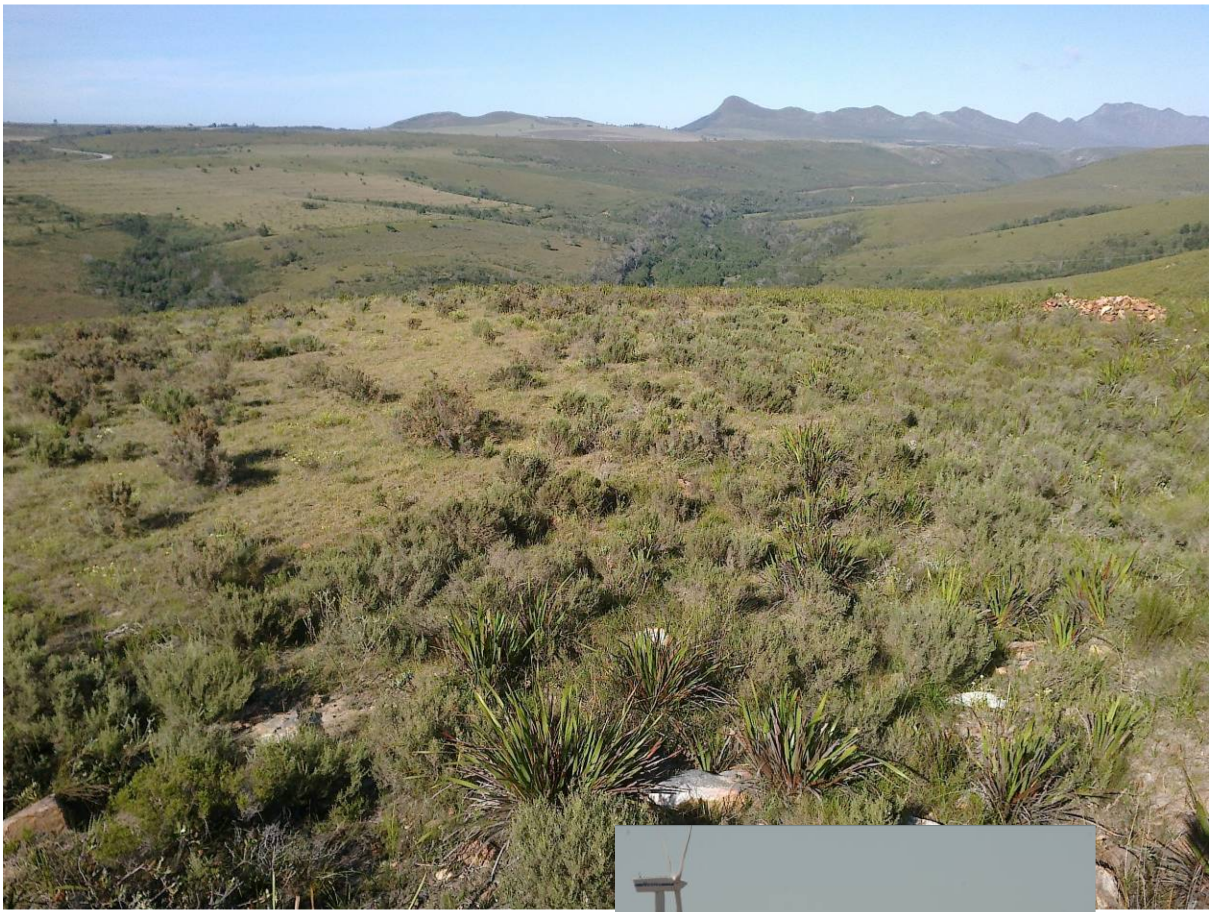
DEEP RIVER WIND ENERGY FACILITY

Avian impact assessment



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EXECUTIVE SUMMARY

This study contains an extensive review of relevant literature on wind energy impacts on birds, and identifies potential impacts of the proposed Deep River Wind Energy Facility on the avifauna of the Humansdorp area of the Eastern Cape, South Africa. These expected impacts are: habitat destruction by construction of the facility itself and any ancillary infrastructure, disturbance and possible displacement of sensitive species by the operation of the facility, and mortality in collision with the blades of the wind turbines, or in collision or electrocution incidents associated with ancillary infrastructure.

The impact zone of the proposed wind energy facility features a mixture of Fynbos, Renosterveld and grassy pasturelands, set in an area of undulating relief, traversed by the Krom and Diep Rivers, and with scattered patches of forest (including stands of alien trees) and artificial impoundments of various sizes. The area is likely to support over 240 bird species, including 19 red-listed species, 41 endemics, and five red-listed endemics. Resident and/or seasonal influxes of Denham's Bustard *Neotis denhami* and Whitebellied Korhaan *Eupodotis senegalensis*, flocks or breeding pairs of Blue Crane *Anthropoides paradiseus*, a range of locally resident or visiting raptors, including Martial Eagle *Polemaetus bellicosus*, African Crowned Eagle *Stephanoeatus coronatus*, African Marsh Harrier *Circus ranivorus*, Black Harrier *Circus maurus*, Peregrine Falcon *Falco peregrinus* and Lanner Falcon *F. biarmicus* foraging in or moving through the area, and a suite of smaller, restricted range endemics, including Knysna Woodpecker *Campethera notata* and Knysna Warbler *Bradypterus sylvaticus*, are the species of greatest conservation significance which are most likely to be impacted by the wind energy facility, both in terms of the anticipated collision and disturbance impacts of the development.

The proposed Deep River Wind Energy Facility could have a significant, long-term impact on components of the avifauna of the surrounding area. The most obvious and immediate negative impacts are likely to be on the bustards and cranes which forage and possibly nest on the site, and on the soaring raptors which may visit the area from nesting or roosting sites nearby. These priority species may be disturbed by the construction of the wind energy facility, and/or lose foraging habitat (in terms of the area covered by the construction footprint and by displacement from areas with operating turbines), and/or sustain mortalities in collisions with the turbine blades, or by collision with or electrocution on the new power infrastructure.

These effects may be reduced to acceptable and sustainable levels by adherence to a proposed mitigation scheme. A comprehensive programme to fully monitor the actual impacts of the facility on the broader avifauna of the area is recommended and outlined, from pre-construction and into the operational phase of the project. Full clarity on the likely environmental impact of this facility can only be reached once pre-construction monitoring has been completed.

CONSULTANT'S DECLARATION OF INDEPENDENCE

Andrew Jenkins (*AVISENSE* Consulting) is an independent consultant to Savannah Environmental Pty (Ltd) and VentuSA Energy. He has no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of this specialist performing such work.

1. INTRODUCTION

VentuSA Energy is planning to construct a wind energy facility (project name 'Deep River Wind Energy Facility') just north-east of the town of Gouda, Western Cape Province, South Africa (Fig 1). Savannah Environmental (Pty) Ltd was appointed to do the Environmental Impact Assessment study, and subsequently appointed *AVISENSE* Consulting to conduct the specialist avifaunal assessment. The study was conducted by Dr Andrew Jenkins, an ornithologist with over 20 years of experience in avian research and impact assessment work. He has been involved in the design and/or execution of many of the completed EIA and EMP studies for wind energy facilities in South Africa to date, including two of the three operational facilities, at Darling and Klipheuwel, Western Cape Province.

2. TERMS OF REFERENCE

The terms of reference for this environmental impact study, as supplied by Savannah Environmental (Pty) Ltd, were to provide:

- An indication of the methods used in determining the significance of potential impacts.
- A description of all the environmental issues (pertaining to birds) identified during the EIA process.
- An assessment of the significance of each of the identified direct, indirect and cumulative impacts, in terms of the expected nature, extent, duration, probability and severity of each, as well as in terms of the reversibility of impacts, and the degree to which each can be mitigated.
- A description and comparative assessment of alternatives in the development plan.
- Recommendations on practical mitigation of potentially significant negative impacts for inclusion in the Environmental Management Plan, with an indication of the expected efficacy of such mitigation measures.
- A description of any assumptions, uncertainties or knowledge gaps affecting this assessment.
- An environmental impact statement with a summary of key findings, an assessment of positive and negative implications of the proposed development, and a comparative assessment of identified alternatives.

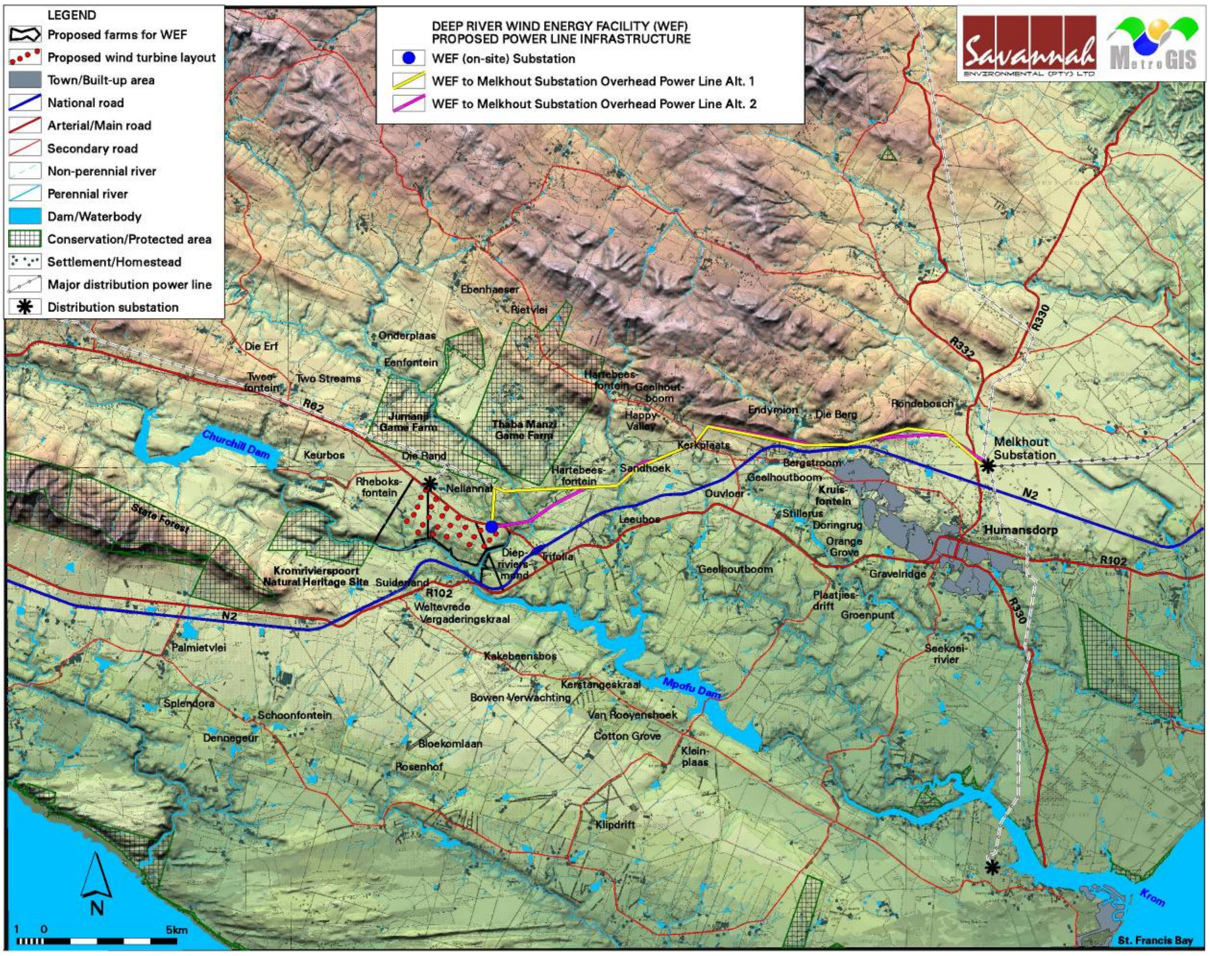

FIGURE 1. General location and layout of the proposed Deep River Wind Energy Facility.

3. STUDY METHODS

3.1. Approach

The initial scoping study, which forms the background to this report, included the following steps:

- A review of available published and unpublished literature pertaining to bird interactions with wind energy facilities is provided summarising the issues involved and the current level of knowledge in this field. Various information sources (listed below), including data on the birdlife of the area and previous studies of bird interactions with wind energy facility and electricity infrastructure, were examined.
- An inclusive, annotated list of the avifauna likely to occur within the impact zone of the proposed wind energy facility was compiled using a combination of the

existing distributional data and previous experience/knowledge of the avifauna of the general area.

- A short-list of priority bird species (defined in terms of conservation status and endemism) which could possibly be impacted by the proposed wind energy facility was extracted from the total bird list. These species were subsequently considered as adequate surrogates for the local avifauna generally, and mitigation of impacts on these species was considered likely to accommodate any less important bird populations that may also potentially be affected.
- A summary of more likely and significant impacts of the wind energy facility on the local avifauna was drawn up, and a brief methodology was devised for the EIA phase for confirming these impacts and developing an effective mitigation strategy.

