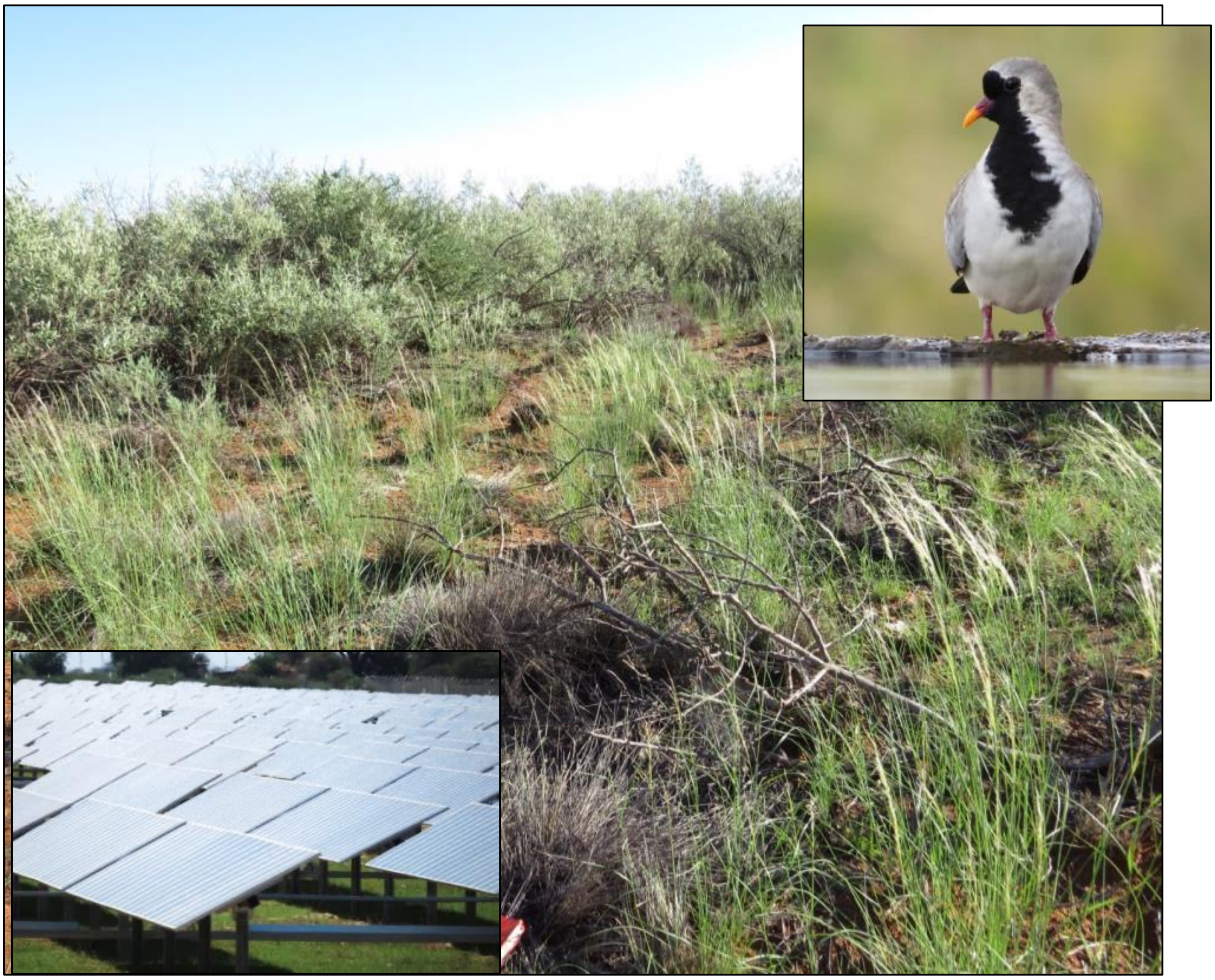
Pre-construction Avian Impact Assessment of the Boitshoko Solar Power Plant (RF) (Pty) Ltd, near Kathu, Northern Cape: March 2016



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1 SUMMARY

This study reports on avian monitoring in the wet-season for the proposed Boitshoko Solar Power Plant Power Plant (RF) located on the farm "Lime Bank" north of Kathu, Northern Cape. Its specific objective is to determine the numbers of birds attracted to the proposed solar farm after rains in March 2016. The project investigated a preferred (280 ha) and alternative area (300 ha), for a pre-construction assessment of the impacts to birds. The possible impacts are: (i) collision with the PV facility itself from birds perceiving the panels as open water – the "Lake Effect"; (ii) disturbance by construction and maintenance activities, (iii) displacement through habitat removal and construction work and (iv) direct collision with the power line network.

Our observations indicate that the over-grazed habitat, dominated by Acacia thickets in the Eastern Kalahari Bioregion had 76 avian species recorded in or around Lime Bank farm of which 4 are collision-prone (Martial Eagle *Polemaetus bellicosus,* Black-chested Snake-Eagle *Circaetus pectoralis,* Pale Chanting Goshawk *Melierax canorus,* Greater Kestrel *Falco rupicoloides*). The Martial Eagle, an Endangered species, occurred on the pylons just outside the alternative PV site.

In the thicket, we found relatively low species richness of smaller birds (ave 16 species km^{-1}) but healthy numbers of birds (36 birds km^{-1}). The **Passage rate** of the large collision-prone birds was 0.0 birds per of observation, as none were observed traversing either the preferred or alternative sites. Other species that may be attracted to the panels such as wetland birds (2 sp) or sandgrouse were present but in low numbers. Territorial Yellow-billed Hornbills *Tockus leucomelas* that may pose a risk to the panels by attacking their own reflections were recorded on site in low numbers.

To mitigate the possible problems of impacts with the solar panels, we recommend that: (i) bird scaring techniques including rotating prisms and experimental use of Torri lines are used if birds are found to impact the PV panels; (ii) construct the solar park in the preferred area where fewer red-listed occurred; (iii) construct it as far from the pans that attract the wetland species and sandgrouse; (iv) all power lines – *present and future* – must be marked with bird diverters to reduce the possible impact of the raptorial species; and (v) all PV panels use non-reflective surfaces to prevent damage by hornbills.

If these mitigation measures are followed to minimize any impacts to the threatened raptors highlighted here, then we can recommend that this solar site development can go ahead, with a full post-construction monitoring protocol in place as it does so.

1.1 CONSULTANT'S DECLARATION OF INDEPENDENCE

Birds & Bats Unlimited are independent consultants to Subsolar. They have no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of this specialist performing such work.

1.2 QUALIFICATIONS OF SPECIALIST CONSULTANT

Birds & Bats Unlimited Environmental Consultants (http://www.birds-and-bats-unlimited.com/), were approached to undertake the specialist avifaunal assessment for the pre-construction phase of the Photovoltaic solar parks proposed by Boitshoko Solar Power Plant (RF) (Pty) Ltd, north of Kathu, Northern Cape. Dr Rob Simmons is an experienced ornithologist, with 30 years' experience in avian research and impact assessment work. He has published over 100 peer-reviewed papers and 2 books, (see www.fitzpatrick.uct.ac.za/docs/robert.html for details). More than fifty avian impact assessments have been undertaken throughout Namibia and South Africa. He also undertakes long-term research on threatened species (raptors, flamingos and terns) and their predators (cats) at the FitzPatrick Institute, UCT.

Marlei Martins, co-director of Birds & Bats Unlimited, has over 5 years' consultancy experience in avian wind farm impacts as well as environmental issues, and has been employed by several other consultancy companies all over South Africa because of her expertise in this field. She has published papers on her observations including a new species of raptor to South Africa (https://www.linkedin.com/in/marlei-martins-a0374a27?trk=nav_responsive_tab_profile).

