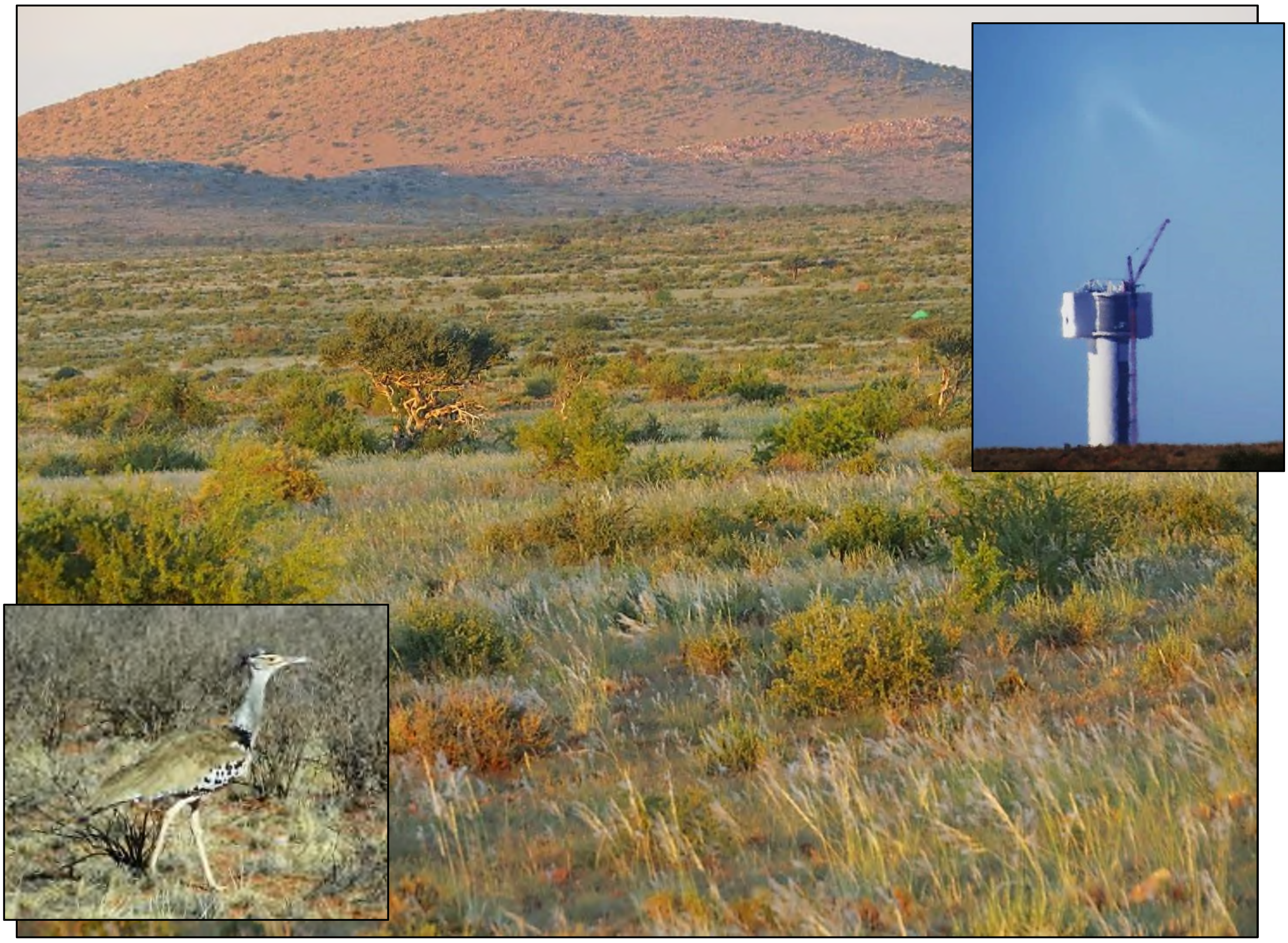
FINAL PRE-CONSTRUCTION AVIAN IMPACT ASSESSMENT OF THE CSP TOWER 7, KAROS SOLAR VALLEY, NEAR UPINGTON, NORTHERN CAPE



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1 SUMMARY

This study reports on avian monitoring for the proposed Karoshoek Solar Valley Development, proposed by Emvelo Eco Projects (Pty) Ltd on various farms near “Karoshoek” east of Upington, Northern Cape. Our objective is to determine the numbers of collision-prone birds attracted to the proposed solar development at CSP Tower 7 site before rains (November 2015) and after rains (March 2016), to understand and mitigate any possible impacts to sensitive and threatened species.

A review of recent literature on Concentrating Solar Power (CSP) and their effects on avifauna reveals that CSP tower technology, which utilizes heliostat mirrors focused on a central tower, may kill birds that fly through the solar flux. Here, we identify potential impacts associated with these facilities in the proposed Karoshoek Solar Development.

The possible impacts are:

- Displacement of nationally important species from their habitats by the presence of the heliostat mirrors;
- Loss of habitats for such species due to direct habitat destruction;
- Disturbance during construction of the array; and
- Feather singeing, or direct mortality, if aerial birds fly through the solar flux.

Indirect and cumulative impacts include water abstraction from the Orange River which may reduce flow rate in low-flow seasons and force avifauna to seek alternative habitats.

The impact zone of the CSP Tower 7 site lies on the interface of Nama Karoo and Kalahari Savanna. Bird atlas data, combined with our own, indicates that the Karoshoek Solar Valley area supports up to 114 bird species, including 14 species ranked in the top 100 collision-prone species. Six of these species are also red-listed: Black Harrier *Circus maurus*, Lanner Falcon *Falco biarmicus,* Kori Bustard *Ardeotis kori,* Ludwig’s Bustard *Neotis ludwigi*, Verreaux’s Eagle *Aquila verreauxi* and Secretarybird *Saggitarius serpentarius.* Harriers, eagles and bustards are highly collision-prone species, and the raptors are highly aerial birds, and may be impacted the CSP solar flux. Similarly, the proximity to the Orange River may attract wetland species seeking other wetland areas, and cause mortality as birds attempt to land on the heliostats. In addition, resident birds will lose habitat totaling ~950 ha in the increased area.

