BirdLife South Africa / Endangered Wildlife Trust

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

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Executive summary

1. The wind energy industry is poised for rapid expansion into many areas of southern Africa. While experiences in other parts of the world suggest that this industry may be detrimental to birds (through the destruction of habitat, the displacement of populations from preferred habitat, and collision mortality with wind turbines, guyed masts and power lines), these effects are highly site- and taxon-specific in operation. Raptors, large terrestrial species and wetland birds are thought to be most susceptible, and areas of higher topographic relief are often implicated in negative impact scenarios.

2. In order to fully understand and successfully mitigate the possible impacts of wind farms on the region's birds (and to bring the local situation into line with international best practice in this field), it is essential that objective, structured and scientific monitoring of both resident and passing avifauna be initiated as soon as possible at all proposed development sites.

3. The Birds & Wind Energy Specialist Group, convened by the Wildlife & Energy Programme of the Endangered Wildlife Trust, and BirdLife South Africa, proposes the following guidelines and monitoring protocols for evaluating wind energy development proposals, including a 3-4 tier assessment process: (i) Reconnaissance – a brief site visit informs a desk-top assessment of likely avifauna and possible impacts, and the design of a site-specific survey and monitoring project, (ii) Baseline monitoring (EIA) – a full assessment of the significance of likely impacts and available mitigation options, based on the results of systematic and quantified monitoring as specified at scoping, (iii) Post-construction monitoring – duplication of the baseline work, but including the collection of mortality data, to develop a complete before:after picture of impacts, and refine the mitigation effort, and (iv) if warranted, more detailed and intensive research on affected threatened species.

4. To streamline this approach, a shortlist of priority species (threatened or rare birds, in particular those unique to the region, and especially those which are possibly susceptible to wind energy impacts and which occur in the given development area at relatively high densities) should be drawn up at the scoping stage, and these should be the primary (but not necessarily the sole) focus of all subsequent monitoring and assessment.

5. Similarly, the amount of monitoring effort required at each site should be set in terms of the anticipated sensitivity of the local avifauna and the prevalence of contributing environmental conditions (for example, the diversity and relative abundance of priority species present, proximity to important flyways, wetlands or other focal sites, and topographic complexity).

6. On-site work must be coupled with the collection of directly comparable data at a nearby, closely matched control or reference site. This will provide much needed context for the analysis of pre- *vs* post-construction monitoring data.

7. In some situations, where proposed wind energy developments are likely to impinge on flyways used by relatively large numbers of threatened and impact sensitive birds, and particularly where these movements are likely to take place at night or in conditions of poor visibility (e.g. the Cape Columbine Peninsula), it may be necessary to use radar to gather sufficient information on flight paths to fully evaluate the development proposal and inform mitigation requirements.

8. Baseline monitoring will require periodic visits to both the development and reference sites, sufficient in frequency to adequately sample all major variations in environmental conditions (with no fewer than four visits), and spanning a total study period of not less than 12 months. Variables measured/mapped on each site visit should include (i) density estimates for small terrestrial birds (in most cases not

priority species, but potentially affected on a landscape scale by multiple developments in one area), (ii) absolute counts, density estimates or abundance indices for large terrestrial birds and raptors, (iii) passage rates of birds flying through the proposed development area, (iv) occupancy/numbers/breeding success at any focal raptor sites, (v) bird numbers at any focal wetlands, and (vi) full details of any incidental sightings of priority species.

9. Post-construction monitoring should effectively duplicate the baseline work, with the addition of surveys for collision and electrocution victims under the turbines and ancillary power infrastructure.

10. While analysis and reporting on an individual development basis will be the responsibility of the relevant avifaunal specialist, all data emanating from the above process should also be housed centrally by the Birds & Wind Energy Specialist Group to facilitate the assessment of results on a multi-project, landscape and national scale.

11. These guidelines will be revised periodically as required, based on experience gained in implementing them, and ongoing input from various sectors.

12. A list of qualified avian specialists currently doing impact assessment and monitoring work at proposed wind energy sites in terms of these guidelines is available at www.birdlife.org.za and www.ewt.org.za.

Foreword 1

The Wind Energy Industry and the Best Practice Monitoring Guidelines

The South African Wind Energy Association (SAWEA) has been involved as a stakeholder in the 2012 revision of the Best Practice Guidelines for Avian Impact Assessment at proposed wind farm sites in South Africa. SAWEA supports the development of a best practice guideline which is in line with international best practice, and reiterates the importance of a guideline which is practical and pragmatic.