2 BACKGROUND

2.1 PHOTO-VOLTAIC SOLAR POWER

Renewable energy is generally provided either by water, wind or solar power. As a signatory to the Kyoto Protocol South Africa needs to promote green energy sources that emit no greenhouse gases or other pollution. Southern Africa's Kalahari region is one of the Earth's hot spots for solar radiation because deserts provide some of the longest periods of continuous sunlight in the world http://www.iir-sa.gr/files/news/PV.pdf. This makes it the ideal hub for solar projects that capture the sun's energy to provide an energy-hungry South Africa with the power it requires.

Three options are generally employed to capture solar energy (i) Concentrated Solar Power (CSPs) using heliostats that focus the sun's energy onto a central tower that heats a salt or oil heat transfer liquid that drives a turbine (CSP tower); (ii) a CSP using trough technology with smaller parabolic mirrors that capture and focus the energy onto a central pipe that also employs a heat-transfer liquid to drive a turbine; or (iii) the preferred option by Boitshoko Solar Power Plant (RF) (Pty) Ltd that captures the sunlight using conventional **Photovoltaic (PV) technology**. This technology does not use concentrated heat but uses sunlight directly to create electricity. There are fewer direct risks associated with this from an avian perspective other than birds possibly perceiving the shiny mirror-surfaces for water, and being drawn to them (the so-called "Lake Effect" – Kagan et al. 2014). This latter technology is the only one assessed in this report for the Boitshoko development.

2.2 POTENTIAL AVIAN IMPACTS

As with any type of large scale development, habitat may be permanently disturbed, displacing the resident and migrant species. A preferred area of 280 ha, and alternative area of 300 ha and a laydown area (development footprint to allow for sensitive areas on site) were investigated. Whatever the final size, this will reduce habitat availability for resident birds where construction takes place. It is a simple exercise to calculate the numbers potentially lost from our estimates of birds per unit area. These are likely to be minimal considerations given that smaller birds generally occur at higher densities than larger birds, breed faster, and are less likely to suffer high population reduction. However, avoidance of some habitats will reduce the impact.

The main avian impacts according to a position paper on the subject by Birdlife SA (http://www.birdlife.org.za/images/stories/conservation/birds_and_wind_energy/solar_power.pdf) are:

(i) displacement of nationally important species from their habitats;

(ii) loss of habitats for such species;

(iii) disturbance during construction, and operation of the facility;

(iv) collision with the photovoltaic panels (mistaking them for water bodies); or

(v) collision with associated infra-structure.

The nature and magnitude of impacts to birds from solar facilities is related to three factors: (i) location, (ii) size of the facility, and (iii) the technology involved (i.e. Photovoltaic *vs* CSP trough *vs* CSP tower). Thus, the location in relation to avian flyways, wetlands, roosting areas and the habitat removed in the footprint may have an important effect on the impact to birds of the solar site. The size of the footprint will be directly related to the negative impact on birds, thus habitat of range-restricted or collision-prone species around the site must be determined with accuracy.

Avian fatalities at PV sites have been summarised from those investigated in the USA by two recent reports (Kagan et al. 2014, Walston et al. 2015). Of the three types of solar energy capture (Photo-voltaic, CSP troughs and CSP towers) the Photo-voltaic sites recorded medium levels of avian fatalities relative to the CSP trough and CSP towers in one review (Kagan et al. 2014).

Given that impact trauma was the most common cause of mortality at two of the three solar sites investigated, minimising the reasons for the cause of that trauma are paramount. Biologists believe that birds mistake the panels in the solar arrays for a body of water (the Lake effect – Kagan et al. 2014) and suffer physical trauma when they attempt to land on it. Birds, particularly wetland species, are the main victims of this sort of impact.

In a review of all bird fatalities at large scale operational solar plants across the world (mainly the USA but one in Israel) Walston et al. (2015) found that few solar plants had undertaken systematic monitoring of bird fatalities (Table 1).

Table 1. Summary of all avian fatality data from large-scale solar facilities from the USA (after Walston et al. 2015). The results for PV technology are given in **bold**.

Project Name	Avian Fatality Data – systematic or incidental?	Survey Period	Incidental Fatalities	Systematic Fatalities (Unadjusted)**
Mohave Solar (CSP trough)	Yes – Incidental	Aug. 2013–March 2014	14	None collected

Genesis (CSP trough)	Yes – Incidental	Jan. 2012–May 2014	183	None collected
California Solar One (CSP Tower)	Yes – Systematic	May 1982–May 1983 (40 visits)	Not Available	70 (114 birds)
California Valley Solar Ranch (PV)	Yes – Systematic	Aug. 2012–Aug. 2013	Not Available	368
Desert Sunlight (PV)	Yes – Incidental	Sept. 2011–March 2014	154	None collected
Crescent Dunes (CSP tower)	Yes - systematic	Under construction	Not available	Not available
Ivanpah (CSP Tower)	Yes – Systematic	Oct. 2013–March 2014	159	376 (includes 7 injured birds)
Topaz Solar Farm (PV)	Yes – Incidental and Systematic	Jan. 2013 –Jan. 2014	19	41

*Causes of death include: solar flux, impact trauma, predation, electrocution and emaciation
** Unadjusted refers to the fact that numbers are not adjusted for biases resulting from predator removal or human observer bias

In summarising the avian species found, Walston et al. (2015) noted

- most birds were small passerines (40%-63% at 7 solar farms);
- Kagan et al. (2014) also found 20 of the 30 birds identified at the Genesis (trough) site in California were smaller passerine birds or swallows;
- Waterbirds such as grebes, herons and gulls were also killed suggesting these species may be attracted by the *perceived* availability of water or the lake effect (Kagan et al. 2014);
- waterbirds averaged 11% of the fatalities at solar farms, but reached 46% of all fatalities at one solar PV facility (Desert Sunlight) in California;
- Too few fatalities at different types of facilities occur to test the Lake Effect of Kagan et al. (2014) (i.e. wetland birds are attracted to the mirrors because they mistake them for open water);
- there was a clear trend at all solar facilities for resident species to dominate the fatalities. For example at the Genesis facility 64% of the fatalities were resident species, meaning that 36% were migrants (Walston et al. 2015), the highest among those reviewed.

Tabulating fatalities of birds at solar sites is not enough to determine the impact to birds of conservation significance. They must be collected systematically and account for human error in (not) finding carcasses, and the rate of carcass removal by scavengers.

In arid environments where sensitive species may not occur at all if rains do not fall, even a full year's monitoring is unlikely to be sufficient. Thus, visits must be timed to coincide with the most productive (wet-season) time of year, even if they are minimal.

Therefore, this site will have to be closely and *systematically* monitored by ornithologists familiar with these birds, to determine movements occurring through the proposed sites just before, and during, rain events. More importantly, appropriate mitigation measures would need to be sought if significant mortalities of sensitive species were found. As a relatively new field, and with the burgeoning solar farm industry in South Africa focussed on the Kalahari Desert adjacent to the Orange River, we need to be pro-active in our research and innovative designs to reduce mortality. However, some methods are being used at facilities in the USA and these include audible bird scaring devices, visual devices to reduce attraction, and mechanical spikes and other measures to prevent birds from perching on dangerous surfaces (treated below).

2.2.1 Habitat loss – Destruction, Disturbance and Displacement

The construction and maintenance of PV technology causes mainly permanent habitat destruction and disturbance. Maintenance activities are likely to cause some disturbance to birds in the general surrounds, and especially the shy or ground-nesting species resident in the area. Mitigation of such effects requires that best-practice principles be rigorously applied – i.e. sites are selected to avoid the destruction of key habitats for red data species, and the disturbance and construction and the final footprint size, for key species, should all be kept to a minimum. Construction time for each facility is unknown.

