BirdLife South Africa

Birds and Solar Energy Best Practice Guidelines

Best Practice Guidelines for assessing and monitoring the impact of solar energy facilities on birds in southern Africa

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BirdLife SOUTH AFRICA
Giving Conservation Wings

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Executive summary

The solar energy industry is expanding rapidly in 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 and burn mortality associated with elements of the solar hardware and ancillary infrastructure), the nature and implications of these effects are poorly understood.

In order to fully understand and successfully avoid and minimize the possible impacts of solar energy on the region's birds, it is essential that sufficient, project- and site-specific data are gathered to both inform the avifaunal impact assessment process and build our understanding of the impacts and potential mitigation measures.

The Birds and Renewable Energy Specialist Group (BARESG), convened by BirdLife South Africa and the Wildlife and Energy Programme of the Endangered Wildlife Trust, proposes the following guidelines and monitoring protocols for evaluating utility-scale solar energy development proposals. The Guidelines are aimed at environmental assessment practitioners, avifaunal specialists, developers and regulators and propose a tiered assessment process, including:

(i) **Initial screening or scoping** – an initial assessment of the likely avifauna and possible impacts, preferably informed by a brief site visit and by desk-top collation of available data; also including the design of a site-specific survey and monitoring project should this be deemed necessary.

(ii) **Data collection** – further accumulation and consolidation of the relevant avian data, possibly including the execution of baseline data collection work as specified by the scoping study, intended to inform the avian impact study.

(iii) **Impact assessment** - a full assessment of the likely impacts and available mitigation options, based on the results of systematic and quantified monitoring if this was deemed a requisite at scoping.

(iv) **Monitoring and mitigation** –repetition of baseline data collection, plus the collection of mortality data. This helps to develop a complete before and after picture of impacts, and to determine if proposed mitigation measures are implemented and are effective, or require further refinement. Mitigation may only be necessary for projects with the potential for significant negative impacts on birds (i.e. large area affected and/or vulnerable species present).

The quantity and quality of baseline data required to inform the assessment process at each site should be set in terms of the size of the site and the predicted impacts of the solar technology in question, and the anticipated sensitivity of the local avifauna (for example, the diversity and relative abundance of priority species present, proximity to important flyways, wetlands or other focal sites), and should vary from a single, short field visit (Regime 1, for e.g. at a small, low impact site with low avifaunal sensitivity), to a series of multi-day survey periods, including the collection of various forms of data describing avian abundance, distribution and movement and spread over 12 months (Regime 3, for e.g. at a large, impactful development located in a sensitive habitat).

To streamline the impact assessment process, a short list of priority species should be drawn up at the scoping stage. Priority species should include threatened or rare birds, in particular those unique to the region, and especially those that may be susceptible to solar energy impacts. These species should be the primary (but not necessarily the sole) focus of subsequent monitoring and assessment.

Monitoring at the larger and/or more impactful sites will require periodic surveys conducted frequently enough to adequately sample all major variations in environmental conditions, with no fewer than four surveys spanning all four seasons. Variables measured/mapped on each survey 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) census counts, density estimates or abundance indices for large terrestrial birds and raptors, (iii) passage rates of birds flying through the proposed development area, including nocturnal movements, (iv) occupancy/numbers/breeding success at any focal species sites, (v) bird numbers at any focal wetlands (within a variable distance of the proposed project, depending on the size and relative importance of the wetland), and (vi) full details of any incidental sightings of priority species.

Post-construction monitoring should effectively duplicate the baseline data collection work. This will provide an indication of any differences in avian use and abundance at the facility after construction. Surveys for collision and burn mortalities around the solar arrays, and collision and electrocution victims under the ancillary power infrastructure, should also be conducted. Fatality rate estimates should take into account scavenger removal, searcher efficiency, and areas not searched.

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 BARESG and/or the South African National Biodiversity Institute (SANBI)) to facilitate the assessment of results on a multi-project, landscape and national scale.

These guidelines will be revised periodically as required, based on experience gained in implementing them, and on-going input from various sectors. This is the first edition and replaces BirdLife South Africa's *Guidelines to Minimise the Impact on Birds of Solar Facilities and Associated Infrastructure in South Africa* (Smit 2012).

A list of qualified avian specialists who have agreed to adhere to these guidelines is available at www.birdlife.org.za.

Glossary of terms and acronyms

Accuracy — The degree to which the result of a measurement and/or calculation aligns with the true value (accuracy is different to precision, the latter which is a measure of how close different measurements are to each other).

Adaptive management — An iterative decision-making process used in the face of uncertainty where the effectiveness of management policies and practices are monitored and continually improved on.

Assessment regime — The recommended approach to avifaunal impact assessment (and in some cases monitoring) based on the solar energy technology, project size, and likely risks associated with a project. Three regimes are outlined in these guidelines: Regime 1 (low risk projects) require a short site visit by an avifaunal specialist; Regime 2 and 3 (medium and high risk) require structured data collection over at least 6 months and 12 months respectively, and should include comparative post-construction monitoring and estimates of fatalities.

Avifaunal sensitivity — The sensitivity of an area based the number of priority species present or potentially present, the regional, national or global importance of the affected area for these species (both individually and collectively), and the perceived susceptibility of these species (both individually and collectively) to the anticipated impacts of development.

For example, an area would be considered to be of high avifaunal sensitivity if one or more of the following is found (or suspected to occur) within the broader impact zone: 1) avifaunal habitat (e.g. a wetlands, nesting or roost sites) of regional or national significance, 2) population of a priority species that is of regional or national significance, and/or 3) a bird movement corridor that of regional or national significance 4) a protected area and/or Important Bird and Biodiversity Area.

An area would be considered to be of medium avifaunal sensitivity if it does not qualify as high avifaunal sensitivity, but one or more of the following is found (or suspected to occur) within the broader impact zone 1) avifaunal habitat (e.g. a wetland, nesting or roost sites) of local significance, 2) a locally significant population of a priority species, 3) a locally significant a bird movement corridor.

An area would be considered to be of low avifaunal sensitivity if it is does not meet any of the above criteria.

BARESG — The Birds and Renewable Energy Specialist Group, a group of bird specialists who guide BirdLife South Africa and the Endangered Wildlife Trust's work on birds and renewable energy.

Bird habitats — Habitats available and important to birds, usually shaped by factors such as vegetation structure, topography, land use and sources of food and water.

BIRP — Birds in Reserves Project, a project run by the Animal Demography Unit (University of Cape Town) that collects bird occurrence data inside South African protected areas. For more information visit

	http://birp.adu.org.za.
Broader impact zone	The area in which potentially impacted birds are likely to occur. This will extend beyond the development footprint/ developable area, but should be included in monitoring and impact assessment surveys. This could include the considerable space requirements of large birds of prey.
CAR	Coordinated Avifaunal Roadcounts, a programme where large terrestrial birds are monitored from vehicles along fixed routes. See http://car.adu.org.za for more information.
CSP	Concentrated Solar Power. Also known as solar thermal energy.
Cumulative impact	Impacts on a species, ecosystem or resource as a result of the sum of actions in the past, present and foreseeable future, from multiple SEFs or a SEF in combination with other developments.
CWAC	Coordinated Waterbird Counts, a voluntary programme of bird censuses at a number of South African wetlands. See http://cwac.adu.org.za for more information.
Developable area	The area in which solar energy hardware, and associated road and power infrastructure might be located.
Fatal flaw	In the context of these guidelines a fatal flaw is an impact that is of very high negative significance that cannot be mitigated to acceptable levels, and as a result the project should not proceed.
IBA	Important Bird and Biodiversity Area. Part of a global network of sites that are critical for the long-term viability of bird populations. See www.birdlife.org.za/conservation/important-bird-areas for more information.
Impact assessment	A systematic process of identifying, assessing and reporting environmental impacts associated with an activity; this should include the consideration of mitigation measures and alternatives.
Impact zone	Usually taken to mean the area directly impacted by development, e.g. the development footprint (compare to "broader impact zone")
Mitigation	An activity or process designed to avoid, reduce, restore, or compensate for the significant negative environmental impacts associated with a development.
Monitoring	In the context of these Guidelines, monitoring refers to the collection and collation of data in order to document the impacts of a development. It includes the collection of pre- and post-construction survey data, as well as the collection of mortality data.
Priority species	Threatened or rare birds (in particular those unique to the region and especially those which are possibly susceptible to solar energy impacts), which occur in the given development area at relatively high densities or have high levels of activity in the area. These species should be the primary (but not necessarily the sole) focus of all subsequent monitoring and assessment.
PV	Photovoltaic

Red flag A warning signal. In the context of these guidelines a red flag would indicate that the impacts of a SEF on birds (or their habitats) are likely to be unsustainable.

SABAP The Southern African Bird Atlas Project - bird species data collected by volunteers. There have been two SABAP projects; i.e. SABAP1 (completed in 1991) and SABAP2 (started in 2007 and ongoing). The unit of data collection for SABAP2 is a pentad (five minutes of latitude by five minutes of longitude). See http://sabap2.adu.org.za for more information.

Scoping A process to identify issues that are likely to be important in the impact assessment process and to define the scope of work required in the assessment (e.g. timing, spatial extent and data collection methodologies). Largely based on desktop analysis of available data, but preferably also informed by a brief site visit.

Screening A preliminary assessment of the potential environmental impacts of a proposed development and of its likely significance (precedes scoping and impact assessment).

SEF A solar energy facility. See "solar energy facility" below.

Significant impacts In the context of these Guidelines, significant impacts are those impacts that will have effects that are likely to persist for a long time, will affect a large area, and/or extend far beyond the area in which the activity occurs. Where species are concerned, significant impacts would be those that negatively affect the favourable conservation status of a population at a given scale. Where possible, impacts should be contextualised in terms of the population size, distribution, and current mortality rates. Population modelling may be useful to help determine the significance of impacts for some species (beyond the scope of these guidelines).

Solar energy facility Also known as a solar farm, a power plant that uses the sun to generate electricity.

1. Introduction

KEY POINTS

- Solar energy can impact avifauna directly by injuring or killing birds that collide with photovoltaic (PV) panels or reflective Concentrated Solar Power (CSP) heliostats, or with associated infrastructure. At CSP power tower facilities birds may also be burned when they fly through concentrated beams of solar flux. This effect may be exacerbated if the reflective surfaces making up the solar hardware serve to attract birds to the area.
- Solar developments can also impact birds indirectly by destroying or degrading large areas of habitat, displacing sensitive species, by causing disturbance (at both the construction and operational phases) that affects presence or breeding and/or foraging success of key species, and by depleting or polluting ground water in efforts to keep solar panels and heliostats clean.
- These guidelines were developed to ensure that any negative impacts on threatened or potentially threatened bird species are identified and effectively mitigated using structured, methodical and scientific methods. At present, our understanding of the impacts of utility-scale solar energy facilities on birds is limited. It is therefore essential that we gather relevant and accurate data at proposed new developments to anticipate and fully document actual impacts in order to ensure the future sustainability of this industry.
- A multi-tiered approach is proposed with the overarching aims of 1) informing current environmental impact assessment processes, 2) developing our understanding of the effects of solar energy facilities on southern African birds, and 3) identifying the most effective means to avoid, minimize, and mitigate these impacts.

BirdLife South Africa supports the increased use of renewable energy generation as a means to meet the country's electricity demands in a more sustainable way. South Africa is among the world's top 10 developing countries required to significantly reduce their carbon emissions (Seymore et al. 2014), and the introduction of low-carbon technologies into the country's compliment of power generation will greatly assist with achieving this important objective (Walwyn and Brent 2015). Given that South Africa receives among the highest levels of solar radiation on earth (Fluri 2009; Munzhedi et al. 2009), it is clear that solar power generation should feature prominently in our future efforts to convert to a more sustainable energy mix.

Two broad types of utility-scale solar power generators or Solar Energy Facilities (SEFs) are currently proposed, under construction, or in operation in South Africa:

1. Photovoltaic (PV) SEFs, which convert solar radiation directly into electricity by exposing solar cells to incoming radiation, either by arranging them conventionally in multiple flat panels, or by using lenses or reflective surfaces to concentrate radiation onto a smaller array of more efficient cells (Hernandez et al. 2014).

2. Concentrated Solar Power (CSP) SEFs, which use an array of reflective surfaces (arranged as troughs, fresnels or dishes) to focus the sun's heat onto a receiving element, which in turn is used to heat water to generate steam to turn turbines or generators (Hernandez et al. 2014).

Each of these various technological configurations present quite markedly different structures to the environment, and have widely differing spatial requirements per unit of power generated (Phillips 2013; Hernandez *et al.* 2014).

The number of solar energy development proposals in South Africa has rapidly increased over the last five years, with more than 500 projects proposed and under review by the Department of Environmental Affairs (Walwyn & Brent 2015). Of these, almost 400 have already been authorised, and more than 40 have been selected as preferred bidders (with many of these already under construction or connected to the grid). Unfortunately, our ability to make meaningful recommendations on the nature and quantity of avian data required to manage the interface between avifauna and this expanding industry is compromised by our limited understanding of exactly how each of the various solar technologies available are likely to affect our birds. Only recently have telling, empirical data started to emerge from monitoring work at operating facilities in other parts of the world (e.g. Kagan et al. 2014, Walston et al. 2015), and there are few clear patterns common to these studies to help us draft a sensible set of generic guidelines. The physical extent of natural habitat affected by many proposed developments is a concern, and measured avian mortality rates at a number of solar projects have been unexpectedly high (Kagan et al. 2014, Walston et al. 2015). Hence, the need to develop and institute a set of protocols to serve as a blueprint for avian impact assessments at solar development sites has steadily escalated, and such a step is now deemed critical to ensure that the industry rolls out on a sustainable basis in our region.

