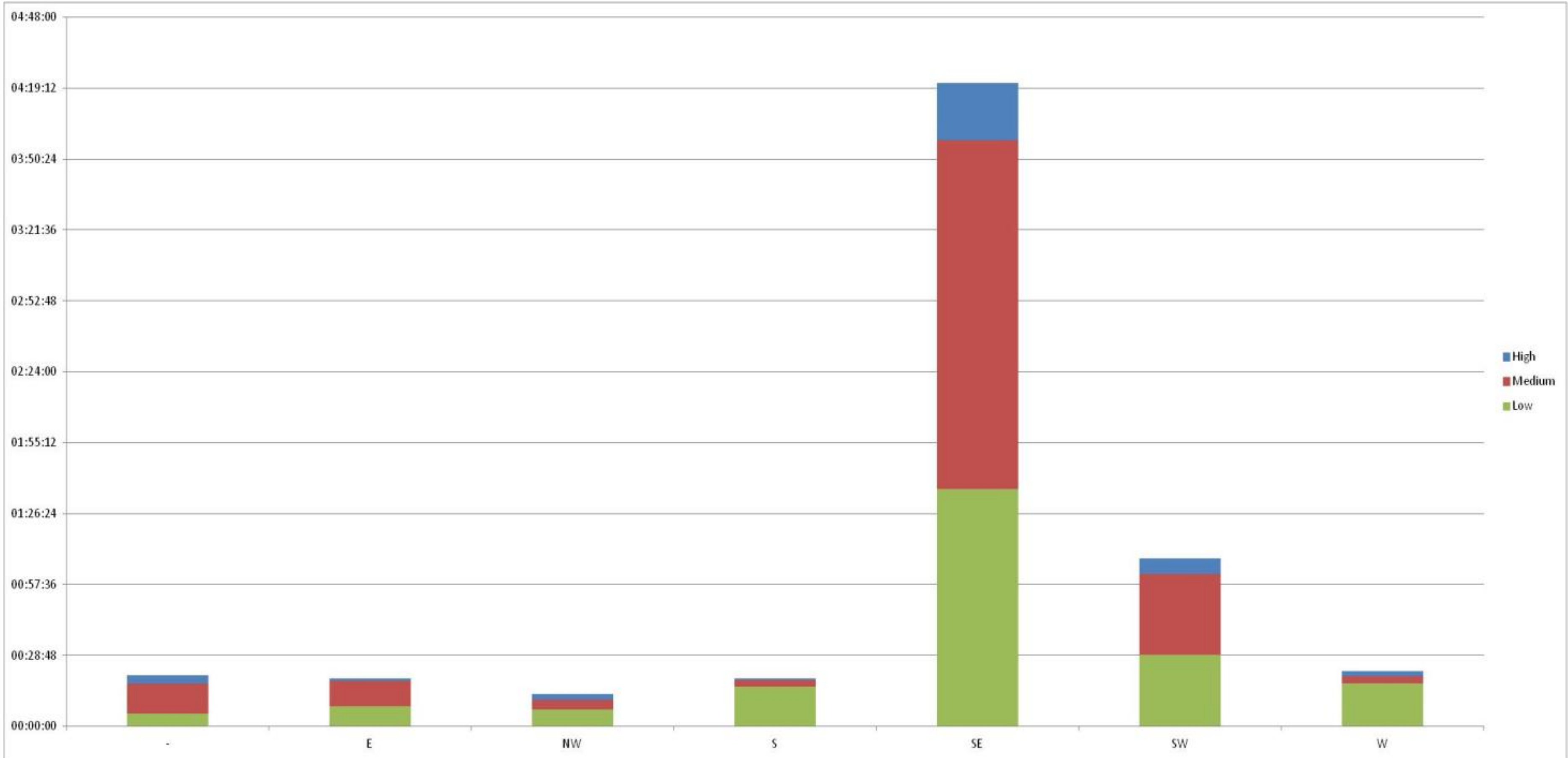

Figure 6.5: Duration of priority species flights in various wind directions. Time is hours: minutes: seconds.

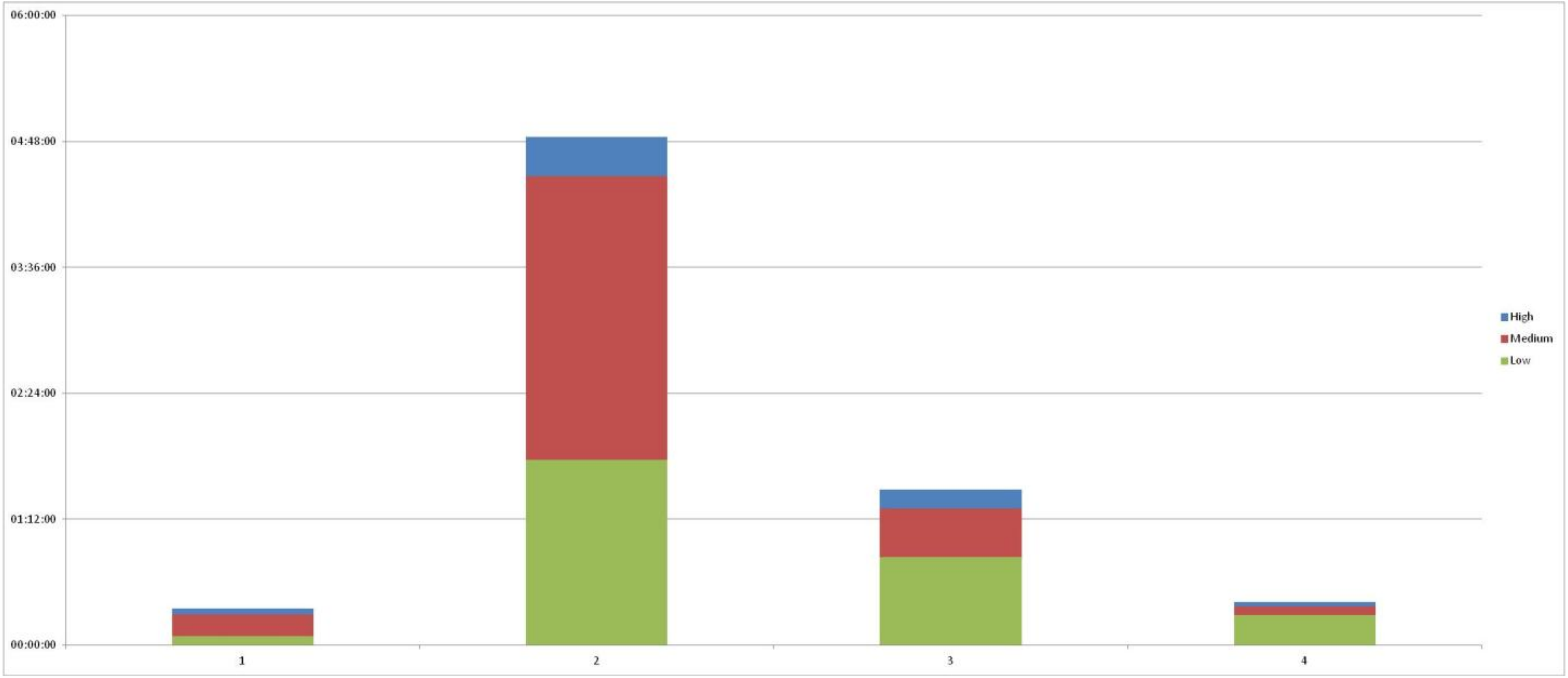

Figure 6.6: Flight heights and duration of priority species in various wind strengths (1 = calm; 2 = light; 3 = moderate; 4 = strong). Time is hours: minutes: seconds.

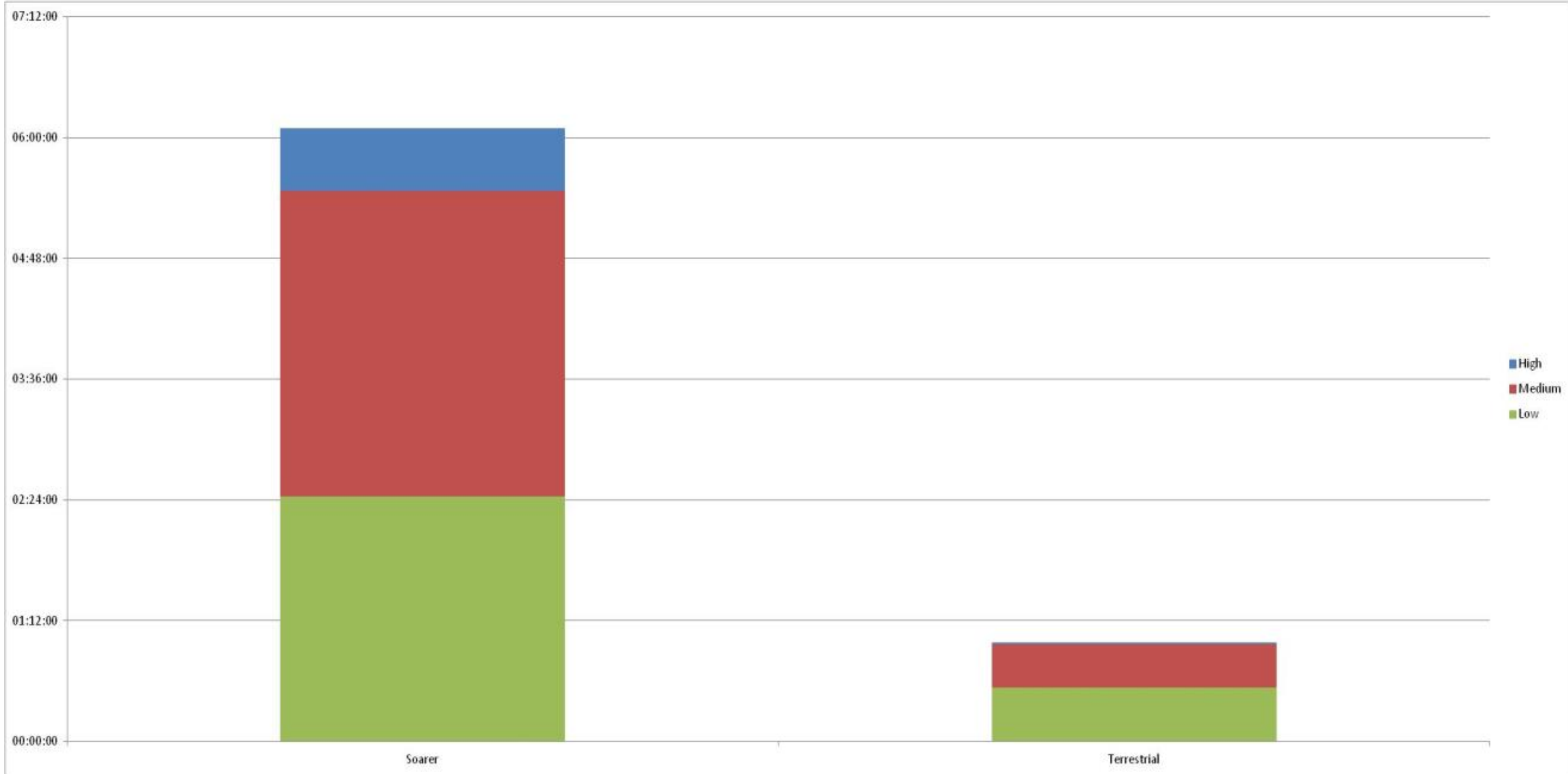

Figure 6.7: Breakdown of priority species classes vantage point (VP) observations (all flight heights). Time is hours: minutes: seconds.

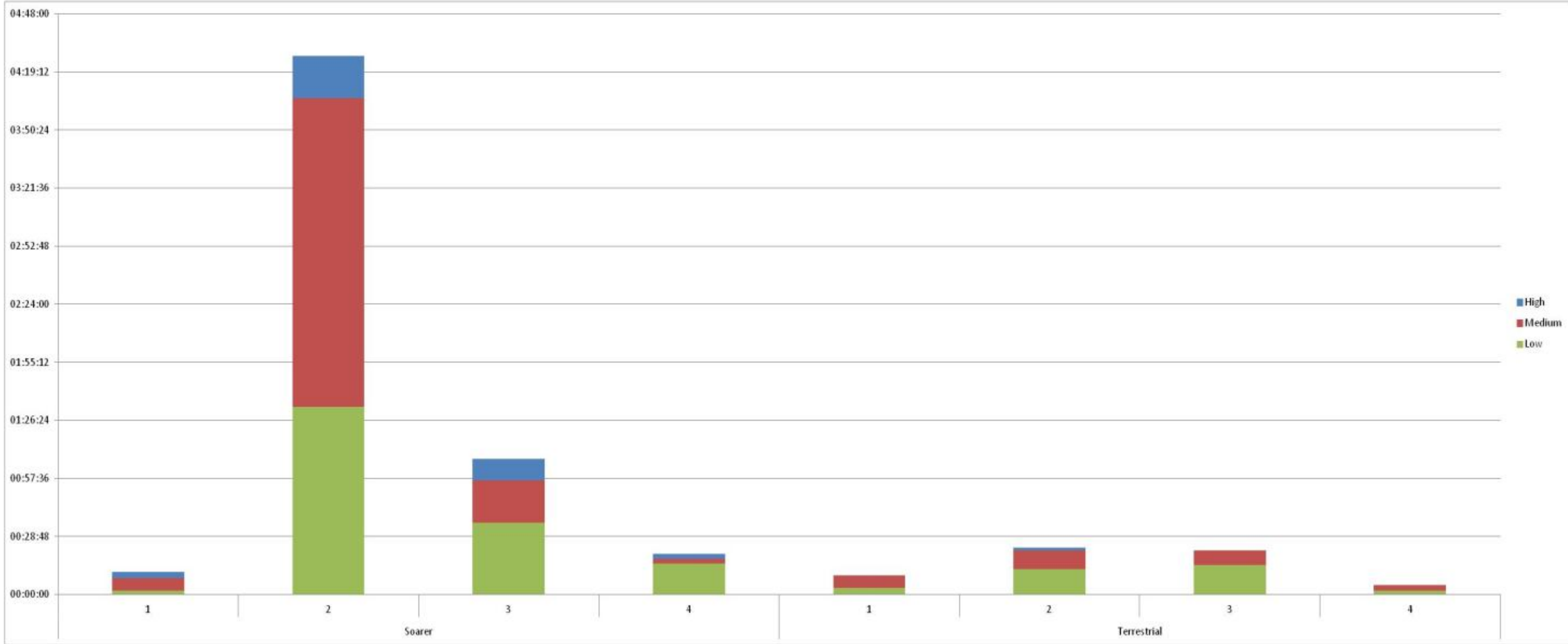

Figure 6.8: Flight heights and duration of priority species classes in various wind strengths (1 = calm; 2 = light; 3 = moderate; 4 = strong) in summer. Time is hours: minutes: seconds.