The present guidelines were designed with the specific objective of protecting South Africa's bird species from negative impacts associated with wind farm developments, specifically those which are conservation concern and/or those which may be sensitive to the potential impacts of wind energy facilities. In order for the South African wind energy industry as a whole, and each individual project, to be developed in a sustainable manner it is important that this objective is met.

The establishment of a sustainable and environmentally sensitive wind energy industry in South Africa will only be achieved through responsible and careful development. Due care needs to be employed to reduce the risk of negative impacts on important bird species and communities. The early implementation of a robust bird monitoring programme in line with the requirements set out in these guidelines will not only highlight potential impacts on birds, but will also inform developers of the potential risks to the project and may, in some cases, provide information to suggest that a proposed project is highly sensitive and poses a significant development risk. In many cases where some risk is identified this may be effectively mitigated through the adjustment of the development design to remove, reduce or avoid impacts on birds. Early-stage risk identification and impact mitigation can only be effective if suitable and sufficient scientific data has been collected to inform the project development process.

SAWEA supports the implementation of these guidelines on all proposed wind energy developments.

Duncan Ayling, Environmental spokesperson, South African Wind Energy Association

Foreword 2

BirdLife South Africa and the Best Practice Monitoring Guidelines

Our country needs to reduce its dependence on non-renewable means of energy generation. Harnessing the wind's energy is an obvious and attractive option, but this technology is not without environmental impacts. These include aesthetic and noise impacts, habitat loss, and collision mortality and displacement of bats and birds.

Given the recent spate of wind energy development applications in South Africa, BirdLife South Africa (BLSA) is justifiably concerned about the potential impacts of wind farms on our birds. However, we believe that by intelligent application of the lessons learned by our colleagues in other parts of the world, and by working openly with the relevant stakeholders, we can substantially reduce these negative effects. We have obtained advice and assistance from our partners in European countries where wind energy development is already quite advanced. We have also collaborated with the Wildlife and Energy Programme of the Endangered Wildlife Trust (EWT-WEP), and engaged directly with local developers, environmental assessment practitioners and specialist ornithologists alike in our efforts to address this looming problem.

Bird collision data from a handful of European and American sites demonstrate clearly that wind farms can adversely affect bird populations if they are built in the wrong places, and that effective mitigation of such impacts is mainly about understanding bird movements through the affected area, and the corresponding placement of turbines in the landscape. With this in mind, our efforts to influence the national roll-out of wind energy have focused on the critical, early stages of the impact assessment process. By drafting and disseminating two critical documents - the Birds and Wind Energy Sensitivity Map, and the Pre- and Post-construction Monitoring Guidelines (this document), BLSA/EWT-WEP have helped to sensitise both industry and government to the considerable avian issues at stake. We believe that if all stakeholders adhere strictly to these guidelines (which are in full compliance with the minimum standards of international best practice), government will issue the right authorisations for wind energy development, developers will apply appropriate and effective mitigation, and impacts on birds to will be limited to acceptable and sustainable levels.

BirdLife South Africa sincerely appreciates the inputs of the experts on the Birds and Wind Energy Specialist Group, and congratulates the authors of this report for producing a thorough and practical document, which will contribute greatly to the conservation of our country's birds.

Mark Anderson, CEO BirdLife South Africa

Foreword 3

The Endangered Wildlife Trust and the Best Practice Monitoring Guidelines

The Endangered Wildlife Trust (EWT) has been pioneering Conservation in Action since 1973. In this time, the EWT has been at the forefront of developing innovative, strategic partnerships with various industries to generate proactive mitigation measures to reduce harmful impacts on our environment, and to catalyse management practices throughout the sector which reduce wildlife losses.

With the recent emergence of wind generated power as a key element in our future energy mix, we have the perfect opportunity to get ahead of the game, and to apply best practice proactively in the development of wind farms and their associated infrastructure. Unfortunately, the emergence of this possible new threat to our avifauna comes at a time when birds globally are declining in conservation status and where South Africa has among the highest number of birds at risk of extinction in Africa. There is therefore no time to lose in ensuring that wind farm development in South Africa poses as little threat as possible to our birds and to the environment at large.

In this context, the EWT is proud to be working with long-standing partner BirdLife South Africa and a range of new collaborators in the wind energy sector to develop these best practice guidelines, which aim to ensure that the development of wind energy infrastructure takes place sustainably, and without detrimentally affecting the region’s birds.