To meet this urgent need, the present document prescribes the best practice approach to gathering bird data at proposed utility-scale solar energy plants, primarily for the purposes of accurate and effective impact assessment. It has been drawn up in terms of the relevant information currently available in both the published and the grey literature. This document should be considered as a major revision of BirdLife South Africa's first, abbreviated guide to birds and solar energy (Smit 2012), and acknowledges the pressing need to (i) measure the actual effects of solar energy plants on birds as quickly as possible, in order to identify and mitigate any detrimental impacts on threatened or potentially threatened species, and (ii) 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). The guidelines have been compiled in full consultation with the presiding authorities, NGOs and representatives of the solar industry, and will be periodically updated, supplemented and revised, as local specialists and research practitioners gain much-needed experience in this field.

1.1. Impacts of CSP developments

CSP plants incorporate the use of large, reflective surfaces (heliostats) which introduce the risk of collision-related trauma, comparable with the high collision rates reported for expanses of exposed glass incorporated into many urban skyscrapers (Drewitt and Langston 2008). In addition, these reflective surfaces focus beams of sunlight into a small area resulting in concentrated solar flux in the airspace surrounding the receiver unit. In the most problematic CSP configuration, large heliostat arrays focus solar flux on a central "power tower", exposing passing birds to the risk of being singed or even incinerated in these flux beams, particularly as they aggregate close to the receiver. Objects near the receiving unit are exposed to solar flux that is equivalent to temperatures of >800ºC (McCrary et al. 1986; Hernandez et al. 2014). In combination, these sources of injury or mortality are generally considered to be the most obvious and significant impact of solar energy development on birds, as well as a major drawback of the use of this particular technology. To put this impact into broader context, measured and estimated avian mortality rates for major CSP plants (using the central "power tower" configuration) in the USA are comparable with, and may even exceed, those derived from some of the more impactful wind farms (Kagan et al. 2014, Smallwood 2014). In fact, given that this mortality is presumably a function of the volume of bird traffic present in the vicinity of a proposed CSP project, incorporating the best practice guidelines that have been developed for wind energy facilities (Jenkins et al. 2012) in designing and implementing bird monitoring and impact assessment studies for power tower CSP projects should be considered. Most of those requirements have been included, essentially verbatim, in the guidelines for such projects set out below. However, since there is evidence that some species of birds may be attracted to solar energy facilities that have reflective surfaces similar to bodies of water, additional monitoring considerations may be appropriate. Other known or putative impacts of CSP plants are destruction or degradation of extensive tracts of natural habitat, excessive use of water (which may drain local reserves in naturally dry habitats), and air and water pollution resulting from the use of dust suppressants (Lovich and Ennen 2011; Hernandez et al. 2014). CSP facilities also produce a large amount of wastewater (brine), which can be difficult to manage and treat.

1.2. Impacts of solar PV developments

Solar PV facilities tend to cover large areas (about 2-5 ha per MW – Ong et al. 2013, Hernandez et al. 2014). New developments in panel technology, such as thin film coating, have increased the efficiencies of PV panels over time. In many cases PV facilities have involved the complete removal of vegetation from the inclusive footprint of the installed plant (Lovich and Ennen 2011; DeVault et al. 2014). It is this tendency to destroy, degrade, fragment or otherwise displace birds from large areas of natural habitat that has stimulated most concern to date about the implications for avifauna of large-scale solar PV development (Lovich and Ennen 2011; RSPB 2011; Smit 2012), particularly in relation to species with restricted ranges and very specific habitat requirements. In addition, recent findings at facilities in North America suggest that collision mortality impacts may be underestimated at solar PV plants, with collision trauma with PV panels, perhaps associated with polarised light pollution and/or with waterbirds mistaking large arrays of PV panels as wetlands – the so-called "lake effect" - (Horváth et al. 2009; Lovich and Ennen 2011), emerging as a significant impact factor at one site where mortality monitoring is on-going (Kagan et al. 2014).

Other possible impacts of solar PV farms include noise and disturbance generated by construction and maintenance activities, the attraction of novel species to an area by the artificial provision of otherwise scarce resources – for example perches, nest sites and shade (DeVault et al. 2014), and chemical pollution associated with measures taken to keep the PV panels clean, such as the use of dust suppressants (Lovich and Ennen 2011).

1.3. Impacts of solar developments generally

The overall environmental impacts of solar energy developments globally are poorly understood (Tsoutsos et al. 2005; Gunerhan et al. 2009; Lovich and Ennen 2011; Turney and Fthenakis 2011; Hernandez et al. 2014), as are the specific impacts of these plants on birds (RSPB 2011; De Vault et al. 2014). Unlike wind energy development, there is presently no clear pattern in the types of birds negatively affected by solar plants, and solar flux and collision casualties recorded to date include a wide variety of avian guilds (McCary 1986, Kagan et al. 2014). However, there are indications that insects and aerial insectivores may for some reason be attracted to the vicinity of CSP facilities (particularly power tower projects), that waterbirds may be attracted to both PV and CSP facilities in mistaking the hardware for expanses of open water, and that at least some of the larger, more mobile species considered prone to collision with wind turbines, may also be prone to trauma- and solar flux-based mortality (McCary 1986, Kagan et al. 2014). Additional studies are required to verify these theories.

Infrastructure commonly associated with renewable energy facilities, including solar plants, may also have detrimental effects on birds. The construction and maintenance of substations, power lines, servitudes and roadways causes both temporary and permanent habitat destruction and disturbance, and overhead power lines pose a collision and possibly an electrocution threat to certain species (Lehman et al. 2007; Jenkins et al. 2010; Dwyer et al. 2014). Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. Also, power line service roads or servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, and to prevent vegetation from intruding into the legally prescribed clearance gaps between the ground and the conductors. These activities have an impact on birds breeding, foraging and roosting in or in close proximity to the power line corridor, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any given power line (e.g. King and Byers 2002). Power line collision risk affects a particular suite of susceptible species, mainly comprising large, heavy birds (such as bustards, cranes and large raptors), and smaller, fast-flying birds (such as gamebirds, waterfowl and small raptors - Bevanger 1994; 1998; Janss 2000; Anderson 2001; Drewitt and Langston 2008; Jenkins et al. 2010), while electrocution risk is strongly influenced by the voltage and design of the power lines erected (generally occurring on lower voltage infrastructure where air gaps between the electrified lines are relatively small), and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energised components (Lehman et al. 2007).

Potentially positive impacts of solar energy projects on birds include the use of the various raised structural components of these developments as artificial nesting and roosting sites by a suite of otherwise tree-nesting species (Lovich and Ennen 2011; Hernandez et al. 2014). The ultimate impact of this phenomenon – in terms of the effect of inflated numbers of some species on the overall species composition in the vicinity of the development area, and the possible need for management or removal of these nests by the developer – remains unclear at this stage.

Given the wide variation in the nature and significance of the predicted impact profiles of the different types of solar energy development, the low levels of confidence attending these predictions, we recommend that a gradient of survey and monitoring requirements be imposed on avian studies for solar development EIAs. This gradient should range from no more than would be required to address the impacts of a regular, industrial or commercial development on a greenfield site (generally one short site visit), to the full gamut of baseline and post-construction monitoring that would be required for a commercial-scale wind farm (Jenkins et al. 2012). The project technology, size, and the estimated sensitivity of the receiving environment, should be used as the primary factors affecting where along this gradient a given development should fall (Table 1).

The parameters used in compiling this matrix were assigned in terms of the following assumptions and conditions:

i. Within each technology, larger projects will generally be more impactful than smaller ones.

ii. CSP power tower projects include the risk of flying birds dying or being injured on contact with highly concentrated solar flux (McCary et al. 1986, Kagan et al. 2014). Theoretically, this risk may also be present at trough, dish and possibly fresnel CSP projects, but the extent to which commuting or foraging birds are exposed to high beams of concentrated solar flux is probably far less in these more compact technologies (and may even be negligible), and the authors are not aware of any such incidents to date.

iii. The avian sensitivity of the receiving environment is a function of the relative abundance and/or diversity of Red List and/or endemic and/or restricted range species present or likely to be present, and their perceived susceptibility to the anticipated impacts of solar energy development. Sensitive avian environments could also include important migratory routes and regionally significant concentrations of more common species. Initial assessment of sensitivity should be at the discretion of the consulting specialist, and subject to review as data are collected on site.

All CSP power tower projects, all other solar energy projects that may affect sensitive avifauna, and all solar projects larger than 150ha, should be subject to an integrated programme of baseline monitoring of avifauna, impact assessment, and operational-phase monitoring of avifauna (Table 1). Given the rate and extent of proposed solar energy development, these studies should be done as quickly as possible, but using scientific methods to generate accurate, representative and comparable information. Pre-project data collection should occur 1-2 years before to project approval, in order to be included in and inform required environmental analysis documents and project decisions.

The present document lays out the means and standards required to achieve the following aims:

a) To inform the current environmental impact assessment processes.
b) To develop our understanding of the effects of solar energy plants on southern African birds.
c) To identify the most effective means to mitigate these impacts.

Table 1. Recommended avian assessment regimes in relation to proposed solar energy technology, project size, and known impact risks.

Regime 1: One site visit; 1-5 days.

Regime 2: Pre- and post-construction; 3 x 3-5 days over 6 months, mortalities.

Regime 3: Pre- and post-construction; 4-5 x 4-8 days over 12 months, mortalities

Type	**Size** [1]	**Avifaunal Sensitivity** [2]		
		Low	**Medium**	**High**
All except CSP power tower	Small (<30 ha)	Regime 1	Regime 1	Regime 2
	Medium (30-150 ha)	Regime 1	Regime 2	Regime 2
	Large (>150 ha)	Regime 2	Regime 2	Regime 3
CSP power tower	All	Regime 3		

[1] For multi-phased projects, the aggregate footprint of all the phases should be used. At 3ha per MW, Small = < 10 MW, Medium = 10-50 MW, Large = > 50MW.

[2] The avifaunal sensitivity is based on the number of priority species present, or potentially present, the regional, national or global importance of the affected area for these species (both individually and collectively), and the perceived susceptibility of these species (both individually and collectively) to the anticipated impacts of development. For example, an area would be considered to be of *high avifaunal sensitivity* if one or more of the following is found (or suspected to occur) within the broader impact zone: 1) avifaunal habitat (e.g. a wetlands, nesting or roost sites) of regional or national significance, 2) a population of a priority species that is of regional or national significance, and/or 3) a bird movement corridor that is of regional or national significance, and 4) a protected area and/or Important Bird and Biodiversity Area. An area would be considered to be of *medium avifaunal sensitivity* if it does not qualify as high avifaunal sensitivity, but one or more of the following is found (or suspected to occur) within the broader impact zone 1) avifaunal habitat (e.g. a wetland, nesting or roost sites) of local significance, 2) a locally significant population of a priority species, 3) a locally significant bird movement corridor. An area would be considered to be of *low avifaunal sensitivity* if it is does not meet any of the above criteria.

[3] Different technologies may carry different intrinsic levels of risk, which should be taken into account in impact significance ratings.

2. Recommended protocols

KEY POINTS

- Assessment and decision-making should follow a multi-tiered approach:
- Stage 1, **scoping**, should inform project screening or the scoping phase of the impact assessment, and is the stage where the project should be allocated to one of the three assessment regimes (Table 1).
- Stage 2, more in-depth study**,** possibly including structured and repeated **data collection** on which to base the impact assessment report and provide a baseline against which post-construction monitoring can be compared.
- Stage 3, **impact assessment**, informed by the data collected during Stage 2.
- Stage 4, a second period of data collection may be necessary post-construction for **monitoring and mitigation** of actual project impacts.
- In some instances, a fifth stage of assessment may be necessary to formally and intensively research important project-specific issues pertaining to known or anticipated significant impacts.
- In general, data collection effort should be proportional to the size of the proposed SEF, topographic and/or habitat heterogeneity on site, the relative importance of the local avifauna, and the anticipated susceptibility of these birds to the potential negative impacts.
- These guidelines set out the minimum requirements for responsible EIA reporting. In some instances more work may be necessary to provide sufficient information for decision-making.
- Data collection and monitoring should focus mainly on a shortlist of priority species.
- All higher risk projects (assessment regimes 2 and 3) should provide quantitative information on the abundance, distribution and risk to key species or groups of species, and serve to inform and improve mitigation measures.

We recommend that a multi-tiered approach be applied to assessing each solar development application (Fig. 1), similar to the one applied to wind energy development in South Africa, Europe and North America (e.g. Scottish Natural Heritage 2005; Kuvlesky et al. 2007; U.S. Fish and Wildlife Service 2012; Jenkins et al. 2012).

The first tier, scoping, could be undertaken as part of the project screening (i.e. before the EIA process), but must be included in the scoping phase of the impact assessment. Should the scoping report endorse the development, a full avian impact assessment should then be based on the second tier of work (a more in-depth assessment of impacts and mitigation, possibly requiring the collection of baseline data), with the scope of this additional work informed by the findings of the avifaunal scoping study. Baseline data-collection and monitoring may be central to the following impact assessment process, and where deemed necessary, this should be used to determine 1) if the project should proceed, 2) what measures are necessary to avoid, minimize and mitigate the impacts of the project, and 3) the nature and extent of construction-phase and post-construction (operational-phase) monitoring.