Since the degree and significance of bird impacts will be related to the abundance and movements of key species, we calculated bird densities in the expanded site footprint

and the passage rate of the collision-prone birds through the site. In total we recorded 30 species on the CSP Tower 7 site. Our 1 km surveys revealed a similar species richness of smaller birds in both the wet season and dry season (15.3 v 13.2 species km^{-1}). The **Passage rate** of larger collision-prone birds was medium-low at 0.42 birds per hour of observation, and it was higher the wet season than the dry season. Two red-data bustards were recorded on site and two high-sensitivity areas were apparent on the CSP Tower 7 area. No wetland birds were seen. Sandgrouse regularly traversed the site (2.7 birds h^{-1}) in both seasons and those commuting at high levels are at risk from the solar flux. Some large Sociable Weaver nests were present on site, and displaced birds may attempt to build on the heliostat mirror infrastructure. This represents a high impact site, and medium-high with appropriate mitigation.

The volume of water required for cooling and other processes at a CSP tower is *c.* 250 000 m^3 of water per year. Thus, the 3 CSP towers (3 x 250 000m^3) and 5 CSP troughs (5 x 80 000 m^3) planned for the Karos Solar Valley development will require amounts exceeding 1.15 million m^3 of water from the Orange River. In arid areas this can be a challenge, and the source, volume and conservation of such water must be carefully regulated.

We quantified the impacts and found medium-high levels of significance for the threatened collision-prone species present on CSP tower site 7 that requires mitigation.

To mitigate the possible impacts identified we recommend that:

- The CSP tower site avoid the two high sensitivity areas identified;
- Bird scaring techniques are used on the mirrors and the tower, including rotating prisms, avian distress calls and experimental use of Torri lines (ribbons used on trawlers to deter albatrosses from taking baited hooks and drowning), if birds are found to impact the CSP infrastructure.

Systematic monitoring during construction and post-construction of the CSP facility is recommended by trained ornithologists given the high probability of avian impacts at the CSP Tower 7 facility on collision-prone birds.

1.1 Consultant's declaration of Independence

Birds & Bats Unlimited are independent consultants to Savannah Environmental. 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 (http://www.birds-and-bats-unlimited.com/), were approached to undertake the specialist avifaunal assessment for the pre-construction phase of the CSP solar parks proposed by Emvelo (Pty) Ltd, east of Upington, 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 at renewable energy sites have been undertaken in 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 (http://www.birds-and-bats-unlimited.com/).

2 TERMS OF REFERENCE

- To provide a desktop and field assessment of all potential impacts to avifauna from the CSP tower site 7 within Karoshoek Solar Valley development, near Upington;
- The final avian impact assessment should include assessments of all expanded areas proposed after the initial site visit in November 2015;
- To provide a summary of expected impacts for all threatened or collision-prone species found in the area;
- To quantify the expected impacts with and without mitigation measures;
- To determine the cumulative impacts to the avifauna in the area;
- To provide possible mitigation measures to reduce impacts wherever they occur;

- Provide recommendations for an environmental management plan to monitor the site, during and post-construction to determine impacts to the avifauna, and provide mitigation solutions were necessary.

We start with a review of the solar technology to be employed to contextualize it, relative to possible, and known, avian impacts elsewhere in the world.

3 BACKGROUND

3.1 CSP SOLAR POWER

Water, wind or solar power are all renewable energy sources with the potential to supply the human population with unlimited non-polluting power. As a major greenhouse gas emitter, South Africa is a signatory to the Kyoto Protocol and is committed to turning to green energy sources that emit no greenhouse gases or other pollutants. 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/CSP.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 liquid that drives a turbine (CSP tower). This is the preferred option by the developer Emvelo (Pty) Ltd, in the Ilanga Solar development CSP Tower 7;

(ii) A CSP using Trough technology with smaller parabolic mirrors that capture and focus the sun's energy onto a central pipe that also employs a heat-transfer liquid to heat steam to drive a turbine; and

(iii) Photo-voltaic panels that capture and convert sunlight directly into electrical power using conventional PV technology.

There are fewer direct risks associated with the PV and CSP trough technology than CSP Towers from an avian perspective (see below). However, all forms of solar technology appear to draw in birds because research suggests birds perceive the shiny mirrored-surfaces as open water (the so-called "Lake Effect" – Kagan et al. 2014). This CSP tower technology is the only one assessed in this report for the Emvelo solar development at CSP Tower 7 site.

3.2 POTENTIAL AVIAN IMPACTS WITH CSP TOWER FACILITIES

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:

- displacement of nationally important species from their habitats;
- loss of habitats for such species;
- disturbance during construction, and operation of the facility;
- collision with the CSP heliostat mirrors (mistaking them for water bodies); or
- feather singeing or incineration in the concentrated solar flux.

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

An area up 1520 ha is required in the operation of the CSP Tower 7 facility, and this will reduce habitat availability for 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.

Avian fatalities at CSP 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 (PV, CSP trough and CSP tower) the CSP tower sites recorded the highest levels of avian fatalities relative to the PV and CSP trough sites in one review (Kagan et al. 2014).

This is due in the main to one facility at Ivanpah in the Mojave Desert in the western USA. Avian fatalities there show clear signs that the victims' feathers have been singed. These include falcons, hawks, warblers and sparrows http://www.livescience.com/_43458-bird-deaths-ivanpah-solar-energy-plant.html. In a follow up report (Harvey and associates 2015), over 3500 birds were estimated to have died at the same facility in a year. It is necessary to point out that this is not exactly the same technology as proposed for the Karoshoek facility, even though the principle used is the same (a concentrated solar beam focussed on a tall central tower: photo 1).

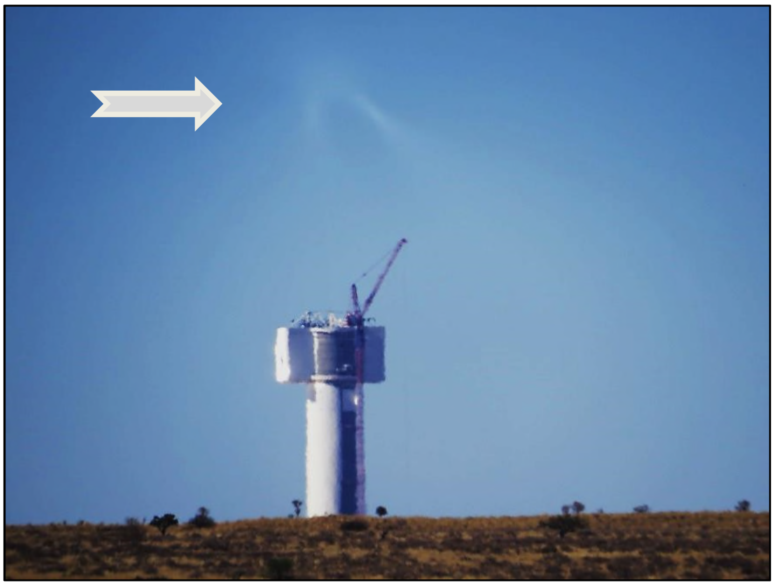

Photo 1: An example of the solar flux focussed at the "standby" points above a CSP tower in the Northern Cape. Birds entering this area are likely to be incinerated and create "streamers" as they are killed.