From the habitat destruction point of view, it is a simple exercise to calculate the numbers of birds potentially lost from our density estimates of important species/birds per unit area of habitat. These are likely to be minimal considerations given that smaller birds are generally more common than larger birds, breed faster, and are less likely to suffer high population reduction. However, where range-restricted species occur on sites ear-marked for development this can have a larger impact.

During our brief 3-day site visit in March 2016 we encountered over 30 resident species that could be displaced by habitat destruction (Appendix1).

Because photo-voltaic facilities are relatively new in South Africa, and there are no *published* studies of avian mortalities here and few in other parts of the world (Table 1), this section is necessarily brief and is in need of further study in southern Africa.

2.2.2 Collision – with reticulation lines and PV panels

Several bird species are well known to collide with overhead power lines, fences, towers and other aerial objects (Jenkins et al. 2010). The most frequently killed have been tabulated and the reasons for their propensity for collision investigated (Martin and Shaw 2010). The extenuating factors were then extrapolated to all South African species based on wing loading, aerial flights, nocturnal activity, flocking behaviour and several other contributing factors (BARESG 2014). We have used Birdlife South Africa's list and taken the top 100 species as the most likely to collide with power lines. The most collision-prone species are generally the larger scavenging species such as vultures, but also raptors and wetland species. It is somewhat surprising that birds also collide with ground-based structures and, as mentioned above (Table 1), these include passerine and wetland birds in collision with photo-voltaic panels in the USA. While we do not know which species will be similarly prone in South Africa, they are likely to be a similar suite of birds (i.e. wetland and aerial species) and it is these we assessed during our surveys.

2.3 Study Methods

2.3.1 Aims, Methods and Terms of Reference

The primary aims of the avian pre-construction monitoring at the PV site proposed by Boitshoko Solar Power Plant (RF) (Pty) Ltd at Lime Bank farm near Kathu, Northern Cape are to:

1. Determine the *densities* of birds regularly present, or resident, within the impact area of the PVs and Photovoltaic areas before the construction phase;
2. Document the *patterns and movements* of birds in the vicinity of the proposed PVs and PV areas before their construction;
3. Monitor the patterns and movements of birds in the PV areas in relation to time of day, and over a wet and dry season when bird numbers and species richness may change;
4. Establish a pre-impact baseline for all Red data and endemic bird species including all breeding birds within the study area;
5. Inform final design, construction and management strategy of development with a view to mitigating potential impacts.

We consulted several published sources of bird data including the Coordinated Waterfowl Counts (CWAC), Coordinated Avifaunal Road Count (CAR) of the Animal Demography Unit, University of Cape Town, the Important Bird Areas Programme (IBA) of Birdlife South Africa, and the Southern African Bird Atlas Programme (SABAP) to determine if previous data was available for this area. Only limited SABAP2 data http://sabap2.adu.

org.za/index.php was available for this remote region.

We augmented these data with our own pre-construction (wet-season) site visit in March 2016 to be followed up by a (dry-season) visit in August 2016 to survey avifauna in both the preferred and alternative solar park areas on Lime Bank farm.

We spent 2 full days on site, recording bird presence and activity throughout the designated preferred and alternative PV areas. This report provides the first results of the bird monitoring undertaken in March 2016.

2.3.2 Limitations and Assumptions

Inaccuracies in the above sources of information can limit or bias this study in the following ways

- The SABAP1 data for this area is over 20 years old (Harrison *et al.* 1997), so we have used only the new SABAP 2 data set. This has a higher spatial resolution specific to the areas investigated and is up to date (2007 to 2015). However, there were few to no cards available in the pentads that cover the solar park itself and *none* were full protocol - this limits the overall species totals;
- Use of the older SABAP 1 data set will include species that are found in an area 9-fold larger (in a quarter-degree square) than found in a smaller pentad of 9 km x 8 km, artificially inflating the species totals given;
- Our own additional data derived from one dry-season site visit is still insufficient to cover all areas of the farm in any depth. We may miss certain rare species or nocturnal species that a longer visit to the sites would reveal;
- We operate in a near complete vacuum of data on the effects of solar farms on Southern African avifauna. This arises mainly through the recent advent of solar farms in South Africa (13 are in operation in 2016 in the Northern Cape but none have released data on impacts to avian species).

While no data set can be a perfect representation of what is present and at risk on a site, our familiarity with arid systems and wide-scale surveys of the avifauna in wet and dry periods elsewhere (Seymour et al. 2015), means we are unlikely to have missed many important species in the survey reported below.

2.4 Study Area

The proposed PV solar park to be developed by Boitshoko Solar Power Plant (RF) (Pty) Ltd is sited on the remaining extent of the farm Lime Bank No. 471, approximately 15 km north-west of Kathu in the Northern Cape. It is 280 ha in area. The farm Lime Bank 671/RE/1, is centred on S 27° 36′ 43″ E22° 57′ 28″. An alternative area of 300 ha (hereafter Lime Bank 2), about 1.5 km west, was simultaneously assessed for avian species and possible impacts (Figure 1). The laydown development footprint itself is 250 ha to allow for the exclusion of highly sensitive areas.

2.4.1 Vegetation of the study area

The study area occurs in Savannah biome on red Kalahari Sand and is classified as Kathu Bushveld (Mucina and Rutherford 2006, p522). Vegetation is dominated by dense stands of *A. melifera* and a few tall Camelthorn trees (A*cacia erioloba*). Grass cover is highly variable depending on rain and grazing pressure. The study area experiences summer rainfall averaging 220-380 mm per annum, with high variability. High day-time