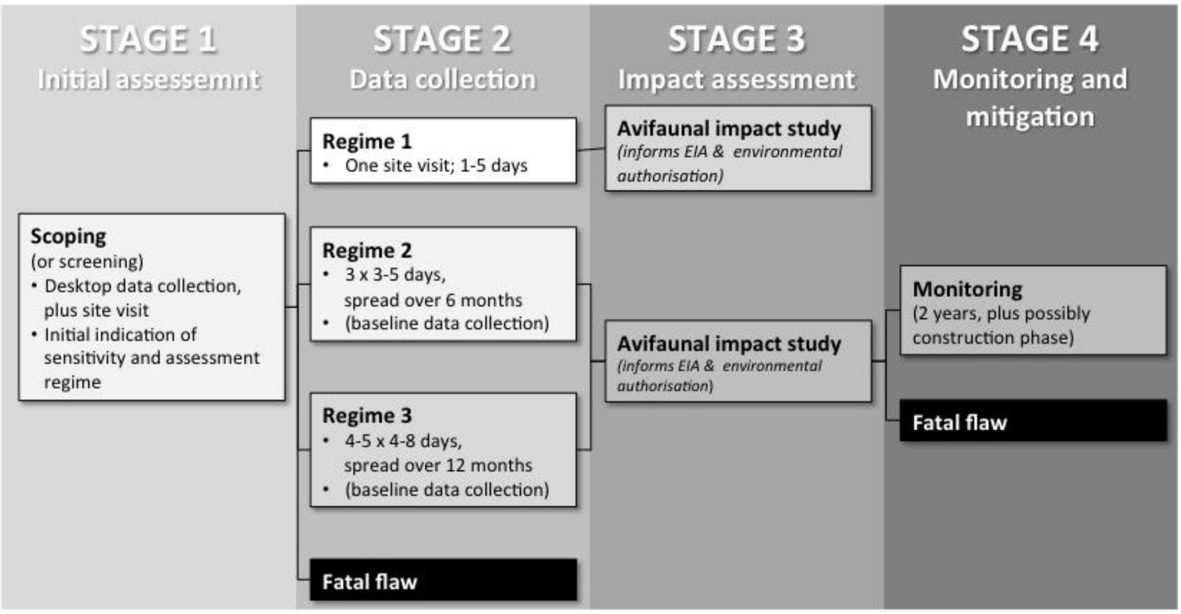

Figure 1. Recommended multi-tier process for assessing the potential and realised impacts of proposed solar energy developments in South Africa, with the scope of work required depending on project technology and size, and the perceived sensitivity of the receiving environment. A fatal flaw is where impacts are deemed to be unsustainable and cannot be mitigated; the project should not proceed. A fatal flaw may be identified at any stage of the process.

Should the third stage in the process, avian impact assessment, also endorse the proposed development and it goes ahead, a fourth tier of work could consist of construction-phase monitoring (where required), leading on to post-construction monitoring, in which the actual impacts of the project are documented, and effective mitigation measures are designed and implemented. Should significant effects be observed, an adaptive management approach to reduce impacts may be required. For example, the testing of avian detection and deterrent systems could be explored on a pilot basis, with a monitoring program designed to assess the efficacy of such a system; or variation in the spacing of PV panels could be assessed to determine if collision rates change with different panel configurations.

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 populations. However, these additional studies will not always help reduce potential impacts to acceptable (sustainable) levels.

2.1. Stage 1: Scoping

KEY POINTS

- The aim of scoping is to 1) define the study area, 2) characterise the site, 3) provide an initial indication of the likely impacts of the facility, 4) determine whether or not additional field data will be required to inform the EIA, and 5) determine the nature and scope of data collection and analysis required.
- Scoping should include a desktop study using existing information, and ideally a site visit to fully and directly evaluate the impact risks inherent to the project, particularly where existing data are few.
- The study area should be defined during scoping and would typically extend well beyond the boundaries of the development footprint itself.
- The resulting scoping report should describe the birds potentially affected and the nature of the risk. It should also highlight any obvious red flags to development.
- The scoping report should describe the effort required for baseline data collection and impact assessment.
- The avifaunal scoping report must be included in the scoping phase of the impact assessment, but could also be used in project screening, before initiating a formal EIA.

2.1.1. Aims of scoping

The main aims of a scoping 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 (construction storage and staging areas, the main civil works , and associated road and electrical infrastructure) could take place. However, because birds are highly mobile animals, and because an important potential impact of at least some forms of solar energy facilities (SEFs) is the effect of the project on birds that move through the proposed development area, as well as those which are resident within it, the avian impact zone of any proposed solar development will likely extend beyond the boundaries of this central core. Of particular concern in some instances is that monitored areas are large enough to include the considerable space requirements of large birds of prey, which may reside several kilometres outside of the core development area, but regularly forage within it. How far the study area extends in each case should be determined by the avifaunal specialist, and should be defined at the scoping stage of the assessment process, perhaps with opportunity for subsequent refinement during the impact assessment.

   Generally, the extent of the broader impact zone of at least some projects 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 impact zone, which is the area within which all additional survey and monitoring work will be carried out, is done realistically and objectively, balancing the potential impacts of the SEF with the availability of resources to conduct the monitoring.

ii. To **characterize the site** in terms of:

- the bird habitats present (habitats available and important to birds, usually shaped by factors such as vegetation structure, surface water, topography, land use and food sources),
- a list of species likely to occur in those habitats,
- a list of priority species likely to occur, with notes on the value of the site for these birds and the relative sensitivity of the affected area,
- 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 (these could be landscape-scale features that may influence the location of the SEF, or finer-scale features that should guide micro-siting of solar arrays).

iii. To provide an initial estimation of **likely impacts** of the proposed SEF.

iv. To **determine whether or not some level of baseline data collection is necessary, and to detail the nature and scale of such work** required to measure anticipated impacts and to provide input on mitigation. Table 1 provides a generic guide to these requirements, but depends on the relative sensitivity of the site which is established at scoping level.

In summary, scoping should yield a scoping report, which should describe the avifauna at risk, detail, the nature of that risk, and preliminary options for mitigation. The report should speak to the relative sensitivity of the site and highlight any red flags to development, determine whether or not additional data, baseline data collection is necessary and, if so, define the nature and scope of this work required to fully inform the avian impact assessment report.

2.1.2. Information sources used in scoping

Scoping should be based on:

i. A **desk-top study** of the local avifauna, using relevant, pre-existing information (Hockey *et al*. 2005) and datasets - for example

  a. the BirdLife South Africa / Endangered Wildlife Trust avian wind farm sensitivity map for South Africa (Retief et al. 2012),
  b. the Southern African Bird Atlas data (SABAP 1 - (Harrison et al. 1997), and SABAP 2, http://sabap2.adu.org.za),
  c. Coordinated Waterbird Counts (CWAC, http://cwac.adu.org.za, Taylor et al. 1999),
  d. Coordinated Avifaunal Roadcounts (CAR, http://car.adu.org.za, Young et al. 2003),
  e. the Birds in Reserves Project (BIRP, http://birp.adu.org.za),
  f. the Important Bird and Biodiversity Areas initiative (Barnes 1998, http://www.birdlife.org.za/conservation/important-bird-areas/iba-directory),
  g. provincial conservation plans and provincial species databases (where available), and
  h. data from the Endangered Wildlife Trust's programmes (www.ewt.org.za) and associated specialist research studies.

ii. Ideally, a short **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. This is particularly important, and should be considered obligatory, in instances where there are few if any existing data available to inform initial decision making. Also, note that a single site 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. Equally, note that in cases where the proposed project is small and/or located in a known, low impact habitat, this initial site visit may prove sufficient to serve the purposes of the full avian impact study.

Again, it is important to be aware of the limitations of a study that primarily relies on desktop information, particularly where an area has been poorly surveyed and/or the data is out-of-date; a lack of data does not equate to a lack of impacts.

2.1.3. Priority species

Avian impact studies, and all data collection conducted to inform such studies, should focus on a shortlist of priority species, defined in terms of (i) threat status or rarity (see Barnes 2000 and Taylor 2014), (ii) uniqueness or endemism, (iii) susceptibility to disturbance or collision impacts, and (iv) relative use of the site. High relative use could be as a result of usage by a relatively small number of individuals of a priority species, (e.g. breeding raptor), or use by large numbers of different birds. These species should be identified in the scoping/avian impact assessment report and/or by the BirdLife South Africa/EWT sensitivity mapping exercise (Retief et al. 2012 or updates thereof) which, while it was developed primarily with wind energy developments in mind, may have considerable bearing on impact assessments for some kinds of solar projects. This will generally result in a strong emphasis on large, Red List species (e.g. cranes, bustards and raptors – Drewitt and Langston 2006; 2008; Jenkins et al. 2010). Because the complete destruction of large tracts of habitat is a worrisome feature of many types of solar energy development (Lovich and Ennen 2011; Hernandez et al. 2014), the impact of this industry on small, Red List, threatened or range-restricted species – e.g. certain larks and pipits - may be more prevalent and significant than is generally believed to be the case for wind energy, and such species should feature more prominently in priority species lists for solar assessments as a result. Also, given the possibility that solar facilities may be mistaken for waterbodies and actually attract wetland birds into otherwise waterless areas, Red list waterbirds – flamingos, storks, pelicans – may also be regularly implicated.

The overall sensitivity of the receiving environment to the avifaunal impacts of solar energy development is essentially a function of the number of priority species present, the regional, national or even global importance of the affected area for these species (both individually and collectively), and the perceived susceptibility of these species (both individually and collectively) to the anticipated impacts of development. For example, an area known or thought likely to support a globally significant population of a single, highly threatened species (e.g. Red Lark *Calendulauda burra*, Yellow-breasted Pipit *Anthus chloris*) would be considered highly sensitive, as would an area known or thought likely to support a diversity of threatened but more widely distributed species (e.g. a suite of large raptors or large terrestrial birds), or a site that includes or is close to a known critical resource for large numbers of aggregating species (e.g. a regionally significant wetland). In contrast, an area that includes tracts of replaceable, homogeneous vegetation, no important populations of threatened or range-restricted species, and no obvious key resources for large numbers of birds, would be considered as relatively insensitive to development.

While immediate conservation imperatives and practical constraints encourage focus on priority species, it is also important to account for subtler, systemic effects of solar 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 SEFs 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 from the vicinity of a SEF may also have a substantial, knock-on effect. Hence, some level of monitoring of small passerines and other ecologically pivotal bird populations will be required at all sites where additional survey and monitoring work is a pre-condition (i.e. Regimes 2 and 3), and certain non-threatened, but impact-susceptible species will emerge as priority species by virtue of their perceived value to the ecosystem, as well as the potential cumulative impacts of development on these species. 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 (Devereux 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 data collection or 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, including possible identification of unsuitable areas for SEFs.

2.1.4. Timing

While the avifaunal scoping study could coincide with and serve as the scoping study for the purposes of EIA, it is not necessary to wait until the formal EIA starts in order to start additional survey and monitoring should this be required. It may prove to be extremely valuable for developers to commission an avifaunal scoping study before initiating a formal impact assessment process as this might help avoid unnecessary investment in unsuitable sites.

2.1.5. Reporting (Avifaunal Scoping Report)

The Avifaunal Scoping Report should describe the nature and extent of the study area, and the nature and relative sensitivity of the receiving environment and its birds, provide a preliminary indication of the potential impacts of development and the location of any no-go areas, and outline the scope of any additional field data collection that might be required to fully inform the EIA, and should be included in the Scoping Report for the SEF.

2.2. Stage 2: Data collection

KEY POINTS

- Structured and repeated baseline data collection is not required for the lower-risk development proposals (assessment regime 1). Such projects require only that the consulting specialist visit the site at least once, and spend sufficient time there to obtain first-hand knowledge of the avian habitats present, in order to predict the affected avifauna, the nature and scale of impacts and the best mitigation options available.
- In the event that structured and repeated data collection is deemed a requirement (assessment regimes 2 and 3), it should provide 1) a basis for the avifaunal impact assessment and 2) a baseline against which the results of post-construction (operational phase) monitoring can be compared, focusing particularly on the small bird populations likely to lose habitat to the development footprint, vantage point-based counts of bird movements through the area, and numbers of larger, wider-ranging species that may be resident in the general area.
- Additional baseline data collection should be done over a period of 6-12 months, ideally encompassing a wide range of environmental conditions, and in some cases (assessment regime 3) including the full spectrum of "seasonal" variation present within a complete annual cycle.
- Before data collection commences, the avian habitats available on the project should be mapped using available information (e.g. satellite images and GIS data).

Number and density of small birds (assessment regimes 2 and 3):

- The number and/or density of small birds can be surveyed using walked transects, fixed point counts and/or checklist surveys. All major habitat types within the impact zone should be sampled in proportion to their availability on site, and areas should be sampled at various distances radiating away from the core development area, well beyond the actual footprint. Checklist surveys are suitable for monitoring species in the broader impact zone affected area of the SEF, but must be complemented by transect or fixed-point counts within and around the actual development area.

Numbers of raptors and large terrestrial birds (assessment regimes 2 and 3):

- The numbers of raptors and large terrestrial birds should be surveyed on each visit. Any breeding pairs and/or nest sites of priority species located within and around the development area during this survey work must be plotted and treated as focal sites for subsequent monitoring.

Focal point surveys (assessment regimes 2 and 3):

- Nest sites of large terrestrial species and any habitats likely to support nest sites of key raptors should be surveyed and checked on each survey to confirm occupancy. Any evidence of breeding activity and/or its outcomes must be recorded.
- Wetlands should be identified, mapped and surveyed for waterbirds on each survey, using the standard protocols set out by the CWAC initiative.
- Power lines should be checked for signs of bird collisions and electrocutions; the findings should be recorded as per post-construction phase mortality reports.
- Incidental sightings of priority species, particularly if suggestive of breeding, important feeding or roosting sites, or flight paths, should be recorded.