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 heliostats 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 susceptible to 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). However we can summarise their findings as follows:

- 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 CSP trough site in California were smaller passerine birds or swallows;
- they also recovered waterbirds such as grebes, herons and gulls suggesting these species may be attracted by the *perceived* availability of water or the lake effect (Kagan et al. 2014);
- overall, waterbirds were found to average 11% of the fatalities at solar farms, but reached 46% of all fatalities at the solar PV facility (Desert Sunlight) in California;

- there were too few fatalities at different types of facilities to test the lake effect of Kagan et al. (2014);
- there was a clear trend at all solar facilities for resident species to dominate the fatalities; and
- most fatalities were recorded at the CSP towers.

Table 1. Summary of all avian fatality data from large-scale solar facilities from the USA (after Walston et al. 2015). The results for CSP tower 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 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
Topaz Solar Farm (PV)	Yes – Incidental and Systematic	Jan. 2013 –Jan. 2014	19	41
California Solar One (CSP tower)	Yes – Systematic	May 1982–May 1983 (40visits)	Not Available	70 (114 birds)
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)

*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

Tabulating fatalities of birds at solar sites is insufficient 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 an arid environment where sensitive species may not occur at all if rains do not fall (Dean 2004, Dean et al. 2009) even a full year's monitoring is unlikely to be sufficient. Thus, visits must be timed to coincide with the most productive time of year – the rain season. Therefore, the present CSP Tower 7 site was closely and *systematically* monitored by Birds & Bats Unlimited, over a dry and wet season, to determine movements and rates of passage of all collision-prone species (as defined by BARESG 2014). We followed the draft Birdlife/EWT guidelines (Jenkins et al. 2015) for such monitoring to minimise the possibility of inappropriate or under-sampling obvious in most other EIA reports on solar arrays.

As a relatively new field, and with the burgeoning solar farm industry in South Africa focussed on the Kalahari Desert, we need to be pro-active in our research and innovative in our designs to reduce mortality.

3.2.1 Habitat loss – Destruction, Disturbance and Displacement

The construction and maintenance of CSP technology causes mainly permanent habitat destruction under the heliostat mirrors. 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 expected to take 2-3 years.

From a habitat removal 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.

Because CSP facilities are not yet operational in South Africa, and there are relatively few published studies of avian mortalities at such sites in other parts of the world (Table 1), this section is necessarily brief and is in need of further study, transparency and data sharing in southern Africa.

3.2.2 Collision – with reticulation lines and CSP tower heliostats

Several South African bird species are well known to collide with overhead power lines, fences, towers and other aerial objects (Jenkins et al. 2010). These 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, red-data status (Taylor et al. 2015) 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 species such as bustards and cranes, but also raptors. It is somewhat surprising that birds also collide with ground-based structures and, as shown above (Table 1), these include passerines, and wetland birds in collision with CSP troughs 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 wetland and aerial species, as well as those known to collide with aerial structures (bustards and raptors). It is these we focused on during our surveys. A separate Basic Assessment will be undertaken for the power lines.

3.2.3 Feather singeing and incineration in the solar flux

Air temperatures close to the receiving area at the top of the CSP tower often exceed 500°C. This temperature is only reached when the heliostats are focused on the area, and it declines as one gets closer to the mirrors, further from the focus. Modelling of the temperature at different heights indicates that only above ~175m on a 200m tower will temperatures exceed 400°C. This is critical because it is at this point that feathers start to curl and melt (Kagen et al. 2014), and birds can no longer stay airborne.

Avian fatalities arising from birds passing through the solar flux have been recorded at the Mojave Desert CSP plants at Ivanpah in the USA with clear signs that the victims' feathers have been singed. http://www.livescience.com/43458-bird-deaths-ivanpah-solar-energy-plant.html. It is thought that insects are attracted to the intense light at the plants, this attracts migrants, and predatory raptors are attracted to both insects and other birds as potential prey.

Direct deaths are reported at both Ivanpah and Crescent Dunes in the USA by birds being incinerated as they pass through the highest solar flux, to create "streamers": plumes of smoke and steam as the bird evaporates http://www.basinandrangewatch.org/Crescent-Dunes-Solar-Flux.html

There are no data for avian deaths at CSP tower sites in Africa, thus, it is not known if southern African birds will be susceptible to incineration or singeing. There are, however, a number of highly aerial species including the Hirundines (swifts and swallows), soaring raptors (eagles, falcons, buzzards) and sandgrouse that sometimes forage, soar, or commute at high levels and may be susceptible to solar flux burning.

4 STUDY METHODS

4.1 Aims and methods

The primary aims of the avian pre-construction monitoring at the CSP Tower 7 proposed by Emvelo Eco Projects (Pty) Ltd at the Karoshoek Solar Valley development are to:

- Determine the densities of birds regularly present, or resident, within the impact area of the CSP towers before the construction phase;
- Document the patterns and movements of birds in the vicinity of the proposed

CSPs before their construction;
- ➢ Monitor the patterns and rates of movements of birds in the CSP areas in relation to time of day, and over one dry and one wet season when bird numbers and species richness may change;
- ➢ Establish a pre-construction baseline for all Red data and collision-prone bird species including all breeding birds within the study area;
- ➢ Quantify the impacts before and after mitigation;
- ➢ Quantify, if possible, the cumulative impacts around the solar park; and
- ➢ 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:

- Information on the ecology (Hockey et al 2005), distribution (Harrison et al. 1997) and conservation status (Taylor et al. 2015) of all South African birds;
- The Important Bird Areas Programme (IBA) of Birdlife South Africa (Barnes 1998);
- Contemporary South-Africa-wide atlas data were extracted from the Southern African Bird Atlas Project (SABAP), which were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant "pentads" of 5' x 5' (of 9 km x 8km) surrounding the planned development areas. From these data we compiled a list of the avifauna likely to occur within the impact zone of the proposed power lines. Because of the remoteness of the area there were limited SABAP2 data available at http://sabap2.adu.org.za/index.php for this region.
- These data were combined with data from two visits to the area in November 2015 and March 2016 to record bird densities and passage rates.