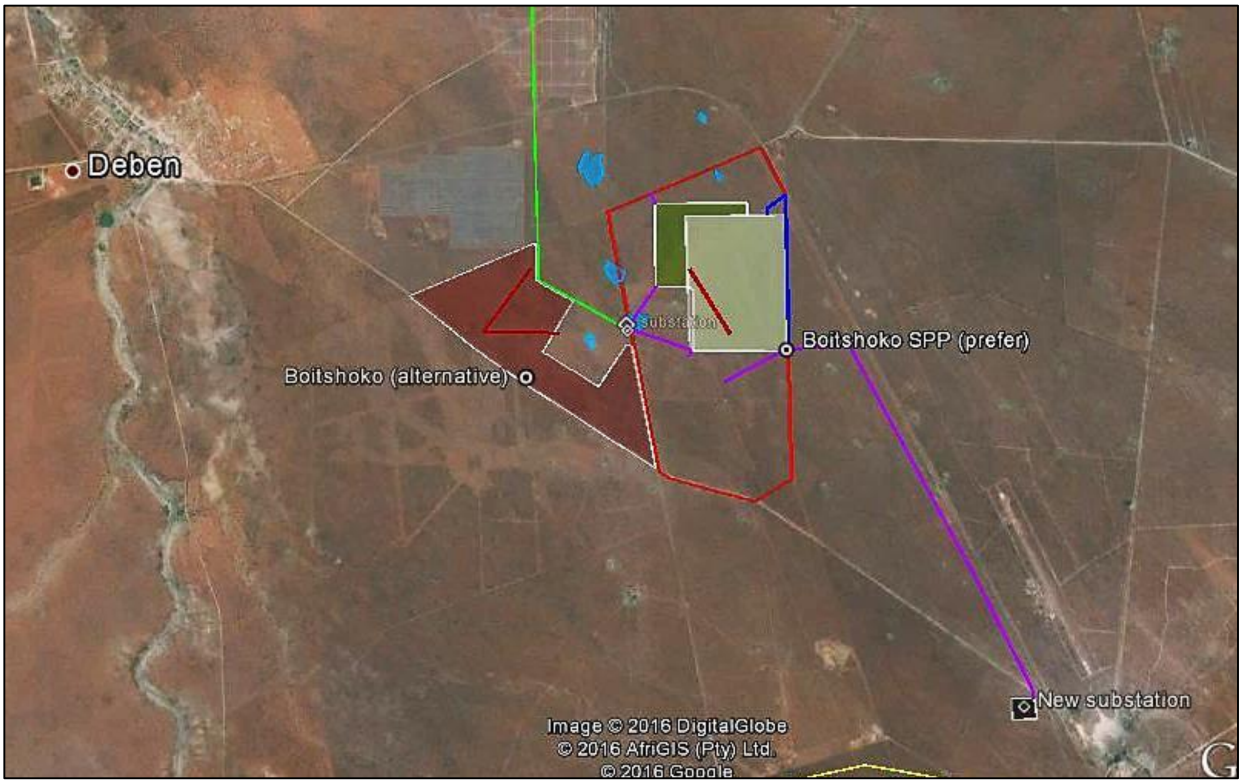

Figure 1: The proposed solar park study area on Lime Bank farm in relation to Deben, Northern Cape. The preferred area is shown in light green and the alternative is red. The light purple lines indicate the possible new reticulation lines to the existing or proposed substations.

temperatures occur in summer (mean 37°C) and minimum temperature average below zero in July (Mucina and Rutherford 2006). During our visit, rain had fallen, thunderstorms were active in the area and the veld was green, the trees were in leaf and some grass sward layer was apparent. Thus, we can classify this as a wet-season assessment with a flush of vegetation and grass.

2.4.2 Avian microhabitats

Bird habitat in the region consists mainly of bush-thickened *Acacia mellifera*, but with some mature camel thorn *Acacia erioloba*. Taller trees and those growing near farm reservoirs are regularly used by passerine birds as nest sites, perch sites (for foraging) and for shade and roosting in the hottest times of day. Two studies in the Kalahari have indicated that taller trees add significantly to the avian species richness of an area (because of the diverse niches they offer) and their removal, therefore, can reduce species richness (Seymour and Simmons 2008, Seymour and Dean 2010).

Artificial habitats are provided by land owners in the form of windmills, farm reservoirs and power line poles. Some pans occur outside the immediate study area and may attract wetland birds and arid-adapted birds including sandgrouse, doves, finches, weavers, sparrow-larks and raptors when flooded.

Photo 1: The main bush-thickened vegetation types present in the Lime Bank farm. In the foreground are *Rhus* bushes and in the background are *Acacia mellifera* thickets. More open ground was used by larks (for nesting) and Nightjars for roosting (inset).

2.5 On-Site Methods

Between 11 and 12 March 2016 we surveyed birds in three 1-km transects in areas proposed for the PV solar arrays in the preferred and alternative areas. These transects covered main habitat types present in the areas (bush-thickened *Acacia* and *Rhus* areas and the artificial water points (Photos 1 and 2).


Photo 2: Artificial habitats provide perch and hunting sites for raptors such as this Martial Eagle (left) and a dependable source of water for doves (right), canaries, whydahs and finches in the Lime Bank study area.

We did not undertake power line surveys because they occurred just outside the chosen site. On drive surveys between Vantage Point sites (below) we simultaneously recorded all large birds within the solar farm.

All **1-km bird transects** took place in the morning (bird-active) hours.

- Each transect was walked slowly over 35- to 50-minute duration (depending on terrain and number of birds present).
- All species were identified where possible using Swarovski 8.5 x 42 binoculars, and the number of individual birds and the perpendicular distance to them, recorded.
- In dense habitat many species are identified by call and the distance to them estimated if they cannot be observed. This allows an estimate of the density (birds per unit area and km) and the species richness in each area.
- We simultaneously recorded all large birds (mainly raptors) and noted and recorded the position of any nests found.
- Over 100 individual birds were recorded in the preferred and alternative PV areas

in these transects alone.

The most important aspect of this monitoring is **Vantage Point (VP) observations**.

- VPs determine the number of flights **of collision-prone species** per hour through the possible area of impact.
- This gives an indication of the collision-risk to larger species that may impact the infrastructure in the solar park.
- 12 hours per VP is the minimum recommended observation time (Jenkins et al. 2015);
- Each VP should have a view-shed (area of observation) not exceeding 2 km.

3 RESULTS

3.1 PRESENCE AND MOVEMENTS OF SENSITIVE SPECIES

Large sensitive species, observed from our walking transects or VPs, are defined as those species that are known, or expected, to be at risk from the PV infrastructure, or attracted by the reflective surfaces of the PV panels. These species are typically threatened red data species that occur in the study areas (e.g. eagles and korhaans), but could include wetland species attracted by the panels. Data were available from 13 bird atlas cards of Southern African Bird Atlas Projects (SABAP), obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant "pentads" of 5′ x 5′ (Table 2). From these data we compiled a list of the avifauna likely to occur within the impact zone of the proposed PV site. These data were augmented from our 2-day March 2016 visit undertaken to the proposed site.

3.2 AVIAN SPECIES RICHNESS AND RED DATA SPECIES

A total of 76 bird species were recorded around the Boitshoko Lime Bank farm from our records combined with bird atlas cards. Of these, 48 bird species were recorded on the 13 bird atlas cards submitted to the Animal Demography Unit from 2007 to 2016 (Appendix 1). Of these, 2 species (Greater Kestrel *Falco rupicoloides* and Black-chested Snake-Eagle *Circaetus pectoralis*) were collision-prone as ranked by the BARESG (2014), and none were red-listed. However, we recorded two additional collision-prone species in our 2-day visit: the Endangered Martial Eagle *Polemaetus bellicosus* (perch-hunting from the pylons) and the Pale Chanting Goshawk *Melierax canorus*. Both occurred just outside the boundary of the proposed solar farm. Therefore, a total of four **collision-prone**

species potentially occur on the site, **of which one is red-listed** (Table 2).

Seasonal differences in the composition of the bird community are expected to be large in an arid environment (Dean 2004). This arises for several reasons for different groups of birds: wetland species (e.g. geese, stilts and crakes) are attracted by the sudden appearance of wetlands that were not available prior to pans flooding. They follow rain fronts to find such ephemeral wetlands (Simmons et al. 1999, Henry et al. 2016). Other birds, including sandgrouse will use pans that fill with water. For other nomadic species (e.g. bustards) they are attracted to high rainfall areas because of the flush of insects that follow rains (Allan and Osborne 2005). Thus, an arid area such as

Table 2. Red-listed (**in red**) and collision-prone bird species (**in bold**) known to occur over the proposed PV Boitshoko development at Lime Bank farm drawn from SABAP2 atlas cards for 2 pentads (2735_2255 and 2735_2250). These are based on just 13 cards, submitted to the SABAP2 project from 2007 to 2016. Those shaded in the below table were seen in our 2-day March 2016 site visit but not previously recorded.

Common name	Scientific name	Red-list status	Reporting Rate*	Collision Rank**
Martial Eagle	*Polemaetus bellicosus*	**Endangered**	**100%**	**5**
Black-chested Snake-Eagle	*Circaetus pectorialis*	Least threatened	**7.7%**	**56**
Pale Chanting Goshawk	*Melierax canorus*	Least threatened	**50%**	**73**
Greater Kestrel	*Falco rupicoloides*	Least threatened	**7.7%**	**97**

*Reporting rate is a measure of the likelihood of occurrence, a "0" denotes it was not recorded in the atlas period. For Martial Eagle we saw it twice in 2 days' work giving it a 100% reporting rate

** Collision rank derived from the BAWESG 2014 guidelines. Smaller numbers denote more collision-prone.

the Kalahari Desert is very much a "boom or bust" landscape and one dry season visit can give a biased impression relative to the explosion in biodiversity that can follow high rainfall events. This visit measured the avian diversity after good rains that fell in February 2016 and continued into March at the time of our visit.