Bird movements (assessment regimes 2 and 3):

- Understanding bird movements on a site requires significant time and effort, but it can be critical to inform the impact assessment and mitigation strategy for the higher risk SEFs.
- *Vantage point surveys* should provide information on the time spent flying over or in the vicinity of the development area, the relative use of different parts of the area, and the proportion of flying time different species spend flying at different heights in relation to the proposed development area.
- A maximum radius of 2 km should be surveyed from each vantage point.
- Vantage points should be positioned to obtain a representative sample of bird movements across a development site, with particular focus on the location of power towers, should these be proposed.
- A minimum of 12 hours should be accumulated at each vantage point on each site visit, and coverage should include all times of day (dawn, midday, late afternoon).

It is necessary to collect data on site for the following reasons:

i. To predict the nature and significance of impacts on birds, and thereby inform the broader environmental impact assessment report for the development and related decisions.
ii. To help mitigate impacts by informing the final design, construction and management strategy of the development.
iii. In higher risk projects (assessment regimes 2 and 3), it is also necessary to monitor the impacts on birds. Data collected pre-construction provides a baseline against which the results of post-construction monitoring can be assessed.

2.2.1. Lower risk sites (assessment regime 1)

For assessment regime 1, the consulting avian specialist should visit the development site at least once (Note: if the site is visited as part of the scoping study this may be sufficient to inform the impact assessment), and spend sufficient time there to obtain first-hand knowledge of the avian habitats present, in order to predict the affected avifauna, the nature and scale of possible impacts and the best mitigation options available. This assessment should be informed substantially by the specialist's previous experience of similar habitats and bird taxa, supplemented by the existing data describing the birds likely to be present (e.g. SABAP 1 and 2 data). The specialist should endeavour to see as much of the inclusive affected area as possible, and any field data collected on site should also be used in the assessment. If there is reason to suspect an obvious and predictable seasonal peak in avian abundance or activity in the general area of the proposed development, the site visit should ideally be timed to coincide with this peak time (e.g. soon after rain which prompts influxes of birds into dry areas, or in summer when the majority of migratory birds would be present). All other factors aside, the time spent on site should be greater in instances where the existing bird data are few. Beyond these simple but important requirements, the scope of work done on site for lower risk project is largely at the discretion of the consulting specialist.

The avifaunal specialist may recommend more rigorous assessment (i.e. regime 2 and 3) if the assessment reveals unexpected sensitivities.

2.2.2. Higher risk sites (assessment regimes 2 and 3)

For assessment regimes 2 and 3 it is necessary to estimate the abundance of birds regularly present or resident within the broader impact area of the SEF before its construction, establishing a quantitative baseline, to document patterns of bird movements in the vicinity of the proposed SEF before its construction, and to estimate predicted collision risk (the frequency with which individuals or flocks fly through the future collision risk area of the proposed SEF) for key species. This additional, structured and repeated data collection serves a dual function. It is necessary to inform the impact assessment process for higher risk projects, and it yields the baseline data on species presence, abundance and distribution required to determine the actual impacts of the built and operational solar farm.

(a) Timing of study

For higher risk sites, additional data collection is required to guide and inform the avian impact assessment report. It should therefore be completed before the impact assessment is finalised and before the EIA application is submitted to the authorities for a decision.

If there is a significant gap (i.e. more than 3 years) between the completion of the initial data collection and impact assessment and the anticipated commencement of construction, consideration should be given to repeating the baseline data collection (or parts thereof) to assess whether there have been any changes in species abundance, movements and/or habitat use. This is particularly advisable where a there have been obvious changes in the habitat in and around the proposed development.

(b) Duration

Additional baseline data collection should be done over 6-12 months, ideally to include sample counts representative of as much as possible of the full spectrum of prevailing environmental conditions (e.g. peak wet and dry seasons) likely to occur on each site (Drewitt and Langston 2006). The requirement to extend monitoring over the 12 months depends on the solar technology proposed, the spatial extent of the project, and the sensitivity of the habitat affected (Table 1). In such instances, while monitoring need not span a full 365 days, the duration should be sufficient to ensure that the full annual cycle is represented. This time-span may not have direct biological relevance, but presents a compromise between the extremes of either attempting to accommodate inevitable (and probably significant) variation between years, or distilling the process into a very short sampling window.

The duration of monitoring should be extended where there is a high risk of significant impacts on priority species and

1. there is likely to be strong inter-annual variation in the presence and movement of priority species (see for example Gove et al. 2013), or
2. there is a high degree of uncertainty related to the potential impacts and/or mitigation measures required, and further monitoring would help reduce this uncertainty.

(c) Frequency and timing of surveys

The necessity for surveys at all and, in the event that they are required, the frequency of surveys, should be determined by the perceived sensitivity of the site, modulated by practical constraints (human capacity, size and accessibility of the site, time, and finances). For the highest risk SEFs, four to five visits to the site, timed to coincide to include maximum environmental variation, should be considered as an absolute minimum for achieving adequate coverage. However, the quality and utility of the additional monitoring data is generally proportional to sampling frequency, so the number of iterations of each sampling technique per survey, and the number of surveys accumulated, should always be kept at a practical maximum. All other things being equal, surveys should be spaced more or less equally throughout the study period.

(d) Habitat classification and mapping

Before sampling and counting commence, the study area should be defined and avian habitats available should be mapped using a combination of satellite imagery (Google Earth) and GIS tools. These maps should later be subject to ground-truthing and refinement according to on-site experience and/or the findings of scoping phase botanical surveys.

(e) Bird numbers or relative abundance

Bird population monitoring may present some challenges. Proposed developments can cover large areas, at least some of the priority species are large birds (cranes, bustards, eagles, vultures) that have 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. Furthermore, some of the proposed development sites are situated in remote 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. However 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. Ultimately, the scope of work done at any given development site should be determined primarily by the birds present and the anticipated risk of impacts, and not by financial constraints imposed by the project proponent.

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 SEF (when applicable – assessment regimes 2 and 3), including data for a representative range of avian guilds. The main concern for comparative studies is that the same technique be used throughout the baseline and post-construction monitoring.

(f) Small terrestrial species (assessment regimes 2 and 3)

Given that most SEF projects seem likely to involve the degradation or sometimes complete destruction of 10s or even 100s of hectares of natural habitat, quantifying the direct, net effect of the development footprint, as well as the knock-on, peripheral effects, on small terrestrial bird populations in each case is an important part of determining the overall impact of any given SEF proposal. This is also to further our understanding of the general effects of SEFs, and in particular the possible cumulative impacts of widespread SEF development on the broader avifauna. Given the potentially very large area put to solar energy development in 10-20 years' time (http://www.sapvia.co.za/, Fluri 2009), we need to assess now whether or not components of small bird communities are likely to be displaced or lose damaging quantities of prime habitat, before we effect landscape-scale distributional changes, with the longer-term ecological damage that such changes could bring.

The abundance of small birds can be surveyed using either walked transects, or fixed point counts, depending on habitat structure. Check-list surveys are suitable for monitoring species in the broader impact of the SEF, but should be complemented by transect or fixed-point counts conducted more strictly within the solar energy development area.

Data should be collected both within the actual footprint of the development (to quantify the small bird populations lost or directly displaced), and in the surrounding area, with sampling sites radiating out to as far as at least 1-2 km outside of the of the inclusive development area (to quantify the extent to which species or communities are indirectly displaced or changed, and to compare affected populations with those located well beyond the impact radius of the development). The latter samples would obviously form the focus of post-construction surveys. Note that while it will be important to repeat baseline data collection post-construction, the aim is to gather comparable samples and not exact replicates. The nature and scale of changes imposed on the development footprint by the built facility will preclude any chance of directly reproducing pre-construction counts once the plant is completed and operational.

(i) Walked transects:

Small birds could be monitored by means of walked, linear transect methods in open habitats (Leddy et al. 1999; 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 present. 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 solar arrays to maximize the value of the data in comparison with post-construction phase survey results. Transects should be surveyed according to standard procedures (for example, as described by Emlen 1977; Bibby et al. 2000). These procedures should take into account possible biases caused by different observers, detectability, time of day, bird song activity and/or weather conditions. 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 by range-finder, estimated by eye (in which case calibration is necessary), 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. 2001; Thomas et al. 2010), or equivalent approaches (Bibby et al. 2000; Newson et al. 2008). 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}) or an index of kilometric abundance. The estimates based on the latter approach do not take the probability of detection into account. It is preferable to have many fairly short (e.g. 200m) transects than few long (e.g. 2km) transects.

WALKED TRANSECTS
Recommended variables to record for each transect include:

- Project name
- Transect number
- Date
- Observer/s
- Start/finish time

- GPS location at start and finish
- Orientation of transect
- 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

(ii) Fixed point counts:

Another acceptable way to measure small bird densities, especially in taller, denser habitat, is to use fixed point counts. For fixed point counts 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 relative abundance in closed habitats with raised and/or dense vegetation (Bibby et al. 2000).

Again, survey locations should be selected to represent the habitats covered more or less in proportion to their availability, and positioned at varying distances away from the core development area to test for any gradient of impact. 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). It is important to record whether birds are seen or heard as it may be difficult to hear birds once the SEF is operational.

FIXED POINT COUNTS
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

(iii) Checklist surveys:

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, 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 that record a particular species.

The objective of checklist surveys and analysis is to provide a robust comparison of relative density, per species, between before and after-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 and Nichols 2003; Joseph et al. 2006). A 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 SEF, but should be complemented by transect or fixed-point counts conducted more strictly within the solar development area. The latter counts will provide a more sensitive measure of density at the localities most likely to be impacted by the solar arrays.

The protocol for a checklist survey requires (a) the definition of a survey area (to permit comparable repeat visits), (b) the application of a constant 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 and Freeman 2008).

Where possible and appropriate the protocols used by SABAP2 (the second Southern African Bird Atlas Project) should be used. Details of these protocols are available on the project's website (http://sabap2.adu.org.za/). For SABAP2, the survey area is the "pentad", a 5x5-minute grid resulting in a cell of roughly 8x9 km. The size of a pentad makes it advisable to survey using a vehicle to cover the area. Pentads could be suitable survey areas for large SEFs, particularly if the SEF is located centrally within the pentad, and the data collected will be compatible with the SABAP2 database. Every pentad that includes a portion of the SEF should be surveyed, as a minimum. Relatively small SEFs would perhaps be better served by transect or point counts.

(g) Large terrestrial species and raptors (assessment regimes 2 and 3)

Large terrestrial birds (e.g. cranes, bustards, storks, and most raptors) cannot be adequately surveyed using walked transects. Populations of such birds should be estimated on each visit to the project area either by means of a dedicated census (vehicle-based absolute count), or by means of road counts (vehicle-based sampling best applied at relatively large proposed SEFs, 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). Again, these surveys should extend well beyond the specified boundaries of the development, in order to account for indirect disturbance and displacement impacts that might result from the construction and operation of the proposed SEF and to compare numbers of birds located within the impact zone of the development with those located outside of it. This extension of the survey area also takes into account the potential for almost complete destruction or modification of habitat within the actual footprint of the proposed solar plant.

(i) Census counts:

Census counts of priority species involve searching as much of the broader impact area of the SEF as possible in the course of a day, using the available road infrastructure 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 total number of each target species present within the broader study area on that sampling day. In planning a census count approach, be sure to allow for the substantial changes that will be imposed on the development area and its surrounds by the built facility, and ensure that the count process is repeatable post-construction.

CENSUS COUNTS OF LARGE PRIORITY SPECIES

Recommended variables to record for each 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)
- GPS location of observer
- Distance and direction from observer
- Plot birds sighted on map and/or record GPS points
- 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

(ii) Road Counts:

Road counts of large terrestrial birds and raptors require that one or a number of driven transects be established (depending on site size, terrain and infrastructure), 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 within the impact zone. Be sure to plan the survey routes used carefully, allowing for the significant changes in road infrastructure and access likely to result from the construction of the new plant, which might complicate post-construction data collection. 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 or 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 (birds.km^{-1}).

ROAD COUNTS

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
- 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

(iii) Focal site surveys and monitoring:

Nest sites

Any habitats within the broader impact zone of the proposed SEF (extending well beyond deemed the actual development footprint) 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 following protocols in 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 evidence of breeding, and where possible, the outcomes of such activity, that may take place over the survey period (Scottish Natural Heritage 2010). Disturbance of breeding birds must be kept to a minimum during surveys. 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. Evidence of breeding should be assigned the same status categories as used in BIRP (Harrison et al. 2007).

NEST SITE SURVEYS
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

Wetlands and evaporation ponds

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). In arid areas particular attention should be given to identifying ephemeral wetlands. Some priority species (e.g. Blue Crane *Anthropoides paradiseus*) may only occupy roosts at night; suspected roosts should therefore be visited late in the day to tally the numbers of birds as they accumulate into the evening.

WETLAND SURVEYS
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)
- Tidal state (if wetland is tidal)

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)
- Activity (e.g. feeding, roosting, transit)
- Additional notes

Power lines

As an extension of the focal site monitoring, any power lines within the proposed development area should be checked on every survey iteration for signs of bird collisions and electrocutions, and the findings should be recorded as per post-construction phase mortality report (see below).

(iv) 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.

INCIDENTAL OBSERVATIONS
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
- 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

(h) Bird movements (assessment regimes 2 and 3)

A spatially explicit understanding of bird movements in and around proposed SEFs is a priority, given that the nature and incidence of flights over and around solar farms must surely influence the risk of collision mortality and the potential for localised displacement of flight paths. However, because the collection of such data requires a significant investment of time and effort, and because the underlying biology and mechanics of collision mortality at solar facilities is not as clear as it is at wind energy sites (and hence the value of vantage point data to help mitigate collision impacts is not as obvious), we propose a less onerous approach to vantage point studies at proposed SEFs. This said, the basic principles, aims and requirements of vantage point work remain the same.