This report combines the data gleaned from all sources to give an assessment of the birds present in the site and, the potential impacts they face arising from the solar developments.

4.2 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 power lines and is up to date (2007 to 2015). However, there were only 9 cards 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 may not only include (Orange River) species that are very unlikely to be found in this arid area, but also artificially inflate the species totals given. For example, Todd (2012) reported 190 bird species from atlas data including Black Storks *Ciconia nigra*, many of which are unlikely to occur on site because they are wetland species;
- Our own additional data derived from one dry-season and one wet-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 timed for the dry and wet seasons would uncover;
- 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 (two are in operation in 2016 and neither have released data on what species are being killed or displaced).

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 surveys reported below.

4.3 STUDY AREA

The Karoshoek Solar Valley Development is located approximately 30 km east of Upington within the Khara Hais Local Municipality, which falls under the Siyanda District Municipality in the Northern Cape. The 150 MW CSP tower facility is proposed on the farm Matjes Rivier 41 and the CSP Tower 7 site is geographically centred on S28°35'40.8" E21°30'38.3".

4.3.1 Vegetation of the study area

The study area occurs on the interface between the Nama Karoo biome to the south and Kalahari Savannah biome to the north (Mucina and Rutherford 2006, p44). A large swathe of Bushmanland Arid Grassland runs north-south through the park (Mucina and Rutherford p335), and elements of five other vegetation types are found and described by Todd (2012). The area experiences summer rainfall up to 510 mm near Upington. High day-time temperatures occur in summer (mean 37°C) and relatively cool temperatures occur in winter (4-23°C). The site was dry and all but the larger trees were dormant in November 2015, our first site visit. Substantial rains (~250 mm in February and March 2016), had fallen by our second site visit in March 2016, and new grass cover was evident and the *Rhigozum* bushes and *Acacia* and *Boscia* trees were in full leaf.

4.3.2 Avian microhabitats

Bird habitat in the region consists of two basic vegetation types: Nama Karoo scrub and Kalahari Savannah with a very sparse cover of *Boscia* and *Acacia* trees along the dry water courses. The main avian micro-habitats were provided by the grasses, (exploited by bustards, korhaans, larks, sparrow-larks and doves (Photo 1) and the trees (exploited by flycatchers, canaries, sociable weavers and perching raptors)(Photo 2). Artificial habitats are provided by the farmers - windmills, water points and power poles. No natural pans occurred on this relatively open site, dominated by *Rhigozum* shrubs.

Photo 2: A threatened Kori Bustards, foraging through Rhigozum shrubs in November 2015. These species were relatively common on the CSP Tower 7 site, and probably breed there.

Photo 3: Typical wet-season habitat in the relatively open terrain of CSP Tower 7 site in the Karoshoek valley area showing well-grazed pasture on sandy ground. Mature *Boscia albitrunca* trees (background) provided shade for birds and other animals.

5 ON SITE METHODS

Two site visits were undertaken to the CSP Tower 7 site to coincide with different environmental conditions:

- a dry season visit from 31 October - 7 November 2015;
- a wet-season visit following on-going rains from 29 February – 9 March 2016;
- in each visit we surveyed birds in 1-km transects in areas proposed for the CSP solar array. These transects covered all main habitat types present;
- we also undertook Vantage Point observations covering 12 h in each season as promoted by the draft BARESG guidelines (Jenkins et al. 2015).

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

- Each transect was walked slowly over 35 to 60 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;
- Some cryptic bird (e.g. lark), species were identified by call, and the distance to them estimated. This allows an estimate of the density (birds per unit area and

per km, expressed as bird km^{-1}) and the species richness in each area;

- We simultaneously recorded all large birds (mainly bustards and raptors) and noted and recorded the position of any nests found;
- Over 900 (dry season) and 1300 (wet season) individual birds were recorded in the CSP areas in these transects alone.

The most important aspect of this monitoring is **Vantage Point (VP) surveys:**

- This determines the number of flights **of collision-prone species** per hour through the possible area of impact, which in turn 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 for each VP (draft BARESG guidelines: Jenkins et al. 2015);
- Each VP should have a view-shed (area of observation) not exceeding 2 km;
- Because of the large size and flat nature of the terrain we walked some areas not well covered by the VP points at each site.
- Over 500 sandgrouse were also recorded during these observations

6 RESULTS

6.1 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 CSP infrastructure, or attracted by the reflective surfaces of the CSP troughs. These species are typically large and threatened red data species that occur in the study areas (e.g. bustards and raptors), but could include wetland species attracted to the mirrored surfaces.

No recent (SABAP2) data were available from the Southern African Bird Atlas Projects website (http://sabap2.adu.org.za/index.php) for the Karoshoek solar footprint itself. Therefore, we took information from a slightly wider net that included the Ilanga power line (Birds Unlimited 2014). To these we added our own dry- (November 2015) and wet-season (March 2016) data for those species found directly on site.

6.2 AVIAN SPECIES RICHNESS AND RED DATA SPECIES

The CSP Tower 7 is shown in Figure 1. A total of 114 bird species were recorded on the 17 bird atlas cards from the Ilanga solar development and similar areas to the west (following the proposed Ilanga power line) submitted to the Animal Demography Unit from 2007 to 2014 (Appendix 1). Of these, 8 were collision-prone as ranked by BARESG (2014), and only 2 were red-listed (Kori Bustard *Ardeotis kori* and Lanner Falcon *Falco biarmicus*).

However, we noted four additional red data species in our two site visits: a Black Harrier *Circus maurus*, breeding Verreaux's Eagles *Aquila verreauxii*, a Secretarybird *Sagittarius serpentarius*, and numerous Ludwig's Bustards *Neotis ludwigi*. Thus, 6 red-data species occur in the development area (Table 2)**.** A further 8 collision-prone species (Table 2) were recorded, giving 14 collision prone/red data species in total for the greater Karoshoek Solar Valley development area.

This may over-estimate the numbers on site because the SABAP2 data includes some Orange River pentads. Therefore, we tallied only species recorded in our transects, VPs and incidental observations to determine overall species richness in the dry and wet seasons over the development area alone. A total of 72 species were recorded which will be added to the SABAP2 data base.