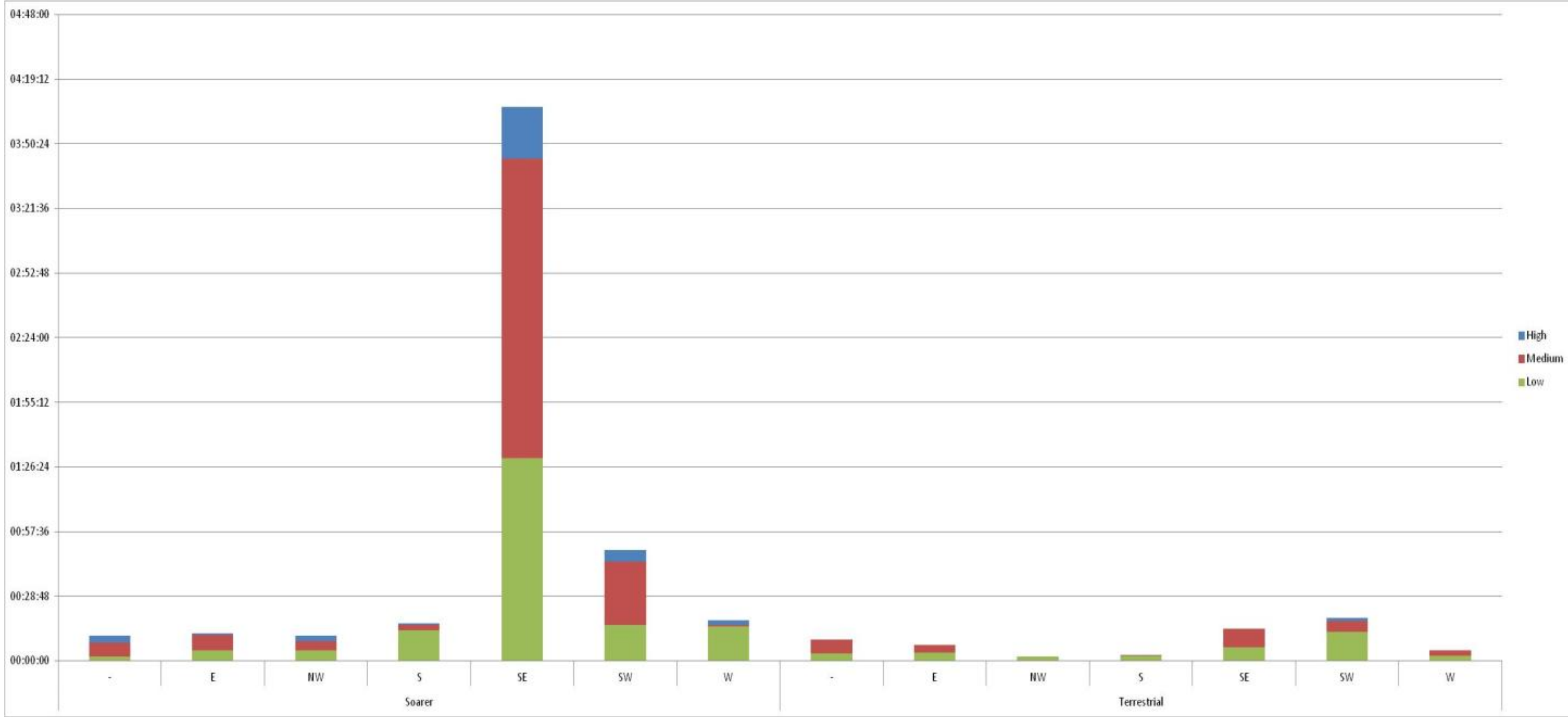

Figure 6.9: Duration of priority species flights in various wind directions. Time is hours: minutes: seconds.

The data collected for priority species for the VP counts in the sampling periods to date provide some preliminary pointers for the following:

- Soaring species spent a lot more time flying at medium height over the turbine area than terrestrial species. This is to be expected as terrestrial species generally spend their time foraging on the ground – soaring species would therefore be more at risk of collisions than terrestrial species, all things being equal;
- There are preliminary indications of an association between light winds and soaring species flying at medium height over the turbine area;
- There are preliminary indications of an association between south-easterly winds (and to a lesser extent south-westerly winds) and soaring species flying at medium height over the turbine area;
- Based purely on time spent at medium height over the turbine area, Amur Falcons are most likely to interact with the turbines, followed by Blue Cranes and Denham's Bustard.

The conclusions above must be viewed as preliminary, as another sampling period is yet to be completed in the course of 2012. The final dataset will be subjected to rigorous statistical analysis to assess whether preliminary indications of associations between variables are indeed statistically significant.

In order to form a picture of the spatial distribution of priority species flights over the turbine area, a distribution map of flights was prepared. This was done by overlaying a 100 m x 100 m grid over the survey area. Each grid square was then given a weighting score taking into account the duration of individual flight lines and the number of individual birds crossing the square (see Figures 6.10 – 6.12 for the map of medium altitude flights recorded).

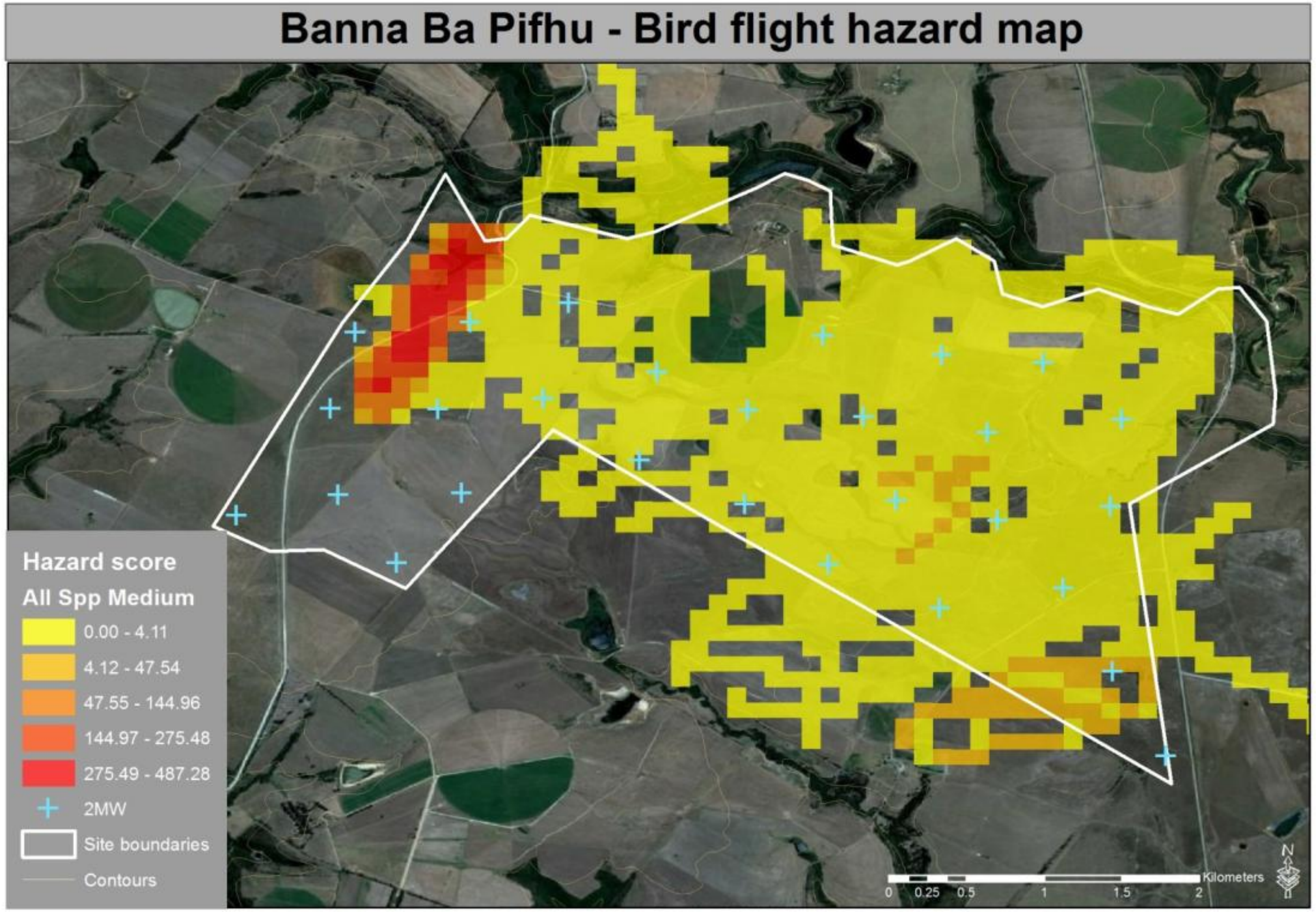

Figure 6.10: Map of medium height flights recorded at VP points – all species.

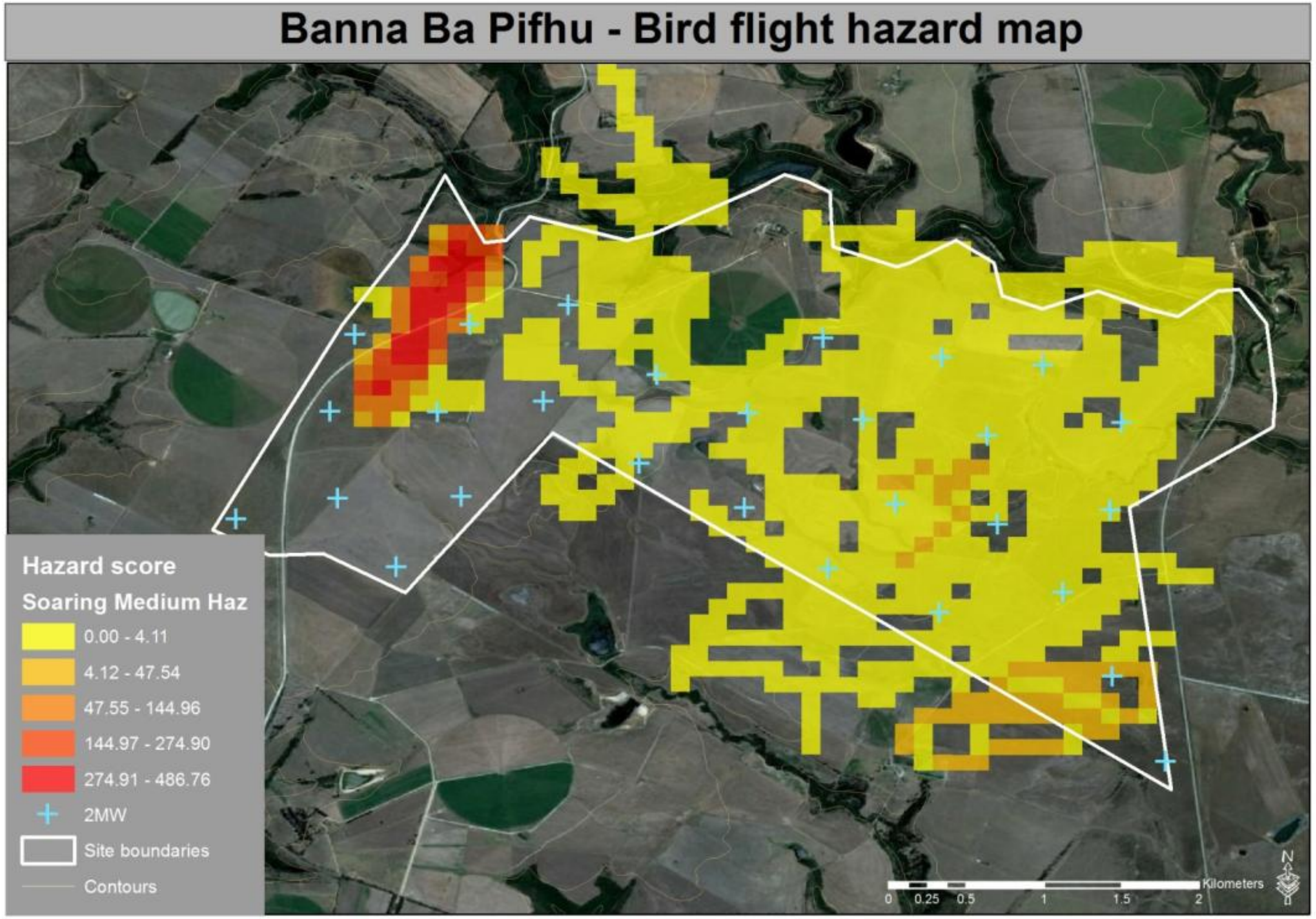

Figure 6.11: Map of medium height flights recorded at VP points – soaring species.