3.2.1 Birds in the preferred and alternative sites of the proposed PV

From three 1-km transects we recorded a mean of 16.0 species km^{-1} (Table 3). The preferred area held 18 species km^{-1} (and 41 birds km^{-1}), and in the alternative area we recorded fewer species, (15 species km^{-1}) and fewer birds (33.5 birds km^{-1}). However this was based on just three transects and the differences are probably not significant.

Table 3: Bird species and numbers recorded over 1 km in the two PV sites at Lime Bank 1 and 2, March 2016.

Summary	Species	Birds	Habitat
Lime Bank 1 (transect 1)	18	41	Acacia mellifera thicket, Rhus, bare ground
Lime Bank 2 (transect 1) *	12	25	Acacia erioloba, mellifera thicket, Rhus, bare ground
Lime Bank 2 (transect 2) *	18	42	Acacia erioloba, mellifera thicket, Rhus, bare ground
Means	**16.00**	**36.00**	

* Lime Bank 2 = alternative site

The VP observations totalling 12 h in each site on 12 and 13 March revealed no collision-prone birds inside the borders of either the Preferred or the Alternative proposed PV sites. A Martial Eagle was observed perched 300 m north of the north-east corner of the Alternative site, but was not seen in flight over the site (photo 2).

A Pale Chanting Goshawk was also recorded in flight, but west of the western boundary of the alternative site (Figure 2).

Since neither of these species was seen within the borders the Passage Rate of collision-prone birds through either site was 0.0 birds $hour^{-1}$. This may change with further observations as these birds may hunt around the artificial water sources in the dry season where prey may be attracted.

Other aerial birds were recorded within the two sites but they are not classified as highly collision-prone. We recorded their presence on the assumption that they may be attracted to the panels as a source of water and could interact in an unknown manner with the perceived water as posited by the Lake Effect of Kagen et al. (2014).

These include Namaqua Sandgrouse *Pterocles Namaqua* that are attracted to flooded pans to drink and Northern Black Korhaans *Afrotis afraoides* that undertake aerial display flights in the breeding season. In total 15 sandgrouse flights were recorded in 12 h observation in the preferred site and 2 korhaan flights in the same area over the same period. The sandgrouse were concentrated around the pan on the western edge of the preferred site (Figure 2).

Importantly, we recorded no wetland species in 24 hours of observation at either site, suggesting that future collisions by these species with the PV panels may be unlikely. That two species (Egyptian Goose *Alopochen aegyptiacus* and Cattle Egret *Bubulcus ibis*) are known to occur in the area from atlas records suggests the possibility of impacts is not completely zero. Neither are red data species.

Yellow-billed Hornbill *Tockus leucomelas* were recorded in the area in both our surveys and bird atlas data, and there is a low probability that these may smash the panels if they see their own reflections (Dr A Kemp pers comm).

In summary, few differences existed in small bird numbers with respect to the preferred *vs* the alternative proposed PV site. No collision-prone birds were recorded on either site, but two species (Martial Eagle and Pale Chanting Goshawk) may hunt within them at times.

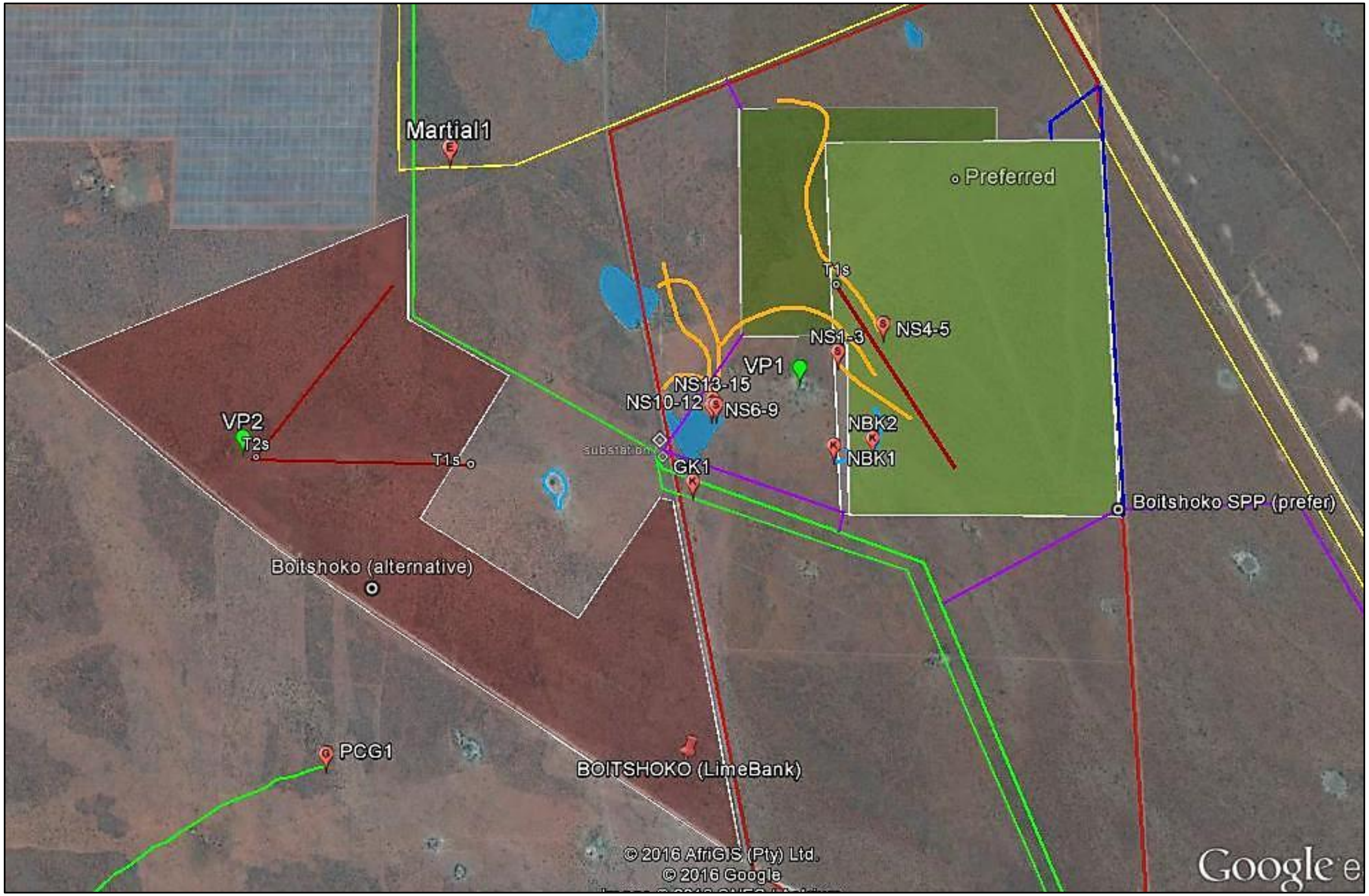

Figure 2: The preferred (right) and alternative (left) Boitshoko PV sites on Lime Bank farm. The only collision-prone birds recorded in 12 h VP observations on both sites was the Martial Eagle perched on pylons outside the area (Martial 1), and a Pale Chanting Goshawk (PCG1), bottom left. The other flight lines indicate those of Namaqua Sandgrouse (NS1-15 – orange lines) flying to and from a pan area midway between the two sites, and Northern Black Korhaan (NBK). A scale is given by the 1 km transect lines in red.