In summary, a total of **14 collision-prone species** occur in the greater Karoshoek solar development areas, **of which six are red-listed.**

Table 2. Threatened (**in red**) and collision-prone bird species (**in bold**) likely to occur over the proposed CSP Tower 7 development drawn from SABAP2 atlas cards for four pentads. These are based on 17 cards, submitted to the SABAP2 project from 2007 to 2015. Those shaded were seen in our site visits in November 2015 and March 2016, but not previously recorded.

					Susceptible to:
Common name	**Scientific name**	**Threat status**	**Reporting Rate***	**Collision Rank****	**Disturbance**
Verreaux's Eagle	*Aquila verreauxii*	**Vulnerable**		**2**	Moderate
Black Harrier	*Circus maurus*	**Endangered**		**6**	High
Ludwig's Bustard	*Neotis ludwigii*	**Endangered**		**10**	Moderate
Secretarybird	*Saggitarius serpentarius*	**Vulnerable**		**12**	Moderate
Lanner Falcon	*Falco biarmicus*	**Near-threatened**	6%	**22**	
African Fish Eagle	*Haliaetus vocifer*	-	35%	**27**	
Kori Bustard	*Ardeotis kori*	**Vulnerable**	6%	**37**	Moderate
Karoo Korhaan	*Eupodotis vigorii*		6%	**49**	
Booted Eagle	*Aquila pennatus*	-		**55**	
Black-chested Snake Eagle	*Circaetus pectoralis*			**56**	
Pale Chanting Goshawk	*Melierax canorus*	-	6%	**73**	Moderate
N Black Korhaan	*Afrotis afroides*		12%	**91**	
Black-shouldered Kite	*Elanus caeruleus*	-	24%	**96**	
Spotted Eagle Owl	*Bubo africanus*	-	6%	**100**	

*Reporting rate is a measure of the likelihood of occurrence, as recorded in the atlas period.

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

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. ducks, herons, 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 (Lloyd 2005);
- nomadic species (e.g. bustards, larks) 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 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 (Lloyd 1999).
These differences were apparent after good rains that fell in February 2016 and continued into March at the time of our second visit. Thus, the avian species richness values will be close to their maximum.

6.2.1 Density of birds recorded within the proposed CSP sites

We recorded a total of 30 arid-adapted species on CSP Tower site 7 in our two site visits.

In our 1-km surveys we recorded an average of only 10.0 species km^{-1} in the dry season and 15.3 species km^{-1} in the wet season (Table 3). The density of birds per kilometre was also higher in the wet season (75.0 birds km^{-1}) than the wet season (Table 3). This was due to flocks of Grey-backed Sparrow-Lark that were feeding in the area in March 2016 (Appendix 1).

Table 3: Comparison of Dry vs Wet season bird species richness recorded over 1 km at CSP Tower 7 in November 2015 and March 2016.

Summary	**Species km^{-1}**	**Birds km^{-1}**	**Collision-prone species**
CSP Tower 7 dry season	10.0	25.5	Northern Black Korhaan
CSP Tower 7 wet season	15.3	75.0	**Kori Bustard,** Northern Black Korhaan
Means	**13.2 sp km^{-1}**	**55.2 birds km^{-1}**	**2 species**

6.2.2 Passage rates of collision-prone species within CSP TOWER 7

Two collision prone species in the top 100 (BARESG 2014) were present in the CSP Tower 7 site, of which two were red data species (Table 4). The rate at which they flew through the site differed between the seasons (Table 4), averaging 0.42 birds h^{-1}.

Other aerial species that may be influenced by the solar flux or mirrored surfaces included Namaqua Sandgrouse that were active in both seasons (averaging 2.7 birds h^{-1}: Appendix 1), and the larks that undertake aerial displays.

Table 4: Comparison of the Passage Rates of Collision-prone species from VP observation at Ilanga CSP Tower 7 in November 2015 and March 2016.

Summary	Birds	Hours	Passage Rate	Collision-prone species
Passage Rate (dry season)	4	12	0.33 birds h^{-1}	Northern Black Korhaan
Passage Rate (wet season)	7	14	0.50 birds h^{-1}	**Kori Bustard, Ludwig's Bustard**, Northern Black Korhaan
Means	**11**	**26**	**0.42 birds h^{-1}**	**3 species**

Sociable Weavers were recorded on site and a large nest site occurred in the south-eastern corner of CSP Tower site 7.Of the 3 species of collision-prone birds recorded on site, two species were bustards (Ludwig's and Kori Bustard: Photo 1), and one was a korhaan. Two small raptors were observed but could not be identified (Figure 2).

6.2.3 Flights paths of collision-prone species within CSP tower site 7

The flight paths of the collision-prone species through the proposed CSP Tower 7 (Figure 2) indicate that four species were recorded including Ludwig's and Kori Bustards. The red-data bustards were recorded only in November in the late breeding season, suggesting they are likely to breed on site (Allan 2005). The korhaans performed territorial display flights within the site in both seasons.

Other non-collision-prone species attracted to water were recorded on site in relatively large numbers, and these included Namaqua Sandgrouse (138 birds in 24 hours: 5.75 birds h^{-1}) flying randomly in the north-west section of the site. Their interaction with solar flux or mirrored surfaces is unknown in southern Africa.

In summary:

- 72 species, 14 collision-prone species and 6 threatened red-data species have been recorded within the Karoshoek Solar Valley Development;

- Species richness was lower on CSP Tower 7 (31 species recorded) with higher species densities in the wet (15.0 km^{-1}) than the dry season (10.0 km^{-1});
- Namaqua Sandgrouse were numerous in both seasons;
- Three collision-prone species were recorded in CSP Tower 7 of which two are red-data species (Ludwig's and Kori Bustard).
- The Passage Rate of these birds was medium-low at 0.42 birds h^{-1}.

6.3 SENSITIVITY MAP OF COLLISION-PRONE RED DATA SPECIES

By combining all records of the collision-prone red data species we can map the most sensitive areas for birds within CSP Tower 7 site. Two areas of high avian sensitivity were identified. The first in the north encompassed an area where two red-data species were present in March 2016 (Ludwig's Bustard, Kori Bustard). Both were probably breeding. Numerous flights of displaying Northern Black Korhaans were also recorded in this area.