The purpose of vantage point watches at proposed SEFs is to collect data on all species (but focusing on priority species where necessary) to allow estimation of:

i. The time spent flying over the proposed development area,
ii. The relative use of different parts of the development area, including a range of heights above the proposed solar energy hardware.

Counts of bird traffic over and around a proposed/operational facility should be conducted from suitable vantage points. The same vantage point location should be used for each subsequent survey as even small changes in observer position can affect results (Scottish Natural Heritage 2013). Vantage point watches should be designed to obtain a representative sample of bird movements across a development site and allow for the thorough analysis of the data. GIS can be used to facilitate the identification of vantage points with the best inclusive viewsheds. Vantage points should be strategically positioned to cover key areas proximal to potentially relevant habitat features (e.g. wetlands, areas of threatened habitat, ridge-lines or drainage lines), and in the case of CSP power tower facilities, to cover the proposed location of any towers proposed.

Surveys 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 survey. Alternatively, watches can be divided into three shifts distributed through the day, 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. A minimum of 12 hours per season should be accumulated at each vantage point. Night-time watches, coincident with clear, moonlit conditions, might be valuable at sites where nocturnal activity is considered likely or possible.

Observation and data collection should ideally be focused in the direction of the proposed development area from the vantage point, extending to 90^{o} 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. In contrast to the recommendations for wind energy sites, unless proven otherwise at a given site, it should be possible for single observers to collect adequate VP data to serve the purposes of most solar energy facilities, which means that teams of two observers can gather information at two VPs simultaneously if the viewsheds are 180^{o}, or two observers 'back to back' could observe a viewshed of 360 ^{o}, reducing the required duration of each site visit. As with all the survey methods, clear written documentation, describing what has been done, is essential.

Vantage point surveys require many hours to be spent on site collecting data, with tedium and fatigue affecting both the quality and quantity of useful information obtained. Other challenges include the inability 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 2013).

VANTAGE POINT SURVEYS

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 and gradient of underlying slope (flat, gentle, steep)*
- Aspect of slope (none, north, north-east, east…)*
- Flight direction and height*
- Identifiable flight path indicators (valley, neck or saddle, ridge line, thermal source…)
- Time lost
- Plot flight-paths 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 anemometer, and/or sourced from the wind data collected on-site by the developer for the relevant date and time.

Also note that while vantage point surveys are the primary means of gathering data on bird movements, in some instances these direct observations may benefit from supplementary data from remote sensing equipment (e.g. radar) or bird-based telemetry. Please see BirdLife South Africa's position statement on the use of tracking of birds, available at www.birdlife.org.za, for more information on tracking devices.

2.3. Stage 3: Impact assessment

KEY POINTS

- The avian impact assessment should be compiled in terms of the data available for the site in the literature, as well as data collected on the site expressly for this purpose.
- The results of this analysis should inform the positioning of solar arrays, the operation of the SEF, and the significance of the potential impacts of the proposed project alternatives (with and without mitigation).
- The impact assessment should also inform the nature and extent of monitoring required during construction and operation of the facility.

Avifaunal impact assessments rely on a number of assumptions. The baseline data collection protocols outlined in this document represent a compromise between practicality (time and cost) and statistical rigor. Relying on imperfect data and research findings from different regions (and often different species) means that there will always be a degree of uncertainty and risk associated with assessments.

2.3.1 Impact assessment

The avifaunal impact assessment for lower risk projects (Regime 1) should be done on the basis of the data collected on-site, the relevant information available in the published literature and from citizen-science databases, and the specialist's past experience of this or similar habitats, and in terms of the standard principles of impact assessment. Note that an absence of confirmed knowledge of risk does not mean that risk is absent, and when in doubt the precautionary principle should be invoked, and project proponents and their consultants should err in favour of environmental protection and sustainability.

The avifaunal impact assessment for higher-risk SEF developments (regime 2 and 3) should be based on the various datasets collected during baseline surveys detailed above. The impact assessment must include an analysis (statistical measurement and mapping, where appropriate) of the following variables:

i. Abundance estimates for small terrestrial birds (in most cases not priority species, but potentially affected on a landscape scale by multiple developments in one area), through linear transect surveys, fixed point counts or reporting rates;
ii. Counts, density estimates or abundance indices for large terrestrial birds and raptors;
iii. Flight behaviour of priority species flying over or around the proposed solar development area, at risk of collision or of sustaining burn injuries;
iv. Occupancy/numbers/breeding success at any focal nest sites;
v. Bird numbers at any focal wetlands and local movements between waterbodies;
vi. Full details of any incidental sightings of priority species;
vii. Collision mortalities related to any existing power lines.

The results of this analysis should be used to:

i. Develop a topographical map indicating the area that would be impacted by the proposed development alternatives and the location of key habitats and flyways that should not be developed or otherwise transformed.
ii. Inform the final location and layout of the solar array/s (or to define no-go areas and areas that should be sufficiently buffered against development).
iii. Assess the significance of the potential impact of the proposed project alternatives and related activities - with and without mitigation - on bird species and communities (with regards to potential disturbance, displacement, habitat loss and mortality), including consideration of the spatial and temporal extent of these impacts. Although current levels of knowledge preclude accurate estimation of potential mortality rates, an indication of the relative risk of mortality as a result of impact trauma, and in the case of CSP power towers facilities solar flux related mortality, should be provided.
iv. Inform actions that should be taken to prevent or, if prevention is not feasible, to mitigate (minimize, restore, or compensate for) negative impacts during the planning, construction and operational phases of the development.
v. Inform the nature and extent of monitoring required during the post-construction phase.
vi. Determine whether or not the proposed development (or parts thereof) is fatally flawed and should not be recommended for approval, and highlight this finding.

Significant negative impacts would be those impacts that diminish the conservation status of a species or population. Where possible, impacts on a given taxon should be contextualised in terms of the size and distribution of the affected population, and any known trends in key demographic parameters. This may require the development of population models (beyond the scope of these guidelines).

The avifaunal impact assessment must include a description of the limitations and assumptions of the field study. Where vantage point surveys have been conducted, a map indicating the location of the vantage points, and ideally showing the viewshed from each vantage point, should be provided, together with a map of the proposed layout of the solar farm.

Where other developments are proposed in a region, the impact assessment must include consideration of cumulative impacts.

2.3.2 Measures to avoid, minimize and mitigate project related impacts on birds

The options available for mitigation are likely to change as our understanding of the impacts increases and new methods are tested. At present, mitigation alternatives can be divided into the following broad categories:

a) *Site selection* - e.g. avoid developing in or near important habitat for birds.
b) *Landscape management* - e.g. minimise clearing of natural vegetation, cover ponds with wire mesh or netting to reduce the possibilities of attracting, drowning and poisoning, avoid creating conditions that will attract birds (e.g. standing water and waste) if they may be susceptible to other impacts, or create conditions that will attract and benefit birds if this will contribute to their conservation.
c) *Infrastructure management* - e.g. adjust the tilt of heliostats and solar panels when in standby mode to reduce risk of collisions and/or solar flux injuries. In addition, other facility features that pose hazards to birds should be placed in areas that will minimize risk to birds

such as electrified infrastructure. Minimize use of outdoor lighting at the solar facility. Research indicates that lights can attract and confuse migrating birds (Gehring et al. 2009, Manville 2005, 2009, 2013) and bats are known to feed on concentrations of insects at lights (Fenton 1997). Some insectivorous birds may also be attracted to lights. The goal of every facility should be to minimize the use of lights needed to operate the facility to the maximum extent practicable. If the perimeter of the solar project is fenced, utilize systematic fence marking to reduce avian collisions with fences. Markings should be at an appropriate height to be visible to birds flying at or above the height of the solar panels.

2.4. Stage 4: Monitoring and mitigation (assessment regimes 2 and 3)

KEY POINTS

- The construction phase of the SEF development is likely to be highly impactful, although many of these impacts will be temporary. Having environmental monitors present on site to guide management and mitigation efforts and to monitor the effects of construction activities is optimal, but not necessarily mandatory for smaller sites and/or lower risk sites.
- Post-construction monitoring is not required for lower-risk projects (assessment regime 1), although it is encouraged. Any incidents of bird injury or mortality observed during operations should be recorded and reported.
- For higher-risk projects (assessment regimes 2 and 3), post-construction monitoring is necessary to a) determine the actual impacts of the SEF, b) determine if additional mitigation is required at the SEF and c) learn about impacts and improve future assessments.
- Post-construction monitoring does not negate the need to first avoid, minimise and mitigate negative impacts during the project development stage.
- Post-construction monitoring should be started as the facility becomes operational, bearing in mind that the effects of a SEF may change over time
- Post-construction monitoring can be divided into three categories: a) habitat classification, b) quantifying bird numbers and movements (replicating baseline data collection), and c) estimating bird mortalities.
- There are three components to estimating bird fatality rates: a) estimation of searcher efficiency and scavenger removal rates, b) carcass searches, and c) data analysis incorporating systematically collected data from a and b above.
- A minimum of 20- 30% of the solar hardware (plus an area with a diameter of 300 m around the CSP power tower, where relevant) should be methodically searched for fatalities, with a search interval informed by scavenger removal trials and objective monitoring. Any evidence of mortalities or injuries within the remaining area should be carefully recorded and included in reports as incidental finds.
- The search area should be defined and consistently applied throughout monitoring.
- Observed mortality rates must to be adjusted to account for searcher efficiency (which can change seasonally depending on vegetative condition of the site), scavenger removal and the percent of the facility covered by the monitoring effort. Some of these factors may change seasonally due to the breeding season of scavengers and the whether visibility of the survey area changes through the year.
- The duration and scope of post-construction monitoring should be informed by the outcomes of the previous year's monitoring, and should be reviewed annually.
- Post-construction monitoring of bird abundance and movements and fatality surveys should span 2-3 years to take inter-annual variation into account. However, if significant problems are found or suspected, the post-construction monitoring should continue as needed in conjunction

with adaptive management, taking into account the risks related to the particular site and species involved.

2.4.1. Construction phase bird monitoring

The construction phase of a SEF is likely to be the most intense period in terms of disturbance and displacement of birds. It is important to gain a better understanding of how construction impacts on birds, and how these impacts can be minimised (e.g. Pearce-Higgins et al. 2012 for a wind energy project).

Construction-phase bird monitoring could be used to:

a) Determine whether or not proposed protective buffers are actually effective in minimising impacts on sensitive birds during construction.
b) Provide insights into the triggers and duration of any observed changes in species presence, abundance and behaviour.
c) Provide an opportunity to gather additional data on priority species and focal points (particularly if any nest sites have been identified).

Construction phase monitoring will not be necessary for all solar farms, but may be recommended by the specialist in the impact assessment. This could happen if, for instance, there is a focal site of specific interest or concern, and/or if there is a need to gather additional data on a priority species and/or if there are anticipated impacts on the breeding success of a priority species.

If the specialist recommends construction-phase monitoring, the duration, frequency and scope of work should be outlined in the impact assessment report and included in the environmental management plan. Without pre-empting the recommendations of the specialist, surveys of a few days in duration, with a particular emphasis on focal point surveys, could be anticipated.

Construction phase monitoring could be undertaken by the avifaunal specialist team and/or a suitably qualified environmental control officer, depending on the nature and scope of the work. The results of this monitoring should inform any additional mitigation that may be required and included in revisions of the environmental management plan.

2.4.2. Post-construction data collection or monitoring

Post-construction data collection or monitoring is critical to:

i. Determine the actual impacts of the SEF.
ii. Determine if additional mitigation is required (adaptive management).
iii. Provide indication of likely impacts from scaling-up (similar developments in same general area);
iv. Improve future assessments.

By committing to post-construction monitoring developers will help facilitate the development of a sustainable solar energy industry and reduce risk and costs to both the environment and industry in the long run.

Post-construction monitoring should assess if there are any changes in a) habitat available to birds in and around the SEF, b) abundance and species composition of birds, c) movements of priority species, and d) breeding success of priority species. It should also provide an indication of fatality rates as a result of collisions, burning and electrocution, and if there are any spatial, temporal or conditional patterns to the frequency of collisions. Most importantly, post-construction monitoring should highlight if additional mitigation is required to reduce impacts to acceptable levels.

Commitment to post-construction monitoring does not negate the need to attempt to avoid, minimise, and otherwise mitigate negative impacts identified in the impact assessment, but it can help minimise unanticipated negative impacts. Post-construction monitoring is particularly important given the heavy reliance on adaptive management that characterises many environmental impact assessments for SEFs in South Africa, as well as the inherently steep learning curve.

Post-construction monitoring can be divided into three categories: a) habitat classification, b) quantifying bird numbers and movements (replicating baseline data collection) and c) quantifying bird mortalities. It may be necessary to introduce a fourth category of monitoring should there be a need to investigate and resolve a specific impact.

Post-construction monitoring is not required for lower-risk projects (assessment regime 1), although it is encouraged. Any incidents that may affect birds (e.g. injuries, mortality or other relevant observations) should always be recorded by the environmental manager and reported to the consulting specialist.

For higher-risk projects (assessment regimes 2 and 3), post-construction monitoring is necessary to a) determine the actual impacts of the SEF; b) determine if additional mitigation is required at the SEF;, c) learn about the appropriateness of baseline data collection, the nature of measured impacts, and improve the efficiency of future assessments; and d) help assess the implications of scaling-up within the same general area.

2.4.3. Timing

Post-construction monitoring should be started as soon as possible after the first unit or project phase becomes fully operational. This should ensure that the immediate effects of the facility on resident and passing birds are recorded (arguably before they have time to adjust or habituate to the development), while avoiding the confusing, short-term effects of the construction process. However, it should be born in mind that it may also be more important to obtain an understanding of the impacts of the SEF as they are manifest over the lifespan of the facility. Over time the habitat within the SEF and the behaviour of birds within it may change. Consideration should be given to how impacts might change over time and it may be necessary to repeat certain aspects of monitoring at different time intervals.