The present EIA report builds on the scoping study, with emphasis on the outcome of a site visit, made on 10 November 2010. While the scoping phase identified potential avifaunal issues associated with the proposed wind energy facility and its possible associated infrastructure, the EIA investigates these issues in more detail and includes:

- Field surveys of large terrestrial species, raptors and endemic passerines within the study area to determine the relative importance of local populations of these key taxa.
- Refinement of the expected species and priority species lists based on (i), and compilation of SABAP 2 atlas lists for the pentads visited during the site visit.
- Estimates of the extent and direction of possible movements of these species within/through the anticipated impact zone of the wind energy facility, in relation to the distribution of available resources – nesting or roosting sites (wetlands, stands of trees, existing power lines), foraging areas (croplands, wetlands), sources of list for slope soaring birds (ridge lines).
- Identification of any sensitive/high risk areas to locate wind turbines within the broader study area, in terms of (i) to (iii) above.
- Recommendations on mitigation where necessary (particularly with reference to the siting of turbines).
- A comprehensive, long-term programme for monitoring actual impacts from pre- to post-construction phases of the development, and improving our understanding of the long-term effects of wind energy developments on South African avifauna.

3.2. Data sources used

The following data sources and reports were used in the compilation of this report:

- Bird distribution data of the Southern African Bird Atlas Project (SABAP – Harrison *et al.* 1997) were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant quarter-degree squares (SABAP 1: 3424BA Kruisfontein - 51 cards submitted over the atlas period, 205 species recorded) or pentads (SABAP 2: 3400_2430 – five cards submitted so far for this pentad). A composite list of species likely to occur in the impact zone of the wind energy facility was drawn up as a combination of these data, refined by a more specific assessment of the actual habitats affected, based on general knowledge of the avifauna of the region (APPENDIX 1).
- Conservation status and endemism of all species considered likely to occur in the area was determined as per the most recent iteration of the national Red-list for birds (Barnes 2000), informed by a more recent revision for raptors (Jenkins 2008a), the most recent iteration of the global list of threatened species (http://www.iucnredlist.org), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- Data from the Animal Demography Unit's Coordinated Avifaunal Roadcount project (CAR: http://car.adu.org.za/, Young *et al.* 2003), and Coordinated Waterbird Counts (CWAC: http://cwac.adu.org.za/, Taylor *et al.* 1999).
- Data from the Animal Demography Unit's Coordinated Avifaunal Roadcount project (CAR: http://car.adu.org.za/, Young *et al.* 2003).
- EIA reports and any subsequent monitoring reports on the potential impacts on birds of other proposed and/or constructed and operational wind energy facilities in South Africa (e.g. van Rooyen 2001a, Küyler 2004, Jenkins 2008b, 2009).

3.3. Limitations & assumptions

Any inaccuracies in the above sources of information could limit this study. The SABAP 1 data for this area are comprehensive but they are now >15 years old (Harrison *et al.* 1997), a problem that is compounded by the relative lack of more recent, SABAP 2 data for the area. This deficiency was partially addressed by the short visit to the site.

Given that there are currently only three, very small wind energy facilities operational in South Africa (totaling only 8 turbines between them), practical experience of the environmental effects of wind energy facilities in this country is extremely limited, and we must base our estimates of the possible impacts of new facilities largely on lessons learned internationally. While many of the established, general principles can probably be usefully applied here, care should be taken in adapting international knowledge and experience to uniquely South African birds and conditions.

4. BACKGROUND TO THE STUDY

4.1 Interactions between wind energy facilities and birds

Recent literature reviews (www.nrel.gov, Kingsley & Whittam 2005, Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Stewart *et al.* 2007, Drewitt & Langston 2008, Krijgsveld *et al.* 2009, Sovacool 2009) are essential summaries and sources of information in this field. While the number of comprehensive, longer-term analyses of the effects of wind energy facilities on birds is increasing, and the body of empirical data describing these effects is rapidly growing, scientific research in this field is still in its infancy (Madders & Whitfield 2006, Stewart *et al.* 2007), and much of the available information originates from short-term, unpublished, descriptive studies, most of which have been carried out in the United States, and more recently across western Europe, where wind power generation is a more established and developed industry.

Concern about the impacts of wind facilities on birds first arose in the 1980s when numerous raptor mortalities were detected at facilities at Altamont Pass Wind Resource Area (California, USA) and Tarifa (southern Spain). More recently, there has been additional concern about the degree to which birds avoid or are excluded from the areas occupied by wind energy facilities – either because of the visible action of the turbine blades or because of the noise they generate - and hence suffer a loss of habitat (Larsen & Guillemette 2007, Stewart *et al.* 2007, Devereaux *et al.* 2008. Pearce-Higgins *et al.* 2009). With a few important exceptions, most studies completed to date suggest low absolute numbers of bird fatalities at wind energy facilities (Kingsley & Whittam 2005), and low casualty rates relative to other existing sources of anthropogenic avian mortality on a per structure basis (Crockford 1992, Colson & associates 1995, Gill *et al.* 1996, and Erickson *et al*. 2001).

4.1.1 Collisions with turbines

Collision rates

As more monitoring has been conducted at a growing number of sites, some generic standards and common units have been established, with bird collisions with turbine blades generally measured in mortalities/turbine/year, mortalities/Mega-Watt/year, or mortalities /Giga-Watt Hour (Smallwood & Thelander 2008, Sovacool 2009). Wherever possible, measured collision rates should allow for (i) casualty remains which are not detected by observers (searcher efficiency - Newton & Little 2009), and (ii) casualties which are removed by scavengers before detection, and the rate at which this occurs (scavenger removal rate). Also, although collision rates may appear relatively low in many instances, cumulative effects over time, especially when applied to large, long lived, slow reproducing and/or threatened species (many of which are collision-prone), may be of considerable conservation significance.

The National Wind Co-ordinating Committee (2004) estimates that 2.3 birds are killed per turbine per year in the US outside of California – correcting for searcher efficiency and scavenger rates. However, this index ranges from as low as 0.63 mortalities/turbine/year in Oregon, to as high as 10 mortalities/turbine/year in Tennessee (NWCC 2004), illustrating the wide variance in mortality rates between sites. Curry & Kerlinger (2000) found that only 13% of the >5000 turbines at Altamont Pass, California were responsible for all Golden Eagle *Aquila chrysaetos* and Red-tailed Hawk *Buteo jamaicensis* collisions, but the most recent aggregate casualty estimates for Altamont run to >1000 raptor mortalities/turbine/year, and nearly 3000 mortalities/turbine/year overall (Smallwood & Thelander 2008), including >60 Golden Eagles, and at a mean rate of about 2-4 mortalities/MW/year.

At the Tarifa and Navarre wind energy facilities on the Straits of Gibraltar, southern Spain, about 0.04-0.08 birds are killed per turbine/year (Janss 2000a, de Lucas *et al.* 2008), with relatively high collision rates for threatened raptors such as Griffon Vulture *Gyps fulvus*, of particular concern (Table 1). At the same sites, collisions have also been found to be non-randomly distributed between turbines, with >50% of the vulture casualties recorded at Tarifa being killed by only 15% of the turbine array at the facility (Acha 1997). Collision rates from other European sites are equally variable, with certain locations sporadically problematic (Everaert 2003, Newton & Little 2009, Table 1).

To date, only eight wind turbines have been constructed in South Africa at two pilot wind energy facilities at Klipheuwel and Darling in the Western Cape (van Rooyen 2001, Jenkins 2001, 2003) and, more recently, in the first phase of a bigger development at Coega in the Eastern Cape. An avian mortality monitoring program was established at the Klipheuwel facility once the turbines were operational, involving regular site visits to monitor both bird traffic through the area and detect bird mortalities (Küyler 2004). This study found that (i) 9-57% of birds observed within 500m of the turbines were flying at blade height, and (ii) 0-32% of birds sighted were flying either between the turbines or within the arc of the rotors of the outermost turbines. Five bird carcasses were found on the three-turbine site during the 8-month monitoring period, of which two, a Horus Swift *Apus horus* and a Large-billed Lark *Galerida magnirostris*, were thought to have been killed by collision with turbine blades, indicating a net collision rate for birds of about 1.00 mortality/turbine/year.

It is important to note here that simple estimates of aggregate collision rates for birds are not an adequate expression of biodiversity impact. Rather, consideration must be given to the conservation status of the species affected or potentially affected, and the possibility that even relatively low collision rates for some threatened birds may not be sustainable in the long term.

Causes of collision

Multiple factors influence the number of birds killed at wind energy facilities. These can be classified into three broad groupings: (i) avian variables, (ii) location variables, and (iii) facility-related variables. Although only one study has so far shown a direct relationship between the abundance of birds in an area and the number of collisions (Everaert 2003), it would seem logical to assume that the more birds there are flying through an array of turbines, the higher the chances of a collision occurring. The nature of the birds present in the area is also very important as some species are more vulnerable to collision with turbines than others, and feature disproportionately frequently in collision surveys (Drewitt & Langston 2006, 2008, de Lucas *et al.* 2008). Species-specific variation in behaviour, from general levels of activity to particular foraging or commuting strategies, also affect susceptibility to collision (Barrios & Rodríguez 2004, Smallwood *et al.* 2009). There may also be seasonal and temporal differences in behaviour, for example breeding males displaying may be particularly at risk.

Landscape features can potentially channel birds towards a certain area, and in the case of raptors, influence their flight and foraging behaviour. Ridges and steep slopes are important factors in determining the extent to which an area is used by gliding and soaring birds (Barrios & Rodríguez 2004). High densities of prey will attract raptors, increasing the time spent hunting, and as a result reducing the time spent being observant. Poor weather affects visibility. Birds fly lower during strong headwinds (Hanowski & Hawrot 2000, Richardson 2000), so when the turbines are functioning at their maximum speed, birds are likely to be flying at their lowest, exponentially increasing collision risk (Drewitt & Langston 2006, 2008).

Larger wind energy facilities, with more turbines, are almost by definition more likely to incur significant numbers of bird casualties (Kingsley & Whittam 2005), and turbine size may be proportional to collision risk, with taller turbines associated with higher mortality rates in some instances (e.g. de Lucas *et al.* 2009, but see Howell 1995, Erickson *et al.* 1999, Barclay *et al.* 2007), although with newer technology, fewer, larger turbines are needed to generate equivalent or even greater quantities of power, possibly resulting in fewer collisions per Megawatt of power produced (Erickson *et al.* 1999). Certain turbine tower structures, and particularly the old-fashioned lattice designs, present many potential perches for birds, increasing the likelihood of collisions occurring as birds land at or leave these perch or roost sites. This generally is not a problem associated with more modern, tubular tower designs (Drewitt & Langston 2006, 2008), such as those proposed for this project.

Illumination of turbines and other infrastructure is often associated with increased collision risk (Winkelman 1995, Erickson *et al.* 2001), either because birds moving long distances at night do so by celestial navigation, and may confuse lights for stars (Kemper 1964), or because lights attract insects, which in turn attract birds. Changing constant lighting to intermittent lighting has been shown to reduce nocturnal collision rates (Richardson 2000, APLIC 1994, Jaroslow 1979, Weir 1976) and changing flood-lighting from white to red can reduce mortality rates by up to 80% (Weir 1976).

Spacing between turbines at a wind facility can have an effect on the number of collisions. Some authors have suggested that paths should be left between turbines to allow free passage through the turbine strings (Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Drewitt & Langston 2008). This approach tallies well with wind energy generation principles, which require relatively large spaces between turbines in order to avoid wake and turbulence effects. An alternative perspective suggests that all attempts by birds to fly through wind energy facilities, rather than over or around them, should be discouraged to minimise collision risk (Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Drewitt & Langston 2008). This approach effectively renders the entire footprint of the facility as lost habitat (see below).

Collision prone birds

Collision prone birds are generally either (i) large species and/or species with high ratios of body weight to wing surface area (wing loading), which confers low maneuverability (cranes, bustards, vultures, gamebirds, waterfowl, falcons), (ii) species which fly at high speeds (gamebirds, pigeons and sandgrouse, swifts, falcons), (iii) species which are distracted in flight - predators or species with aerial displays (many raptors, aerial insectivores, some open country passerines), (iv) species which habitually fly in low light conditions, and (v) species with narrow fields of forward binocular vision (Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010, Noguera *et al.* 2010). These traits confer high levels of *susceptibility*, which may be compounded by high levels of *exposure* to man-made obstacles such as overhead power lines and wind turbine areas (Jenkins *et al.* 2010). Exposure is greatest in (i) very aerial species, (ii) species inclined to make regular and/or long distance movements (migrants, any species with widely separated resource areas - food, water, roost and nest sites), (iii) species that regularly fly in flocks (increasing the chances of incurring multiple fatalities in single collision incidents).

Table 1. Results of recent published studies of the effects of wind energy facilities on local avifauna.