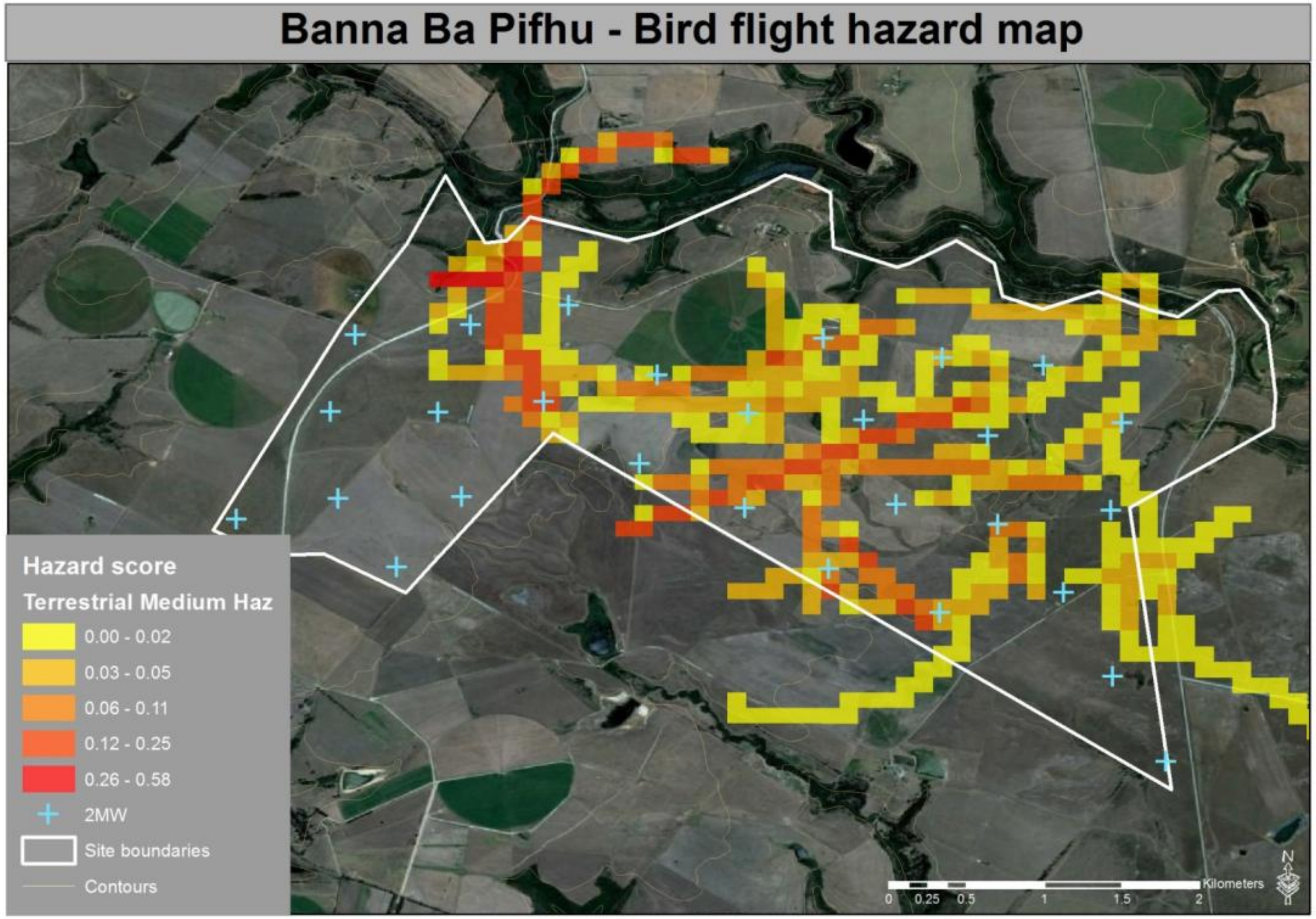

Figure 6.12: Map of medium height flights recorded at VP points – terrestrial species.

As far as collision risk is concerned, the following preliminary observations are made, based on the data gathered to date:

- The passage rates for priority species of 6.88 birds/hour (all heights) and 2.56 birds/hour (medium heights) indicate significant flight activity over the turbine area.
- Based solely on the amount of time spent at medium height over the turbine area, soaring species seem to be more at risk of collision than terrestrial species.
- Of the priority species recorded (both soaring and terrestrial species), Amur Falcons are most exposed to potential collision risk, based on the number of birds observed at the site at medium height over the turbine area.
- Of the terrestrial priority species recorded, Blue Cranes and Denham's Bustard are most exposed to potential collision risk, based on the number of birds observed at the site at medium height over the turbine area.
- Flight patterns of priority species at medium height recorded to date indicate areas where flight activity is more concentrated (see Figures 6.10 – 6.12), although it is acknowledged that observations are inevitably biased towards the centre of the VP area. At this stage it seems that suitable foraging habitat might be an important factor in flight activity patterns.

6.5.2 Management actions for mitigation of collision risk

The following management actions are recommended to reduce the risk of collisions to priority species:

- The baseline monitoring should continue as planned in order to gather additional data during autumn 2012 period. Once the monitoring has been completed, the dataset must be analysed in order to establish the statistical significance of potential trends that have been identified so far (e.g. the influence of wind direction and wind strength). This will assist in the formulation of the final recommendations. The additional data will also contribute towards the further refinement of the bird flight hazard maps and the micro-siting of the turbines.
- Once the turbines have been constructed, post-construction monitoring as per the latest version of the *Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa* (Jenkins *et al.* 2011) should be implemented to assess actual collision rates. If actual collision rates indicate high mortality levels, the following mitigation measures will have to be considered:

    - Negotiating appropriate off-set compensation for turbine related collision mortality;
    - As a last resort, halting operation of specific turbines during high risk conditions, or reducing rotor speed, to reduce the risk of collision mortality.

6.5.3 Displacement due to disturbance

The transect was counted 12 times: four times in summer, four times in early spring and four times in late spring. A total of 8449 birds were recorded, of which 574 were priority species and 7975 non-priority species, belonging to 117 species (see Appendix 6.3). An Index of Kilometric Abundance (IKA = birds/km) was calculated for each priority species, and also a figure for all priority species combined, which comes to 3.19 birds/km (see Figure 6.3 above). An indication of habitat preference was determined by calculating a habitat/species diversity index (habitat surface/number of species recorded for that habitat type - see Figures 6.13 and 6.14 below) and a habitat/species abundance index (habitat surface/number of individual birds recorded for that habitat type – see Figures 6.15 and 6.16 below). The former is needed to get an indication of which habitat type supports the greatest variety of species at the site, and the latter to get an indication of which habitat is likely to attract the biggest number of individual birds.

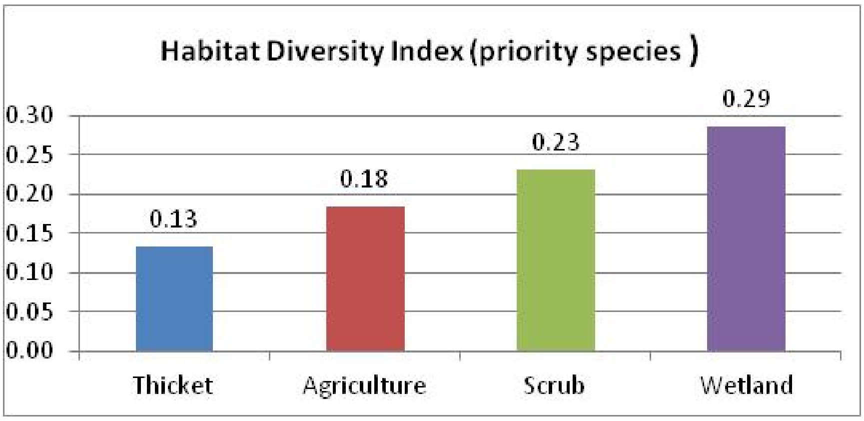

Figure 6.13: Habitat Diversity Index for priority species

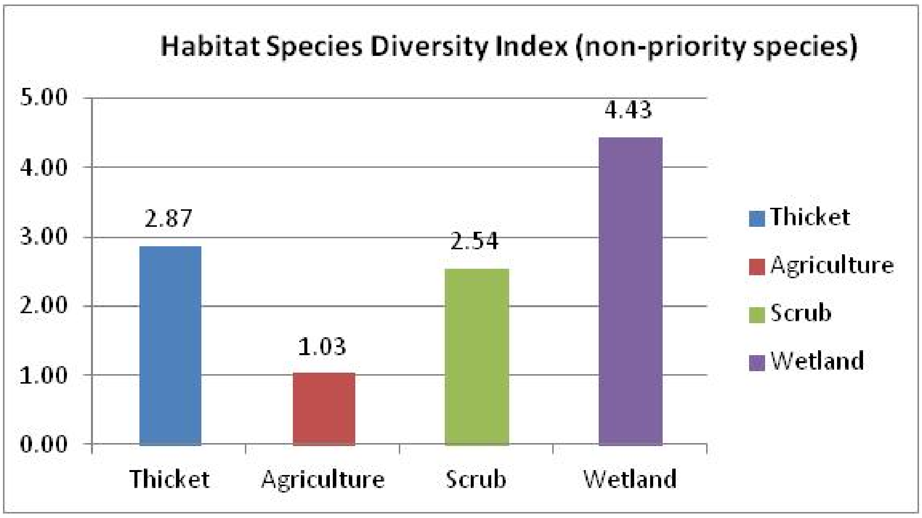

Figure 6.14: Habitat Diversity Index for non-priority species

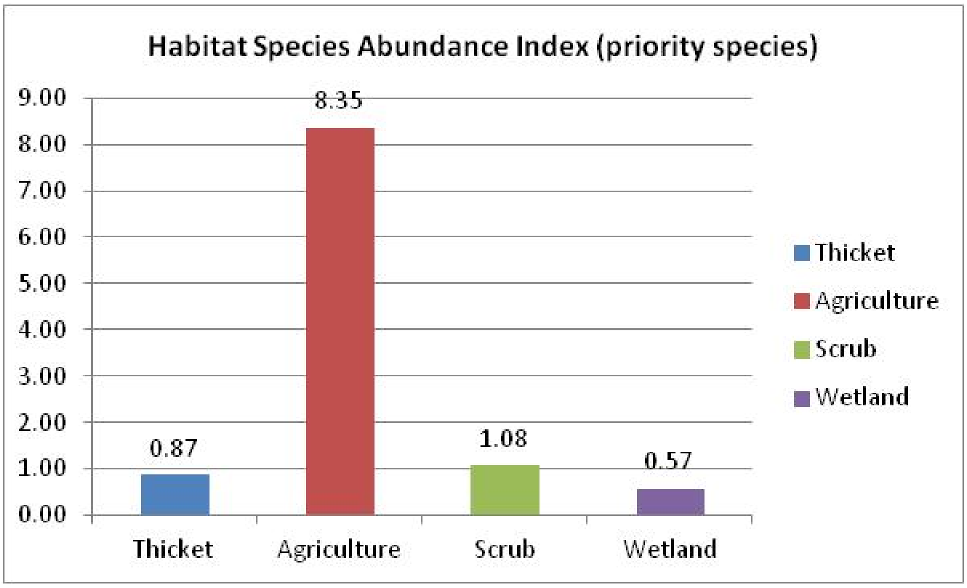

Figure 6.15: Habitat Abundance Index for priority species

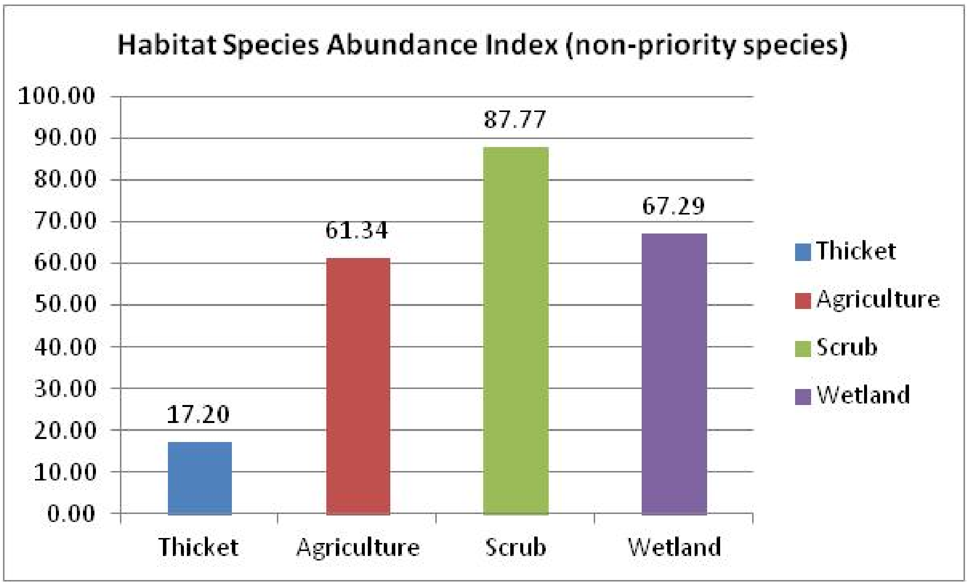

Figure 6.16: Habitat Abundance Index for non-priority species

From the results of the transect surveys the following preliminary trends emerge:

- The survey area supports high densities of Blue Crane (1.64 birds/km), Amur Falcon (0.62 bird/km) and Black-winged Lapwing (0.43 birds/km), which indicate the suitability of the study area across multiple habitat types for these species (see Figures 6.17 and 6.18);
- Wetlands tend to support a high variety of birds; while agriculture supports the highest number of birds (but fewer species);