Yolan Friedmann, CEO Endangered Wildlife Trust

Foreword 4

Eskom and the Best Practice Monitoring Guidelines

As a state-owned company (SOC), Eskom supports South Africa's commitment to the three objectives of the Convention of Biological Diversity's Strategic Plan, namely; "the conservation of biological diversity, the use of the components of biological diversity in a sustainable manner, and the fair and equitable sharing of the benefits of biological diversity". Due to the nature and extent of our operations, Eskom can have an impact on wildlife, and on birds in particular. We work hard to manage and minimise this impact while still supplying power to the country, and in doing so we promote the conservation of southern Africa's biodiversity, and demonstrate our commitment to the national biodiversity strategy. Avian interactions are one of the key high-level indicators that Eskom uses to measure its impact on biodiversity.

We whole-heartedly endorse the BLSA/EWT best practice guidelines for monitoring birds and bird impacts at wind energy sites, and believe that adoption and implementation of these protocols in the roll-out of the wind energy industry in our country will be instrumental in substantially reducing the impact of wind farms on our avifauna.

Dr S.J. Lennon, Group Executive, Sustainability Division, Eskom Holdings SOC Ltd

1. Introduction

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

This should be done by means of an integrated programme of pre- and post-construction monitoring projects, set up at all the proposed development sites. Each such project should broadly comply with the guidelines provided here, although the scale of each project, the level of detail and technical input, and the relative emphasis on each survey and monitoring component, will vary from site to site in terms of the risk potential identified by the initial scoping or environmental impact assessment (EIA) studies. In principle, each project should be as inclusive and extensive (both spatially and temporally) as possible, but kept within reasonable cost constraints, consistent with the anticipated conservation significance of the site and its avifauna. While the need to be more prescriptive on the required minimum standards for monitoring is recognized, the data to empirically test and support such standards are not yet available. In general, the detail and rigor required in any given monitoring project will be proportional to the size of the proposed WEF (*n* turbines and spatial extent), topographic and/or habitat heterogeneity on site, the relative importance of the local avifauna (in terms of diversity, abundance and threat status), and the anticipated susceptibility of these birds to the potential negative impacts of a wind energy development (Table 1).

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

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

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

(i) To develop our understanding of the effects of WEFs on southern African birds.

(ii) To develop the most effective means to mitigate these impacts.

Given the rate and extent of proposed wind energy development, this should be done as quickly as possible, but using scientific methods to generate accurate, comparable information. The current set of best practice guidelines presents the means and standards required to achieve these aims. This is intended to be a living document that will be corrected, updated, and supplemented over time, as local specialist and research practitioners gain much-needed experience in this field. A similarly dynamic list of qualified avian specialists currently doing impact assessment and monitoring work at proposed wind energy sites in terms of these guidelines is available at www.birdlife.org.za and www.ewt.org.za.

2. Recommended protocols

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

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

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

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

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

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

2.1 Stage 1: Reconnaissance

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

The main aims of a reconnaissance study are:

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

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

(ii) To characterize the site in terms of:

- the avian habitats present,
- an inclusive list of species likely to occur there,
- an inclusive list of priority species likely to occur there, with notes on the relative value of the site for these birds,
- input on likely seasonality of presence/absence and/or movements for key species,
- any obvious, highly sensitive, no-go areas to be avoided by the development from the outset.

This should be done by means of:

- a desk-top study of the local avifauna, using relevant, pre-existing information (Hockey *et al.* 2005) and datasets - for example the BirdLife South Africa / Endangered Wildlife Trust avian wind farm sensitivity map for South Africa (Retief *et al.* 2012), the Southern African Bird Atlas data (SABAP 1 - Harrison *et al.* 1997, and SABAP 2), Coordinated Waterbird Counts (CWAC, Taylor *et al.* 1999), Coordinated Avifaunal Roadcounts (CAR, Young *et al.* 2003), the Birds in Reserves project (BIRP) and the Important Bird Areas initiative (Barnes 1998) (for updates on all these datasets see http://adu.org.za/), as well as data from the Endangered Wildlife Trust's programmes and associated specialist research studies, and

- a short (2-4 day) site visit to the area to search for key species and resources, and to develop an on-site understanding of where (and possibly when) priority species are likely to occur and move around the site (note that such a visit will not allow for seasonal variation in the composition and behaviour of the local avifauna, and such variation must therefore be estimated in terms of the existing information for the site or region, and the experience of the consulting specialist).

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

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

Note: In many cases, by this stage in the process a prospective developer has already erected a number of 15-80 m high, guyed lattice masts at locations around the proposed development area in order to gather wind data for the project. Ideally, specialists should have been consulted before the installation of these masts on the need to attach markers to the guy wires in order to reduce collision risk for birds, but this often not the case. In the event that guy wires of existing guyed masts have not been marked, specialist should provide input in reconnaissance reports on the need to do so retrospectively. Also, all such masts should be checked for collision mortalities from the onset of baseline monitoring until the completion of post-construction monitoring (see below).