Location	***n* wind farm/s assessed**	**Turbine hub height (m)**	***n* turbines**	**Habitat**	**Bird groups assessed**	**Evidence of displacement?**	**Collision rate (birds/turbine/year)**	**Reference**
Tarifa, Southern Spain	2	18-36	66-190	Hilly woodland	Raptors	N/A	Raptors = 0.27, Griffon Vultures = 0.12	Barrios & Rodríguez 2004
Tarifa, Southern Spain	2	28-36	66-190	Hilly woodland	Raptors	N/A	0.04-0.07, mostly Griffon Vultures	de Lucas *et al.* 2008
East Anglia, UK	2	60	8	Croplands	Gamebirds, corvids, larks and see-eaters	Minimal, only gamebirds significantly affected	N/A	Devereaux *et al.* 2008
Altamont Pass, California	1	14-43	5400	Hilly grassland	Various	N/A	4.67 , raptors = 1.94	Smallwood & Thelander 2008
Southern Spain	1	44	16	Hilly woodland	Various	Yes, >75% reduction in raptor sightings	0.03	Farfán *et al.* 2009
Netherlands	3	67-78	7-10	Farmland	Various	N/A	27.0-39.0	Krijgsveld *et al.* 2009
Northumberland, UK	1	30	9	Coastal	Seabirds	N/A	16.5-21.5, mostly large gulls	Newton & Little 2009
N England & Scotland	12	30-70	14-42	Moorland	Gamebirds, shorebirds, raptors, passerines	Yes, 53% reduction in Hen Harrier *Circus cyaneus* sightings, other species also decreased	N/A	Pearce-Higgins *et al.* 2009

Soaring species may be particularly prone to colliding with wind turbines where the latter are placed along ridges to exploit the same updrafts favoured by such birds - vultures, storks, cranes, and most raptors - for cross-country flying (Erickson et al. 2001, Kerlinger & Dowdell 2003, Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010, Noguera *et al.* 2010). Large soaring birds – for example, many raptors and storks - depend heavily on external sources of energy for sustainable flight (Pennycuick 1989). In terrestrial situations, this generally requires that they locate and exploit pockets or waves of rising air, either in the form of bubbles of vertically rising, differentially heated air – thermal soaring - or in the form of wind forced up over rises in the landscape, creating waves of rising turbulence – slope soaring.

Certain species are morphologically specialised for flying in open landscapes with high relief and strong prevailing winds, and are particularly dependent on slope soaring opportunities for efficient aerial foraging and travel. South African examples might include Bearded *Gypaetus barbatus* and Cape Vulture *Gyps coprotheres*, Verreaux's Eagle *Aquila verreauxii*, Jackal Buzzard *Buteo rufofuscus*, Rock Kestrel *Falco rupicolus*, Peregrine Falcon *Falco peregrinus*, Lanner Falcon *Falco biarmicus* and Black Stork *Ciconia nigra* and, to a lesser extent, most other open-country raptors. Such species are potentially threatened by wind energy developments where turbines are situated to exploit the wind shear created by hills and ridge-lines. In these situations, birds and industry are competing for the same wind resource, and the risk that slope soaring birds will collide with the turbine blades, or else be prevented from using foraging habitat critical for their survival, is greatly increased. Evidence of these effects has been obtained from several operational wind energy facilities in other parts of the world – for example relatively high mortality rates of large eagles, buzzards and kestrels at Altamont Pass, California (>1100 raptors killed annually or 1.9 raptor casualties/MW/year, Smallwood & Thelander 2008), and of vultures and kestrels at Tarifa, Spain (0.15-0.19 casualties/turbine/year, Barrios & Rodríguez 2004, de Lucas *et al.* 2008, Table 1), and displacement of raptors generally in southern Spain (Farfán *et al.* 2009) and of large eagles in Scotland (Walker *et al.* 2005) – and one study has shown that the additive impact of wind farm mortality on an already threatened raptor could theoretically cause its localised extinction (Carrete *et al.* 2009).

Mitigating collision risk

The only direct way to reduce the risk of birds colliding with turbine blades is to make the blades more conspicuous and hence easier to avoid. Blade conspicuity is compromised by a phenomenon known as 'motion smear' or retinal blur, in which rapidly moving objects become less visible the closer they are to the eye (McIsaac 2001, Hodos 2002). The retinal image can only be processed up to a certain speed, after which the image cannot be perceived. This effect is magnified in low light conditions, so that even slow blade rotation can be difficult for birds to see.

Laboratory-based studies of visual acuity in raptors have determined that (i) visual acuity appears superior when objects are viewed at a distance, suggesting that the birds may view nearby objects with one visual field and objects further away with another, (ii) moderate motion of the visual stimulus significantly influences acuity, and kestrels may be unable to resolve all portions of an object such as a rotating turbine blade because of motion smear, especially under low contrast or dim lighting conditions, (iii) this deficiency can be addressed by patterning the blade surface in a way which maximises the time between successive stimulations of the same retinal region, and (v) the easiest, cheapest and most visible blade pattern for this purpose, effective across the widest variety of backgrounds, is a single black blade in an array of white blades (McIsaac 2001, Hodos 2002). Hence blade marking may be an important means to reduce collision rates by making the rotating turbine blades as conspicuous as possible under the least favourable visual conditions, particularly at facilities where raptors are known or likely to be frequent collision casualties.

Even if the turbine rotors are marked in this way, many species may still be susceptible to colliding with them, especially during strong winds (when the rotor speed is high and birds tend to fly low and with less control) and when visibility is poor (at night or in thick mist). All other collision mitigation options operate indirectly, by reducing the frequency with which collision prone species are exposed to collision risk. This is achieved mainly by (i) siting farms and individual turbines away from areas of high avifaunal density or aggregation, regular commute routes or hazardous flight behavior, (ii) using low risk turbine designs and configurations, which discourage birds from perching on turbine towers or blades, and allow sufficient space for commuting birds to fly safely through the turbine strings, and (iii) carefully monitoring collision incidence, and being prepared to shut-down problem turbines at particular times or under particular conditions.

Effective mitigation can only be achieved with a commitment to rigorous pre- and post-construction monitoring (see below), ideally using a combination of occasional, direct observation of birds commuting or foraging through and around the wind energy facility, coupled with constant, remote tracking of avian traffic using specialised radar equipment (e.g. see http://www.detect-inc.com/wind.html). Such systems can be programmed to set the relevant turbines to idle as birds enter a pre-determined danger zone around the turbine array, and to re-engage those turbines once the birds have safely passed.

4.1.2 Habitat loss – destruction, disturbance and displacement

Although the final, destructive footprint of most wind energy facilities is likely to be relatively small, the construction phase of development inevitably incurs quite extensive temporary damage or permanent destruction of habitat, which may be of lasting significance in cases where wind energy facility sites coincide with critical areas for restricted range, endemic and/or threatened species. Similarly, construction, and to a lesser extent ongoing maintenance activities, are likely to cause some disturbance of birds in the general surrounds, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - sites are selected to avoid the destruction of key habitats, and construction and final footprints, as well as sources of disturbance of key species, must be kept to an absolute minimum. Some studies have shown significant decreases in the numbers of certain birds in areas where wind energy facilities are operational as a direct result of avoidance of the noise or movement of the turbines (e.g. Larsen & Guillemette 2007, Farfán *et al.* 2009, Table 1), while others have shown decreases which may be attributed to a combination of collision casualties and avoidance or exclusion from the impact zone of the facility in question (Stewart *et al.* 2007). Such displacement effects are probably more relevant in situations where wind energy facilities are built in natural habitat (Pearce-Higgins *et al.* 2009, Madders & Whitfield 2006) than in more modified environments such as farmland (Devereaux *et al.* 2008), and are highly species-specific in operation.

4.1.3 Impacts of associated infrastructure

Infrastructure commonly associated with wind energy facilities may also have detrimental effects on birds. The construction and maintenance of substations, and roadways causes both temporary and permanent habitat destruction and disturbance, and overhead power lines substations and other live ancillary infrastructure may pose an electrocution risk to certain species (Van Rooyen 2004a, Lehman *et al.* 2007, Jenkins *et al.* 2010).

Electrocution on power infrastructure

Avian electrocutions occur when a bird perches or attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004b, Lehman *et al.* 2007). Electrocution risk is strongly influenced by the voltage and design of the hardware installed (generally occurring on lower voltage infrastructure where air gaps are relatively small), and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energised components. Mitigation of electrocution risk involves the use of bird-safe structures (ideally with critical air gaps >2 m), the physical exclusion of birds from high risk areas of live infrastructure, and comprehensive insulation of such areas (van Rooyen 2004b, Lehman *et al.* 2007).

4.2. Description of the proposed wind energy facility

The proposed wind energy facility will be located on portions 4 and 16 of the Farm Diep Rivier's Mond 358, and the remaining extent of Farm 891, in an inclusive area of about 7 km^2, about 18 km west of Humansdorp in the Eastern Cape Province, South Africa (Fig. 1). The facility will comprise 25 wind turbines, with a generating capacity of about 50 MW, and will include a dedicated substation, a new power line link, either to the nearby

Diep River substation, or by one of two alternative routes to the Melkhout substation (Fig. 1), a workshop area, and a network of new or upgraded access and service roads.

5. DESCRIPTION OF THE AFFECTED ENVIRONMENT

5.1 Vegetation of the study area

The affected environment falls at the interface of the Eastern Fynbos-Renosterveld and Albany Thicket bioregions, and the junction of the Fynbos and Albany Thicket biomes (Mucina & Rutherford 2006). The natural vegetation of the study area is dominated by Tsitsikamma Sandstone Fynbos (low montane or undulating proteoid shrubland with an ericoid understorey and interspersed with fynbos thicket), with Langkloof Shale Renosterveld (medium dense shrubland dominated by renosterbos) in the valley bottoms and on the lower slopes (Mucina & Rutherford 2006), and patches of Southern Afrotemperate Forest along the watercourses.

5.2 Avian microhabitats

The area features an open, flattish, grassy, heathland plateau, bound along its south-western and south-eastern edges by the upper reaches of the Krom and Diep Rivers respectively (Fig. 1), with dense pockets of alien-encroached forest in the incised valleys of these rivers, and in their tributaries which drain the plateau to the south. The site is positioned just upstream of the Impofu Dam, and downstream of the Churchill Dam, both impoundments built on the Krom River, and is sandwiched between the N2 highway and the R26 to Kareedouw. Average rainfall in the general area exceeds 650 mm annum, which falls throughout the year with a slight peak in late winter. Altitude averages about 190 m above sea level on site. Land use is mainly cattle and sheep ranching, with limited agriculture. There are no buildings in the proposed development area, and road access is restricted to a sparse network of farm tracks.

FIGURE 2a. Old pasturelands on the main plateau at the proposed Deep River WEF site.

FIGURE 2b. Heathlands (Fynbos/Renosterveld) on the edge of the plateau, sloping away to the forest-choked valley of the Krom River, on the south-western border of the study area.

FIGURE 2c. The proposed development area includes a number of small wetlands.

Avian habitats within the broader impact zone comprise a mix of (i) quite degraded, rocky Fynbos (or Renosterveld) covered ridgeline and slopes, (ii) flat, grassy old pastureland, with small areas of active cultivation, (iii) patches of indigenous/alien forest, and (iv) various forms of wetlands (including the major and minor river courses, and a scattering of natural vleis and small artificial impoundments (Figs 2a-c).

5.3 Avifauna of the impact area

The study area is located about 50 km south-east of the Kouga-Baviaanskloof Complex, 40 km east of the Tsitsikamma National Park, and about 30 km east of the Maitland-Gamtoos Coast – all of which are recognized as national Important Bird Areas (Barnes 1998), and supports a diverse avifauna, including some significant populations of rare, threatened and/or endemic species. Over 240 bird species may occur with some regularity within the anticipated impact zone of the wind energy facility (Appendix 1), including 41 endemic or near-endemic species, 19 red-listed species, and five species – Knysna Woodpecker *Campethera notata*, White-bellied Korhaan *Eupodotis senegalensis*, Blue Crane *Anthropoides paradiseus*, Black Harrier *Circus maurus* and Knysna Warbler *Bradypterus sylvaticus* - which are both endemic and red-listed (Barnes 1998, 2000, Table 1).