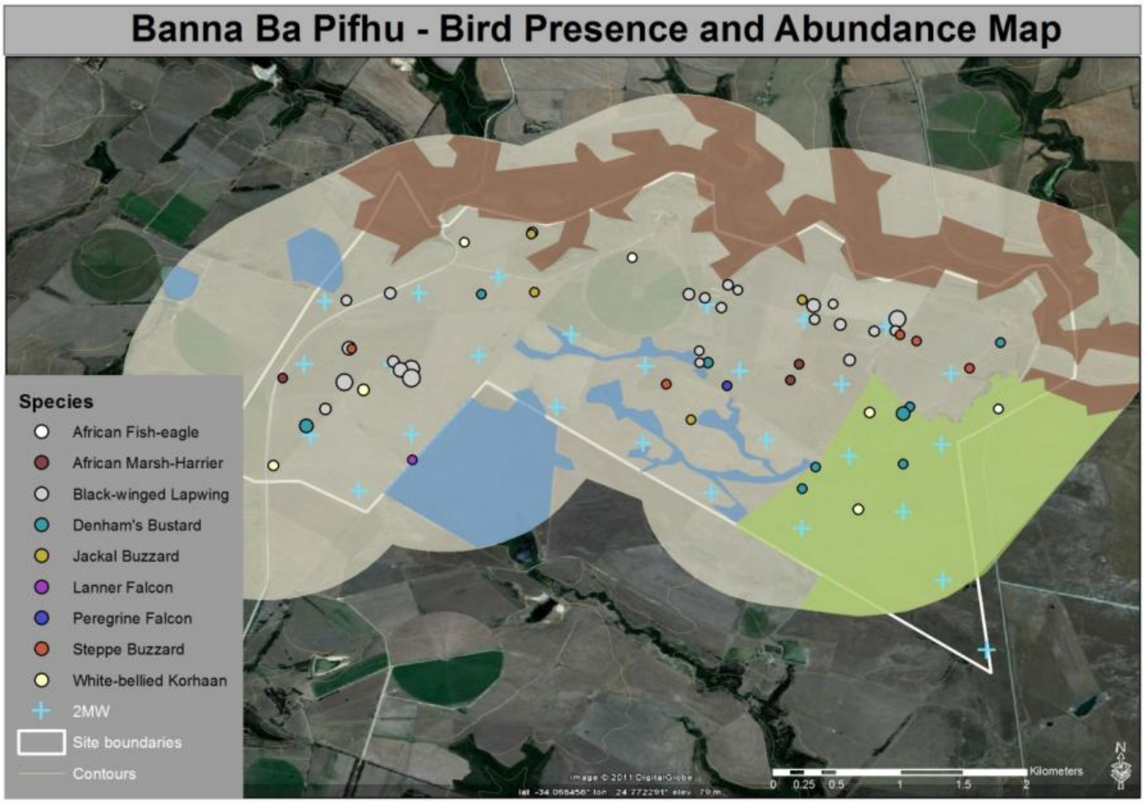

Figure 6.17: Map indicating the location of priority species (excluding Blue Crane) recorded during pre-construction monitoring

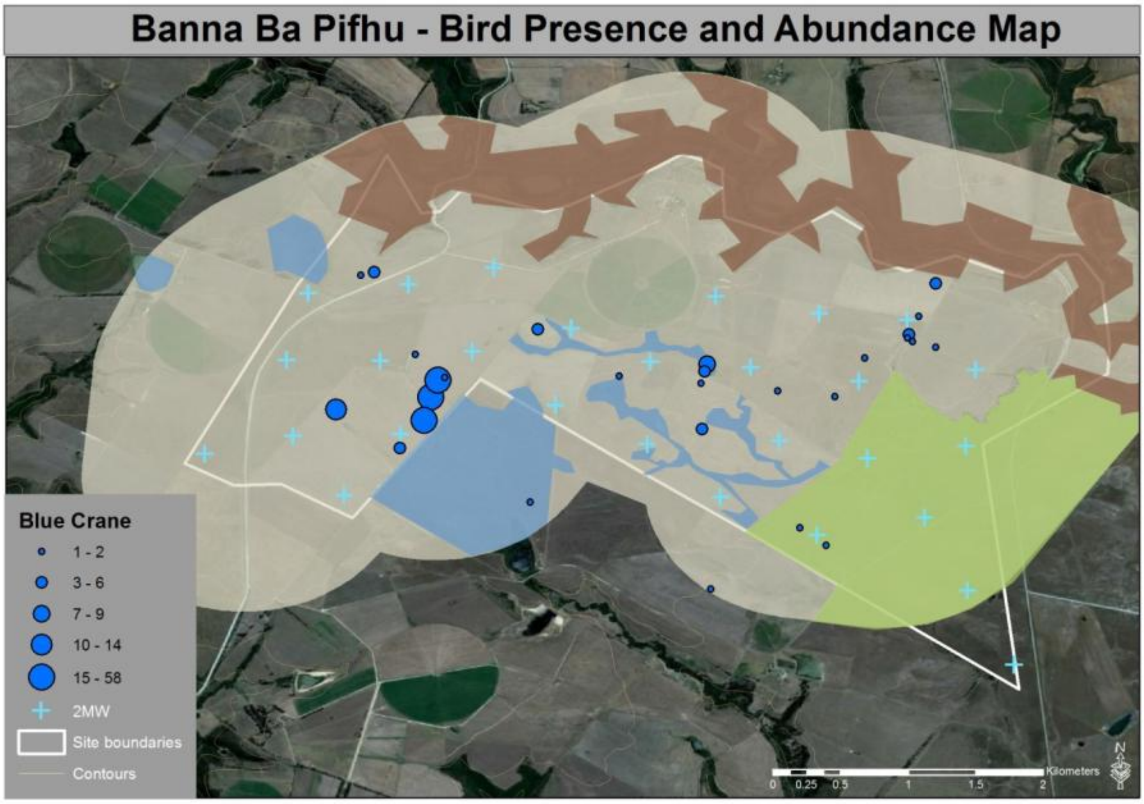

Figure 6.18: Map indicating the location of Blue Cranes recorded during pre-construction monitoring

At this stage, it can only be speculated about the impact of potential displacement on large terrestrial birds in the study area, particularly Denham's Bustard, White-bellied Korhaan and Blue Crane as this will only become apparent once the post-construction monitoring commences. If the birds are displaced, potentially this will be the most significant impact of the wind farm on birds. Very little published literature is available on the impact of wind farms on bustards, but the little that is available seems to indicate that displacement is likely (Langgemach 2008). The usual response of Denham's Bustards during the surveys is to flush in response to pedestrian and vehicle traffic. The potential for habituation is always there, but due to lack of research results, no unequivocal predictions can be made. As far as raptors are concerned, the chances of displacement are low, based on research results elsewhere (Madders and Whitfield 2008). This trend also seems to be supported by the results of the limited post-construction monitoring conducted at the existing four turbines at the Darling Wind Farm (Van Rooyen 2011).

In addition to transect surveys and point counts, areas of suitable habitat on and outside the proposed site area were searched for the presence of raptor nests (riverine cliffs) bustard and korhaan nests (scrub) and wetlands (blue crane roosts). To date, no such potential focal points were discovered during these searches.

The following management actions are proposed to minimise the impact of displacement on priority species:

- The monitoring should continue as planned for the autumn of 2012 in order to gather additional baseline data over four seasons;

- Access to the remainder of the site should be strictly controlled in order to minimise potential disturbance of sensitive priority species, particularly Denham's Bustard and White-bellied Korhaan which favours the scrub habitat on the site, both during construction and the operational phase;

- Post-construction monitoring should be implemented to assess the impact of displacement, particularly on priority species. Initially, a 12 month period of post-construction monitoring should be undertaken, using the same protocol as is currently implemented. Thereafter, the frequency for further monitoring will be informed by the results of the initial 12-month period;

- Should the results of the post-construction monitoring indicate significant displacement of priority species, appropriate off-set compensation should be negotiated with developer to compensate for the loss of priority species habitat; and

- During the construction period, activity should be restricted to the construction footprint itself. Access to the rest of the properties must be strictly controlled to prevent unnecessary disturbance of birds.

6.5.4 Habitat change and loss

The scale of direct habitat loss resulting from the construction of a wind farm and associated infrastructure depends on the size of the project but, generally speaking, is likely to be small per turbine base. Typically, actual habitat loss amounts to 2–5% of the total development area (Fox *et al*. 2006 as cited by Drewitt & Langston 2006). Direct habitat loss is not regarded as a major impact on avifauna compared to the potential impact of collisions with the turbines and, in particular, potential displacement due to disturbance.

The infrastructure footprint must be restricted to the minimum in accordance with the recommendations of the ecological specialist study (see Chapter 5 of this report).

6.5.5 Power line related collision mortality

It is proposed to connect the wind farm substation to the existing 66 kV Melkhout / St. Francis overhead power line, which passes through the site. No additional power line infrastructure will be required. No additional impacts are therefore envisaged.

6.5.6 Cumulative impacts

Currently there is no agreed method for determining significant adverse cumulative impacts on ornithological receptors. SNH (2005) guidance on cumulative effects of wind farms on birds recommends a five-stage process to aid in the ornithological assessment:

- Define the species/habitat to be considered;
- Consider the limits or 'search area' of the study;
- Decide the methods to be employed;

- Review the findings of existing studies; and
- Draw conclusions of cumulative effects within the study area.

It is impossible to say at this stage what the cumulative impact of all the proposed wind developments will be on birds, firstly because there is no baseline to measure it against, and secondly because the extent of actual impacts will only become known once a few wind farms are developed. It is therefore imperative that pre-construction and post-construction monitoring are implemented at all the new proposed sites, in accordance with the latest *Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa* (Jenkins *et al.* 2011), which was released by the Endangered Wildlife Trust and Birdlife South Africa in March 2011. This will provide the data necessary to improve the assessment of the cumulative impact of wind development on priority species. At this stage, indications are that, depending on the number of wind farms that are developed, displacement may emerge as a significant impact, particularly for species such as Denham's Bustard, White-bellied Korhaan and Secretarybird. The extent of the impact on the regional populations of these species however will depend on a species' susceptibility to displacement and number of wind farms that are actually developed. It is highly unlikely that every wind farm planned in the Jeffreys Bay, Humansdorp and Oyster Bay area will actually be developed.

6.5.7 Impact assessment

The criteria for the assessment of impacts are fully explained in the Chapter 4 of this report. A summary of the impact assessments is provided below in Table 6.4 below.

Table 6.4: Impact summary

Nature of impact	Status (negative or positive)	Extent	Duration	Intensity	Probability	Significance (no mitigation)	Mitigation/Management Actions	Significance (with mitigation)	Confidence level
CONSTRUCTION PHASE									
Displacement of priority species due to disturbance	Negative	Local	Short term	High	Highly probable	High	▪ Restrict the construction activities to the footprint area. Do not allow any access to the remainder of the property.	Medium	High
Displacement of priority species due to habitat destruction	Negative	Site	Long term	Low	Highly probable	Low	• No mitigation is possible to prevent the permanent habitat transformation caused by the construction of the wind farm infrastructure. In order to prevent unnecessary habitat destruction (i.e. more than is necessary), the recommendations of the specialist ecological study must be strictly adhered to.	Low	High

Nature of impact	Status (negative or positive)	Extent	Duration	Intensity	Probability	Significance (no mitigation)	Mitigation/Management Actions	Significance (with mitigation)	Confidence level
OPERATIONAL PHASE									
Displacement of priority species due to disturbance caused by the operation of the wind farm.	Negative	Local	Medium to long term, depending on whether habituation takes place.	High	Highly probable for bustards, probable for Blue Cranes, Secretarybirds and korhaans, and improbable for raptors.	Medium-high	▪ Post-construction monitoring should be implemented to assess the impact of displacement, particularly on priority species. Initially, a 12 month period of post-construction monitoring should be implemented, using the same protocol as is currently implemented. Thereafter, the frequency for further monitoring will be informed by the results of the initial 12-month period. ▪ Very little practical mitigation is possible other than to restrict access to the remainder of the property. Maintenance personnel and vehicles must be strictly supervised in order for ensure that no unnecessary disturbance of priority species takes place.	Medium to low, depending on whether habituation takes place, or off-set compensation is implemented.	Raptors – high Bustards, cranes and korhaans - medium

Nature of impact	Status (negative or positive)	Extent	Duration	Intensity	Probability	Significance (no mitigation)	Mitigation/Management Actions	Significance (with mitigation)	Confidence level
Collisions of priority species with the turbines	Negative	Mostly local and regional but international in the case of migratory species, namely White Stork, Steppe Buzzard and Amur Falcon.	Long term	High	Probable for soaring species, especially Amur Falcon, possible for Blue Cranes, korhaans and bustards.	Medium	• The monitoring should continue as planned in order to gather additional data during the late autumn 2012 period. Once the monitoring has been completed, the dataset must be analysed in order to establish the statistical significance of potential trends that have been identified so far (e.g. the influence of wind direction and wind strength). This will assist in the formulation of the final recommendations. The additional data will also contribute towards the further refinement of the bird flight hazard maps and the micro-siting of the turbines. ▪ Once the turbines have been constructed, post-construction monitoring as per the latest version of *Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa* (Jenkins *et al.* 2011) should be implemented to compare actual collision rates with predicted collision rates. If actual collision rates indicate unsustainable mortality levels, the following mitigation measures will have to be considered: o Negotiating appropriate off-set compensation for turbine related collision mortality; o As a last resort, halting operation of specific turbines during high risk conditions, or reducing rotor speed, to reduce the risk of collision mortality	Low	Low - medium

6.6 CONCLUSIONS

Although this is a relatively small wind farm site, it is not without intrinsic value for priority avifauna from a foraging, roosting and breeding perspective. The combination of pastures, wetlands and scrub is particularly well suited for Denham's Bustard, Blue Crane, White-bellied Korhaan, Black-winged Lapwing and Amur Falcon, as is the whole of the Jeffreys Bay, Humansdorp and Oyster Bay agricultural districts. Displacement of some priority species is possible, particularly Denham's Bustard, but at this stage, with no wind farms having been constructed as yet in the area, it is not possible to test the validity of this statement. However, should this impact materialise, the cumulative effect of displacement of particularly Denham's Bustard and White-bellied Korhaan might have regional or even national implications, depending on the number of wind farms that gets to be developed in the region, and the level of displacement. As far as the risk of mortality due to collisions is concerned, with the data currently available, it would seem that soaring species, and particularly Amur Falcons, might potentially be most exposed to this impact. Implementation of the proposed mitigation measures should reduce some of the envisaged impacts from medium to low, but while some impacts are low to start with, for others, very little practical mitigation is possible (see Table 6.4).