2.4.4. Duration and scope

The duration of post-construction monitoring should be determined by the sensitivity of environment and potential risk to birds. The avifaunal impact report should provide a preliminary indication of the likely duration of post-construction monitoring. As a rule of thumb survey protocols used in baseline data collection should be repeated during the first two years of operation, and should be combined with monitoring of fatalities. This should be subject to review at the end of this time and in the event that significant impacts are measured it may be necessary to extend data collection for longer. It may also be desirable to repeat post-construction monitoring protocols periodically (perhaps every 3-5 years) over the lifetime of the project.

Although post-construction monitoring is unavoidably onerous, there may be substantial benefits to maximising its duration and frequency, particularly where significant inter-annual variation in the presence of some species is expected (e.g. wet and dry periods in arid areas – Dean et al. 2009), where data point to significant operational phase impacts and/or there is a need to distinguish between impacts relating to construction and impacts of a more permanent nature.

2.4.5. Habitat classification

Any observed changes in bird numbers and movements at a SEF could be linked to changes in the available habitat (as well as changes in weather conditions, rainfall, level of the water table, pollution etc.). The avian habitats available should therefore be mapped at least once a year (at the same time every year), using the same methodology used in the scoping phase of monitoring.

2.4.6. Bird abundance and movements

In order to determine if there are any impacts relating to displacement and/or disturbance, all methods used to estimate bird abundance and movements during baseline data collection should be applied in exactly the same way (and under similar environmental conditions) in the post-construction-phase in order to ensure the comparability of these two data sets. This includes sample counts of small terrestrial species, counts of large terrestrial species and raptors, focal site surveys and vantage point surveys. To minimise the impacts of observer bias, the same observers should ideally be used for before and after-construction.

If pre-construction monitoring included areas no longer considered for development, the broader impact zone can be redefined and the extent of post-construction phase monitoring may be reduced.

2.4.7. Fatality estimates

The primary aims of monitoring fatalities are to:

a) Estimate the number and rate of fatalities at a SEF,
b) Describe the species composition of fatalities (as well as the age and sex where possible),
c) Record and document the circumstances and site characteristics surrounding avian fatalities at solar arrays and ancillary infrastructure of the SEF (this could aid understanding the cause of fatalities, and hence possible mitigation),
d) Mitigate impacts by informing final operational planning and on-going management.
e) Inform future management decisions regarding the siting and operation of SEFs, throughout southern Africa.

There are three components to estimating fatalities:

a) Experimental assessment of search efficiency and scavenging rates of bird carcasses on the site,
b) Regular searches for casualties (McCary et al. 1986, Kagan et al. 2014; H.T. Harvey & Associates 2014, Smallwood 2014; e.gs for wind farms - Morrison 2002; Barrios and Rodríguez 2004; Krijgsveld et al. 2009),
c) Data analysis incorporating systematically collected data from a and b above (Smallwood 2007; Bernardino et al. 2013; Smallwood 2013; 2014).

(a) Searcher efficiency and scavenger removal

The value of surveying the area for carcasses only holds if some measure of the accuracy of the survey method is developed (Morrison 2002; Bernardino et al. 2013; Smallwood 2014). The search area, the probability of a carcass being detected, and the rate of removal/decay of the carcass must be accounted for when estimating collision rates and when designing the monitoring protocol (Korner-Nievergelt et al. 2011; Strickland et al. 2011; Bernardino et al. 2013 Smallwood 2014). Scavenging rates, carcass persistence and searcher efficiency may differ for different sizes of birds, it may therefore be necessary to use separate estimates for small, medium and large birds (Strickland et al. 2011).

(i) Searcher efficiency

In order to estimate the probability of a field team member detecting a carcass, a sample of suitable bird carcasses (of similar size and colour to a variety of the priority species) should be obtained and distributed randomly around the site. The number and location of the carcasses should be recorded. The proportion of the carcasses located in surveys will indicate the relative efficiency of the survey method (Morrison 2002; Barrios and Rodríguez 2004; Krijgsveld et al. 2009). These trials should be done during the scheduled carcass searches, without the knowledge of the field teams. Separate trials should be conducted for each individual searcher or search team.

This process should be repeated at least twice a year (i.e. once in summer and once in winter) to account for different conditions. 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).

(ii) Scavenger removal

In order to determine the rates at which carcasses are scavenged, or decay to the point that they are no longer obvious to the field workers, fresh carcasses of similar size and colour to a variety of the priority species should be placed randomly around the site and the location of each carcass recorded. As far as possible, carcasses used in trials should mimic the species characteristics and state of carcasses collected around the solar energy hardware (e.g. Smallwood 2013; 2014). Care should be taken to avoid tainting carcasses with human scent (Whelan et al. 1994) and the total number of carcasses set out should not be less than 20, but not so plentiful as to saturate the food-supply for the local scavengers (Smallwood 2007; 2014).

These sites should be checked daily for the first week to record any changes in the presence, location and condition of each carcass. After the first week, the search interval can be increased and searches should continue for up to a month (Gove et al. 2013) or more. This should provide an indication of scavenge rate (average persistence time) that should inform subsequent survey work, 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; Strickland et al. 2011; Smallwood 2014). Scavenger numbers and activity in the area may vary seasonally (Smallwood 2007; Schutgens et al. 2014). Scavenge and decomposition rates should therefore be measured at least twice over a monitoring year, once in winter and once in summer. Scavenger removal rates may also differ according to ground-cover (Á. Camiña, pers. comm.) and carcass size; it may be necessary to stratify surveys to account for this.

(b) Carcass searches

(i) Search effort

The accuracy of fatality rate estimates is influenced by the survey effort. If only a small proportion of the aggregate solar energy hardware is surveyed, there is risk that those arrays are not representative of the solar farm. If monitoring is only conducted over a short time-span, key events may be missed (Peron et al. 2013; Smallwood 2014). If only a small area beneath the solar arrays is surveyed, some carcasses may not be detected and recorded (Smallwood 2013). While there are practical and cost implications of increasing search effort, this must be weighed against the risks of introducing different sources of bias. Maximising search effort (e.g. by increasing the frequency, and the duration of surveys, and the proportion of the project surveyed) will reduce the risk of inaccurate results.

(ii) Search area

The area searched should be selected through stratified random sampling and should be clearly defined at the outset of post-construction monitoring. For larger projects, it may be necessary to select these plots from within pre-determined, concentric areas at varying distance from the core development – e.g. project, project perimeter and project periphery. The total search area should cover a minimum of 20-30% of the solar arrays/heliostats (H.T. Harvey & Associates 2014, Smallwood 2014). The area below and around each solar element – heliostat or PV panel - should be visually checked regularly for bird casualties using transects. In most cases the area around each element is likely to have been cleared and maintained, which should facilitate location of even small bird casualties, provided that regular clearing and cleaning of the area does not remove a fraction of the accumulated mortalities. Where visibility (ground cover) around solar elements is highly variable these different areas should be mapped and assigned visibility classes to control for varying probabilities of detection (Strickland et al. 2011; Smallwood 2013). The groundcover and terrain will influence the time spent searching each element or array. In addition to the area beneath the solar elements, the surfaces of the elements themselves should be searched for collision victims and/or signs of collisions – e.g. feather sprays, blood spatter or dust imprints. Each such set of signs should be carefully documented and photographed for later evaluation.

Perimeter fences and other infrastructure that may pose a risk to birds should also be searched. For CSP power tower SEFs, an additional area with a diameter of 300 m around the central tower should also be surveyed. In tandem with surveys of the solar farm, 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). It may also be necessary to search equivalent areas of nearby, similar habitat for carcasses in order to establish the baseline level of natural mortality in the area (e.g. H.T. Harvey & Associates 2014).

(iii) Search interval

The period between searching each of the various sections of the solar project, should be informed by assessments of scavenge and decomposition rates conducted in the initial stages of the monitoring period. As a rule of thumb, a search interval of two weeks is most likely.

Strickland et al. (2011) suggested that the search interval should ideally be shorter than the average carcass removal time. However scavenger trials in the Karoo indicated that large bird carcasses (>1kg) were either removed within a few days (although feathers may remain for longer), or persisted for a long time (Schutgens et al. 2014). There may therefore be limited value in sampling every two weeks vs. every month. It is unclear if a similar pattern can be expected for small birds or for different environments. This will need to be tested.

RECORDING AND REPORTING MORTALITIES:
All suspected incidents should be comprehensively documented, detailing the following recommended variables:

- Observer name
- Project name
- Date
- Time
- Species
- Age class (where possible)
- Sex (where possible)
- GPS location/s
- Condition of remains
- Likely cause of mortality
- Nearest solar array/hardware
- Distance to nearest solar array/hardware by number
- Compass bearing to solar array/hardware
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Plot on map
- Photograph the site the evidence was located

(iv) Carcass management

All physical evidence should then be photographed, referenced, checked for age and sex (where possible), collected, bagged and carefully labelled (label inside and outside the bag(s) - if double-bagged, put one label inside outer bag), and refrigerated or frozen to await further examination and possible post-mortem. Handling of carcasses should be limited, particularly if these are to be used in scavenger removal trials. The provincial conservation authority should be consulted to confirm what, if any permits are required to keep and transport carcasses. They should also be consulted to help determine what should ultimately happen to the carcasses (e.g. if they should be used in searcher efficiency/scavenger removal trials or lodged with a museum).

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, or advise on other, humane methods to handle the bird. In such cases, the immediate area of the recovery should be searched for evidence of interaction with the solar hardware or any other indications of the cause of injury, and any such evidence should be fully documented (as above).

(v) Ad hoc recording of fatalities

Maintenance staff at all solar energy facilities should be required to report bird mortalities through a formalised reporting system (preferably established in terms of a clearly laid out spreadsheet) throughout the lifespan of the facility. All information outlined in the box above (particularly the GPS position) should be recorded as far as possible, and periodically submitted to the SANBI centralised database. It would also be valuable to have these carcasses labelled, bagged and frozen.

All mortalities should be reported to BirdLife South Africa and the Department of Environmental Affairs. This should be additional to post-construction monitoring and does not replace formal carcass searches. Where there are incidental carcass finds at arrays that are being formally monitored, these should be included in final estimates of fatality rates, or they should be left in place where they may be detected during formal searches (Smallwood 2013). Details of incidental carcass finds should be included in post-construction monitoring reports.

(vi) Alternative survey methods

Trained dogs can be used to assist in the detection of carcases (Bevanger et al. 2010; Paula et al. 2011) and could be considered as an alternative search method, or could be used to test observer bias. The use of dogs can increase searcher efficiency, reduce observer bias and reduce the amount of time required to search (Paula et al. 2011). This technique may be particularly useful where the visibility is poor due to vegetation cover, but does require significant levels of skill on the part of handlers and dogs, and on-going training for the dogs. While the use of dogs for carcass searches is encouraged, it is not a requirement. To ensure comparability of results, the same survey methods should be used throughout the study.

(c) Fatality estimators

Observed mortality rates need to be adjusted to account for searcher efficiency, scavenger removal and the probability that some carcasses will be outside the search area (Ledec et al. 2011; Korner-Nievergelt et al. 2011; Strickland et al. 2011; Bernardino et al. 2013). There have been many different formulas proposed to estimate mortality rates at wind energy facilities (e.g. Ledec et al. 2011; Erickson et al. 2004; Smallwood 2007; Korner-Nievergelt et al. 2011; Smallwood 2013; Péron et al. 2013); these may need to be adapted before being used at SEFs.

2.4.8. Reporting

Quarterly reports, summarising interim findings should be complied and submitted to BirdLife South Africa and the Department of Environmental Affairs. At the end of each year of monitoring, a more detailed post-construction monitoring report analysing the results should be completed and submitted to relevant stakeholders.

As a minimum, the report should attempt to answer the following questions:

a) Has the habitat available to birds in and around the SEF changed?
b) Has the number of birds and/or species composition changed?
c) Have the distributions and/or movements of priority species changed?
d) Has the breeding success at focal nest sites changed?
e) If yes to any of the above, what is the nature of the observed changes? (Compare these changes before (during) and after construction).
f) What is the nature of and likely drivers of any changes observed?
g) What are the annual mortality rates and total number of bird (and bat) fatalities at the SEF? Ideally these numbers should be reported in a uniform way and directly comparable between different projects. Mortality rates should be reported per MW (nameplate capacity) and per identifiable element in the solar array. Data should be reported in both raw and corrected forms.
h) What was the species composition, and it is possible to determine, the age and sex of fatalities?
i) What proportion of fatalities is likely to have been due to interaction with the solar energy hardware, and what other mortality factors are implicated?

j) Are there any factors (site characteristics, proximity to solar hardware) that may contribute to these fatalities?
k) What is the likely demographic and ecological significance of any observed changes (magnitude and direction of change)?
l) What are the likely impacts on populations (locally and more widely)?
m) Is additional monitoring and/or mitigation necessary?

The post-construction monitoring report should include a comparison of the predicted and observed impacts, as this may provide useful insights for future impact assessments. If additional mitigation was implemented on the basis of previous post-constriction phase monitoring, the report should include an assessment of the effectiveness of these measures. The need for further post-construction monitoring and the scope of any further work should also be reviewed.

Monitoring reports and supporting data should be publically available and shared with BirdLife South Africa, EWT, provincial authorities, Department of Environmental Affairs, the South African National Biodiversity Institute and any other relevant body (e.g. a national database, when this is established).

The findings and recommendations of the post-construction monitoring report should be included in the updated Environmental Management Programme. Should significant impacts be observed, mitigation and/or compensation options should be discussed with the developer, the Department of Environmental Affairs and other stakeholders.