4 QUANTIFYING THE IMPACTS

Nature: The impact of the proposed PV areas (both preferred and alternative) will generally be negative given the certainty that: (i) 250-300 ha will be transformed and the associated bird habitat destroyed; (ii) birds may collide with the panels if they mistakenly perceive them as open water; and (iii) collision-prone species living around the periphery may collide with the power lines linking the solar development to the substation.

Yellow-billed Hornbills which were recorded on site may additionally pose a risk to PV panels, if they use reflective surfaces, given that this genus is known to attack their own reflections. This seems of low probability because PV panels use non-reflective surfaces.

It must be noted that the pylons (as opposed to the transmission lines they carry) can also be considered positive for Martial Eagles given that they can provide breeding platforms for them in a tree-less environment.

The Extent (**E,** from 1-5) of the impact will occur within the preferred PV area (of 250 ha) = **(1),** and along the reticulation lines = **(3)**

The Duration (**D**, from 1-5) will be long-term **(4)** for the lifetime of the PV area and the transmission lines for all species.

The Magnitude (**M,** from 0-10) of the PV area is expected to have a low impact **(1)** for the raptors and the korhaans **(1)**; for the transmission line Martial Eagles both benefit (breeding sites) and may be killed in low numbers, giving a low-medium Magnitude of **(3).**

For wetland birds, higher numbers **(3)** may be killed by collision with the panels (Kagen et al. 2014) or the transmission lines (Jenkins et al. 2010). Few smaller birds will be lost from habitat destruction of 250 ha given the low density of birds in the over-grazed habitat that covers much of both PV areas.

The Probability of occurrence (**P,** from 1-5) of the raptors (Martial Eagle and goshawk) having some sort of interaction with the PV panels and transmission line is ranked medium low **(2)** because the farm dams on site may be attractive as a hunting site for the raptors in the dry season. For the wetland birds, the probability of occurrence is very low **(1)** because they are only found in these areas during rains, reducing the probability of future impacts.

The Significance S, [calculated as **S = (E+D+M)P**], is as follows (Table 4) for the species identified as at risk in the (i) PV site, and (ii) the adjacent power line.

The scale varies from 0 (no significance) to 100 (highly significant and unacceptable). A score above 50 is considered very high and mitigation is required.

Table 4. A summary of the quantified impacts to the collision-prone raptors and wetland bird species likely to be impacted by the (i) proposed PV plant and (ii) new power lines.

(i) Within the PV site itself

Nature: Mostly negative due to direct impact mortality (or avoidance of area) around the **PV site** for the Red-listed bird groups identified as at risk above.
(**ME**= Martial Eagle and other raptors, **WB** = Wetland birds):

	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**
Magnitude	**1 (ME), 1 (WB)**	**1 (ME), 1 (WB)**
Probability	**2 (ME), 2 (WB)**	**1 (ME), 1(WB)**
Significance (E+D+M)P	**12 (ME), 12 (WB)** **Low risk**	**6 (ME), 6 (WB)** **Low risk**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Low	(mitigations untested)
Irreplaceable loss of species?	No	
Can impacts be mitigated?	Probably yes, but most mitigation measures are untested in PV sites.	

(ii) Mitigation for impacts for the PV panels

There are three classes of mitigation for the PV panels: (i) move them well away from highly sensitive bird area (especially pans or other well-used bird areas), or (ii) employ bird-diverters to deter birds mistaking the panels for open water. If, in the post-construction monitoring, hornbills are found to attack their own reflections in the panels, and smash them, then covering the affected panels with a fine wire mesh is recommended.

It is also recommended that Boitshoko install video cameras above some panels for post-construction monitoring of any mortality of birds in the vicinity, through direct observation and carcass searches in a systematic and regular fashion.

Cumulative impacts:

For the PV itself the mortality and displacement impact on birds is poorly known, but many solar farms are now being constructed in the Kalahari/Karoo and more will occur in the future : thus more research and monitoring of the combined impacts is required. See section 4.1 below.

Residual impacts:

After mitigation, direct mortality through collision or area avoidance by the species identified above may still occur. An environmental management programme will assess the efficacy of the mitigations to reduce direct impacts or any problems with hornbills, and further research and mitigation can then be suggested and tested as the need arises.

(ii) Along the reticulation lines from the PV site to the substation
Nature: Negative due to direct impact mortality due to **new transmission line** for the collision-prone bird groups identified as at risk above.
(**ME**= Martial Eagle + other raptors, **WB** = Wetland birds):

	Without mitigation	**With mitigation**
Extent	**3**	**2**
Duration	**4**	**4**
Magnitude	**3 (ME)**, **4 (WB)**	**2(ME), 2 (WB)**
Probability	**2(ME), 2 (WB)**	**1(ME), 1 (WB)**

Significance (E+D+M)P	**20 (ME), 10 (WB) (Low)**	**8 (ME), 8 (WB) (Low)**
Status (+ve or –ve)	Negative	Neutral
Reversibility	Medium- High	Medium-High
Irreplaceable loss of species?	No, few raptors or other collision-prone birds occur within either site	
Can impacts be mitigated?	Yes, by marking all existing and all future lines with bird diverters. Experiments in the Karoo by the EWT indicate that mortalities from impacts with transmission lines fitted with bird diverters can reduce mortality by 80% for some bird groups (C. Hoogstadt pers comm.)	
(ii) Mitigation for power lines: There are three classes of mitigation for birds around **power lines**: (i) re-position the lines to avoid intersecting the movements of the birds, (ii) add bird diverters to all new lines and motivate Eskom to mark all existing lines that are killing substantial numbers of birds, such that collision-prone species more readily detect and avoid contact, or (iii) bury the lines. We suggest that there is now enough long-term and well-executed research to show that un-marked lines are killing such large numbers of birds (such as bustards) that we recommend that **all new transmission lines be marked with bird diverters,** as they go up. The priority areas - those with the highest mortality rate - should be considered first.		

4.1 CUMULATIVE IMPACTS

Cumulative impacts are defined as "Impacts that result from incremental changes caused by either past, present or reasonably foreseeable actions together with the project" (Hyder, 1999, in Masden et al. 2010).

Thus, in this context, cumulative impacts are those that will impact the general avian communities in and around the Boitshoko Solar Power Plant Power Plant (RF) development, mainly by other solar farms and associated infrastructure. This will happen via the same factors identified here viz: collision, avoidance and displacement. Therefore, we need to know as a starting point the number of solar farms around the region within 50 km and 120km, and secondly, to know their impact on avifauna.

Given the general assumption that footprint size and bird impacts are linearly related for PV and CSP solar farms, a starting point in determining cumulative impacts is to determine:

- the number of bird displaced per unit area, by habitat destruction, or disturbed or displaced by human activity;
- the number of birds killed by collision with the structures on site;
- the number of birds killed by collision with infrastructure leading away from the site;
- the number of birds killed by flying through the solar flux of CSP tower sites.

By the end of 2015 there were 27 proposed or approved renewable energy farms of various sizes within 120 km of Boitshoko, and 12 within 50 km (Figure 3). We have attached a current status table (Table 5) depicting the sites proposed within a 50 km radius, as they are the most likely to add to the cumulative impact of the Boitshoko Solar Power Plant (RF) (Pty) Ltd.

Table 5: Approved/Proposed Renewable Energy sites within a 50km radius of Boitshoko. Source: http://egis.environment.gov.za/frontpage.aspx?m=27 Directorate of Environmental Affairs) in 2016.