As far as collision risk is concerned, the following preliminary observations were made, based on the data gathered to date:

- The passage rates for priority species of 6.88 birds/hour (all heights) and 2.56 birds/hour (medium heights) indicate significant flight activity over the turbine area.
- Based solely on the amount of time spent at medium height over the turbine area, soaring species seem to be more at risk of collision than terrestrial species.
- Of the priority species recorded (both soaring and terrestrial species), Amur Falcons are most exposed to potential collision risk, based on the number of birds observed at the site at medium height over the turbine area.
- Of the terrestrial priority species recorded, Blue Cranes and Denham's Bustard are most exposed to potential collision risk, based on the number of birds observed at the site at medium height over the turbine area.
- Flight patterns of priority species at medium height recorded to date indicate areas where flight activity is more concentrated, although it is acknowledged that observations are inevitably biased towards the centre of the VP area. At this stage it seems that suitable foraging habitat might be an important factor in flight activity patterns.

From the results of the transect surveys the following preliminary trends emerge:

- The survey area supports high densities of Blue Crane, Amur Falcon and Black-winged Lapwing, which indicate the suitability of the study area across multiple habitat types for these species;
- Wetlands tend to support a high variety of birds; while agriculture supports the highest number of birds (but fewer species);

The following management actions are proposed to minimise the impact of displacement on priority species:

- The monitoring should continue as planned the autumn of 2012 in order to gather additional baseline data over four seasons.

- Access to the remainder of the site should be strictly controlled in order to minimise potential disturbance of sensitive priority species, particularly Denham's Bustard, both during the construction phase and the operational phase.

- Post-construction monitoring should be implemented to assess the impact of displacement, particularly on priority species. Initially, a 12 month period of post-construction monitoring should be implemented, using the same protocol as is currently implemented. Thereafter, the frequency for further monitoring will be informed by the results of the initial 12-month period;

- Should the results of the post-construction monitoring indicate significant displacement of priority species, appropriate off-set compensation should be negotiated with developer to compensate for the loss of priority species habitat; and

- During construction activity should be restricted to the construction footprint itself. Access to the rest of the properties must be strictly controlled to prevent unnecessary disturbance of birds.

6.7 REFERENCES

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Appendix 6.1: Best practice guidelines

Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa

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EXECUTIVE SUMMARY

1. The wind energy industry is poised for rapid expansion into many areas of southern Africa. While experiences in other parts of the world suggest that this industry may be detrimental to birds (through the destruction of habitat, the displacement of populations from preferred habitat, and collision mortality with wind turbines and power lines), these effects are highly site- and taxon-specific in operation. Raptors, large terrestrial species and wetland birds are thought to be most susceptible, and areas of higher topographic relief are often implicated in negative impact scenarios.
2. In order to fully understand and successfully mitigate the possible impacts of wind farms on the region's birds (and to bring the local situation into line with international best practice in this field), it is essential that objective, structured and scientific monitoring of both resident and passing avifauna be initiated as soon as possible at all proposed development sites.
3. The Birds & Wind Energy Specialist Group, convened by the Wildlife & Energy Programme of the Endangered Wildlife Trust, and BirdLife South Africa, proposes the following guidelines and monitoring protocols for evaluating wind energy development proposals, including a 3-4 tier assessment process: (i) Reconnaissance (scoping) – a brief site visit informs a desk-top assessment of likely avifauna and possible impacts, and the design of a site-specific survey and monitoring project, (ii) Baseline monitoring (EIA) – a full assessment of the significance of likely impacts and available mitigation options, based on the results of systematic and quantified monitoring as specified at scoping, (iii) Post-construction monitoring – duplication of the baseline work, but including the collection of mortality data, to develop a complete before:after picture of impacts, and refine the mitigation effort, and (iv) if warranted, more detailed and intensive research on affected threatened species.
4. To streamline this approach, a shortlist of priority species (threatened or rare birds, in particular those unique to the region, and especially those which are possibly susceptible to wind energy impacts and which occur in the given development area at relatively high densities) should be drawn up at the scoping stage, and these should be the primary focus of all subsequent monitoring and assessment.
5. Similarly, the amount of monitoring effort required at each site should be set in terms of the anticipated sensitivity of the local avifauna and the prevalence of contributing environmental conditions (for example, the diversity and relative abundance of priority species present, proximity to important flyways, wetlands or other focal sites, and topographic complexity).
6. On-site work must be coupled with the collection of directly comparable data at a nearby, closely matched control site. This will provide much needed context for the analysis of pre- *vs* post-construction monitoring data.
7. In some situations, where proposed wind energy developments are likely to impinge on flyways used by relatively large numbers of threatened and impact sensitive birds, and particularly where these movements are likely to take place at night or in conditions of poor visibility (e.g. the Cape Columbine Peninsula), it may be necessary

to use radar to gather sufficient information on flight paths to fully evaluate the development proposal and inform mitigation requirements.

8. Baseline monitoring will require periodic visits to both the development and control sites, sufficient in frequency to adequately sample all major variations in environmental conditions, and spanning a total study period of not less than 12 months. Variables measured/mapped on each site visit should include (i) density estimates for small terrestrial birds (in most cases not priority species, but potentially affected on a landscape scale by multiple developments in one area), (ii) absolute counts, density estimates or abundance indices for large terrestrial birds and raptors, (iii) passage rates of birds flying through the proposed development area, (iv) occupancy/numbers/breeding success at any focal raptor sites, (v) bird numbers at any focal wetlands, and (vi) full details of any incidental sightings of priority species.
9. Post-construction monitoring should effectively duplicate the baseline work, with the addition of surveys for collision and electrocution victims under the turbines and ancillary power infrastructure.
10. While analysis and reporting on an individual development basis will be the responsibility of the relevant avifaunal specialist, all data emanating from the above process should also be housed centrally by the Birds & Wind Energy Specialist Group to facilitate the assessment of results on a multi-project, landscape and national scale.
11. Although these guidelines are already in use, and should remain so, they will be revised by February 2012, based on experience gained implementing them in the interim, and input from various sectors. Thereafter it is likely that periodic revision will be required.

1. INTRODUCTION

The wind energy industry is in the process of rapid expansion in southern Africa (and more broadly on the continent, as well as globally – World Wind Energy Association 2010). A short-list of credible, scientific studies done or ongoing in other parts of the world (Drewitt & Langston 2006, 2008 and references therein, Jordan & Smallie 2010) have established that the most prevalent impacts of wind energy facilities (WEFs) on birds are displacement of sensitive species from development areas, and mortality of susceptible species, primarily in collisions with development hardware. However, the nature and extent of these impacts is highly dependent on both site- and species-specific variables (Drewitt & Langston 2006, 2008 and references therein, Jordan & Smallie 2010), and there is no empirically based understanding of the likely effects of wind energy development on southern African birds. The South African Birds & Wind Energy Specialist Group (BAWESG) therefore recognizes the need to measure these effects as quickly as possible, in order to identify and mitigate any detrimental impacts on threatened or potentially threatened species. BAWESG also recognizes the need to gather these data in a structured, methodical and scientific manner, in order to arrive at tested and defensible answers to critical questions (Stewart *et al.* 2007).

This should be done by means of an integrated programme of pre- and post-construction monitoring projects, set up at all the proposed development sites. Each such project should broadly comply with the guidelines provided here, although the scale of each project, the level of detail and technical input, and the relative emphasis on each survey and monitoring component, will vary from site to site in terms of the risk potential identified by the initial scoping or environmental impact assessment (EIA) studies. In principle, each project should be as inclusive and extensive (both spatially and temporally) as possible, but kept within reasonable cost constraints, consistent with the anticipated conservation significance of the site and its avifauna. In general, the detail and rigor required in any given monitoring project will be proportional to the size of the proposed WEF (*n* turbines and spatial extent), topographic and/or habitat heterogeneity on site, the relative importance of the local avifauna (in terms of diversity, abundance and threat status), and the anticipated susceptibility of these birds to the potential negative impacts of a wind energy development (Table 1).

In this context, a three to four tier system of survey and monitoring, which has been applied in both Europe and North America (e.g. Scottish Natural Heritage 2005, Kuvlevsky *et al.* 2007), is probably a good approach to use here. The current South African EIA process provides the first tier product in such a system in the form of what is presently considered as a full specialist impact assessment report, but which is actually no more than a reconnaissance or scoping study. Should this initial scoping report endorse the development, a full avian impact assessment (AIA) should then be based on the second tier of work, comprising baseline survey and monitoring. Should the AIA also endorse the proposed development and it goes ahead, a third tier of work would consist of a comparative post-construction survey and monitoring effort. Note that while the more general development impacts associated with the actual construction of each wind energy facility are not a primary focus of this document, BAWESG acknowledges that these may be severe. The scale and mitigation of these impacts should be referred to explicitly in scoping level and AIA reports, should be integral to the ultimate Record of Decision (RoD), and should be monitored and mitigated under the development construction management plan.

In each instance, pre- and post-construction monitoring should be undertaken at least one nearby control site, matched as closely as possible to the proposed development site, to validate before:after comparisons of bird populations and movements. Lastly, at selected sites where bird impacts are expected to be particularly direct and severe (in terms of the relative biodiversity value of the affected avifauna, and/or the inherent risk potential of the proposed facility), additional, more customized and experimental research initiatives may be required, such as intensive, long-term monitoring of marked or even satellite tagged populations (e.g. Nygård *et al.* 2010).

The overarching aims of this multi-tiered approach would be:

(i) To develop our understanding of the effects of WEFs on southern African birds.
(ii) To develop the most effective means to mitigate these impacts.

Given the rate and extent of proposed wind energy development, this should be done as quickly as possible, but using scientific methods to generate accurate, comparable information. The current set of best practice guidelines presents the means and standards required to achieve these aims. This is intended to be a living document that will be corrected, updated, and supplemented over time, as local specialist and research practitioners gain much-needed experience in this field.

2. RECOMMENDED PROTOCOLS

Time, human capacity and finances are all legitimate constraints on the extent and intensity of monitoring work possible, but cannot at any stage be allowed to override the need to maintain the levels of coverage required to thoroughly evaluate the sustainability of a proposed WEF. Bird density and activity monitoring should focus data collection on a shortlist of priority species, defined in terms of (i) threat status or rarity, (ii) uniqueness or endemism, (iii) susceptibility to disturbance or collision impacts, and (iv) relative abundance on site. These species should be identified in the scoping/AIA report and/or by the BAWESG sensitivity mapping exercise. This will generally result in a strong emphasis on large, red-listed species (e.g. cranes, bustards and raptors – Drewitt & Langston 2006, 2008, Jenkins *et al*. 2010).

Factors which might motivate for intensified monitoring effort include high densities or diversity of threatened and/or endemic species, or the proximity of known and important avian flyways or wetlands, all of which add substantially to the potential impact of a given development (Table 1). Conversely, the absence of such factors would indicate reduced survey and monitoring requirements, although the interplay of these variables is likely to be complex and site-specific. Current levels of understanding preclude the establishment of any broadly applicable rules on monitoring intensity at this stage (Table 1).

Table 1. *Qualitative grading of required bird monitoring effort at proposed WEF sites in relation to a sample suite of potentially relevant parameters. Note that the inter-play between these and other contributing factors at each facility is likely to be complex and highly site specific, and is not represented in this table. The quantity of monitoring required in each case should ultimately be determined by the on-site specialist, with input from the Birds & Wind Energy Specialist Group if and when required.*

Required survey effort	Size of proposed WEF	Topography	Threatened species	Flyways	Importance for priority species	Proximity of significant wetlands
Lower	<20 turbines	Flat	No red-listed endemics and only few red-listed species are present	Site does not impinge on a known avian flyway	No priority species breeding or roosting communally within the affected area	No regionally or nationally significant wetlands within the affected area
Medium	20-100 turbines	Undulating	At least one red-listed endemic and some red-listed species are present	No information available on avian flyways in the area	One priority species breeding or roosting communally within the affected area	One regionally or nationally significant wetland within the affected area
Higher	>100 turbines	Hilly with prominent and defined ridges	Multiple red-listed endemics and many red-listed species are present	Site impinges on a known avian flyway	>1 priority species breeding or roosting communally within the affected area	>1 regionally or nationally significant wetland within the affected area

While immediate conservation imperatives and practical constraints motivate for focus on priority species, it is also important to account for more subtle, systemic effects of wind energy developments, which may be magnified over very large facilities, or by multiple facilities in the same area. For example, widespread, selective displacement of smaller, more common species by WEFs may ultimately be detrimental to the status of these birds and, perhaps more significantly, may upset the balance and effective functioning of the local ecosystem. Similarly, the loss of relatively common but ecologically pivotal species (e.g. non-threatened apex predators such as Verreaux's Eagle *Aquila verreauxii*) from the vicinity of a WEF may also have a substantial, knock-on effect. Hence, some level of monitoring of small bird populations will be required at all sites, and certain non-threatened but impact susceptible species will emerge as priority species by virtue of their perceived value to the ecosystem. Also note that quantitative surveys of small bird populations may be the only way in which to adequately test for impact phenomena such as displacement (Devereaux *et al.* 2008, Farfán *et al.* 2009), given that large target species occur so sparsely in the environment that it may not be possible to submit density or abundance estimates to rigorous statistical examination.