A second high sensitivity area in the south end of site 7 encompassed an area where 2 red data Kori Bustards were located (Figure 4). Given that they were recorded in both seasons the chances are high that they breed here too. Thus, CSP Tower 7 site is of relatively high sensitivity due to the threatened bustards that were recorded and probably breed there.

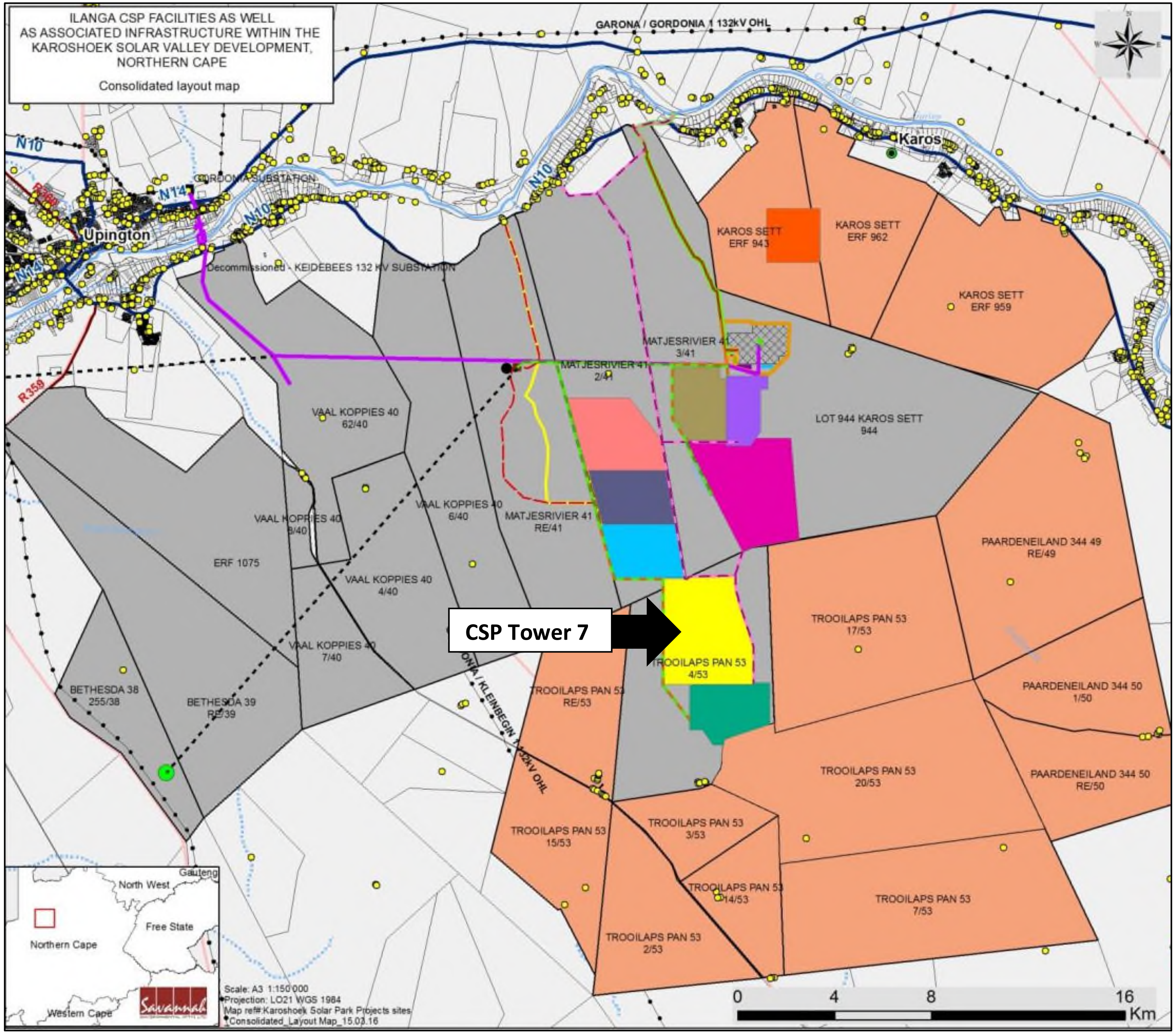

Figure 1: Layout of the **Ilanga Karoshoek** solar park showing the location of CSP Tower 7 site.