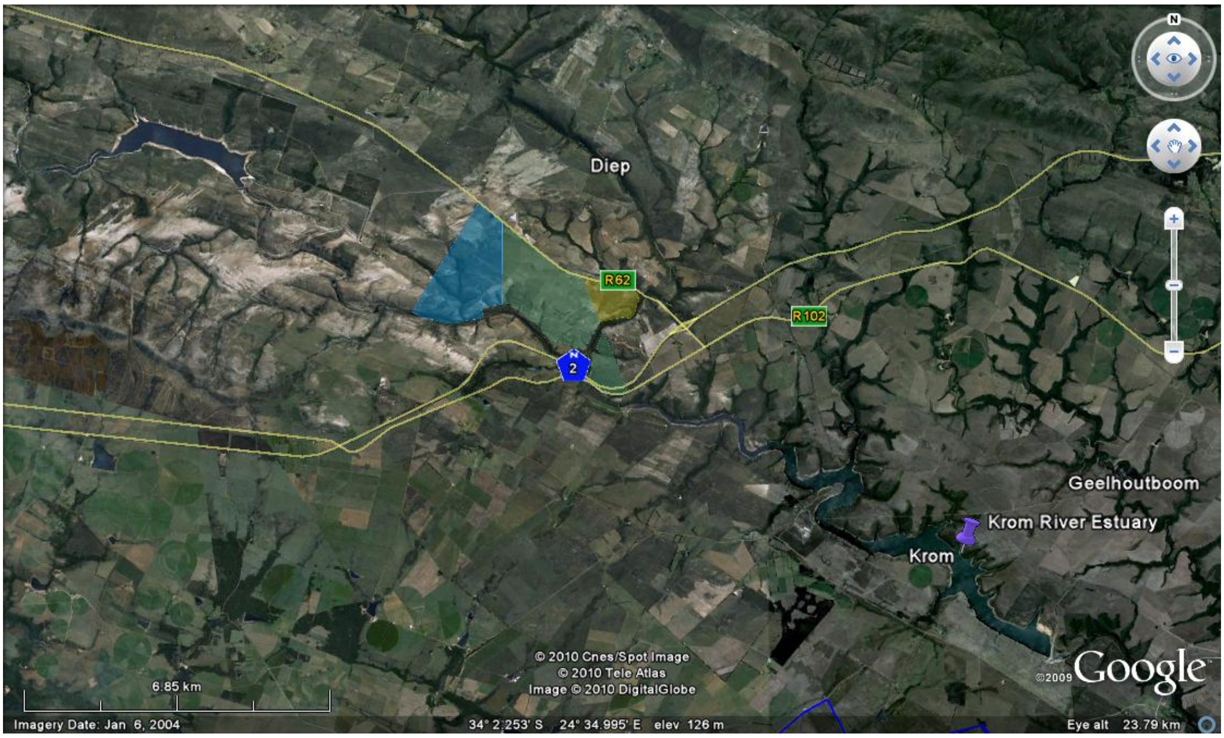

FIGURE 3. Location of the proposed Deep River Wind Energy Facility in relation to the surrounding major rivers and waterbodies.

The coastal plain between Tsitsikamma and Port Elizabeth is arguably the most important area for Denham's Bustard in the country (Young *et al.* 2003), and also supports important numbers of Blue Crane and White-bellied Korhaan. Large wetlands flanking the development area, including at least two large impoundments on the Krom River (Fig. 3), the Krom River Estuary, and the Krom and Diep Rivers themselves, support some wetland birds (although numbers and diversity of birds using the two big impoundments were not that high during the site visit), while areas of high relief along the valleys of both rivers provide (limited) habitat for cliff-nesting raptors, including Lanner and possibly Peregrine Falcon (Jenkins 1994). Forest patches may attract African Crowned Eagle, and possibly support at least one pair of breeding Martial Eagle in the near vicinity. Vlei areas along the river courses will attract African Marsh Harrier, and the Fynbos slopes and/or grassy Renosterveld flats will support Black Harrier as a seasonal visitor (Curtis *et al.* 2004). Seventy-eight species were seen during a site visit on November 29-30 2010 (Appendix 1). Although the visit was short, coverage of the area was good (Fig. 4). Notable observations included:

1. Four sightings of a total of six Denham's Bustard, including displaying and fighting males on the heathland/pastureland ecotone, suggesting that the development area is important for the species, and probably supports nesting birds in season.
2. Sightings of two pairs of Blue Crane, both in open pastureland close to small wetlands, suitable for breeding sites.
3. A single, adult Martial Eagle, soaring over pastureland just to the north of the development area (Fig. 4).

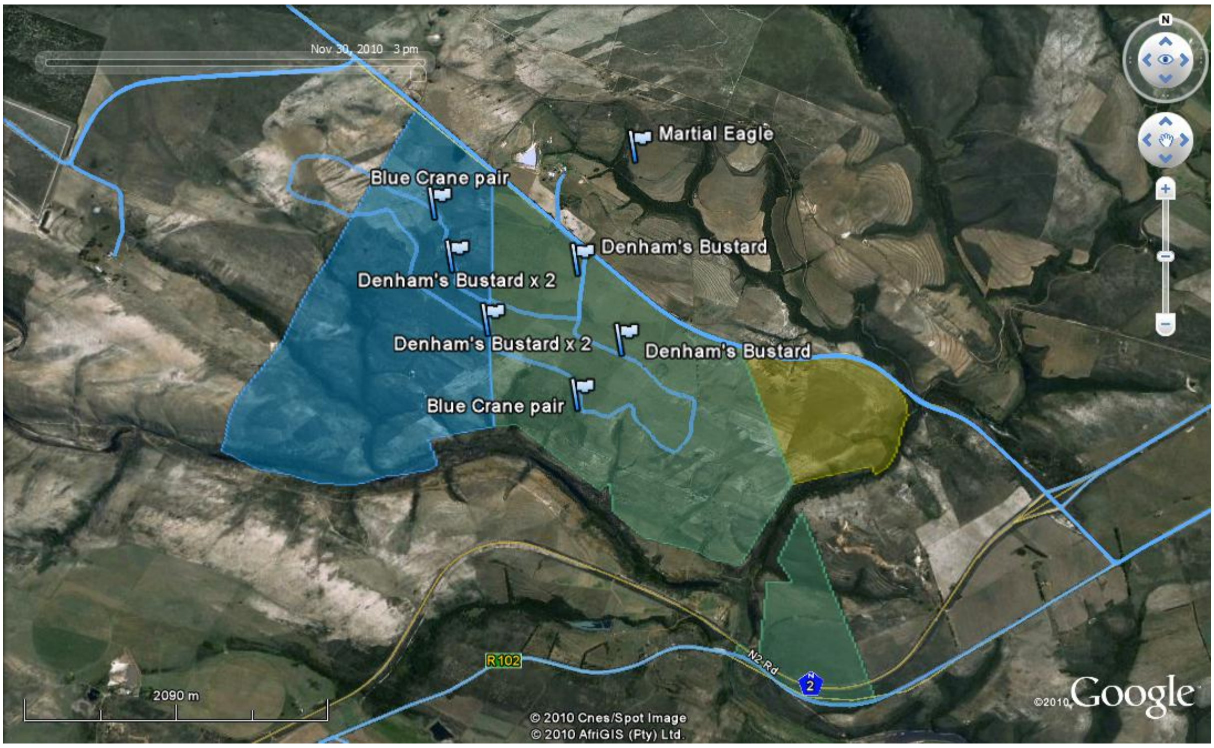

FIGURE 4. Area coverage (blue lines) and the distribution of significant sightings made at the Deep River WEF site during the November site visit.

Table 2. Priority bird species considered central to the avian impact assessment process for the Deep River Wind Energy Facility, selected on the basis of South African (Barnes 2000) or global conservation status (www.iucnredlist.org or http://www.birdlife.org/datazone/species/), level of endemism, relative abundance on site (SABAP reporting rates, direct observation), and estimated conservation or ecological significance of the local population. Red-listed endemic species are shaded in grey.

Common name	Scientific name	SA conservation status / (Global conservation status)	Regional endemism	Average SABAP reporting rate (*N* = 56 cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Knysna Woodpecker	*Campethera notata*		Endemic	0.0	Low	Forest patches	-	-	Moderate
Denham's Bustard	*Neotis denhami*	Vulnerable (Near-threatened)	-	19.6	High	Pasturelands and heathlands	High	-	High
White-bellied Korhaan	*Eupodotis senegalensis*	Near-threatened	Endemic	3.6	Moderate	Pasturelands	Moderate	-	High
Blue Crane	*Anthropoides paradiseus*	Vulnerable (Vulnerable)	Endemic	12.5	Moderate	Croplands, pasturelands and wetlands	High	-	High
Black-winged Lapwing	*Vanellus melanopterus*	Near-threatened	-		Low	Pasturelands	-	-	High
African Marsh Harrier	*Circus ranivorus*	Vulnerable	-	17.9	Moderate	Wetlands, pasturelands and croplands	Moderate	-	Moderate
Black Harrier	*Circus maurus*	Near-threatened (Vulnerable)	Endemic	3.6	Moderate	Heathlands, wetlands and croplands	Moderate	-	High
Martial Eagle	*Polemaetus bellicosus*	Vulnerable (Near-threatened)	-	1.8	Moderate	Heathlands, pasturelands, and forest patches	High	High	Moderate
African Crowned Eagle	*Stephanoeatus coronatus*			0.0	Low	Forest patches			
Secretarybird	*Sagittarius serpentarius*	Near-threatened	-	3.6	Moderate	Pasturelands and heathlands	High	-	Moderate

Common name	**Scientific name**	**SA conservation status / (Global conservation status)**	**Regional endemism**	**Average SABAP reporting rate (*N* = 56 cards)**	**Estimated importance of local population**	**Preferred habitat**	**Risk posed by**		
							Collision	**Electro-cution**	**Disturbance / habitat loss**
Lanner Falcon	*Falco biarmicus*	Near-threatened	-	1.8	Moderate	Pasturelands and croplands	High	Moderate	High
Peregrine Falcon	*Falco peregrinus*	Near-threatened	-	0.0	Moderate	Heathlands and croplands	High	Moderate	-
Lesser Kestrel	*Falco naumanni*	Vulnerable (Vulnerable)	-	0.0	Low	Croplands, pasturelands, forest patches	Moderate	-	-
Amur Falcon	*Falco amurensis*	-	-	0.0	Moderate	Croplands, pasturelands, forest patches	Moderate	-	-
Knysna Warbler	*Bradypterus sylvaticus*	Vulnerable (Vulnerable)	Endemic	1.8	Low	Forest patches	-	-	Moderate
White Stork	*Ciconia ciconia*	-	-	25.0	Moderate	Croplands, pasturelands	High	Moderate	-
Black Stork	*Ciconia nigra*	Near-threatened	-	0.0	Low	Wetlands	High	Moderate	-

While neither Knysna Woodpecker nor Knysna Warbler was seen during the site visit, both are secretive birds and may have been overlooked. Certainly the habitat encountered seemed suitable to support them.

On the basis of these on-site observations, and in combination with the available SABAP atlas data for the general area, 17 priority species are recognised as key in the assessment of avian impacts of the proposed Deep River Wind Energy Facility (Table 2), and as suitable surrogates for impacts on other species. These are mostly nationally and/or globally threatened species which are known to occur, or could occur in relatively high numbers in the development area and which are likely to be, or could be, negatively affected by the wind energy project. Some species are included despite the fact that are not listed by either of the SABAP projects, either because they were seen nearby (Peregrine Falcon *Falco peregrinus*) or because they occur in the general area and the habitat looks suitable (Knysna Woodpecker, Black-winged Plover *Vanellus melanopterus*, African Crowned Eagle *Stephanoaetus coronatus*, Lesser Kestrel *Falco naumanni*, Amur Falcon *Falco amurensis* and Black Stork *Ciconia nigra*). Some (in particular Denham's Bustard, Blue Crane and Martial Eagle) are either known or likely to breed in the general area. Amur Falcon and White Stork *Ciconia ciconia* are neither red-listed nor endemic, but the former probably should be re-classified as threatened (Jenkins 2008a), and the latter is protected under the global Convention on Migratory Species, and occurs in numbers in the area in mid-late summer. In summary, the birds of greatest potential relevance and importance in terms of the possible impacts of the proposed wind energy facility are likely to be:

(i) Resident and/or seasonal influxes of large terrestrial birds, in particular Denham's Bustard and Blue Crane (and including White-bellied Korhaan and White Stork). The former is a widely but patchily spread pan-African species and a regional special, probably occurring permanently on site and may well breed there, while the latter is a threatened, endemic and occurs on site as breeding pairs in summer, and possibly also in large, non-breeding flocks in winter. Both are highly susceptible to collision mortality on power lines (Shaw *et al.* 2010a & b), probably susceptible to turbine collision mortality, and possibly susceptible to disturbance and displacement by the operating wind farm (although experience at the Eskom Klipheuwel Wind Farm site suggests that Blue Crane may be less severely affected – Küyler 2004).

(ii) Resident and breeding and/or visiting raptors, in particular Martial Eagle, and possibly African Crowned Eagle, African Marsh Harrier *Circus ranivorus*, Black Harrier, Secretarybird *Sagittarius serpentarius*, Peregrine Falcon, Lanner Falcon Lesser Kestrel and Amur Falcon. All are soaring species at least to some extent, prone to collision and possibly to displacement by the operating wind farm.

(iii) Localised forest endemics – Knysna Woodpecker and Knysna Warbler. Both have small, patchy ranges limited to the south coastal plain

Table 3. Assessment tables for construction impacts of the proposed Deep River Wind Energy Facility on the local avifauna.

(A) Disturbance

Nature: Noise, movement and temporary occupation of habitat during the building process. Likely to impact all birds in the area to some extent, but sensitive, sedentary and/or habitat specific species will most adversely affected.