Ultimately, each monitoring project should provide much needed quantitative information on the numbers, distributions and risk profiles of key species or groups of species within the local avifauna at a given development site, and serve to inform and improve mitigation measures designed to reduce this risk. The bulk of the work involved should be done by trained observers, under the guidance and supervision of a qualified and experienced specialist ornithologist.

2.1 Stage 1: Reconnaissance

This stage should comprise most of what is currently considered as the EIA stage of the development application process. Local specialists, consulting agencies, developers and (most importantly) the SA Department of Environmental Affairs (DEA) will be required to change their perspectives on the EIA process in order to successfully institute this change, with the full AIA assessment then being compiled in terms of the outcomes of baseline monitoring.

The main aims of a reconnaissance study are:

(i) To define the study area - the core of the area covered by survey and monitoring work done at each proposed development site is determined by the client, and comprises the inclusive area on which development activities (the construction of turbines and associated road and power infrastructure) are likely to take place. However, because birds are highly mobile animals, and because an important potential impact is the effect of the WEF on birds which move through the proposed development area, as well as those which are resident within it, the avian impact zone of any proposed WEF extends well beyond the boundaries of this central core. Of particular concern is that monitored areas are large enough to include the considerable space requirements of large birds of prey, which may reside tens of kilometres outside of the core development area, but regularly forage within it (Walker *et al.* 2005, Madders and Whitfield 2006, Martinéz *et al.* 2010). How far the study area extends in each case should be determined by the on-site specialist, and should be defined at the scoping stage of the assessment process, perhaps with opportunity for subsequent refinement during the AIA stage.

Generally, the extent of the broader impact zone of each project will depend on the dispersal ability and distribution of important populations of priority species that are likely to move into the core impact area with some regularity. It is important that the delineation of this inclusive impact zone, which is the area within which all survey and monitoring work will be carried out, is done realistically and objectively, balancing the potential impacts of the wind farm with the availability of resources to conduct the monitoring.

(ii) To characterize the site in terms of:

- the avian habitats present,
- an inclusive list of species likely to occur there,
- an inclusive list of priority species likely to occur there, with notes on the relative value of the site for these birds,

- input on likely seasonality of presence/absence and/or movements for key species,
- any obvious, highly sensitive, no-go areas to be avoided by the development from the outset.

This should be done by means of:

- a desk-top study of the local avifauna, using relevant, pre-existing information (Hockey *et al.* 2005) and datasets - for example the Southern African Bird Atlas data (SABAP 1 - Harrison *et al.* 1997, and SABAP 2), Coordinated Waterbird Counts (CWAC, Taylor *et al.* 1999), Coordinated Avifaunal Roadcounts (CAR, Young *et al.* 2003), the Birds in Reserves project (BIRP) and the Important Bird Areas initiative (Barnes 1998) (for updates on all these datasets see http://adu.org.za/), as well as data from the Endangered Wildlife Trust's programmes and associated specialist research studies, and
- a short (2-4 day) site visit to the area to search for key species and resources, and to develop an on-site understanding of where (and possibly when) priority species are likely to occur and move around the site (note that such a visit will not allow for seasonal variation in the composition and behaviour of the local avifauna, and such variation must therefore be estimated in terms of the existing information for the site or region, and the experience of the consulting specialist).

(iii) To provide an initial estimation of likely impacts of the proposed WEF, and to assess the nature and scale of baseline monitoring required to measure these impacts, and to provide input on mitigation.

In summary, the reconnaissance exercise should yield a scoping report describing the avifauna at risk detailing the nature of that risk and options for mitigation, as well as outlining the baseline monitoring effort required to inform the AIA report. Whilst the reconnaissance study could in some cases coincide with and serve as the scoping study, it is not necessary to wait until scoping starts in order to start monitoring. As a useful by-product of this work, specialists should be encouraged to register with the SABAP 2 project (http://sabap2.adu.org.za/), and to complete atlas cards for the pentads (5 x 5 minute squares) making up each development site, on every site visit (including those made during baseline and post-construction monitoring).

2.2 Stage 2: Baseline monitoring

The products of this stage in the process should substantially inform the AIA report, and be the basis upon which the RoD is issued by DEA.

The primary aims of baseline monitoring are:

(i) To estimate the number/density of birds regularly present or resident within the broader impact area of the WEF before its construction.
(ii) To document patterns of bird movements in the vicinity of the proposed WEF before its construction (e.g. Erickson *et al.* 1999).

(iii) To estimate predicted collision risk (the frequency with which individuals or flocks fly through the future rotor swept area of the proposed WEF – Morrison 1998, Band *et al.* 2007) for key species.
(iv) To inform comment on the merits of the application in the AIA report in terms of points (i) to (iii).
(v) To establish a pre-impact baseline of bird numbers, distributions and movements.
(vi) To mitigate impacts by informing the final design, construction and management strategy of the development.

Control sites

Monitoring data should be generated for both the broader impact zone of the proposed WEF, and for one or more comparable control sites. In this way, a comparison of data from pre- and post-construction monitoring can be calibrated in terms of an equivalent comparison for a suitable control area, and the effects of regional variation in environmental conditions can be filtered out of the resulting quantification of the actual impacts of the WEF (Anderson *et al.* 1999, Scottish Natural Heritage 2005, Stewart *et al.* 2007, Pearce-Higgins *et al.* 2009). Note that, whenever possible, close neighbouring WEF development areas could use a common control site to minimize the time taken to locate a suitable area and acquire data, and the corresponding costs to the client.

Suitable control sites should:

- match the range of habitats and topography of the proposed WEF site,
- host a similar mix of bird species to those present on the WEF site,
- be at least half the size of the wind farm area,
- be located on ground with a similar mix of habitats and similar topography and aspect (Pearce-Higgins *et al.* 2009),
- be situated as close as possible to the wind farm area, but far enough away to ensure that resident birds on the control site are not directly affected by the wind farm operations once they start, and also that there is little, if any, localised movement of key species between the two areas.

Duration and frequency of monitoring

Monitoring data also should be collected over at least a 12 month period (at both WEF and control sites), and include sample counts representative of the full spectrum of prevailing environmental conditions likely to occur on each site in a year (Drewitt & Langston 2006). This time-span may not have direct biological relevance, but presents a useful compromise between the extremes of either attempting to accommodate inevitable (and probably significant) variation between years, or just distilling the process into a sampling window of only six months, spanning the period between mid-winter and mid-summer. The former option is practically impossible, while the latter is too simplistic and abbreviated to be worthwhile. Within a 12 month sampling period, the frequency of site visits should be determined by the perceived sensitivity of the site, modulated by practical constraints (human capacity, size and accessibility of the site, time, finances). Note that the quality and utility of the monitoring data is generally proportional to sampling frequency, so the number of iterations of each sampling technique per site visit, and the number of site visits per year, should always be kept at a practical maximum.

Equipment and mapping

Field workers should operate in pairs, and will require a number of specialized items of equipment in order to gather monitoring data accurately, quickly and efficiently. In many cases, each team will require the use of an off-road vehicle (ideally a 4x4) to make maximum use of the available road infrastructure on site. Each team member will need a pair of good quality binoculars, and each team will need a spotting scope and a recent regional bird identification guide. A GPS, a digital camera and a means to capture data – a notebook, datasheets, or generic or customized PDA – are also essential equipment. Electronic data capture devices, digital video cameras, hand-held weather stations and laser range-finders are useful, optional extras, that will facilitate the rapid acquisition, collation and processing of the maximum amount of relevant and accurate information on each site visit.

Before sampling and counting commence, the avian habitats available on both the project and the control sites should be mapped using a combination of satellite imagery (Google Earth) and GIS tools. These maps can later be subject to ground-truthing and refinement according to on site experience and/or the findings of scoping phase botanical surveys. Each field team should have at least one set of hard-copy maps (at a minimum scale of 1:50 000) covering the full study area for accurate navigation and plotting of sightings. Digital maps of the area, on which sightings can be plotted directly in digital format, are useful, optional extras, which should facilitate the accurate capture of spatially explicit information.

2.2.1 Bird numbers or densities

Bird population monitoring at southern African WEF development sites presents some unique challenges. Monitoring protocols from Europe and the USA are mostly designed for estimating population densities of small passerines, and/or for use in relatively small development areas (Anderson *et al.* 1999, Erickson *et al*. 1999, Scottish Natural Heritage 2005, Smallwood *et al.* 2009). In southern Africa, many of the proposed developments cover very large areas, many of the priority species are large birds (cranes, bustards, eagles, vultures), with proportionally large space requirements and sparse distributions (Jenkins 2011), and some of the key species are nomadic, with fluctuating densities related to highly stochastic weather events that drive local habitat conditions. These different dispersion parameters render many traditional approaches to monitoring inappropriate and/or ineffective. Furthermore, some of the proposed development sites are situated in remote and rugged terrain, and access limitations may preclude uniform and/or random sampling of all habitats. Hence sampling methods and sample sizes may be determined as much by what is practically possible as by what is required for statistical rigor (although every effort should be made to cover a representative cross-section of the available habitats, or at least to sample those areas most likely to hold priority species). Lastly, there is currently a dearth of suitably experienced people available to do this monitoring, so the quality of the work done is likely to be limited by capacity shortfalls, at least in the short term.

In this context, and within these limitations, it remains a stringent requirement that bird numbers, distributions and activities are monitored as accurately as possible at all proposed WEF and control sites, including data for a representative range of avian guilds.

Sample counts of small terrestrial species

While the emphasis of any monitoring project should be on the priority species identified at the scoping stage (and any other threatened and/or restricted range endemics seen and added to this list subsequently), there is a perceived need to monitor particularly the displacement effects of WEFs on small bird populations, even when these do not include species prioritized by the scoping exercise. This is more to further our understanding of the general effects of WEFs, and in particular the possible cumulative impacts of widespread WEF development on the broader avifauna, than to fulfill any immediate and localized conservation requirement. Given the potentially very large area put to wind energy development in 10-20 years time (http://www.sawea.org.za/), we need to assess now whether or not components of small bird communities are likely to be displaced, before we effect landscape-scale distributional changes, with the longer-term ecological damage that such changes could bring.

Most WEF developments are proposed for open, quite homogeneous terrain, in which small bird populations are relatively visible and uniformly distributed. Such conditions favour the use of walked, linear transect methods over other survey techniques (Bibby *et al.* 2000). The length, number and distribution of these transects on each site may vary according to site size, habitat diversity, and the richness and relative significance of the small terrestrial avifauna. Ideally, all the major habitat types present should be sampled approximately in proportion to their availability on site. Transects should be positioned at varying distances away from the proposed turbine arrays to maximize the value of the data in comparison with post-construction survey results,.

Transects should be walked slowly and carefully, and work should commence from as soon as it is light enough to see clearly in the early morning and extend only until mid-morning, avoiding the warmer middle of the day when birds are less active and vocal, and hence less conspicuous (Bibby *et al.* 2000). If it is not possible to compress all transects into this time period, it is important to otherwise standardize for time of day in project design and/or subsequent data analysis to minimize the possible effect of this factor on survey results. As a general rule, transects should not be walked in adverse conditions, such as heavy rain, strong winds or thick mist. The species, number and perpendicular distance from the transect line of all birds seen should either be measured (preferably using a laser range-finder), estimated by eye, or estimated in terms of pre-selected distance bands (0-10 m, 11-50 m, 51-200 m, >200 m), and recorded for subsequent analysis using DISTANCE (Buckland *et al.* 2010, http://www.ruwpa.st-and.ac.uk/distance/distanceabout.html) or equivalent approaches (Bibby *et al.* 2000). Alternatively, transects can be done with a fixed maximum width, and only birds seen or heard within this distance on either side of the transect line should be recorded (e.g. Leddy *et al.* 1999). These methods yield estimates of density (birds.km^{-2}) for all open country passerines and most other small species, although these estimates are crude for the latter approach as it assumes that the detection rate for different species is constant across the width of the transect (grossly underestimating densities of inconspicuous species). Even distance-based line transects will underestimate actual densities if only a proportion of the population is detected (e.g. singing males). The main concern for comparative studies is that the same technique (and ideally the same observer(s) is used for all counts throughout the pre- and post-implementation monitoring.

The variables recorded for each transect should include:

- Project name
- Transect number
- Date
- Observer/s
- Start/finish time
- GPS location at start and finish
- Distance covered (m)
- Habitat type/mix of habitat types
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)
- Position of sun relative to direction of walk (ahead, above, behind)

  And variables to record for each observation should include:

  - Time
  - Species
  - Number (number of adults/juveniles/chicks)
  - Activity (flushed, flying-display, flying-commute, perched-calling…)
  - Seen or heard?
  - GPS on transect line
  - Distance and direction from observer
  - Perpendicular distance off transect line (m) (if required)
  - Distance band off the transect line (if required)
  - Fixed transect width (if required)
  - Plot on map
  - Additional notes

Another acceptable way to measure small bird densities is to use fixed point counts, in which the observer is positioned at one location (chosen either randomly or systematically to ensure coverage of all available habitats), and records the species and sighting/registration distance of all birds seen over a prescribed period of time. This technique is particularly useful for measuring avian densities in closed habitats with raised and/or dense vegetation (Bibby *et al.* 2000), and can include the use of vocal as well as visual cues as evidence of species presence, particularly valuable in conducting surveys of more cryptic and inconspicuous species (Bibby *et al.* 2000). Again, survey locations should be selected to represent the habitats covered more or less in proportion to their availability. The duration of each count period should be long enough to detect all the birds within the survey area, but short enough to avoid including birds that were not present in the area at the start. As with line transects, the distance from the static observer to each bird or flock of birds registered can either be measured directly (by estimation or using a laser range-finder), or allocated to a range of circular bands of distance from the observer, or else the count can be done with a fixed detection radius, including only the birds seen within this distance (Bibby *et al.* 2000).