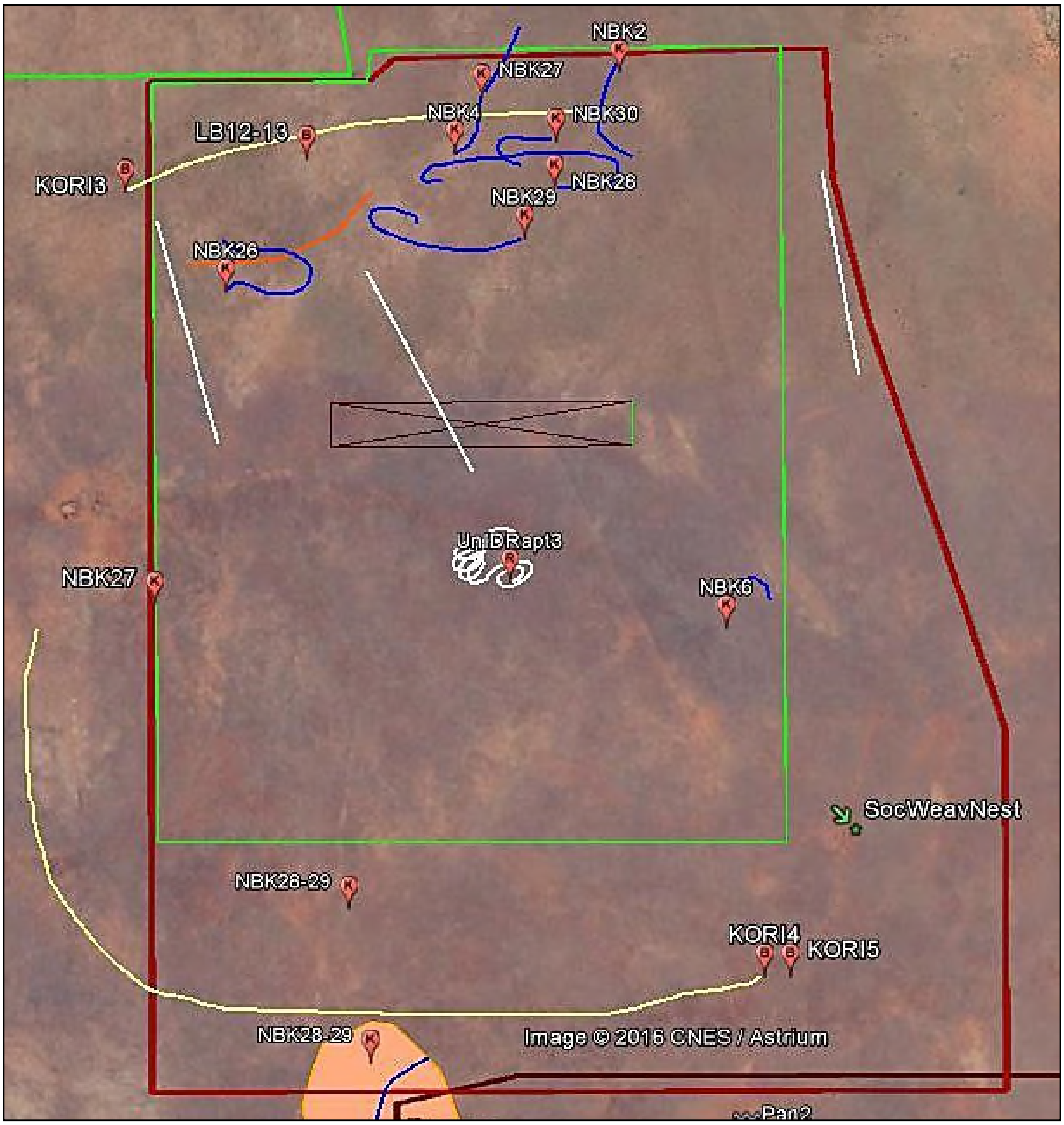

Figure 2: Collision-prone bird movements and perch sites from November 2015 and March 2016 in the CSP Tower 7 site on the farm Trooilaps Pan, near Upington. Two species of threatened collision-prone birds were recorded in flights in the site, LB = Ludwig's Bustard (pale yellow), Kori Bustard = Kori (pale yellow). Two non-threatened, collision-prone species were also recorded: Northern Black Korhaan = NBK and unidentified raptors (probably kestrels).

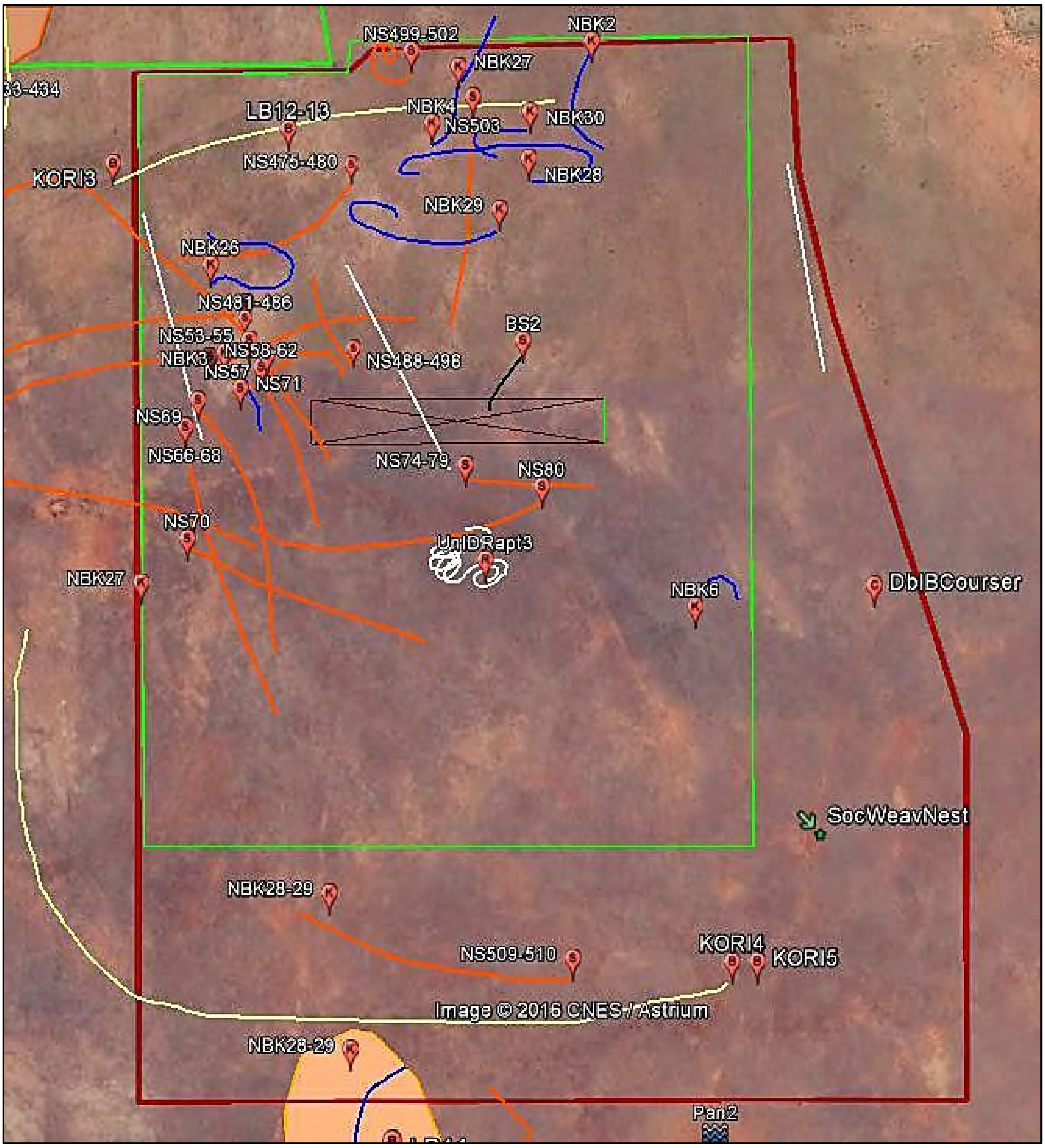

Figure 3: All aerial bird movements and perch sites recorded in November 2015 and March 2016 in the CSP Tower 7 site on the farm Matjes Rivier, near Upington. The main non-collision-prone species recorded in flight in the site was the Namaqua Sandgrouse (orange lines). Flights of 70 Namaqua Sandgrouse were recorded in 26h of observation over the two seasons, mainly in the north-west corner of the site. The scale is given by our 1 km transect (white) lines.