	Without mitigation	With mitigation
Extent	Low-Medium (3)	Low-Medium (3)
Duration	Short (1)	Short (1)
Magnitude	Medium (5)	Medium-Low (4)
Probability	Definite (5)	Definite (5)
Significance	45 (Medium)	40 (Medium)
Status	Negative	Negative
Reversibility	Medium	High
Irreplaceable loss?	Possible	Probably not
Can impacts be mitigated?	Yes	

Mitigation: Abbreviating construction time, scheduling activities around avian breeding and/or movement schedules (timing to be determined after pre-construction monitoring), lowering levels of associated noise, and reducing the size of the inclusive development footprint.

Cumulative impacts: Likely, given that several other WEF projects are proposed within a 30 km radius of the site.

Residual impacts: Some priority species may move away regardless of mitigation.

(B) Habitat loss

Nature: Destruction of habitat for priority species, either temporary – resulting from construction activities peripheral to the built area, or permanent - the area occupied by the completed development.

	Without mitigation	With mitigation
Extent	Low (2)	Low (2)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (3)	Low (2)
Probability	Definite (5)	Definite (5)
Significance	50 (Medium)	45 (Medium-Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Possible	Probably not
Can impacts be mitigated?	Yes	

Mitigation: Minimising habitat destruction caused by the construction of the facility by keeping the lay-down areas as small as possible, building as few temporary roads as possible, and reducing the final extent of developed area to a minimum.

Cumulative impacts: Yes, more wind energy developments in the immediate area will increase habitat losses exponentially. At least six are known within a 30 km radius.

Residual impacts: Some species may be permanently lost to the area regardless of mitigation.

Table 4. Assessment tables for operational impacts of the proposed Deep River Wind Energy Facility on the local avifauna.

(A) Disturbance

Nature: Noise and movement generated by operating turbines and maintenance activities is sufficient to disturb priority species, causing displacement from the area, adjustments to commute routes with energetic costs, or otherwise affecting nesting success or foraging efficiency.

	Without mitigation	**With mitigation**
Extent	Low-Medium (2)	Low-Medium (2)
Duration	Lifetime of the facility (4)	Lifetime of the facility (4)
Magnitude	Medium-High (8)	Medium (7)
Probability	Highly probable (4)	Highly probable (4)
Significance	56 (Medium-High)	48 (Medium)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Possible	Possible
Can impacts be mitigated?	Slightly	

Mitigation: Abbreviating maintenance times, scheduling activities in relation to avian breeding and/or movement schedules (timing to be determined after pre-construction monitoring), and lowering levels of associated noise.

Cumulative impacts: Considerable potential, especially given that there are many other projects proposed for the same general area.

Residual impacts: Some priority species may be permanently lost from the area.

(B) Mortality

Nature: Collision of priority species with the wind turbine blades lines, or electrocution of the same on new power infrastructure.

	Without mitigation	**With mitigation**
Extent	Medium (3)	Low-Medium (2)
Duration	Lifetime of the facility (4)	Lifetime of the facility (4)
Magnitude	High (8)	Medium-High (7)
Probability	Highly probable (4)	Probable (4)
Significance	60 (Medium-High)	52 (Medium)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Yes	Possibly not
Can impacts be mitigated?	Yes	

Mitigation: Careful siting of turbines, painting turbine blades, bird friendly power hardware, monitoring priority bird movements and collisions, turbine management sensitive to these data – radar assisted if necessary.

Cumulative impacts: Yes, if more turbines are built in the same general area (which seems likely), more collision hot-spots are likely, and mortality rates may increase exponentially.

Residual impacts: Some casualties may be incurred regardless of mitigation.

6. IMPACT ASSESSMENT

Impacts of the proposed Wind Energy Facility are most likely to be manifest in the following ways (Tables 3 & 4):

(i) Disturbance and displacement of resident/breeding or non-breeding large terrestrial birds (especially Denham's Bustard) from nesting and/or foraging areas by construction and/or operation of the facility, and /or mortality of these birds in collisions with the turbine blades while commuting between resource areas (croplands, nest sites, roost sites/wetlands).

(ii) Disturbance and displacement of resident/breeding or visiting raptors (especially Martial Eagle) from foraging areas by construction and/or operation of the facility, and /or mortality of these species in collisions with the turbine blades or the new power lines while flying/foraging in the area, or by electrocution when perched on power infrastructure.

(iii) Disturbance and displacement of localised forest endemics – Knysna Woodpecker and Kynsna Warbler.

Mitigation of these impacts will be best achieved in the following ways:

(i) Minimising the disturbance impacts associated with the construction of the facility, by abbreviating construction time, scheduling activities around avian breeding and/or movement schedules (actual timing to be refined by the results of pre-construction monitoring), and lowering levels of associated noise. Possible Denham's Bustard and Blue Crane nest sites particularly relevant here.

(ii) Minimising habitat destruction caused by the construction of the facility by keeping the lay-down areas as small as possible, building as few temporary roads as possible, and reducing the final extent of developed area to a minimum.

(iii) Minimising the disturbance impacts associated with the operation of the facility, by abbreviating maintenance times, scheduling activities in relation to avian breeding and/or movement schedules (actual timing to be refined by the results of pre- and post-construction monitoring), and lowering levels of associated noise. Possible Denham's Bustard and Blue Crane nest sites particularly relevant here.

(iv) Excluding development from within at least 250 m of the edge of the south-west edge of the plateau, overlooking the Krom River, or the north-east edge, overlooking the Diep River, to minimise collision risk for soaring birds and commuting bustards, cranes and wetland species along these valleys, and to limit disturbance impacts on forest patches.

(v) Excluding development from with 150 m of the centre of any wetlands/farm dams on the site, to minimise collision risk for Blue Cranes and wetland species.

(vi) Painting one blade of each turbine black to maximise conspicuousness to oncoming birds. The evidence for this as an effective mitigation measure is not conclusive, but it is suggestive. It might be best to adopt an experimental approach to blade marking, identifying a sample of pairs of potentially high risk turbines in pre-construction monitoring, and marking the blades on one of each pair. Post-construction monitoring should allow empirical testing of efficacy, which would inform subsequent decisions about the need to mark blades more widely in this and other WEFs.

(vii) Ensuring that lighting on the turbines is kept to a minimum, and is coloured (red or green) and intermittent, rather than permanent and white, to reduce confusion effects for nocturnal migrants.

(viii) Minimising the length of any new power lines installed, ensuring that all new lines are marked with bird flight diverters (Jenkins *et al.* 2010) along their entire length, and that all new power line infrastructure is adequately insulated and bird friendly in configuration (Lehman *et al.* 2007). Note that current understanding of power line collision risk in birds precludes any guarantee of successfully distinguishing high risk from medium or low risk sections of a new line (Jenkins *et al.* 2010). The relatively low cost of marking the entire length of a new line during construction, especially quite a short length of line in an area frequented by collision prone birds, more than offsets the risk of not marking the correct sections, causing unnecessary mortality of birds, and then incurring the much greater cost of retro-fitting the line post-construction. In situations where new lines run in parallel with existing, unmarked power lines, this approach has the added benefit of reducing the collision risk posed by the older line.

(ix) Connecting the facility to the national power grid directly at the Diep River substation, or if it is necessary to run a new line to the Melkhout substation, doing this by running the line in the same corridor as the existing transmission line, via the Diep River substation (Alternative 1), and **not** by taking a new length of line across the Diep River to Hartebeesfontein (Alternative 2).

(x) Ensuring that all new power infrastructure (pylons, conductors, transformers, substations) is adequately insulated and bird friendly in configuration (Lehman *et al.* 2007).

(xi) Carefully monitoring the local avifauna both pre- and post-construction (see below), and implementing appropriate additional mitigation as and when significant changes are recorded in the number, distribution or breeding behaviour of any of the priority species listed in this report, or when collision or electrocution mortalities are recorded for any of the priority species listed in this report. An essential weakness of the EIA process here is the dearth of knowledge about the actual movements of key species (bustards, cranes, eagles, other raptors, storks) through the impact area. Such knowledge must be generated as quickly and as accurately as possible in order for this and other wind energy proposals in the area to proceed in an environmentally sustainable way. Radar tracking systems, however expensive, may be the best and most practical solution to this problem.

(xii) Ensuring that the results of pre-construction monitoring are applied to project-specific impact mitigation in a way that allows for the potential cumulative effects on the local/regional avifauna of at least five other wind energy projects proposed for the area within a 30 km radius. Viewed in isolation, each of these projects may pose only a limited threat to the avifauna of the region. However, in combination they may result in landscape-scale displacement of threatened species from key areas of their distributions, the formation of significant barriers to energy-efficient travel between resource areas for regionally important bird populations, and/or significant levels of mortality in these populations in collisions with what may become repeated arrays of turbines spread across foraging areas and/or flight paths of priority species (Masden *et al.* 2010).

The broader, coastal plain area around Humansdorp/Jeffrey's Bay/Cape St Francis is clearly of considerable importance to the regional status of Denham's Bustard. Should this species be substantially impacted by either displacement or mortality associated with WEF development, cumulatively this could have a bearing on the national conservation status of this already threatened bird. Hence, the need for careful monitoring and comprehensive mitigation.

(xiii) Additional mitigation might include re-scheduling construction or maintenance activities on site, shutting down problem turbines either permanently or at certain times of year or in certain conditions, or installing a 'DeTect' or similar radar tracking system to monitor bird movements and institute temporary shut-downs as and when required.

6.1 Impact statement

This is a small- to medium-sized wind energy project, proposed for a site with some conflicting issues in terms of its avifauna. The proposed development will affect populations of regionally or nationally threatened (and impact susceptible) birds (mainly large terrestrial species and raptors) likely to occur within or close to the proposed turbine arrays. The facility will probably have a detrimental impact on these birds, particularly during its operational phase, unless significant commitment is made to mitigating these effects. Careful and responsible implementation of the required mitigation measures should reduce construction and operational phase impacts to tolerable and sustainable levels, especially if every effort is made to monitor impacts throughout and to learn as much as possible about the effects of wind energy developments on South African avifauna. The impacts of this development must be viewed in the context of the potential cumulative effects generated by at least five other wind energy project proposed for the same general area.

7. PROPOSED MONITORING PROGRAMME

The primary aims of a long-term monitoring programme would be to:

(i) Determine the densities of birds resident (especially Denham's Bustard and Blue Crane) within the impact area of the wind energy facility before construction of the facility, and afterwards, once the facility, or phases of the facility, become operational.

(ii) Document patterns of bird activity and movements in the vicinity of the proposed wind energy facility before construction, and afterwards, once the facility is operational.

(iii) Identify sensitive and no-go areas for turbine placement to inform the final layout of the facility and the environmental management plan for both the construction and operational phases of the project.

(iv) Monitor patterns of bird activity and movement in relation to weather conditions, time of day and season for at least a full calendar year after the facility is commissioned.

(v) Register and as far as possible document the circumstances surrounding all avian collisions with the turbines for at least a full calendar year after the facility becomes operational.

Bird density and activity monitoring should focus on rare and/or endemic, potentially disturbance or collision prone species, which occur with some regularity in the area (Table 2, Appendix 1). Ultimately, the study should provide much needed quantitative information on the effects of the facility on the distribution and abundance of birds, and the actual risk it poses to the local avifauna, and serve to inform and improve mitigation measures to reduce this risk. It will also establish a precedent and a template for research and monitoring of avian impacts at possible, future wind energy sites in the region. This programme outline is informed by monitoring studies established in other countries (e.g. Erickson *et al.* 1999, Scottish National Heritage 2005), but is based substantially on those developed for both the Darling and the Klipheuwel wind power demonstration facilities in South Africa (Jenkins 2003, Küyler 2004). The bulk of the work involved should be done by an expert ornithologist or under the supervision of such.

The protocols set out there pre-date the final drafting of the standard monitoring protocols for pre- and post-construction monitoring of birds at South African wind energy developments, as drawn up by the Birds & Wind Energy Specialist Group. Once the latter protocols have been finalised, they should supplement, and where necessary supercede, the measures stipulated here, as determined by the specialist advising the monitoring programme.

7.1 Monitoring protocols

7.1.1 Avian densities before and after

A set of at least 10 walk-transect routes, each of at least 1000 m in length, should be established in areas representative of all the avian habitats present within a 10 km radius of the centre of the development site. Each of these should be walked at least once every two months over at least 6-12 months immediately preceding construction, and at least once every two months over the same calendar period, at least six months after the facility is commissioned. The transects should be walked after 06h00 and before 09h00, and the species, number and perpendicular distance from the transect line of all birds seen should be recorded for subsequent analysis and comparison.

In addition, any cliff-lines situated within or close to the development area (e.g. those just downstream of the Churchill Dam wall) should be surveyed for cliff-nesting raptors at least once every six months using documented protocols (Malan 2009), all sightings of key species (Table 2) on site should carefully plotted and documented, and the major waterbodies/farm dams on and close to the development area should be surveyed for wetland species on each visit to the study area, using the standard protocols set out by the CWAC initiative (Taylor *et al.* 1999).