The variables recorded for each such fixed point count should include:

- Project name
- Fixed point number
- Date
- Observer/s
- Start/finish time
- GPS location
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

  And variables to record for each observation should include:

  - Time
  - Species
  - Number (number of adults/juveniles/chicks)
  - Activity (flushed, flying-display, flying-commute, perched-calling…)
  - Seen or heard?
  - Distance to bird (m) (if required)
  - Distance band containing bird (if required)
  - Fixed radius of count (m) (if required)
  - Additional notes

Counts of large terrestrial species and raptors

Large terrestrial birds, e.g. cranes, bustards, storks, and most raptors, cannot easily be surveyed using walked transects for reasons discussed above. Populations of such birds should be estimated on each visit to the project area either by means of an 'instantaneous' absolute count (only possible at relatively small proposed WEFs) or by means of vehicle-based sampling (best applied at relatively large proposed WEFs, especially those with good networks of roads and tracks). Any obvious breeding pairs and/or nest sites located during this survey work should be plotted and treated as focal sites for subsequent monitoring (see below).

Absolute counts of key species involves searching as much of the broader impact area of the WEF (or the control site) as possible in the course of a day, using the available road infrastructure (or otherwise walking) and prominent vantage points to access and scan large areas, and simply tallying all the individuals observed. This is only practical for the largest and most conspicuous species, and probably is only effective for cranes and bustards. If necessary, counts can be standardized for observer effort (time, area scanned, methods used), but ideally they will be working estimates of the absolute number of each target species present within the study area on that sampling day.

The variables recorded for each absolute count of large, priority species should include:

- Project name
- Count number
- Date
- Observer/s
- Start/finish time
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

  And variables to record for each observation should include:

  - Time
  - Species
  - Number (number of adults/juveniles/chicks)
  - Activity (flushed, flying-display, flying-commute, perched-calling…)
  - Flight direction (if required)
  - Flying height (if required - <30m, 30-150m, >150m)
  - GPS location of observer
  - Distance and direction from observer
  - Plot birds sighted on map
  - Habitat type/mix of habitats
  - Gradient of slope (flat, gentle, steep)
  - Aspect of slope (none, north, north-east, east…)
  - Seen close to (feedlot, dam, river course, ridge or cliff-line…)
  - Seen while driving/walking/scanning
  - Additional notes

Sample counts of large terrestrial birds and raptors require that one or a number (depending on site size, terrain and infrastructure) of driven transects be established, comprising one or a number of set routes, limited by the existing roadways but as far as possible directed to include a representative cross section of habitats on site. These transects should be driven slowly, and all sightings of large terrestrial birds and raptors should be recorded in terms of the same data capture protocols used for walked transects (above), and in general compliance with the road-count protocols described for large terrestrial species (Young *et al.* 2003) and raptors (Malan 2009). In addition, each transect should include a number of stops at vantage points to scan the surrounding area. If sighting distance is used to delineate the area sampled, this method will yield estimates of density (birds.km^{-2}) for all large terrestrial species and birds of prey. Alternatively, variation in sighting distances (perhaps associated with variable terrain of habitat) may preclude the use of this method, and it may only be possible to determine a simple index of abundance, expressed as the number of birds seen per kilometre driven.

The variables recorded for driven transect count of large terrestrial species and raptors should include:

- Project name
- Transect number
- Date
- Observer/s
- Start/finish time
- GPS location at start/finish
- Odometer reading at start/finish
- Distance covered (km)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

  And variables to record for each observation should include:

  - Time
  - Species
  - Number (number of adults/juveniles/chicks)
  - Activity (flushed, flying-display, flying-commute, perched-calling…)
  - Flight direction (if required)
  - Flying height (if required - <30m, 30-150m, >150m)
  - Seen while driving/scanning?
  - Habitat type/mix of habitat types
  - Gradient of slope (flat, gentle, steep)
  - Aspect of slope (none, north, north-east, east…)
  - Seen close to (feedlot, dam, river course, ridge or cliff-line…)
  - GPS on transect line
  - Perpendicular distance off transect line (m) (if required)
  - Distance band off the transect line (if required)
  - Fixed transect width (if required)
  - Plot on map
  - Additional notes

Focal site surveys and monitoring

Any habitats within the broader impact zone of the proposed WEF, or an equivalent area around the control site, deemed likely to support nest sites of key raptor species (including owls) - cliff-lines or quarry faces, power lines, stands of large trees, marshes and drainage lines - should be surveyed using documented protocols (Malan 2009) in the initial stages of the monitoring project. All such sites should be mapped accurately, and checked on each visit to the study area to confirm continued occupancy, and to record any breeding activity, and the outcomes of such activity, that may take place over the survey period (Scottish Natural History 2005). Any nest sites of large terrestrial species (e.g. bustards and especially cranes) that may be located should be treated in the same way, although out of season surveys are unlikely to yield results as these birds do not hold year-round territories.

The variables recorded for each nest site survey should include:

- Project name
- Date
- Observer/s
- Species
- Site name, number or code
- Type of site (nest, roost, foraging…)
- Time checked
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)
- Signs of occupation (fresh droppings, fresh food remains, freshly moulted feathers…)
- Signs of breeding activity (adults at nest, adult incubating or brooding, eggs or nestlings…)
- Number of adults/eggs/nestlings/juveniles seen
- Additional notes

The major wetlands on and close to the development area should also be identified, mapped and surveyed for waterbirds on each visit to the site, using the standard protocols set out by the CWAC initiative (Taylor *et al.* 1999).

The variables recorded for each wetland survey should include:

- Project name
- Date
- Observer/s
- Wetland name, number or code
- Time at start/finish of count
- GPS location at observation point
- Temperature
- Cloud cover

- Wind strength/direction
- Visibility (good, moderate, poor)

  And variables to record for each species counted should include:

  - Species
  - Number (number of adults/juveniles/chicks)
  - Direction of arrival/departure from wetland (if applicable)
  - Additional notes

Incidental observations

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 should be carefully plotted and documented. These could include details of nocturnal species (especially owls) heard calling at night.

The variables recorded for each incidental observation of priority species should include:

- Project name
- Date
- Observer/s
- Time
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (if required - <30m, 30-150m, >150m)
- GPS location of observer
- Plot birds sighted on map
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Seen close to (feedlot, dam, river course, ridge or cliff-line…)
- Seen while driving/walking/scanning
- Additional notes

2.2.2 Bird movements

A spatially explicit understanding of bird movements in and around a proposed WEF site may be more important to determining the sustainability of the project, and to informing an effective mitigation strategy, than knowledge of the numbers of key species present. Developing such an understanding requires a significant investment of time and effort, and may require the use of expensive, highly technical remote sensing equipment.

Figure 1. *The location of properties included in WEF development proposals in the Saldanha Bay/Velddrif area in relation to key wetland and coastal bird sites on the Lower Berg River, and at Saldanha Bay and Langebaan Lagoon. Anticipated, large-scale, nocturnal movements of birds between these resource areas, and through the proposed wind energy development area, necessitate the use of radar for effective baseline monitoring.*

Radar

The state of the art in monitoring bird movements in relation to WEFs involves the use of custom-built radar installations (e.g. http://www.detect-inc.com/wind.html). When set up correctly, these systems can provide round-the-clock coverage of a sizeable area in all weather conditions. They are expensive, and cannot easily distinguish between different species, types or even sizes of birds, but when used in combination with limited direct observation (primarily to calibrate and ground-truth remotely collected information), they are likely to provide the most comprehensive and accurate data possible describing the frequency, height and direction of bird flight paths through a proposed or operational wind farm. The use of a radar system is likely to add significant value to any monitoring project, but may be essential and non-negotiable for use at certain sites as the only means to obtain critical data on large scale movements of birds, or movements of significant numbers of highly threatened species, thought or known to take place at night or in conditions of poor visibility.

Such a situation pertains in the Cape West Coast area between Vredenburg and Velddrif, and including the Cape Columbine Peninsula. This relatively small area lies directly between the West Coast National Park (including Langebaan Lagoon and the Saldanha Bay islands) and the Lower Berg River estuary. Both these locations are listed as Important Bird Areas (Barnes 1998), and between them support 10 000s of waterbirds, and 100 000s of coastal seabirds (including large numbers of red-listed and/or endemic species such as Great White Pelican *Pelecanus onocrotalus*, Greater Flamingo *Phoenicopterus ruber*, Lesser Flamingo *Phoeniconaias minor*, Cape Cormorant *Phalacrocorax capensis* and Caspian Tern *Hydroprogne caspia*).

At present, at least eight wind energy projects are proposed for this area, possibly covering 1000s of hectares and comprising 100s of turbines. The cumulative impact (Masden *et al.* 2009) of these multiple, close-neighbouring WEFs may be substantial, with a strong likelihood that at least some of the proposed turbine arrays impinge on preferred flight lines of wetland and coastal birds between prime resource areas to the north or south (Figure 1). Many of the larger scale movements made by water birds occur at night, so current understanding of the routes used is extremely poor, and is likely to remain so without the strategic deployment of radar to determine if, when, how and how many birds make these potentially hazardous flights, and under what weather conditions (note that radar functionality is reduced in conditions of heavy rainfall). Such information is vital to ensuring that wind energy development in this area proceeds sustainably.

Direct observation
The use of observers positioned on site is the low-tech, labour intensive alternative to radar. The main advantage of this method is that birds are sighted and identified directly by observers in the field, adding greater species specificity to the information collected. The disadvantages include the tedium of spending hours in the field collecting data, the resulting constraints on the quantities of such data that can be accumulated, the inability of observers to gather meaningful movement data at night or in daytime conditions of low visibility, and the risk that sampling periods will miss or under-represent episodic mass movements of birds (Scottish Natural Heritage 2005).

Counts of bird traffic over and around a proposed/operational facility should be conducted from suitable vantage points which together provide overview of as much of development area as possible (Scottish Natural Heritage 2005). Ideally, vantage points should be spaced a maximum of 2 km apart (Scottish Natural Heritage 2005), but capacity constraints are likely to stretch this distance, particularly at very large WEF sites. GIS can be used to facilitate the identification of vantage points with the best inclusive viewsheds, bearing in mind that ready accessibility for observers is also a significant factor in the final selection. Observation and data collection should ideally be focused in the direction of the proposed development area from the vantage point, extending to 90° on either side of that focal point. Bird movement taking place further ‘behind’ the observers may be relevant, and should be included at the discretion of the site specialist or the fieldworkers at the time, but not at the expense of effective ‘forward’ coverage.

Vantage point watches should extend alternately from before dawn to midday, or from midday to after dusk, so that the equivalent of at least one full day of counts is completed at each vantage point for each site visit. Alternatively, watches can be divided into three hour shifts distributed through the day (early morning, midday, late afternoon), although this may prove impractical at vantage points that are relatively difficult to reach. Either way, scheduling should always allow for the detrimental effects of observer fatigue on data quality. When extended across the 12 month monitoring period, these sorts of regimens should provide an adequate (if minimal) sample of bird movements around the facility in relation to a representative cross-section of conditions and times of day (Erickson *et al.* 1999, Scottish Natural Heritage 2005, Krijgsveld *et al.* 2009). Note that nighttime watches coincident with clear, moonlit conditions would also be valuable at sites where nocturnal activity is considered likely or possible.

The purpose of vantage point watches is to collect data on priority species to allow estimation of:

- The time spent flying over the proposed development area
- The relative use of different parts of the development area
- The proportion of flying time spent within the upper and lower height limits as determined by the rotor diameter and rotor hub height of the turbines to be used
- The flight activity of other bird species using the development area.

The variables recorded for each vantage point survey should include:

- Project name
- Vantage point name/number
- Date
- Observer/s
- Start/finish time
- GPS location
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

  And variables to record for each observation should include:

  - Time sighted
  - Species
  - Number (number of adults/juveniles/chicks) at start and end of observation
  - Temperature
  - Cloud cover
  - Wind strength/direction
  - Visibility (good, moderate, poor)
  - Initial sighting distance (m)
  - Flight mode (direct commute-flapping, direct commute-gliding, slope soaring…)*
  - Underlying habitat*

- Gradient of underlying slope (flat, gentle, steep)*
- Aspect of slope (none, north, north-east, east…)*
- Flight direction*
- Flying height (<30m, 30-150m, >150m)*
- Identifiable flight path indicators (valley, neck or saddle, ridge line, thermal source…)
- Time lost
- Plot on map
- Additional notes

Note, variables marked * should be recorded at 15-30 second intervals from the initial sighting, or at least with every change in flight mode, until the bird/flock of birds is lost.

Data gathered in this way can be used to model collision mortality risk (Scottish Natural Heritage 2009, Band *et al.* 2007), assuming that birds included in measures of passage rate through the proposed rotor-swept area will take no avoiding action once the turbines are erected and operational. Such models can then be refined as information on actual avoidance rates in key species is accumulated during post-construction observations at working WEFs.