Specialists are encouraged to submit findings (whether positive, negative or inconclusive) to peer-reviewed scientific journals to promote wider dissemination of results and experience. Among other things this will help improve study design and knowledge of possible impacts. Developers are encouraged to give permission to use data from their facilities for this purpose and to allow access to their sites for independent research.

3. Implementation

KEY POINTS

- These guidelines are aimed at all SEFs that require environmental authorisation for electricity generation.
- These guidelines are not intended for small-scale, distributed solar facilities.
- The scope of monitoring required will vary from site to site; these guidelines set out the minimum effort that is likely to be required. Any deviation from the minimum, or from enhanced protocols, should be well motivated and clearly justified.
- Bird abundance and activity monitoring should focus data collection on priority species, but potential impacts on small and/or common species should not be overlooked.
- A bird specialist must oversee the monitoring and hire capable and competent field staff.
- Peer review of monitoring reports is encouraged. This should be done transparently and both reports should be made available for review.
- Monitoring data and reports should be made publically available, as this will help support the sustainable development of renewable energy.

3.1 Other infrastructure

While the more general development impacts (for example construction of roads, sub-stations and power lines etc.) associated with the actual construction of each SEF are not a primary focus of this document, these may be severe. The scale and mitigation of these impacts should be referred to explicitly in scoping level and Avian Impact Assessment reports should be integral to the ultimate decision to proceed with the project.

3.2 Survey effort

Each 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 subtly 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. 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 SEF.

Monitoring effort should be intensified if there are factors that add substantially to the potential impact of a development, for example high densities or diversity of threatened and/or endemic species, or the close proximity of known and important avian flyways or wetlands.

3.3 Specialists and field teams

The bulk of the work outlined in these guidelines should be done by trained observers, under the guidance and supervision of a qualified and experienced avifaunal specialist. A list of avifaunal specialists who have agreed to follow these guidelines is available at www.birdlife.org.za and www.ewt.org.za. Alternatively please email energy@birdlife.org.za.

The Natural Scientific Professions Act of 2003 provides for the establishment of the South African Council of Natural Scientific Professions (SACNASP) and for the registration of professional, candidate and certified natural scientists. This Act states that only a registered person may practice in a consulting capacity. The specialist should therefore be registered with SACNASP, or work under the supervision of a registered professional as stipulated by the Natural Scientific Professions Act 27 of 2003.

While field staff need not be registered with a professional body, it is the specialist's responsibility to ensure that the team has the necessary skills (for example bird identification and map reading) to undertake the required work. An avifaunal specialist familiar with the site should always oversee monitoring.

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 alone. The field team undertaking carcass searches do not need the same skills as the team monitoring bird populations and movements (although some training is likely to be required).

The role of the developer and operational staff should not be underestimated. Specialists are encouraged to help the developer and their staff gain a clear understanding of the conservation issues on site and developers are encouraged to familiarise themselves with these guidelines and specialists' reports.

3.4 Equipment

Field teams will require a number of specialized items of equipment in order to gather monitoring data accurately, quickly and efficiently. In many cases, especially before the SEF is operational, an off-road vehicle (ideally a 4x4) will be required to make maximum use of the available road infrastructure on site. Each team member will need a pair of good quality binoculars and a recent regional bird identification guide. A spotting scope may prove useful and a GPS, a digital camera and a means to capture data – a notebook, datasheets, or generic or customized PDA – are 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 survey.

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. The importance of accurately and clearly recording data cannot be overemphasised. The text boxes throughout this document should provide the basis for standard recording forms for each project.

3.5 The EIA process and best practice

The stages outlined in these guidelines should be aligned with the similarly named stages of a formal EIA process, although a more proactive approach is also encouraged. For example, the scoping stage as outlined in these guidelines should coincide with, and serve as, the scoping study for the purposes of EIA. However, it may prove to be valuable for developers to commission an avifaunal scoping study as part of their project screening, prior to initiating a formal impact assessment process, as this might help avoid unnecessary investment in unsuitable sites. However, the Scoping Report should always include the avifaunal scoping report to afford stakeholders an opportunity to provide comment at an early stage. Similarly, there may be value in starting baseline data collection prior to beginning the formal EIA process. However, the results of both scoping and baseline data collection should substantially inform the avian impact assessment report, and be the basis upon which an environmental authorisation is issued. Baseline data collection must therefore be completed before the impact assessment is finalised (although, as indicated above, further pre-construction monitoring may be required if there is a prolonged period of time between the completion of the impact assessment and commencement of construction).

It is the responsibility of both the environmental assessment practitioner and the avifaunal specialist to ensure the specialist's work is reflected appropriately in the Scoping and Environmental Impact Assessment reports. This should be reflected in the relevant contracts. It is recommended that avifaunal specialists be registered automatically as an interested and affected party in the EIA process so they can be kept abreast of the progress of proposed developments in which they have been involved.

3.6 Peer review

Peer review is the evaluation a specialist's work by another expert (or experts) in the field in order to maintain or enhance the quality of work. Peer review can be a valuable tool in avifaunal specialist reporting as it can help to maintain standards and increase consistency of recommendations across projects. It can also help to improve and strengthen the end product and add credibility to the process.

The use of professional peer review for renewable energy applications is encouraged, subject to the following:

i. The original author should be advised that a peer review will be conducted. Ideally the original author should be requested to provide a list of potential candidates to conduct the review.
ii. That the 'reviewer' must be given clear terms of reference, explaining the context of the review.
iii. That the results of the peer review must be made available to the original author for right of response.
iv. That the reviewer must complete and submit his/her own declaration of interest with the application to DEA.
v. Both the original report and the peer review report should be made available for public review and decision-making.

3.7 Data Management

While analysis and reporting on an individual SEF basis will be the responsibility of the relevant avifaunal specialist, reports and data emanating from the above process should ultimately be housed centrally by the South African National Biodiversity Institute (SANBI) (or a similar appropriate organisation), with BARESG's guidance, to facilitate the assessment of results on a multiple SEF, landscape and national scale. Permission to publish the findings of such analysis in the relevant media by BirdLife South Africa, BARESG or by accredited academic institutions should be obtained from the developer before the onset of monitoring. This pooling of information is in the interests of collective understanding and building a sustainable renewable energy industry in southern Africa.

SABAP1 and 2 data are utilised extensively in scoping and the impact assessment for SEFs. Specialists are therefore encouraged to register with the SABAP2 project and contribute to the project. This can be done by either submitting incidental records, or preferably full protocol atlas cards which should be completed for all the pentads (5 x 5 minute squares) making up each development site. These cards should be submitted on every survey (including those made during baseline and post-construction phase monitoring). This can be done as a completely separate contribution to ornithology, generated as a by-product of monitoring, rather than as a direct component of the data collected for the client.

For more information on SABAP2 please refer to http://sabap2.adu.org.za.

References

Anderson MD. 2001. The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa. Johannesburg. South Africa.

Band W, Madders M, Whitfield DP. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: De Lucas M, Janss GFE, Ferrer M, editors. Birds and solar farms – risk assessment and mitigation. London: Quercus.

Barnes K. 2000. The Eskom red data book of birds of South Africa, Lesotho and Swaziland. (Barnes KN, editor.). Johannesburg: BirdLife South Africa.

Barnes KN ed. 1998. The Important Bird Areas of Southern Africa. Johannesburg: BirdLife South Africa.

Barrios L, Rodríguez A. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. J. Appl. Ecol. 41:72–81.

Bernardino J, Bispo R, Costa H, Mascarenhas M. 2013. Estimating bird and bat fatality at wind farms: a practical overview of estimators, their assumptions and limitations. New Zeal. J. Zool. 40:67–74.

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

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

Bevanger K, Berntsen F, Clausen S, Dahl EL, Flagstad Ø, Follestad A, Halley D, Hanssen F, Johnsen L, Kvaløy P, et al. 2010. Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway (BirdWind). Report on findings 2007-2010. [accessed 2014 Sep 17]. http://www.nina.no/archive/nina/PppBasePdf/rapport%5C2008%5C355.pdf

Bibby CJ, Burgess ND, Hill DA, Mustoe SH. 2000. Bird Census Techniques. 2nd edition. London: Academic Press.

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L. 2001. Introduction to Distance Sampling. Oxford: Oxford University Press.

Dean WRJ, Barnard P, Anderson MD. 2009. When to stay, when to go: trade-offs for southern African arid-zone birds in times of drought. *South African Journal of Science* 105: 24-27.

DeVault TL, Seamans TW, Schmidt JA, Belant JL, Blackwell BF, Mooers N, Tyson LA & Van Pelt, L. 2014. Bird use of solar photovoltaic installations at US airports: implications for aviation safety. Landscape and Urban Planning 122: 122-128.

Devereux C. 2008. Minimal effects of wind turbines on the distribution of wintering farmland birds. J. Appl. Ecol. 45:1689–1694.

Drewitt AL, Langston RHW. 2006. Assessing the impacts of wind farms on birds. Ibis (Lond. 1859). 148:29–42.

Drewitt AL, Langston RHW. 2008. Collision effects of wind-power generators and other obstacles on birds. Ann. N. Y. Acad. Sci. 1134:233–66.

Dwyer JF, Harness RE, Donohue K. 2014. Predictive model of avian electrocution risk on overhead power lines. Conservation Biology 28: 159-168.

Emlen J. 1977. Estimating breeding seasons densities from transect counts. Auk 94:455–468.

Erickson WP, Jeffrey J, Kronner K, Bay K. 2004. Stateline Wind Project wildlife monitoring final report, July 2001 - December 2003.

Farfán M A, Vargas JM, Duarte J, Real R. 2009. What is the impact of wind farms on birds? A case study in southern Spain. Biodivers. Conserv. 18:3743–3758.

Fluri, T.P. 2009. The potential of concentrating solar power in South Africa. Energy Policy 37: 5075-5080.

Gove B, Langston R, McCluskie A, Pullan J, Scrase I. 2013. Wind farms and birds: An updated analysis of the effects of wind farms on birds, and best practice guidance on integrated planning and impact assessment. Strasbourg.

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

Harrison JA, Allan DG, Underhill LG, Herremans M, Tree AJ, Parker V, Brown CJ eds. 1997. The Atlas of Southern African Birds. Volumes 1 & 2. Johannesburg: BirdLife South Africa.

Harrison JA, Harebottle DM, Wheeler MJ. 2007. Birds in Reserves Project: Instructions. Cape Town.

Hernandez, R.R., Easter, S.B., Murphy-Mariscal, M.L., Maestre, E.T., Tavassoli, M., Allen, E.B., Barrows, C.W., Belnap, J., Ochoa-Hueso, Ravi, S. & Allen, M.F. 2014. Environmental impacts of utility-scale solar energy. Renewable & Sustainable Energy Reviews 29: 766-779.

Horváth, G., Kriska, G., Malik, P. & Robertson, B. 2009. Polarized light pollution: a new kind of ecological photopollution. Frontiers in Ecology and the Environment 7: 317-325.

H.T. Harvey & Associates. 2014. California Valley Solar Ranch Project: Avian and Bat Protection Plan, Sixth Quarterly Postconstruction Fatality Report, 16 November 2013 - 15 February 2014. Unpublished report to HPR II, PLC, California Valley Solar Ranch.

Janss GFE. 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biological Conservation 95: 353-359.

Jenkins AR. 2011. Winds of change: birds and wind energy development in South Africa. *Africa – Birds and Birding* 15:35–38.

Jenkins AR, Smallie JJ, Diamond M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conserv. Int.* 20:263–278.

Jenkins AR, van Rooyen CS, Smallie JJ, Anderson MD, Smit HA 2012. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa: 1st Revision. Endangered Wildlife Trust/BirdLife South Africa, Johannesburg.

Joseph LN, Field S a, Wilcox C, Possingham HP. 2006. Presence-absence versus abundance data for monitoring threatened species. Conserv. Biol. 20:1679–1687.

Kagan RA, Viner TC, Trail PW, Espinoza EO. 2014. Avian Mortality at Solar Energy Facilities in Southern California: A Preliminary Analysis. US National Fish and Wildlife Forensic Laboratory, unpublished internal report.

King DI, Byers BE. 2002. An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds. Wildlife Society Bulletin 30: 868-874.

Korner-Nievergelt F, Korner-Nievergelt P, Behr O, Niermann I, Brinkmann R, Hellriegel B. 2011. A new method to determine bird and bat fatality at wind energy turbines from carcass searches. Wildlife Biol. 17:350–363.

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

Kuvlesky WP, Brennan L a., Morrison ML, Boydston KK, Ballard BM, Bryant FC. 2007. Wind energy development and wildlife conservation: challenges and opportunities. J. Wildl. Manage. 71:2487–2498.

Ledec GC, Rapp KW, Aiello RG. 2011. Greening the wind: Environmental and social considerations for wind power development. World Bank, 141p.

Leddy KL, Higgins KF, Naugle DE. 1999. Effects of wind turbines on upland nesting birds in conservation reserve program grasslands. Wilson Bull. 111:100–104.

Lehman RN, Kennedy PL, Savidge JA. 2007. The state of the art in raptor electrocution research: a global review. Biological Conservation 136: 159-174.

Lovich, J.E. & Ennen, J.R. 2011. Wildlife conservation and solar energy development in the desert southwest, United States. BioScience 61: 982-992.

Malan G. 2009. Raptor survey and monitoring – a field guide for African birds of prey. Pretoria: Briza.

McCrary, M.D., McKennan, R.L., Schreiber, R.W., Wagner, W.D., Sciarrotta, T.C. 1986. Avian mortality at a solar energy plant. J. Field Ornithol. 57: 135-141.

Morrison M. 2002. Searcher bias and scavenging rates in bird / wind energy studies. National Renewable Energy Report SR-500-30876. Colorado.