7.1.2 Bird activity monitoring

Monitoring of bird activity in the vicinity of the facility should be done over a 2-3 day period at least every two months for at least the 6-12 months preceding construction, and at least once per quarter for a full calendar year starting at least 6-12 months after the facility is commissioned. Each monitoring day should involve:

(i) Half-day counts of all priority species flying over or past the impact area (see passage rates below)

(ii) Opportunistic surveys of large terrestrial species and raptors seen when travelling around the site.

7.1.3 Passage rates of priority bird species

Counts of bird traffic over and around the proposed/operational facility should be conducted from suitable vantage points (and a number of these should be selected and used to provide coverage of avian flights in relation to all areas of the site), and extend alternately from dawn to midday, or from midday to dusk, so that the equivalent of four full days of counts is completed each count period. This 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, for all seasons of the year.

Once in position at the selected count station, the observer should record (preferably on a specially designed data sheet) the date, count number, start-time and conditions at start - extent of cloud cover, temperature, wind velocity and visibility – and proceed with the count. The counts should detail all individuals or flocks of the stipulated priority bird species, all raptors, and any additional species of particular interest or conservation concern, seen flying within 500 m of the envisaged or actual periphery of the facility. Each record should include the following data: time, updated weather assessment, species, number, mode of flight (flapping, gliding, soaring), flight activity (commuting, hunting other), direction of flight, vertical zoning relative to the envisaged or actual turbine string (low – below or within the rotor arc, medium – within *c.*100 m of the upper rotor arc, high – >100 m above the upper rotor arc), and horizontal zoning relative to the envisaged or actual turbine string (near – through the turbine string or within the outer rotor arc, middle – within *c.*100 m of the outer rotor arc, distant - >100 m beyond the outer rotor arc) and, for post construction monitoring, notes on any obvious evasive behaviour or flight path changes observed in response to the wind energy facility. The time and weather conditions should again be noted at the end of each count.

7.2 Avian collisions

Collision monitoring should have two components: (i) experimental assessment of search efficiency and scavenging rates of bird carcasses on the site, and (ii) regular searches of the vicinity of the wind farm for collision casualties.

7.2.1 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 the priority species – e.g. Egyptian Goose *Alopochen aegyptiacus*, domestic waterfowl and pigeons) should be obtained and distributed randomly around the site without the knowledge of the surveyor, 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 months of the monitoring period, with the total number of carcasses not less than 20. The proportion of the carcasses located in surveys will indicate the relative efficiency of the survey method.

Simultaneous to this process, the condition and presence of all the carcasses positioned on the site should be monitored throughout the initial two-month period, to determine the rates at which carcassess are scavenged from the area, or decay to the point that they are no longer obvious to the surveyor. 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 twice during the monitoring year, once in winter and once in summer.

7.2.2 Collision victim surveys

The area within a radius of at least 50 m of each of the turbines at the facility should be checked regularly for bird casualties (Anderson *et al.* 1999, Morrison 2002). 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 for 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 precise location (preferably a GPS reading), date and time at which the evidence was found, and the site of the find should be photographed with all the evidence *in situ*. 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).

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 victims using established protocols (see Jenkins *et al.* 2009, Jenkins *et al.* 2010, Shaw *et al.* 2010 a & b).

7. INPUTS TO THE ENVIRONMENTAL MANAGEMENT PLAN

OBJECTIVE:	A wind energy facility that is sustainable in terms of its impacts on local avifauna
Project components	Conducting comprehensive pre- and post-construction monitoring of local avifauna (as per 7. Above) Getting the monitoring protocols right Securing the strategic use of radar Selecting and training a good monitoring team Collecting and collating sufficient accurate survey data pre-construction Analysing the pre-construction survey data to inform the final layout and the construction schedule Collecting and collating sufficient accurate survey data post-construction Analysing the post-construction survey data to inform the sustainable management of the facility
Activity / risk source	Starting pre-construction monitoring too late Appointment of unqualified personnel to do the monitoring Results of pre-construction monitoring not integrated into the final layout and/or the mitigation scheme Lack of clear communication between the scientist analysing the monitoring data and the client Misinterpretation of either the pre- or post-construction monitoring data
Mitigation: Target / Objective	The delivery of an effective impact mitigation scheme for the facility, informed initially by influence of pre-construction monitoring on final construction plans, and refined by post-construction monitoring of actual impacts, and resulting adjustments in management practices and mitigation measures applied

Mitigation: Action / control	Responsibility	Timeframe
Appoint advising scientist and agency to conduct pre- and post-construction monitoring	Client	As soon as possible / practical
Refine monitoring protocol and determine the extent of radar deployment required	Advising scientist, in negotiation with the client	As soon as possible / practical
Appoint radar technologists to service the project, and acquire/hire hardware, software and relevant expertise, IF radar use is approved	Advising scientist, in negotiation with the client	As soon as possible / practical
Start pre-construction monitoring	Monitoring agency	1 year before construction is due to start

Mitigation: Action/control	Responsibility	Timeframe
Periodically collate an analyse pre-construction monitoring data	Advising scientist and radar specialist (if applicable)	Every 3 months of monitoring
Review report on the 6-12 months of pre-construction monitoring, and integrate findings into construction EMP and broader mitigation scheme	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	After a year of pre-construction monitoring
Ensure construction EMP is applied	Relevant Environmental Control Officer	During construction
Refine post-construction monitoring protocol in terms of results pre-construction, and determine the extent of radar deployment required	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	As soon as possible / practical after construction completed
Start post-construction monitoring	Monitoring agency	6 months after construction is completed
Periodically collate and analyse post-construction monitoring data	Advising scientist and radar specialist (if applicable)	Every 3 months of monitoring
Review report on the full year of post-construction monitoring, and integrate findings into operational EMP and broader mitigation scheme	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	1 year post-construction
Review the need for further post-construction monitoring	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	1 year post-construction

Performance indicator	Regular provision of clearly worded, logical and objective information on the interface between the local avifauna and the proposed/operating wind energy facility Clear and logical recommendations on why, how and when to institute mitigation measures to reduce avian impacts of the development, from pre-construction to operational phase Quantifiable reductions in avian impacts once the facility is operational
Monitoring	3-monthly and annual reports produced by the scientist advising the monitoring project

9. REFERENCES

Acha, A. 1997. Negative impact of wind generators on the Eurasian Griffon *Gyps fulvus* in Tarifa, Spain. *Vulture News* 38:10-18.

Allan, D.G. 1994. The abundance and movements of Ludwig's Bustard *Neotis ludwigii*. *Ostrich* 65: 95-105.

Allan, D.G. & Jenkins, A.R. 1990. West Coast heavy mineral sands project: Birdlife on the proposed mining site. Unpublished report. University of Cape Town, Cape Town.

Anderson, M.D. 2001. The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa. Draft report to Eskom Resources and Strategy Division. Johannesburg. South Africa.

Avian Powerline Interation Committee (APLIC). 1994. Mitigating bird collisions with power lines: the state of the art in 1994. Edison Electric Institute. Washington DC.

Barclay, R.M.R, Baerwald, E.F. & Gruver, J.C. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85: 381-387.

Barrios, L. & Rodríguez, A. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. *Journal of Applied Ecology* 41: 72-81.

Barnes, K.N. (ed.) 1998. The Important Bird Areas of southern Africa. BirdLife South Africa, Johannesburg.

Barnes, K.N. (ed.) 2000. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg.

Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. *Ibis* 136: 412-425.

Bevanger, K. 1995. Estimates and population consequences of Tetraonid mortality caused by collisions with high tension power lines in Norway. *Journal of Applied Ecology* 32: 745-753.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electric power lines. *Biological Conservation* 86: 67-76.

Boshoff, A., Piper, S. & Michael, M. 2009. On the distribution and breeding status of the Cape Griffon *Gyps coprotheres* in the Eastern Cape, province, South Africa. *Ostrich* 80: 85-92.

Boshoff, A., Barkhuysen, A., Brown, G. & Michael, M. 2009. Evidence of partial migratory behavior by the Cape Griffon *Gyps coprotheres*. *Ostrich* 80: 129-133.

Bright, J., Langston, R., Bullman, R. Evans, R., Gardner, S., & Pearce-Higgins, J. 2008. Map of bird sensitivities to wind farms in Scotland: A tool to aid planning and conservation. *Biological Conservation* 141: 2342-2356.

Crawford, R.J.M., Cooper, J. & Dyer, B.M. 1995. Conservation of an increasing population of Great White Pelicans *Pelecanus onocrotalus* in South Africa's Western Cape. *S. Afr. J. Mar. Sci.* 15:33-42.

Crawford, R.J.M. & Taylor, R.H. 2000. White Pelican. *In:* Barnes, K.N. (ed.). The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Cape Town. pp. 136.

Crockford, N.J. 1992. A review of the possible impacts of wind farms on birds and other wildlife. Joint Nature Conservation Committee. JNCC Report number 27. Peterborough, United Kingdom.

Curry, R.C., & Kerlinger, P. 2000. Avian mitigation plan: Kenetech model wind turbines, Altamont Pass WRA, California. In: Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

Curtis, O., Simmons, R.E. & Jenkins, A.R. 2004. Black Harrier *Circus maurus* of the Fynbos biome, South Africa: a threatened specialist or an adaptable survivor? *Bird Conservation International* 14: 233-245.

De Lucas, M., Janss, G.F.E., Whitfield, D.P. & Ferrer, M. 2008. Collision fatality of raptors in wind farms does not depend on raptor abundance. *Journal of Applied Ecology* 45: 1695-1703.

Devereaux, C/L., Denny, M.J.H. & Whittingham, M.J. 2008. Minimal effects of wind turbines on the distribution of wintering farmland birds. *Journal of Applied Ecology* 45: 1689-1694.

Drewitt, A.L. & Langston, R.H.W. 2006. Assessing the impacts of wind farms on birds. *Ibis* 148: 29-42.

Drewitt, A.L. & Langston, R.H.W. 2008. Collision effects of wind-power generators and other obstacles on birds. *Annals of the New York Academy of Science* 1134: 233-266.

Erickson, W.P., Johnson, G.D., Strickland, M.D., Young, D.P., Sernka, K.J., Good, R.E. 2001. Avian collisions with wind turbines: a summary of existing studies and comparison to other sources of avian collision mortality in the United States. National Wind Co-ordinating Committee Resource Document.

Erickson, W.P., Johnson, G.D., Strickland, M.D., Kronner, K. & Becker, P.S. 1999. Baseline avian use and behaviour at the CARES Wind Plant Site, Klickitat County, Washington. Unpublished report to the National Renewable Energy Laboratory. NREL, Colorado.

Everaert, J. 2003. Wind turbines and birds in Flanders: Preliminary study results and recommendations. *Natuur. Oriolus* 69: 145-155.

Farfán, M.A., Vargas, J.M. & Duarte, J. 2009. What is the impact of wind farms on birds. A case study in southern Spain. *Biodiversity Conservation* 18: 3743-3758.

Gill, J.P., Townsley, M. & Mudge, G.P. 1996. Review of the impact of wind farms and other aerial structures upon birds. *Scottish Natural Heritage Review* 21.

Gunerhan, H., Hepbasli, A. & Giresunli, U. 2009. Environmental impacts from the solar energy systems. *Energy Sources, Part A: Recovery, Ulilization and Environmental Effects* 31: 131-138.

Hanowski, J.M., & Hawrot, R.Y. 2000. Avian issues in development of wind energy in western Minnesota. In Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V & Brown, C.J. (eds). 1997. The atlas of southern African birds. Vol. 1&2. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Hodos, W. 2002. Minimization of motion smear: Reducing avian collisions with turbines. Unpublished subcontractor report to the National Renewable Energy Laboratory. NREL/SR 500-33249.

Howell, J.A. 1995. Avian mortality at rotor sweep areas equivalents Altamont Pass and Montezuma Hills, California. Prepared for Kenetech Wind Power, San Francisco, California.

Janss, G. 2000a. Bird behaviour in and near a wind farm at Tarifa, Spain: Management considerations. In: Proceedings of National Avian-Wind Power Planning Meeting III, San Diego California, May 1998.

Janss, G.F.E. 2000b. Avian mortality from power lines: a morphologic approach of a species-specific mortality. *Biological Conservation* 95: 353-359.

Jaroslow, B. 1979. A review of factors involved in bird-tower kills, and mitigation procedures. In: G.A. Swanson (Tech co-ord). The Mitigation symposium. A national workshop on mitigation losses of Fish and Wildlife Habitats. US Forest Service General Technical Report. RM-65.

Jenkins, A.R. 1994. The influence of habitat on the distribution and abundance of Peregrine and Lanner Falcons in South Africa. Ostrich 65: 281-290.

Jenkins, A. 1998. Site evaluation for Namakwa Sands heavy minerals sands mine. Unpublished report to the Environmental Evaluation Unit. University of Cape Town, Cape Town.

Jenkins, A.R. 2001. The potential impact of a demonstration wind farm facility on the birds of the Darling / Yzerfontein area, Western Cape Province, South Africa. Unpublished report to the Environmental Evaluation Unit, University of Cape Town, Cape Town.