2.3 Stage 3: Post-construction monitoring

The primary aims of post-construction monitoring are to:

(i) Estimate the numbers/densities of birds regularly present or resident within the broader impact area of the operational WEF.
(ii) Document patterns of bird movements in the vicinity of the operational WEF.
(iii) Compare these data with baseline figures and hence quantify the impacts of displacement and/or collision mortality.
(iv) Quantify and qualify bird collisions with the turbine arrays, as well as additional mortality associated with power lines and other ancillary infrastructure (e.g. Anderson 2001, Lehman *et al.* 2007, Jenkins *et al.* 2010, Shaw *et al.* 2010a & b).
(v) Mitigate impacts of the development by informing ongoing management of the WEF.

2.3.1 Bird numbers and movements

All methods used to estimate bird numbers and movements during baseline monitoring should be applied in exactly the same way to post-construction work in order to ensure the comparability of these two data sets. Further detail on any differences in field techniques and data requirements (e.g. the timing of commencement of post-construction monitoring, the duration over which data collection should be carried out, the need to record bird reactions to the presence of operational turbines) will be provided in a later update of this document. For now, it is important to note that post-construction monitoring should be started as soon as possible after the first turbines become operational to ensure that the immediate effects of the facility on resident and passing birds are recorded, before they have time to adjust or habituate to the development, and should run over a period of at least 12 months.

2.3.2 Avian collisions

The primary aims of avian collision monitoring are to:

(i) Record and document the circumstances surrounding all avian collisions with the turbines, and all bird mortalities caused by ancillary infrastructure of the WEF.
(ii) To quantify the direct effects of the WEF on collision susceptible species.
(iii) To mitigate impacts by informing final operational planning and ongoing management.

Collision monitoring should have two components: (i) experimental assessment of search efficiency and scavenging rates of bird carcasses on the site, (ii) regular searches of the vicinity of the wind farm for collision casualties (Morrison 2002, Barrios & Rodríguez 2004, Krijgsveld *et al.* 2009).

Assessing search efficiency and scavenging rates

The value of surveying the area for collision victims only holds if some measure of the accuracy of the survey method is developed (Morrison 2002). To do this, a sample of suitable bird carcasses (of similar size and colour to a variety of the priority species – e.g. Egyptian Goose *Alopochen aegyptiaca*, domestic waterfowl and pigeons) should be obtained and distributed randomly around the site without the knowledge of the field teams, some time before the site is surveyed. This process should be repeated opportunistically (as and when suitable bird carcasses become available) for the first two-three visits to the site post-construction, with the total number of carcasses set out not less than 20, but not so plentiful as to saturate the food-supply for the local scavengers (Smallwood 2007). The proportion of the carcasses located in surveys will indicate the relative efficiency of the survey method (Morrison 2002, Barrios & Rodríguez 2004, Krijgsveld *et al.* 2009). The location of all carcasses not detected by the survey team should be checked subsequently to discriminate between error due to search efficiency (those carcasses still in place which were missed) and scavenge rate (those immediately removed from the area).

Simultaneous to this process, the condition and presence of all the carcasses positioned on the site should be monitored throughout the initial surveys period, to determine the rates at which carcasses are scavenged, or decay to the point that they are no longer obvious to the field workers. This should provide an indication of scavenge rate that should inform subsequent survey work for collision victims, particularly in terms of the frequency of surveys required to maximise survey efficiency and/or the extent to which estimates of collision frequency should be adjusted to account for scavenge rate (Osborn *et al.* 2000, Morrison 2002). Scavenger numbers and activity in the area may vary seasonally so, ideally, scavenge and decomposition rates should be measured at least twice over a monitoring year, once in winter and once in summer.

Collision victim surveys

The area within a radius of at least 80-120 m of each of the turbines (depending on rotor length) at the facility should be checked regularly for bird casualties (e.g. Anderson *et al.* 1999, Morrison 2002, Smallwood & Thelander 2008, de Lucas *et al.* 2008). The frequency of these surveys should be informed by assessments of scavenge and decomposition rates conducted in the initial stages of the monitoring period (see above), but they should be done at least weekly over the first two months of the study. The area around each turbine, or a larger area encompassing the entire facility, should be divided into quadrants, and each should be carefully and methodically searched for any sign of a bird collision incident (carcasses, dismembered body parts, scattered feathers, injured birds). All suspected collision incidents should be comprehensively documented, detailing the following variables:

- Project name
- Date
- Time
- Species
- Number adults/juveniles
- GPS location/s
- Condition of remains
- Nearest turbine number
- Distance to nearest turbine
- Compass bearing to nearest turbine
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Plot on map
- Photograph the collision site as it was located

All physical evidence should then be collected, bagged and carefully labeled, and refrigerated or frozen to await further examination. If any injured birds are recovered, each should be contained in a suitably-sized cardboard box. The local conservation authority should be notified and requested to transport casualties to the nearest reputable veterinary clinic or wild animal/bird rehabilitation centre. In such cases, the immediate area of the recovery should be searched for evidence of impact with the turbine blades, and any such evidence should be fully documented (as above), including outcome and possible post-mortem.

In tandem with surveys of the wind farm for collision casualties, sample sections of any new lengths of power line associated with the development should also be surveyed for collision and/or electrocution victims using established protocols (Anderson 2001, Shaw *et al.* 2010 a, b).

3. INPUTS TO THE ENVIRONMENTAL MANAGEMENT PLAN

Avian monitoring projects should be integral to the Environmental Management Plan (EMP) for each proposed facility, in order to ensure that the resulting WEF is sustainable in terms of its impact on local avifauna.

Important issues relevant to avian monitoring to consider in developing the EMP:

- Getting the monitoring protocols right – i.e. customizing the generic guidelines to suite the specific issues at each site.
- Securing adequate budget from the developer to cover the costs of monitoring.
- Securing the strategic use of radar (should this be required).
- Selecting and training a good monitoring team.
- Collecting and collating sufficient accurate baseline survey and monitoring data.
- Analysing the baseline survey data to inform the final site selection, turbine layout and construction schedule for the proposed WEF.
- Collecting and collating sufficient accurate monitoring and survey data post-construction.
- Analysing the post-construction survey data to inform the sustainable management of the facility.

Important actions relevant to avian monitoring for inclusion in the EMP:

- Appointing an advising scientist and a monitoring agency to conduct pre- and post-construction monitoring.
- Refining the monitoring protocol and determining the extent of radar deployment required.
- If radar use is warranted, acquiring/hiring hardware, software and relevant expertise including appointing radar technologists to service the project.
- Starting baseline monitoring.
- Periodically collating and analysing baseline monitoring data.
- Compiling a report reviewing the full year of baseline monitoring, and integrating these findings into the construction EMP and the broader mitigation scheme.
- Ensuring that the construction EMP is applied.
- Refining the post-construction monitoring protocol in terms of the baseline work, and determining the extent of radar deployment required.
- Start post-construction monitoring.
- Periodically collating an analysing post-construction monitoring data.
- Compiling a report reviewing the full year of post-construction monitoring, and integrating findings into the operational EMP and the broader mitigation scheme.
- Reviewing the frequency for further post-construction monitoring.

4. DATA MANAGEMENT

While analysis and reporting on an individual WEF basis will be the responsibility of the relevant avifaunal specialist, all data emanating from the above process should also be housed centrally by EWT/BirdLife South Africa (with BAWESG guidance) to facilitate the assessment of results on a multiple WEF, landscape and national scale. Permission to publish the findings of such analysis in the relevant media by EWT/BirdLife South Africa, BAWESG or by accredited academic institutions should be obtained from the developer before the onset of monitoring (and hopefully will not be unreasonably withheld). This pooling of information is in the interests of collective understanding and building a sustainable renewable energy industry in southern Africa.

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Appendix 6.2: Bird habitat at the proposed Banna Ba Pifhu wind facility site

Figure 1: Irrigated pastures

Figure 2: Dryland pastures

Figure 3: Scrub

Figure 4: Wetland

Figure 5: Thicket

Appendix 6.3: List of species recorded at the proposed Banna Ba Pifhu wind facility site

African Black Swift	*Anhinga rufa*
African Darter	*Haliaeetus vocifer*
African Fish-eagle	*Apus barbatus*
African Goshawk	*Circus ranivorus*
African Marsh Harrier	*Anthus cinnamomeus*
African Pipit	*Ortygospiza atricollis*
African Quailfinch	*Platalea alba*
African Sacred Ibis	*Saxicola torquatus*
African Spoonbill	*Falco amurensis*
African Stonechat	*Tachymarptis melba*
Alpine Swift	*Hirundo rustica*
Amur Falcon	*Apalis thoracica*
Barn Swallow	*Circus maurus*
Bar-Throated Apalis	*Lybius torquatus*
Black Harrier	*Ardea melanocephala*
Black-backed puffback	*Vanellus*
Black-Collared Barbet	*Oriolus larvatus*
Black-headed Heron	*Anthropoides paradiseus*
Black-headed Oriole	*Telophorus zeylonus*
Blacksmith Lapwing	*Crithagra sulphuratus*
Black-winged Lapwing	*Riparia paludicola*
Blue Crane	*Serinus canicollis*
Bokmakierie	*Corvus capensis*
Brimstone Canary	*Lamprotornis nitens*
Brown-Throated Martin	*Macronyx capensis*
Burchell's Coucal	*Cossypha caffra*
Cape Batis	*Anas smithii*
Cape Canary	*Passer melanurus*
Cape Crow	*Streptopelia capicola*
Cape Glossy Starling	*Motacilla capensis*
Cape Longclaw	*Anas capensis*
Cape robin-chat	*Ploceus capensis*
Cape Shoveler	*Cisticola textrix*
Cape Sparrow	*Bubulcus ibis*
Cape Teal	*Lanius collaris*

Cape Turtle-Dove	*Coturnix coturnix*
Cape Wagtail	*Sturnus vulgaris*
Cape Weaver	*Estrilda astrild*
Cape White-eye	*Vanellus coronatus*
Cattle Egret	*Neotis denhami*
Cloud Cisticola	*Dicrurus adsimilis*
Common Fiscal	*Alopochen aegyptiaca*
Common Quail	*Stenostira scita*
Common Sandpiper	*Megaceryle maximus*
Common Starling	*Hirundo cucullata*
Common Waxbill	*Coracias garrulus*
Crowned Lapwing	*Egretta alba*
Denham's Bustard	*Egretta garzetta*
Diderick Cuckoo	*Bostrychia hagedash*
Egyptian Goose	*Numida meleagris*
European Roller	*Passer domesticus*
Fiscal Flycatcher	*Buteo rufofuscus*
Forest Canary	*Larus dominicanus*
Fork-tailed Drongo	*Charadrius pecuarius*
Giant Kingfisher	*Euplectes progne*
Great Egret	*Galerida magnirostris*
Greater Striped Swallow	*Apus affinis*
Green wood-hoopoe	*Anthus similis*
Grey Heron	*Cisticola tinniens*
Hadeda ibis	*Cisticola fulvicapilla*
Hamerkop	*Hirundo dimidiata*
Helmeted Guineafowl	*Falco peregrinus*
House Sparrow	*Vidua macroura*
Jackal Buzzard	*Turdus olivaceus*
Kelp Gull	*Calandrella cinerea*
Kittlitz's Plover	*Streptopelia semitorquata*
Knysna Woodpecker	*Fulica cristata*
Lanner Falcon	*Pternistis afer*
Large-billed Lark	*Phalacrocorax africanus*
Levaillant's Cisticola	*Falco rupicolus*
Little Egret	*Hirundo fuligula*
Little Grebe	*Mirafra africana*
Little Swift	*Telophorus olivaceus*
Long-billed Pipit	*Andropadus importunus*
Long-tailed Widowbird	*Laniarius ferrugineus*

Neddicky	*Columba guinea*
Olive Bush-shrike	*Eupodotis senegalensis*
Olive Thrush	*Euplectes orix*
Pearl-breasted Swallow	*Threskiornis aethiopicus*
Peregrine Falcon	*Colius striatus*
Pied Crow	*Burhinus capensis*
Pin-tailed Whydah	*Plectropterus gambensis*
Red-billed Teal	*Buteo vulpinus*
Red-Capped Lark	*Cisticola lais*
Red-chested Cuckoo	*Ciconia ciconia*
Red-eyed Dove	*Phalacrocorax lucidus*
Red-knobbed coot	*Corvus albicollis*
Red-necked Spurfowl	*Apus caffer*
Reed Cormorant	*Anas undulata*
Rock Kestrel	*Cisticola juncidis*
Rock Martin	*Accipiter tachiro*
Rufous-naped Lark	*Dryoscopus cubla*
Sombre Greenbul	*Vanellus armatus*
Southern Boubou	*Centropus burchellii*
Southern Grey-headed Sparrow	*Batis capensis*
Southern Red Bishop	*Zosterops virens*
Southern Tchagra	*Actitis hypoleucos*
Speckled Mousebird	*Chrysococcyx caprius*
Speckled Pigeon	*Crithagra scotops*
Spotted Thick-knee	*Phoeniculus purpureus*
Spur-winged Goose	*Ardea cinerea*
Steppe Buzzard	*Scopus umbretta*
Tambourine Dove	*Campethera notata*
Wailing Cisticola	*Falco biarmicus*
White Stork	*Tachybaptus ruficollis*
White-bellied Korhaan	*Corvus albus*
White-Breasted Cormorant	*Anas erythrorhyncha*
White-Necked Raven	*Cuculus solitarius*
White-rumped Swift	*Passer diffusus*
White-throated Swallow	*Tchagra tchagra*
White-winged Tern	*Turtur tympanistria*
Wood Sandpiper	*Hirundo albigularis*
Yellow Bishop	*Chlidonias leucopterus*
Yellow Canary	*Tringa glareola*
Yellow-billed Duck	*Euplectes capensis*

Yellow-fronted Canary	*Crithagra flaviventris*
Zitting Cisticola	*Crithagra mozambicus*