Munzhedi, R. & Sebitosi, A.B. 2009. Re-drawing the solar map of South Africa for photovoltaic applications. Renewable Energy 34: 165-169.

Newson SE, Evans KL, Noble DG, Greenwood JJD, Gaston KJ. 2008. Use of distance sampling to improve estimates of national population sizes for common and widespread breeding birds in the UK. J. Appl. Ecol. 45:1330–1338.

O'Connor RJ, Hicks RK. 1980. The influence of weather conditions on the detection of birds during Common Birds Census fieldwork. Bird Study 27:137–151.

Ong S, Campbell C, Denholm P, Margolis R, Heath G. 2013. Land-use requirements for solar power plants in the United States. National Renewable Energy Laboratory Technical Report NREL/TP-6A20-56290.

Osborn R., Higgins KF, Usgaard RE, Dieter CD, Nieger RD. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge wind resource area, Minnesota. Am. Midl. Nat. 143:41–52.

Paula J, Leal MC, Silva MJ, Mascarenhas R, Costa H, Mascarenhas M. 2011. Dogs as a tool to improve bird-strike mortality estimates at wind farms. J. Nat. Conserv. 19:202–208.

Pearce-Higgins J, Stephen L, Langston RHW, Bainbridge IP, Bullman R. 2009. The distribution of breeding birds around upland wind farms. J. Appl. Ecol. 46:1323–1331.

Pearce-Higgins JW, Stephen L, Douse A, Langston RHW. 2012. Greater impacts of wind farms on bird populations during construction than subsequent operation: results of a multi-site and multi-species analysis. J. Appl. Ecol. 49:386–394.

Péron G, Hines J. 2013. fatalityCMR-a capture-recapture software to correct raw counts of wildlife fatalities using trial experiments for carcass detection probability and persistence time. Laurel, MD. [accessed 2014 Oct 10]. http://www.mbr-pwrc.usgs.gov/software/doc/fatalityCMR.pdf

Peron G, Hines JE, Nichols JD, Kendall WL, Peters4 KA, Mizrahi DS. 2013. Estimation of bird and bat mortality at wind-power farms with superpopulation models. Matthiopoulos J, editor. J. Appl. Ecol. 50:902–911.

Phillips R, Xavier J, Croxall J. 2003. Effects of satellite transmitters on albatrosses and petrels. Auk 120:1082–1090.

Phillips, J. 2013. Determining the sustainability of large-scale photovoltaic solar power plants. Renewable & Sustainable Energy Reviews 27: 435-444.

Podolsky R. 2004. Application of risk assessment tools: avian risk of collision model. In: Schwartz SS, editor. Proceedings Onshore Wildlife Interactions with Wind Developments: Research Meeting V. Lansdowne, Viginia, November 3-4, 2004. Washington D.C.: Prepared for the Wildlife Subcommittee of the National Wind Coordinating Collaborative (NWCC) by RESOLVE, Inc. p. 186– 187.

Retief E., Diamond M, Anderson MD, Smit DHA, Jenkins DA, Brooks M. 2012. Avian wind farm sensitivity map for South Africa. Johannesburg.

Royle JA, Nichols JD. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777–790.

RSPB. 2011. Solar Power. Unpublished briefing, March 2011.

Schutgens M, Shaw JM, Ryan PG. 2014. Estimating scavenger and search bias for collision fatality surveys of large birds on power lines in the Karoo, South Africa. Ostrich 85:39–45. [accessed 2014 Oct 8]. http://www.tandfonline.com/doi/abs/10.2989/00306525.2014.888691

Scottish Natural Heritage. 2005. Survey methods for use in assessing the impacts of onshore wind farms on bird communities. [accessed 2012 Oct 25]. http://www.anev.org/wp-content/uploads/2012/06/AREVIE1.pdf

Scottish Natural Heritage. 2009. Guidance note. Guidance on methods for monitoring bird populations at onshore wind farms. [accessed 2014 Apr 29]. www.snh.gov.uk

Scottish Natural Heritage. 2010. Survey methods for use in assessing the impacts of onshore wind farms on bird communities.

Scottish Natural Heritage. 2013. Guidance: Recommended bird survey methods to inform impact assessment of onshore wind farms.

Seymore, R., Inglesi-Lotz, R. & Blignaut, J. 2014. A greenhouse gas emissions inventory for South Africa: a comparative analysis. Renewable & Sustainable Energy Reviews 34: 371-379.

Shaw JM, Jenkins AR, Smallie JJ, Ryan PG. 2010. Modelling power-line collision risk for the Blue Crane *Anthropoides paradiseus* in South Africa. Ibis (Lond. 1859). 152:590–599.

Smallwood KS. 2007. Estimating wind turbine–caused bird mortality. J. Wildl. Manage. 71:2781–2791.

Smallwood KS. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildl. Soc. Bull. 37:19–33.

Smallwood KS, Thelander C. 2008. Bird Mortality in the Altamont Pass Wind Resource Area, California. J. Wildl. Manage. 72:215–223.

Smallwood KS. 2014. Testimony (exhibit 3128) given to the Intervenor Centre for Biological Diversity in the matter of "Application for certification for the Palen Solar Energy Generating System". State of California Energy Resources Conservation and Development Commission, Docket No. 09-AFC-7C.

Smit HA. 2012. Guidelines to minimize the impact on birds of solar facilities and associated infrastructure in South Africa. BirdLife South Africa, Johannesburg.

Stewart GB, Pullin AS, Coles CF. 2007. Poor evidence-base for assessment of windfarm impacts on birds. Environ. Conserv. 34:1.

Strickland M., Arnett EB, Erickson WP, Johnson DH, Johnson GD, Morrison ML, Shaffer JA, Warren-Hicks W. 2011. Comprehensive guide to studying wind energy/wildlife interactions. Washington, D.C., USA: Prepared for the National Wind Coordinating Collaborative. [accessed 2012 Oct 10]. http://www.nationalwind.org/

Taylor M. 2014. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. In press. (Taylor M, editor.). Johannesburg: BirdLife South Africa.

Taylor PB, Navarro RA, Wren-Sargent M, Harrison JA, Kieswetter SL. 1999. Total CWAC Report: Coordinated waterbird counts in South Africa, 1992-97. Cape Town.

Thomas L, Buckland ST, Rexstad EA, Laake JL, Strindberg S, Hedley SL, Bishop JRB, Marques TA, Burnham KP. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. J. Appl. Ecol. 47:5–14.

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

Turney, D. & Fthenakis, V. 2011. Environmental impacts from the installation and operation of large-scale solar power plants. Renewable and Sustainable Energy Reviews 15: 3261-3270.

U.S. Fish and Wildlife Service. 2012. U.S. Fish and Wildlife Service land-based wind energy guidelines. Arlington. [accessed 2014 Apr 4]. http://www.fws.gov/windenergy/docs/WEG_final.pdf

Walston, L. J., Rollins, K.E., Smith, K.P., LaGory, K.E., Sinclair, K., Turchi, C., Wendelin, T. & Souder, H. 2015. A review of avian monitoring and mitigation information at existing utility- scale solar facilities.

Walwyn DR, Brent AC. 2015. Renewable energy gathers steam in South Africa. Renewable and Sustainable Energy 41: 390-401.

Wenger SJ, Freeman MC. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. Ecology 89:2953–2959.

Whelan CJ, Dilger ML, Robson D, Hallyn N, Dilger S. 1994. Effects of olfactory cues on artificial-nest experiments. Auk 111:945–952.

Young DJ, Harrison JA, Navarro RA, Anderson MD, Colahan BD eds. 2003. Big birds on farms: Mazda CAR report 1993-2001. Cape Town.

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APPENDICES

1. A step-wise approach to impact assessment and bird monitoring at a proposed solar energy site

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

1. A qualified advising scientist is appointed to conduct monitoring/impact assessment (and preferably post-construction phase monitoring).
2. A scoping study is undertaken, based on a short site visit and desktop information.
3. Monitoring protocols are established and agreed to. Generic guidelines are customised to suit the specific issues at each site. Proposed protocols are discussed with key stakeholders (e.g. BirdLife South Africa and Endangered Wildlife Trust), particularly if consideration is being given to undertaking less than the minimum outlined in these guidelines and/or the site is of high avifaunal sensitivity.
    a. Data are periodically collated and analysed to permit necessary changes to be made at the earliest opportunity. Data collection protocols and schedules are adapted to ensure that sufficient data are accumulated, and sufficient coverage is achieved, to adequately inform development decisions.
    b. There is regular communication between the specialist, developer and their consultants, particularly if there are any potentially significant issues encountered. Where there are potentially significant issues, stakeholders (e.g. BirdLife South Africa and Endangered Wildlife Trust) should also be consulted.
4. An avifaunal impact assessment report is compiled and the findings integrated into the EIA and Environmental Management Programme (EMPr) for the project. Protocols for construction-phase monitoring (where required) and for post-construction monitoring are outlined.
5. The final EIA is submitted to the Department of Environment for environmental authorisation.

For those projects for which environmental authorisation is granted and construction proceeds:

6. The need for further baseline data collection is assessed, particularly if considerable time elapses between collection of data for impact assessment and the commencement of construction.
7. The EMPr is applied during construction, and if necessary, construction-phase monitoring is conducted.
8. The post-construction monitoring protocols are refined and post-construction monitoring is initiated as soon as the solar arrays are in place.
    a. Post-construction phase monitoring data are periodically analysed, and if necessary data collection protocols are adjusted to ensure that sufficient data are accumulated and sufficient coverage is achieved to adequately inform operational decisions.
9. A report reviewing the full year of post-construction phase monitoring is compiled and submitted to the relevant authorities and stakeholders. The findings of monitoring are integrated into the EMPr for the operating solar farm and the broader mitigation scheme. The need for and scope of further post-construction phase monitoring is reviewed.

2. Minimum requirements for avifaunal impact assessment

An avifaunal impact assessment for a SEF should follow a two-tier process:

1) Scoping –a review of existing literature and data, as well as site visit to inform the design of a site-specific survey and pre-construction monitoring plan.
2) Impact assessment – systematic and quantified monitoring over four seasons that will inform a full Environmental Impact Assessment (EIA) detailing and analysing the significance of likely impacts and available mitigation options.

1) Scoping

The scoping assessment should be based on a review of existing literature and bird atlas data, distance from protected areas and recognized Important Bird Areas, as well as avifaunal data collected during a brief site visit to the proposed solar farm site. The Scoping Report should contain the following information:

a. A description of the site in terms of the avifaunal habitats present.
b. A list of bird species and priority bird species likely to occur on the proposed site, with information on the relative value (in terms of breeding, nesting, roosting and foraging) of the site for these birds;
c. A description of the likely seasonal variation in the presence/absence of priority species and preliminary observations of their movements.
d. A preliminary delineation of areas that are potentially highly sensitive, no-go areas that may need to be avoided by the development;
e. A preliminary description of the nature of the impacts that the proposed development may have on the bird species present;
f. A description of any mitigation measures that may be required to manage impacts related to the monitoring and assessment of the site.

The results of the scoping study, particularly information regarding the diversity and abundance of priority species that are likely to be present, proximity to important flyways, wetlands or other focal sites, and topographic complexity, should be used to:

a. Highlight if there are any obvious red flags to the proposed development on all or parts of the site;
b. Inform the required scope, effort, intensity and design of impact assessment (and where relevant, monitoring).

2) Impact assessment

The avifaunal impact assessment should be based on data collected from detailed site surveys, undertaken in accordance with the *BirdLife South Africa Birds and Solar Energy Best Practice Guidelines* The degree of effort should be informed by the likely sensitivity of the site and the species it contains, as well as the size of the proposed solar farm and proposed technology.

For proposed facilities that pose a moderate to high risk to birds, the impact assessment must include an analysis (statistical measurement and mapping) of the following variables:

a. Abundance estimates for small terrestrial birds (in most cases not priority species, but potentially affected on a landscape scale by multiple developments in one area), through linear transect surveys, fixed point counts or reporting rates;
b. Counts, density estimates or abundance indices for large terrestrial birds and raptors, through road transects or vantage point monitoring;
c. Flight behaviour of priority species flying in or near the proposed development area and associated risk of collision;
d. Occupancy/numbers/breeding success at any focal raptor sites;
e. Bird numbers at any focal wetlands and local movements between waterbodies;
f. Full details of any incidental sightings of priority species;
g. Collision mortalities related to any existing power lines.

The results of this analysis should be used to:

a. Develop a topographical map indicating the area that would be impacted by the proposed development alternatives and the location of any key habitats and flyways that should not be developed or otherwise transformed.
b. Inform the final layout of solar arrays (or where the layout cannot be finalized within the EIA, the assessment should be used to define any no go areas and areas that should be sufficiently buffered).
c. Assess the significance of the potential impact of the proposed project alternatives and related activities - with and without mitigation - on avifaunal species and communities (with regards to potential disturbance, displacement, habitat loss and mortality through collision), including consideration of the spatial and temporal extent of these impacts.
d. Inform actions that should be taken to prevent or, if prevention is not feasible, to mitigate negative impacts during the planning, construction and operational phases of the development.
e. Inform the nature and extent of monitoring required during construction and the operational phase.
f. Determine whether or not the proposed development (or parts thereof) is fatally flawed and should not be recommended for approval, and highlight this finding

The avifaunal impact assessment must include a description of the limitations, assumptions and measures of uncertainty relating to the assessment. Where other proposed facilities are proposed in or near to the development in question, the impact assessment must include consideration of cumulative impacts.

The more general development impacts associated with the actual construction of each SEF are not the primary focus of this document. However, these impacts may be severe and should be included in the scoping and impact assessment. Mitigation measures relating to construction-phase impacts should also be outlined in the environmental authorisation and environmental management programme.