Jenkins, A.R. 2003. Populations and movements of priority bird species in the vicinity of the proposed Darling Demonstration Wind Farm facility. Unpublished report to the Environmental Evaluation Unit, University of Cape Town, Cape Town.

Jenkins, A.R. 2008a. A proposed new list of the threatened raptors of southern Africa. Gabar 19 (1): 27-40.

Jenkins, A.R. 2008b. Eskom generation wind energy facility – Western Cape: Avifaunal impact assessment. Report to Savannah Environmental Pty (Ltd).

Jenkins, A., Gibbons, B. & Visagie, R. 2009. Long-term fixed site monitoring of wildlife interactions with power lines across a range of biomes: establishment and maintenance of a long-term bird;power line interaction monitoring site in the De Aar (Hydra) area of the eastern Karoo, Northern Cape. Unpublished report to Eskom.

Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263-278.

Kemper, C.A. 1964. A tower for TV: 30 000 dead birds. *Audubon Magazine* 66: 86-90.

Kerlinger, P. & Dowdell, J. 2003. Breeding bird survey for the Flat Rock wind power project, Lewis County, New York. Prepared for Atlantic Renewable Energy Corporation.

King, D.I. & Byers, B.E. 2002. An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds. *Wildlife Society Bulletin* 30: 868-874.

Kingsley, A. & Whittam, B. 2005. Wind turbines and birds – A background review for environmental assessment. Unpublished report for Environment Canada/Canada Wildlife Service.

Krijgsveld, K.L., Akershoek, K., Schenk, F., Dijk, F. & Dirksen, S. 2009. Collision risk of birds with modern large wind turbines. *Ardea* 97: 357-366.

Küyler, E.J. 2004. The impact of the Eskom Wind Energy Demonstration Facility on local avifauna – Results from the monitoring programme for the time period June 2003 to Jan 2004. Unpublished report to Eskom Peaking Generation.

Kuvlevsky, W.P. Jnr, Brennan, L.A., Morrison, M.L., Boydston, K.K., Ballard, B.M. & Bryant, F.C. 2007. Wind energy development and wildlife conservation: challenges and opportunities. *Journal of Wildlife Management* 71: 2487-2498.

Larsen, J.K. & Guillemette, M. 2007. Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk. *Journal of Applied Ecology* 44: 516-522.

Lehman, R.N., Kennedy, P.L. & Savidge, J.A. 2007. The state of the art in raptor electrocution research: a global review. *Biological Conservation* 136: 159-174.

Madders, M. & Whitfield, D.P. 2006. Upland raptors and the assessment of wind farms impacts. *Ibis* 148: 43-56.

Masden, E.A., Fox, A.D., Furness, R.W., Bullman, R. & Haydon, D.T. 2009. Cumulative impact assessments and bird/wind farm interactions: Developing a conceptual framework. *Environmental Impact Assessment Review* 30: 1-7.

McIsaac, H.P. 2001. Raptor acuity and wind turbine blade conspicuity. Pp. 59-87. National Avian-Wind Power Planning Meeting IV, Proceedings. Prepared by Resolve, Inc., Washington DC.

Mucina. L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

National Wind Co-ordinating Committee. 2004. Wind turbine interactions with birds and bats: A summary of research results and remaining questions. Fact Sheet, Second Edition.

Newton, I. & Little, B. 2009. Assessment of wind-farm and other bird casualties from carcasses found on a Northumbrian beach over an 11-year period. *Bird Study* 56: 158-167.

Noguera, J.C., Pérez, I. & Mínguez, E. 2010. Impacts of terrestrial wind farms on diurnal raptors: developing a spatial vulnerability index and potential vulnerability maps. *Ardeola* 57: 41-53.

Pennycuick, C.J. 1989. Bird flight performance: a practical calculation manual. Oxford University Press, Oxford.

Pierce-Higgins, J.W., Stephen, L., Langston, R.H.W., Bainbridge, I.P. & Bullman, R. 2009. The distribution of breeding birds around upland wind farms. *Journal of Applied Ecology*, Published Online, September 24, 2009.

Richardson, W.J. 2000. Bird migration and wind turbines: Migration timing, flight behaviour and collision risk. In Proceedings of the National Avian-wind Power Planning Meeting III, San Diego, California, May 1998.

Ryan, P.G. & Dean, W.R.J. 2005. Agulhas Long-billed Lark. In: Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds). Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town. Pp 880-881.

Scottish National Heritage. 2005. Survey methods for use in assessing the impacts of onshore windfarms on bird communities. Unpublished Report.

Shaw, J., Jenkins, A.R. & Ryan, P.G. 2010a. Modelling power line collision risk in the Blue Crane *Anthropoides paradiseus* in South Africa. *Ibis* 152: 590-599.

Shaw, J., Jenkins, A.R., Ryan, P.G. & Smallie, J. 2010b. A preliminary survey of avian mortality on power lines in the Overberg, South Africa. *Ostrich* 81: 109-113.

Stewart, G.B., Pullin, A.S. & Coles, C.F. 2007. Poor evidence-base for assessment of windfarm impacts on birds. *Environmental Conservation* 34: 1-11.

Smallie, J. & Strugnell, L. 2010. African Clean Energy Developments (Pty) Ltd Cookhouse Wind Energy Facility – Eastern Cape: Avifaunal impact assessment. Report by the EWT to Savannah Environmental Pty (Ltd).

Smallwood, K.S. & Thelander, C. 2008. Bird mortality in the Altamont Pass Wind Resource Area, California. *Journal of Wildlife Management* 72: 215-223.

Smallwood, K.S., Rugge, L. & Morrison, M.L. 2009. Influence of behavior on bird mortality in wind energy developments. *Journal of Wildlife Management* 73: 1082-1098.

Sovacool, B.K. 2009. Contextualizing avian mortality: a preliminary appraisal of bird and bat fatalities from wind, fossil-fuel, and nuclear electricity. *Energy Policy* 37: 2241-2248.

Tapia, L., Dominguez, J. & Rodriguez, L. 2009. Using probability of occurrence to assess potential interaction between wind farms and a residual population of golden eagle *Aquila chrysaetos* in NW Spain. *Biodiversity & Conservation* 18: 2033-2041.

Tsoutsos, T., Frantzeskaki, N., Gekas, V. 2005. Environmental impacts from solar energy technologies. *Energy Policy* 33: 289-296.

Van Rooyen, C. 2001. Bird Impact Assessment Study – Eskom Wind Energy Demonstration Facility, Western Cape South Africa. Prepared for Eskom Enterprises, TSI Division.

Van Rooyen, C.S. 2004a. The Management of Wildlife Interactions with overhead lines. In The fundamentals and practice of Overhead Line Maintenance (132kV and above), pp217-245. Eskom Technology, Services International, Johannesburg.

Van Rooyen, C.S. 2004b. Investigations into vulture electrocutions on the Edwardsdam-Mareetsane 88kV feeder, Unpublished report, Endangered Wildlife Trust, Johannesburg.

Van Zyl, A.J, Jenkins, A.R. & Allan, D.G. 1994. Evidence for seasonal movement by Rock Kestrels *Falco tinnunculus* and Lanner Falcons *F. biarmicus* in South Africa. *Ostrich* 65:111-121.

Weir, R. D. 1976. Annotated bibliography of bird kills at manmade obstacles: a review of the state of the art and solutions. Canadian Wildlife Services, Ontario Region, Ottawa.

Walker, D., McGrady, M., McCluskie, A., Madders, M. & McLeod, D.R.A. 2005. Resident Golden Eagle ranging behavior before and after construction of a windfarm in Argyll. *Scottish Birds* 25: 24-40.

Winkelman, J.E. 1995. Bird/wind turbine investigations in Europe. In Proceedings of the National Avian- wind Power Planning Meeting 1994.

Young, D.J., Harrison, J.A., Navarro, R.A., Anderson, M.D. & Colahan, B.D. (eds). 2003. Big birds on farms: Mazda CAR report 1993-2001. Avian Demography Unit, Cape Town.

Dr Andrew Jenkins
AVISENSE Consulting cc
Email: Andrew@avisense.co.za
Cell: 082 959 9238
Web: avisense.co.za

Appendix 1. Annotated list of the bird species considered likely to occur within the impact zone of the proposed Deep River Wind Energy Facility. Species seen during the November site visit appear in **bold**.

Common name	Scientific name	Conservation status	Regional endemicity	Habitat			
				Fynbos / Renosterveld slopes	Old pastures and cultivated lands	Indigenous and alien forest	Wetlands
Common Ostrich	***Struthio camelus***			**X**	**X**		
Red-necked Spurfowl	*Pternistes afer*			X	X	X	
Common Quail	*Coturnix coturnix*			X	X		
Helmeted Guineafowl	***Numida meleagris***			**X**	**X**		
Egyptian Goose	***Alopochen aegyptiaca***				**X**		**X**
South African Shelduck	*Tadorna cana*		Endemic				X
Spur-winged Goose	***Plectropterus gambensis***				**X**		**X**
Cape Teal	*Anas capensis*						X
African Black Duck	*Anas sparsa*						X
Yellow-billed Duck	***Anas undulata***						**X**
Cape Shoveler	*Anas smithii*		Endemic				X
Red-billed Teal	***Anas erythrorhyncha***						**X**
Scaly-throated Honeyguide	*Indicator variegatus*					X	
Greater Honeyguide	***Indicator indicator***					**X**	
Lesser Honeyguide	*Indicator minor*					X	
Knysna Woodpecker	*Campethera notata*	Near-threatened	Endemic			X	
Ground Woodpecker	*Geocolaptes olivaceus*		Endemic	X			
Cardinal Woodpecker	*Dendropicos fuscescens*					X	
Olive Woodpecker	*Dendropicos griseocephalus*					X	
Red-fronted Tinkerbird	*Pogoniulus pusillus*					X	
Acacia Pied Barbet	*Tricholaema leucomelas*		Near-endemic			X	

Common name	Scientific name	Conservation status	Regional endemicity	Habitat			
				Fynbos / Renosterveld slopes	Old pastures and cultivated lands	Indigenous and alien forest	Wetlands
Crowned Hornbill	*Tockus alboterminatus*					X	
African Hoopoe	*Upupa africana*					X	
Green Wood-Hoopoe	***Phoeniculus purpureus***					**X**	
European Roller	*Coracias garrulus*				X		
Half-collared Kingfisher	*Alcedo semitorquata*	Near-threatened					X
Malachite Kingfisher	*Alcedo cristata*						X
Brown-hooded Kingfisher	***Halcyon albiventris***					**X**	
Giant Kingfisher	*Megaceryle maximus*						X
Pied Kingfisher	*Ceryle rudis*						X
European Bee-eater	*Merops apiaster*			X	X		
Speckled Mousebird	***Colius striatus***			**X**	**X**		
Red-faced Mousebird	*Urocolius indicus*			X	X		
Jacobin Cuckoo	*Clamator jacobinus*			X		X	
Great Spotted Cuckoo	*Clamator glandarius*			X		X	
Red-chested Cuckoo	***Cuculus solitarius***					**X**	
Black Cuckoo	***Cuculus clamosus***					**X**	
Klaas's Cuckoo	*Chrysococcyx klaas*			X		X	
Diderick Cuckoo	***Chrysococcyx caprius***			**X**		**X**	
Burchell's Coucal	*Centropus burchellii*						X
Alpine Swift	*Tachymarptis melba*			X			
Common Swift	*Apus apus*			X			
African Black Swift	*Apus barbatus*			X			
Little Swift	***Apus affinis***			**X**			
Horus Swift	*Apus horus*			X			
White-rumped Swift	***Apus caffer***			**X**			
Barn Owl	*Tyto alba*			X	X		
Spotted Eagle-Owl	*Bubo africanus*			X	X		

Common name	**Scientific name**	**Conservation status**	**Regional endemicity**	**Habitat**			
				Fynbos / Renosterveld slopes	**Old pastures and cultivated lands**	**Indigenous and alien forest**	**Wetlands**
African Wood-Owl	*Strix woodfordii*					X	
Marsh Owl	*Asio capensis*						X
Fiery-necked Nightjar	*Caprimulgus pectoralis*			X			
Rock Dove	*Columba livia*			X	X		
Speckled Pigeon	***Columba guinea***				**X**		
African Olive-Pigeon	*Columba arquatrix*					X	
Laughing Dove	*Streptopelia senegalensis*			X	X		
Cape Turtle-Dove	***Streptopelia capicola***			**X**	**X**		
Red-eyed Dove	***Streptopelia semitorquata***				**X**	**X**	
Emerald-spotted Wood-Dove	*Turtur chalcospilos*					X	
Tambourine Dove	*Turtur tympanistria*					X	
Namaqua Dove	*Oena capensis*			X			
Denham's Bustard	***Neotis denhami***	**Vulnerable**		**X**	**X**		
Southern Black Korhaan	*Afrotis afra*		Endemic	X	X		
White-bellied Korhaan	*Eupodotis senegalensis*	Vulnerable		X			
Blue Crane	***Anthropoides paradiseus***	**Vulnerable**	**Endemic**	**X**	**X**		
Buff-spotted Flufftail	*Sarothrura elegans*					X	
Red-chested Flufftail	*Sarothrura rufa*						X
African Rail	*Rallus caerulescens*						X
Black Crake	*Amaurornis flavirostris*						X
Baillon's Crake	*Porzana pusilla*						X
African Purple Swamphen	*Porphyrio madagascariensis*						X
African Finfoot	*Podica senegalensis*	Near-threatened	-				X
Common Moorhen	***Gallinula chloropus***						**X**
Red-knobbed Coot	***Fulica cristata***						**X**
African Snipe	*Gallinago nigripennis*			X			X
African Jacana	*Actophilornis africanus*						X