	Project Title	Distance from Boitshoko	Technology	Megawatts	Current Status
1	Sishen Solar	0,0km	Solar PV	0	Withdrawn/Lapsed
2	San Solar	0,0km	Solar PV	75	Approved
3	Kalahari Solar Power	6,54km	Solar PV	0	Approved
4	Vexcen Trading	14,8km	Solar PV	0	Withdrawn/Lapsed
5	Bestwood Solar	15,8km	Solar PV	0	Approved
6	Shirley Solar Park	19,6km	Solar PV	75	Approved
7	Shirley Solar Park	19,6km	Solar PV	75	Approved
8	Adams PV	25,3km	Solar PV	75	Approved
9	Roma Energy Solar	25,7km	Solar PV	0	Withdrawn/Lapsed
10	Keren Energy	35,7km	Solar PV	10	Approved
11	Keren Energy	39,8km	Solar PV	10	Approved
12	East Solar Park	48,75km	Solar PV	75	In Process

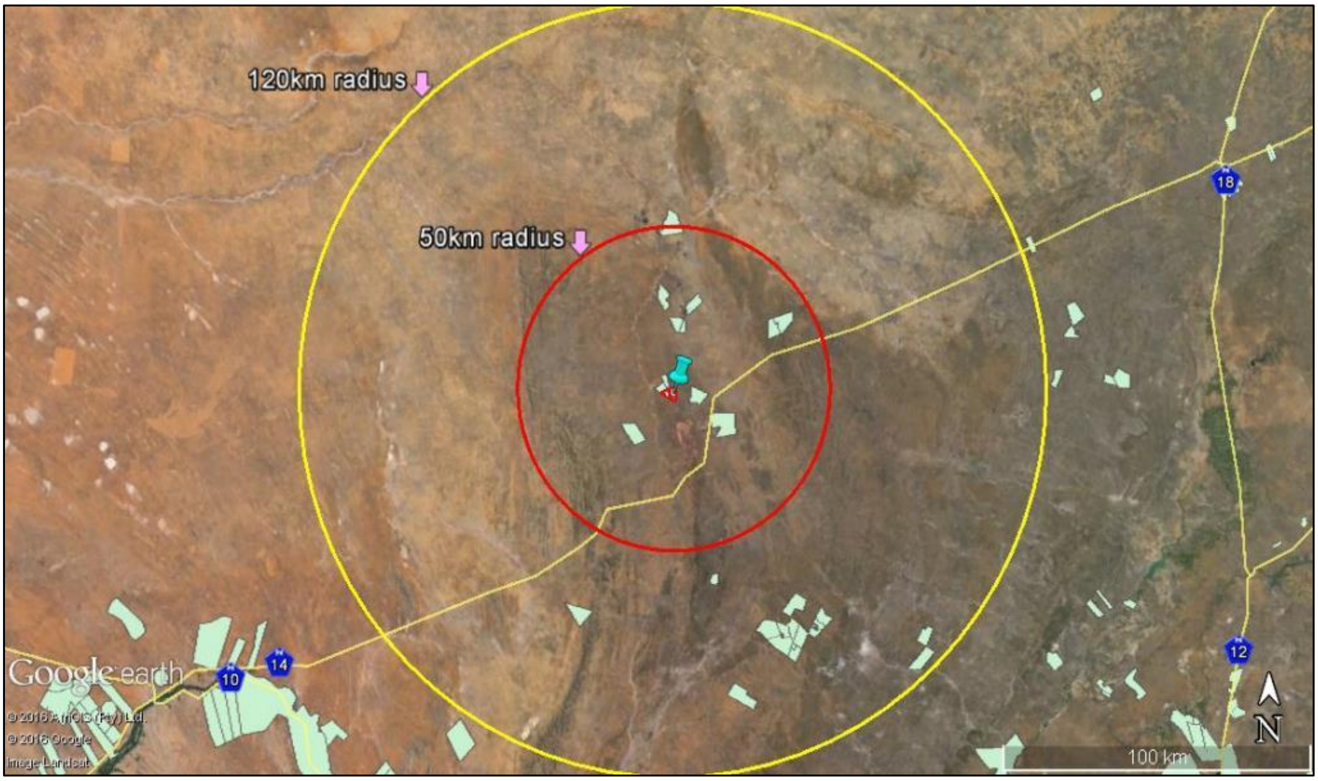

Figure 3: The proposed Boitshoko Solar Power Plant site (blue pin in centre) in relation to all other proposed or approved renewable energy sites of various sizes within 50 km (red circle) and 120 km (yellow circle).

Because there are no post-construction mortality data or displacement data for any of these aspects in South Africa, it is a futile exercise to attempt to put any figures to the Cumulative Impacts for birds in and around the solar sites. Once the data is collected and published (or released to other specialists) for a minimum of a year's monitoring, we can then quantify this aspect. On present data we cannot even guesstimate the cumulative impact.

5 CONCLUSIONS AND RECOMMENDATIONS

The proposed Boitshoko Solar Power Plant Power Plant (RF) on Lime Bank farm, near Kathu, is one of many such renewable energy initiatives that will be proposed for this high-flux solar radiation region of South Africa.

The avifauna of the area may be affected by the infrastructure of the Solar Power (PV) plant but our analysis of the number of birds on site suggests the impact will be minimal based on one site visit in the wet season. It is important to realise that is a preliminary conclusion because it is based on a limited data set and one visit. Our second dry-season visit will help clarify the use of the site by collision-prone species in the surrounding area.

We do not know whether the collision-prone birds that occur around the area, such as the Endangered Martial Eagle, will be pulled into the site in the dry season (to hunt around the farm dams); or, once the PV panels are in place, whether wetland birds will be attracted to them. Too little research in South Africa is presently available to determine that, and thus, a full 12 months of post-construction monitoring by trained ornithologists is a further recommendation.

We also recommend that all available precautions are taken to avoid the *Endangered* Martial Eagles and other threatened birds being attracted to the panels. If birds are attracted and collide with the panels by mistaking it for open water then we recommend that innovative bird deterrent techniques are used such as the Torri lines mentioned in the avian Scoping Report (Simmons and Martins 2016).

If these recommendations can be followed and prove effective, we believe that the Boitshoko PV solar park can be allowed to proceed with the least impact to the avifauna of the area.

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4 April 2016

revised: 22 April 2016

7 APPENDICES

APPENDIX 1: The 48 bird species that were recorded on bird atlas cards covering the Boitshoko PV site at Lime Bank and their likelihood of occurrence. These pentads are: **2735_2255** and **2735_2250** from the period 2007 - 2016. Extracted from the Animal Demography Unit, University of Cape Town website http://sabap2.adu.org.za and based on 13 cards. **Threatened species are given in red,** **collision-prone species in bold,** wetland species are highlighted in blue**.** Our own records of species found on site are given in Appendix 2 table.