2.2 Stage 2: Baseline monitoring

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

The primary aims of baseline monitoring are:

(i) To estimate the number/density of birds regularly present or resident within the broader impact area of the WEF before its construction.

(ii) To document patterns of bird movements in the vicinity of the proposed WEF before its construction (e.g. Erickson *et al.* 1999).

(iii) To estimate predicted collision risk (the frequency with which individuals or flocks fly through the future rotor swept area of the proposed WEF – Morrison 1998, Band *et al.* 2007) for key species.

(iv) To inform comment on the merits of the application in the AIA report in terms of points (i) to (iii).

(v) To establish a pre-impact baseline of bird numbers, distributions and movements.

(vi) To mitigate impacts by informing the final design, construction and management strategy of the development.

Reference sites

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

Suitable reference sites should:

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

Duration and frequency of monitoring

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

Equipment and mapping

Ideally, field workers should operate in pairs on the assumption that two people working together are likely to see and record more, and maintain higher health and safety standards, than one person working alone, but without significant additional costs that may be incurred by the deployment of larger teams. On occasion, it may be possible for experienced observers to effectively and safely survey small project areas alone.

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

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

2.2.1 Bird numbers or densities

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

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

Sample counts of small terrestrial species

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

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

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

Recommended variables to record for each transect include:

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

  And, whenever possible, variables to record for each observation should include:

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

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

Recommended variables to record for each such fixed point count include:

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

  And, whenever possible, variables to record for each observation should include:

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

A further alternative method of measuring the occurrence and relative abundance of small terrestrial species (although in this instance, all species are included in the data collection protocol) is the "checklist survey". This method does not measure absolute density of species, as do the transect and fixed-point methods described in this document, but provides a measure of relative density based on the "reporting rate". In its simplest form, the reporting rate is the proportion of checklists for a particular area which record a particular species. The protocol recommended here is the one used by SABAP2, the second South(ern) African bird atlas project, details of which are available on the project's website (http://sabap2.adu.org.za/). The objective of checklist surveys and analysis is to provide a robust comparison of relative density, per species, between the pre- and post-construction conditions.

The advantage of the checklist survey is that the method is easy to apply in situations where methods of counting birds may be difficult to apply in a consistent manner, for example, where habitats are diverse or visibility limited, and the survey area is very large (Royle & Nichols 2003, Joseph *et al.* 2006). Its disadvantage is that it is dependent on not one, but a series of checklists (preferably at least 10), recorded at different times, so that a robust relative-density statistic can be calculated. Checklist surveys are suitable for monitoring species in the broad "affected area" of the WEF, but should be complemented by transect or fixed-point counts conducted more strictly within the turbine development area (see protocol in this document). The latter counts will provide a more sensitive measure of density at the localities most likely to be impacted by the turbines. (Such transect or point counts could often be done from the same locations as vantage-point monitoring.)

The protocol for a checklist survey requires (a) the definition of a survey area, (b) the application of a minimum amount of survey effort, and (c) coverage of all habitat types within the survey area. All species are recorded as present only, i.e., individuals are not counted. In addition, the order in which species are first observed is recorded, as well as the total number of new species per hour of observation. The minimum amount of time allocated to each checklist should be sufficient to permit coverage of all the habitat types in the survey area: two hours is the specified minimum in the SABAP2 protocol, with a maximum of five days. Note that while larger species and priority species should be included in checklist surveys, these do not replace other methods of measuring the density of these birds, which include the capture of critical information on absolute rather than relative abundance (although see Wenger & Freeman 2008).

For SABAP2, the survey area is the "pentad", a cell of roughly 8x9 kilometres, created by a 5x5-minute grid. The size of a pentad makes it advisable to survey using a vehicle to cover the area. Pentads are suitable survey areas for large WEFs and the data collected will be compatible with the SABAP2 database. Every pentad which includes a portion of the WEF should be surveyed, as a minimum. Relatively small WEFs (<4 kilometres in extent) would perhaps be better served by transect or point counts (described in this document). Statistical analysis of SABAP2-style checklist data is more sophisticated than a simple proportion or percentage of checklists with presence records (as used in SABAP1), and will be described further in a later revision of these guidelines.