Common name	Scientific name	Conservation status	Regional endemicity	Habitat			
				Fynbos / Renosterveld slopes	Old pastures and cultivated lands	Indigenous and alien forest	Wetlands
Water Thick-knee	*Burhinus vermiculatus*						X
Spotted Thick-knee	***Burhinus capensis***			**X**	**X**		
Black-winged Stilt	*Himantopus himantopus*						X
Pied Avocet	*Recurvirostra avosetta*						X
Kittlitz's Plover	*Charadrius pecuarius*						X
Three-banded Plover	*Charadrius tricollaris*						X
Blacksmith Lapwing	***Vanellus armatus***						**X**
Black-winged Lapwing	*Vanellus melanopterus*	Near-threatened		X	X		
Crowned Lapwing	***Vanellus coronatus***			**X**	**X**		
Whiskered Tern	*Chlidonias hybrida*						X
White-winged Tern	*Chlidonias leucopterus*						X
African Cuckoo Hawk	*Aviceda cuculoides*			X		X	
Black-shouldered Kite	***Elanus caeruleus***			**X**	**X**		
Black Kite	***Milvus migrans***			**X**	**X**		
African Fish-Eagle	*Haliaeetus vocifer*						X
African Marsh-Harrier	*Circus ranivorus*	Vulnerable			X		X
Black Harrier	*Circus maurus*	Near-threatened	Endemic	X	X		X
Pallid Harrier	*Circus macrourus*	Near-threatened		X			
African Harrier-Hawk	*Polyboroides typus*					X	
African Goshawk	***Accipiter tachiro***					**X**	
Little Sparrowhawk	*Accipiter minullus*					X	
Rufous-chested Sparrowhawk	*Accipiter rufiventris*					X	
Black Sparrowhawk	*Accipiter melanoleucus*					X	
Steppe Buzzard	***Buteo vulpinus***				**X**	**X**	
Forest Buzzard	*Buteo trizonatus*		Endemic		X	X	
Jackal Buzzard	***Buteo rufofuscus***		**Endemic**	**X**	**X**	**X**	
Verreauxs' Eagle	*Aquila verreauxii*			X			
Booted Eagle	*Aquila pennatus*			X	X		
Martial Eagle	***Polemaetus***	**Vulnerable**		**X**			

Common name	Scientific name	Conservation status	Regional endemicity	Habitat			
				Fynbos / Renosterveld slopes	Old pastures and cultivated lands	Indigenous and alien forest	Wetlands
	bellicosus						
Long-crested Eagle	*Lophaetus occipitalis*					X	X
African Crowned Eagle	*Stephanoaetus coronatus*	Near-threatened				X	
Secretarybird	*Sagittarius serpentarius*	Near-threatened		X	X		
Lesser Kestrel	*Falco naumanni*	Vulnerable		X	X		
Rock Kestrel	***Falco rupicolus***			**X**	**X**		
Amur Falcon	*Falco amurensis*			X	X		
Eurasian Hobby	*Falco subbuteo*			X		X	
Lanner Falcon	*Falco biarmicus*	Near-threatened		X	X		
Peregrine Falcon	*Falco peregrinus*	Near-threatened		X	X		
Little Grebe	***Tachybaptus ruficollis***						**X**
Great Crested Grebe	*Podiceps cristatus*						X
African Darter	*Anhinga rufa*						X
Reed Cormorant	*Phalacrocorax africanus*						X
White-breasted Cormorant	***Phalacrocorax lucidus***						**X**
Little Egret	*Egretta garzetta*						X
Yellow-billed Egret	*Egretta intermedia*						X
Great Egret	*Egretta alba*						X
Grey Heron	*Ardea cinerea*						X
Black-headed Heron	***Ardea melanocephala***			**X**	**X**		**X**
Purple Heron	*Ardea purpurea*						
Cattle Egret	*Bubulcus ibis*				X		X
Squacco Heron	*Ardeola ralloides*						X
Little Bittern	*Ixobrychus minutus*						X
Hamerkop	*Scopus umbretta*						X
Hadeda Ibis	***Bostrychia hagedash***				**X**	**X**	**X**
African Sacred Ibis	*Threskiornis aethiopicus*				X		X
African Spoonbill	*Platalea alba*						X

Common name	Scientific name	Conservation status	Regional endemicity	Habitat			
				Fynbos / Renosterveld slopes	Old pastures and cultivated lands	Indigenous and alien forest	Wetlands
Yellow-billed Stork	*Mycteria ibis*	Near-threatened					X
Black Stork	*Ciconia nigra*	Near-threatened		X			X
White Stork	*Ciconia ciconia*			X	X		X
Black-headed Oriole	***Oriolus larvatus***					**X**	
Fork-tailed Drongo	***Dicrurus adsimilis***					**X**	
Blue-mantled Crested-Flycatcher	*Trochocercus cyanomelas*					X	
African Paradise-Flycatcher	*Terpsiphone viridis*					X	
Black-backed Puffback	*Dryoscopus cubla*					X	
Southern Tchagra	*Tchagra tchagra*		Endemic	X		X	
Southern Boubou	***Laniarius ferrugineus***		**Endemic**	**X**		**X**	
Bokmakierie	***Telophorus zeylonus***		**Near-endemic**	**X**			
Grey-headed Bush-Shrike	*Malaconotus blanchoti*					X	
Cape Batis	*Batis capensis*		Endemic	X		X	
Cape Crow	***Corvus capensis***			**X**	**X**	**X**	
Pied Crow	***Corvus albus***			**X**	**X**		
White-necked Raven	*Corvus albicollis*			X	X		
Red-backed Shrike	*Lanius collurio*			X	X		
Common Fiscal	***Lanius collaris***			**X**	**X**		
Black Cuckooshrike	*Campephaga flava*					X	
Southern Black Tit	*Parus niger*			X		X	
Brown-throated Martin	***Riparia paludicola***						**X**
Banded Martin	*Riparia cincta*			X	X		X
Barn Swallow	***Hirundo rustica***			**X**	**X**		**X**
White-throated Swallow	***Hirundo albigularis***						**X**
Pearl-breasted Swallow	*Hirundo dimidiata*			X	X		X
Greater Striped Swallow	***Hirundo cucullata***			**X**	**X**		

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Lesser Striped Swallow	***Hirundo abyssinica***			**X**	**X**		
Rock Martin	***Hirundo fuligula***			**X**			
Common House-Martin	*Delichon urbicum*			X	X		X
Black Saw-wing	***Psalidoprocne holomelaena***					**X**	
Cape Bulbul	*Pycnonotus capensis*		Endemic	X		X	
Sombre Greenbul	***Andropadus importunus***					**X**	
Fairy Flycatcher	*Stenostira scita*		Endemic	X			
Cape Grassbird	***Sphenoeacus afer***		**Endemic**	**X**			
Victorin's Warbler	*Cryptillas victorini*		Endemic	X			
Little Rush-Warbler	*Bradypterus baboecala*						X
Knysna Warbler	*Bradypterus sylvaticus*	Vulnerable	Endemic			X	
African Reed-Warbler	*Acrocephalus baeticatus*						X
Lesser Swamp-Warbler	*Acrocephalus gracilirostris*						X
Yellow-throated Woodland-Warbler	*Phylloscopus ruficapilla*					X	
Willow Warbler	*Phylloscopus trochilus*					X	
Cape White-eye	***Zosterops virens***		**Endemic**	**X**		**X**	
Lazy Cisticola	*Cisticola aberrans*			X			
Grey-backed Cisticola	***Cisticola subruficapilla***		**Near-endemic**	**X**			
Wailing Cisticola	*Cisticola lais*			X			
Levaillant's Cisticola	*Cisticola tinniens*						X
Neddicky	***Cisticola fulvicapilla***			**X**			
Zitting Cisticola	***Cisticola juncidis***				**X**		
Cloud Cisticola	***Cisticola textrix***		**Near-endemic**		**X**		
Karoo Prinia	***Prinia maculosa***		**Endemic**	**X**		**X**	
Bar-throated Apalis	***Apalis thoracica***					**X**	
Yellow-breasted Apalis	*Apalis flavida*					X	

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Green-backed Camaroptera	*Camaroptera brachyura*					X	
Rufous-naped Lark	***Mirafra africana***			**X**	**X**		
Cape Clapper Lark	***Mirafra apiata***		**Endemic**	**X**	**X**		
Eastern Long-billed Lark	*Certhilauda semitorquata*		Endemic	X	X		
Red-capped Lark	***Calandrella cinerea***			**X**	**X**		
Cape Rock-Thrush	***Monticola rupestris***		**Endemic**	**X**			
Olive Thrush	***Turdus olivaceus***					**X**	
Southern Black Flycatcher	*Melaenornis pammelaina*					X	
Fiscal Flycatcher	*Sigelus silens*		Endemic	X		X	
Spotted Flycatcher	*Muscicapa striata*					X	
African Dusky Flycatcher	*Muscicapa adusta*					X	
Cape Robin-Chat	***Cossypha caffra***					**X**	
White-browed Scrub-Robin	*Cercotrichas leucophrys*					X	
African Stonechat	***Saxicola torquatus***			**X**	**X**		
Capped Wheatear	*Oenanthe pileata*			X	X		
Familiar Chat	*Cercomela familiaris*			X	X		
Ant-eating Chat	*Myrmecocichla formicivora*		Endemic	X			
Red-winged Starling	***Onychognathus morio***			**X**			
Cape Glossy Starling	***Lamprotornis nitens***					**X**	
Pied Starling	***Spreo bicolor***		**Endemic**	**X**	**X**		
Wattled Starling	*Creatophora cinerea*			X	X		
Common Starling	*Sturnus vulgaris*				X		
Cape Sugarbird	*Promerops cafer*		Endemic	X			
Orange-breasted Sunbird	*Anthobaphes violacea*		Endemic	X			
Amethyst Sunbird	***Chalcomitra amethystina***					**X**	

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Malachite Sunbird	***Nectarinia famosa***			**X**		**X**	
Collared Sunbird	*Hedydipna collaris*					X	
Southern Double-collared Sunbird	*Cinnyris chalybeus*		Endemic	X		X	
Greater Double-collared Sunbird	*Cinnyris afer*		Endemic	X		X	
Cape Sugarbird	*Promerops cafer*		Endemic	X			
Spectacled Weaver	*Ploceus ocularis*			X		X	X
Cape Weaver	***Ploceus capensis***		**Endemic**	**X**		**X**	**X**
Southern Masked-Weaver	*Ploceus velatus*			X		X	X
Red-billed Quelea	*Quelea quelea*			X	X		
Southern Red Bishop	***Euplectes orix***				**X**		**X**
Yellow Bishop	***Euplectes capensis***						**X**
Thick-billed Weaver	*Amblyospiza albifrons*						X
African Quailfinch	*Ortygospiza atricollis*				X		
Swee Waxbill	*Coccopygia melanotis*		Endemic			X	
Common Waxbill	*Estrilda astrild*						X
African Firefinch	*Lagonosticta rubricata*					X	
Bronze Mannikin	*Spermestes cucullatus*						X
Pin-tailed Whydah	***Vidua macroura***			**X**	**X**		
Dusky Indigobird	*Vidua funerea*					X	
House Sparrow	*Passer domesticus*			X	X		
Cape Sparrow	*Passer melanurus*		Near-endemic	X	X		
Southern Grey-headed Sparrow	***Passer diffusus***				**X**	**X**	
African Pied Wagtail	*Motacilla aguimp*						X
Cape Wagtail	***Motacilla capensis***			**X**	**X**		**X**
Cape Longclaw	***Macronyx capensis***		**Endemic**	**X**	**X**		
African Pipit	***Anthus cinnamomeus***			**X**	**X**		
Plain-backed Pipit	*Anthus leucophrys*			X	X		
Long-billed Pipit	*Anthus similis*			X	X		

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Cape Canary	***Serinus canicollis***		**Endemic**	**X**	**X**		
Brimstone Canary	*Crithagra sulphuratus*					X	
White-throated Canary	*Crithagra albogularis*		Near-endemic	X			
Streaky-headed Seedeater	*Crithagra gularis*			X			
Cape Bunting	***Emberiza capensis***		**Near-endemic**	**X**	**X**		