SABAP2 list of birds in pentads 2735_2255 and 2735_2250 (N= 13 cards) **LIME BANK 1 and 2**				
Species name	Taxonomic name	Full protocol		
		Rep Rate (%)	n	Number of cards
Barbet, Acacia Pied	*Tricholaema leucomelas*	7.69	1	13
Bulbul, African Red-eyed	*Pycnonotus nigricans*	15.38	2	13
Canary, Black-throated	*Crithagra atrogularis*	7.69	1	13
Canary, Yellow	*Crithagra flaviventris*	15.38	2	13
Chat, Ant-eating	*Myrmecocichla formicivora*	7.69	1	13
Dove, Laughing	*Streptopelia senegalensis*	15.38	2	13
Dove, Red-eyed	*Streptopelia semitorquata*	15.38	2	13
Drongo, Fork-tailed	*Dicrurus adsimilis*	7.69	1	13
Egret, Cattle	*Bubulcus ibis*	7.69	1	13
Finch, Red-headed	*Amadina erythrocephala*	7.69	1	13
Finch, Scaly-feathered	*Sporopipes squamifrons*	15.38	2	13
Flycatcher, Chat	*Bradornis infuscatus*	7.69	1	13
Flycatcher, Fiscal	*Sigelus silens*	15.38	2	13
Flycatcher, Marico	*Bradornis mariquensis*	7.69	1	13
Goose, Egyptian	*Alopochen aegyptiacus*	7.69	1	13
Hornbill, Southern Yellow-billed	*Tockus leucomelas*	7.69	1	13
Kestrel, Greater	*Falco rupicoloides*	7.69	1	13
Lapwing, Blacksmith	*Vanellus armatus*	15.38	2	13
Lapwing, Crowned	*Vanellus coronatus*	7.69	1	13
Lark, Fawn-coloured	*Calendulauda africanoides*	7.69	1	13
Lark, Sabota	*Calendulauda sabota*	7.69	1	13
Martin, Rock	*Hirundo fuligula*	15.38	2	13
Masked-weaver, Southern	*Ploceus velatus*	7.69	1	13
Mousebird, White-backed	*Colius colius*	15.38	2	13
Ostrich, Common	*Struthio camelus*	7.69	1	13
Paradise-whydah, Long-tailed	*Vidua paradisaea*	7.69	1	13

Pigeon, Speckled	*Columba guinea*	7.69	1	13
Prinia, Black-chested	*Prinia flavicans*	15.38	2	13
Pytilia, Green-winged	*Pytilia melba*	7.69	1	13
Roller, Lilac-breasted	*Coracias caudatus*	7.69	1	13
Scrub-robin, Kalahari	*Cercotrichas paean*	15.38	2	13
Snake-eagle, Black-chested	*Circaetus pectoralis*	7.69	1	13
Sparrow, Cape	*Passer melanurus*	7.69	1	13
Sparrow, House	*Passer domesticus*	7.69	1	13
Sparrow, Southern Grey-headed	*Passer diffuses*	7.69	1	13
Sparrow-weaver, White-browed	*Plocepasser mahali*	15.38	2	13
Starling, Cape Glossy	*Lamprotornis nitens*	15.38	2	13
Starling, Wattled	*Creatophora cinerea*	7.69	1	13
Sunbird, Marico	*Cinnyris mariquensis*	7.69	1	13
Swallow, Greater Striped	*Hirundo cucullata*	7.69	1	13
Swift, Little	*Apus affinis*	7.69	1	13
Tchagra, Brown-crowned	*Tchagra australis*	7.69	1	13
Teal, Red-billed	*Anas erythrorhyncha*	7.69	1	13
Tit-babbler, Chestnut-vented	*Parisoma subcaeruleum*	7.69	1	13
Turtle-dove, Cape	*Streptopelia capicola*	15.38	2	13
Wagtail, Cape	*Motacilla capensis*	7.69	1	13
Waxbill, Violet-eared	*Granatina granatina*	7.69	1	13
Woodpecker, Golden-tailed	*Campethera abingoni*	7.69	1	13
Totals: 48 species from 13 cards. No red –data species				

APPENDIX 2: BIRD DENSITIES BY HABITAT

Species recorded on site in 1-km transects on the Preferred (Lime Bank 1) and Alternative (Lime Bank 2) PV sites 11 + 12 March 2016

Species	Number	PerpDist	Date	Transect	Habitat
Cape clapper lark	1	90	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Black-chested prinia	1	50	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Red-crested korhaan	1	150	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
European bee-eater	1	80	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Long-billed crombec	1	40	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Little swift	1	40	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Chestnut-vented titbabbler	1	30	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Black-chested prinia	1	5	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Red-crested korhaan	2	120(10)	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Yellow canary	2	60	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
European bee-eater	1	170	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Namaqua dove	1	40	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground

Cape clapper lark	1	1	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Cape clapper lark	1	30	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Black-chested prinia	2	1	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Yellow canary	1	1	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Northern black korhaan	1	170	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Yellow canary	1	5	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Kalahari scrub-robin	1	1	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Grey-backed sparrowlark	1	30	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
European bee-eater	2	55	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Black-chested prinia	1	70	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Kalahari scrub-robin	1	80	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Red-faced mousebird	2	50	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Namaqua sandgrouse	4	150	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Brown-crowned tchagra	1	90	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Red-crested korhaan	1	150	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Namaqua dove	1	40	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Rufous-cheeked nightjar	1	0	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Kalahari scrub-robin	1	50	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Lesser-grey shrike	1	75	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Black-chested prinia	1	75	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
Desert cisticola	1	20	11/03/2016	LIMEBANK1	Acacia mellifera thicket, Rhus, bare ground
18 species	**41**	**birds**	**In this trans: Red Data species = 0 , Collision-prone species = 0**		
Karoo prinia	1	5	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Karoo prinia	1	15	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Namaqua dove	2	100	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Sabota lark	1	70	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Kalahari scrub-robin	1	40	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Sabota lark	1	40	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Karoo prinia	1	40	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Namaqua dove	1	100	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Cape turtle dove	1	110	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Lesser-grey shrike	2	30	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Barn swallow	1	15	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Karoo prinia	2	30	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Namaqua dove	1	1	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Black-chested prinia	2	30	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Kalahari scrub-robin	1	70	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Fawn-colour lark	1	35	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Northern black korhaan	1	200	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
European bee-eater	2	120	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Red-faced mousebird	2	40	11/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
12 species	**25**	**birds**	**In this trans: Red Data species = 0** **Collision-prone species = 0**		
Kalarhari scrub-robin	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Red-crested korhaan	2	200	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Cape turtle dove	1	700	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Chestnut-vented titbabbler	1	50	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Kalarhari scrub-robin	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Crimson-breasted boubou	2	120	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Chestnut-vented titbabbler	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Black-chested prinia	1	45	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Namaqua dove	1	80	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd

Chestnut-vented titbabbler	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Northern black korhaan	1	45	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Black-chested prinia	2	5	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Red-crested korhaan	1	100	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Cape turtle dove	1	160	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Kalarhari scrub-robin	1	75	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Black-chested prinia	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Brown-crowned tchagra	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Red-crested korhaan	1	120	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Pririt batis	1	100	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Southern masked weaver	1	5	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
White-backed mousebird	3	15	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Northern black korhaan	1	90	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Scaly-feathered finch	2	45	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
White-backed mousebird	4	25	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Chestnut-vented titbabbler	1	60	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Pririt batis	1	80	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Red-backed shrike	1	75	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Black-chested prinia	1	80	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Yellow canary	1	10	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Kalarhari scrub-robin	1	10	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Cape clapper lark	1	80	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Martial eagle	1	1100	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
Lesser-grey shrike	1	75	12/03/2016	LIMEBANK2	Acacia erioloba, mellifera thicket, Rhus, bare grnd
18 species	**42**	**birds**	**In this trans: Red Data species = 1** **Collision-prone species = 1**		
Total Birds	**108**				
Total Species	**30**				
Total Red-data Species	**1**	**Martial eagle**			
Collision-prone species	**2**	**Martial eagle,** **PaleChanting Goshawk**			
Summary	**Species**	**Birds**	**Habitat**		
LI1T1	18	41	Acacia mellifera thicket, Rhus, bare ground **(preferred)**		
LI2T1	12	25	Acacia erioloba, mellifera thicket, Rhus, bare grnd **(alternative)**		
LI2T2	18	42	Acacia erioloba, mellifera thicket, Rhus, bare grnd **(alternative)**		
Means	**16.00**	**36.00**	Overall		
Mean (preferred)	**18.00**	**41.00**			
Mean (alternative)	**15.00**	**33.50**			