Counts of large terrestrial species and raptors

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

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

Recommended variables to record for each absolute count of large, priority species include:

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

    And, whenever possible, variables to record for each observation should include:

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

- Seen while driving/walking/scanning
- Additional notes

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

Recommended variables to record for driven transect counts of large terrestrial species and raptors include:

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

And, whenever possible, variables to record for each observation should include:

- Time
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (if required - <30m, 30-150m, >150m)
- Seen while driving/scanning?
- Habitat type/mix of habitat types
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)

- Seen close to (feedlot, dam, river course, ridge or cliff-line…)
- GPS on transect line
- Perpendicular distance off transect line (m) (if required)
- Distance band off the transect line (if required)
- Fixed transect width (if required)
- Plot on map
- Additional notes

Focal site surveys and monitoring

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

Recommended variables to record for each nest site survey should include:

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

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

Recommended variables to record for each wetland survey should include:

- Project name
- Date
- Observer/s
- Wetland name, number or code
- Time at start/finish of count
- GPS location at observation point
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)

And, whenever possible, variables to record for each species counted should include:

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

Note: As an extension of the focal site/wetland monitoring protocol, any guyed masts present on the proposed development area should be checked on each iteration for signs of bird collisions, and the findings should be recorded as per post-construction collision victim surveys (see below).

Incidental observations

All other, incidental sightings of priority species (and particularly those suggestive of breeding or important feeding or roosting sites or flight paths) within the broader study area should be carefully plotted and documented. These could include details of nocturnal species (especially owls) heard calling at night.

Recommended variables to record for each incidental observation of priority species should include:

- Project name
- Date
- Observer/s
- Time
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (if required - <30m, 30-150m, >150m)
- GPS location of observer
- Plot birds sighted on map
- Habitat type/mix of habitats

- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Seen close to (feedlot, dam, river course, ridge or cliff-line…)
- Seen while driving/walking/scanning
- Additional notes

2.2.2 Bird movements

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

Radar

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

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

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

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

Direct observation

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

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

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

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

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

Recommended variables to record for each vantage point survey should include:

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

And, whenever possible, variables to record for each observation should include:

- Time sighted
- Species
- Number (number of adults/juveniles/chicks) at start and end of observation
- Temperature
- Cloud cover
- Wind strength/direction#
- Visibility (good, moderate, poor)
- Initial sighting distance (m)
- Flight mode (direct commute-flapping, direct commute-gliding, slope soaring…)*
- Underlying habitat*
- Gradient of underlying slope (flat, gentle, steep)*
- Aspect of slope (none, north, north-east, east…)*
- Flight direction*
- Flying height (<30m, 30-150m, >150m)*
- Identifiable flight path indicators (valley, neck or saddle, ridge line, thermal source…)
- Time lost
- Plot on map
- Additional notes

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

\# Wind data can be measured directly using a hand-held anonemeter, and/or sourced from the wind data collected on-site by the developer for the relevant date and time.

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

2.3 Stage 3: Post-construction monitoring

The primary aims of post-construction monitoring are to:

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

2.3.1 Bird numbers and movements

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

2.3.2 Avian collisions

The primary aims of avian collision monitoring are to:

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

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

Assessing search efficiency and scavenging rates

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

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

Collision victim surveys

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

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

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

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

3. A step-wise approach to bird monitoring at a proposed wind energy site

The following are key steps in the successful design and implementation of bird monitoring at a proposed wind energy development site:

- Appoint a qualified and expert advising scientist and a capable monitoring agency to conduct pre- and post-construction monitoring.
- Get the monitoring protocols right – i.e. customise the generic guidelines to suite the specific issues at each site.
- Determine the extent of radar deployment required - if radar use is warranted, secure the budget, and acquire/hire hardware, software and relevant expertise, including the appointment of a radar technologist to service the project.
- Start baseline monitoring.
- Periodically collate and analyse baseline monitoring data, and adjust the data collection protocols and schedule to ensure that sufficient data are accumulated and sufficient coverage is achieved to adequately inform development decisions.
- Compile a report reviewing the full year of baseline monitoring, and integrate these findings into the Environmental Management Plan (EMP) for the project and the broader mitigation scheme.
- Determine whether certain anticipated impacts warrant the implementation of 'during construction' monitoring, and how this can best be achieved subject to construction schedules and activities.
- Ensure that the EMP is applied during construction.
- Refine the post-construction monitoring protocol in terms of the baseline work, and determine the extent of radar deployment required.
- Start post-construction monitoring.
- Periodically collate an analyse post-construction monitoring data, and adjust the data collection protocols and schedule to ensure that sufficient data are accumulated and sufficient coverage is achieved to adequately inform operational decisions.
- Compile a report reviewing the full year of post-construction monitoring, integrate the findings into the EMP for the operating wind farm and the broader mitigation scheme, and review the need for further post-construction monitoring.

4. Data Management

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

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