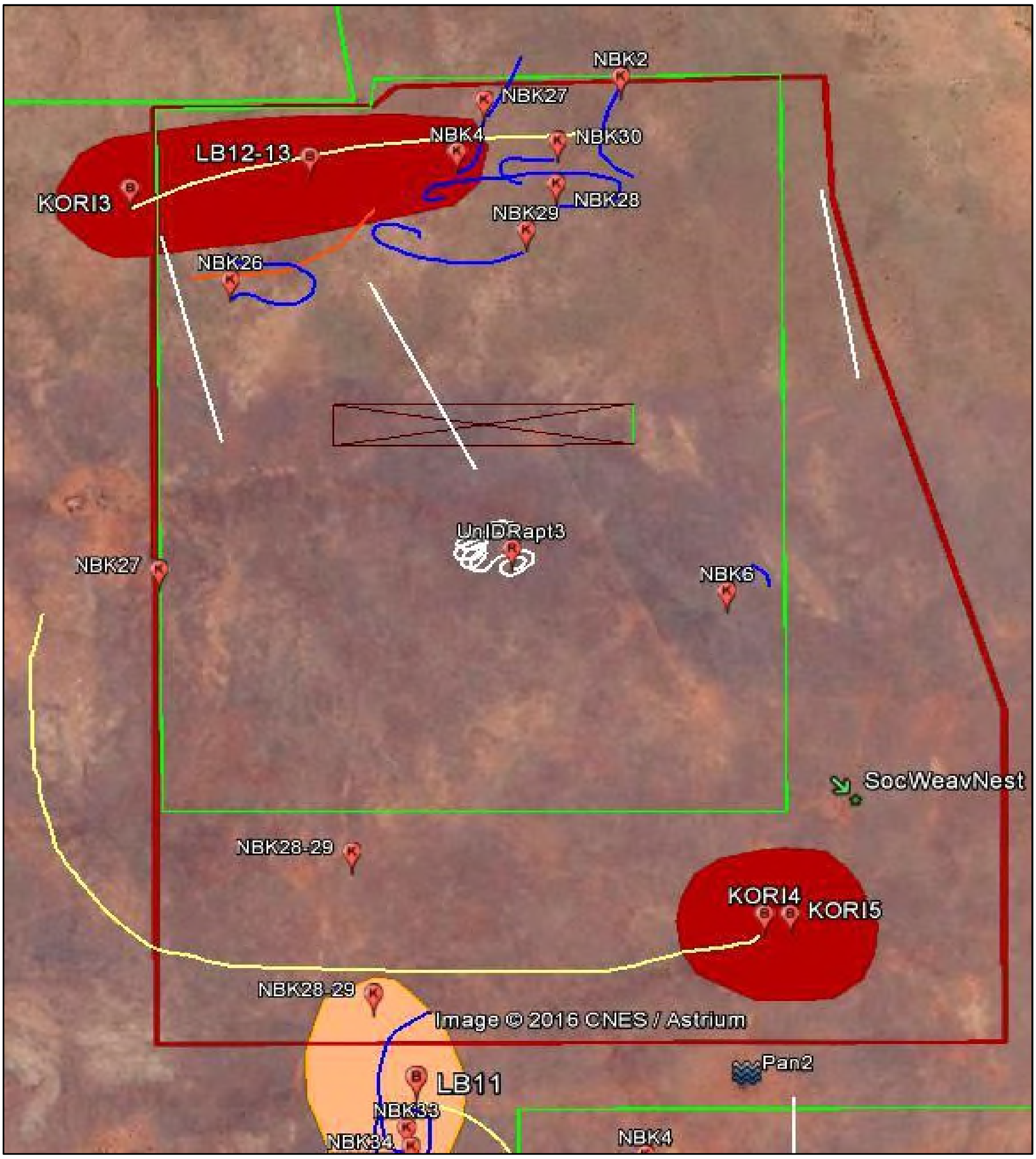

Figure 4: Sensitivity map of the collision-prone species on Karoshoek solar development CSP Tower 7. Two areas of high sensitivity were identified. The upper red polygon indicates where two red-data species were recorded in March 2016 (Ludwig's Bustard = LB, Kori Bustard = Kori1). The lower red polygon encloses an area where 2 Kori Bustards were recorded in November 2015 and March 2016 (NBK = Northern Black Korhaan).

7 QUANTIFYING THE IMPACTS

The Significance (**S**) of the impacts can be semi-quantified by independently assessing the extent (**E**) of the impact in length or area, the duration (**D**) in months or years, the expected Magnitude (**M**) in terms of its impact (minor to major) on the species likely to be affected, and the probability (**P**) that the impact will occur.

- The significance can then be calculated as **S = (E+D+M)P**], as follows (Table 4).

Nature: The impact of the proposed CSP trough areas will generally be negative given the certainty that: (i) ~950 ha will be transformed and the associated bird habitat destroyed; (ii) birds may collide with the CSP heliostats if they mistakenly perceive them as open water; (iii) collision-prone species living around the periphery may collide with any overhead power lines linking the solar development to the substation (this will be assessed in a separate Basic Assessment); (iv) birds flying through the area of high solar flux (above 400°C) around/over the tower will suffer feather singeing or direct incineration.

Three possible sources of mortality require quantification:

(i) **Displacement and avoidance** of the area through habitat removal (occurs at the construction and post-construction phases);

(ii) **Collision** with the heliostat mirrors (occurs post-construction);

(iii) **Feather singeing and incineration** for bird flying at high levels (occurs post-construction).

The Extent (**E,** from 1-5) of the impact will occur within the chosen CSP area (of 1500 ha) = **(2)**

The Duration (**D**, from 1-5) will be long-term **(4)** for the lifetime of the CSP area.

The Magnitude (**M,** from 0-10) of the impact of the CSP areas is expected to have a high impact **(8)** for the red-listed Ludwig's Bustard, Kori Bustards, and lower for the korhaans, the raptor (kestrel) **(2)** and very low for any wetland birds **(1).**
Of the red data species six Ludwig's Bustards and one Kori Bustard will be displaced by habitat destruction of 1520 ha on site.

The Probability of occurrence (**P,** from 1-5) of the bustards and raptors occurring and having a negative interaction with the CSP tower is ranked high **(5)** because they will always occur and probably breed when conditions are favourable and all be displaced by habitat destruction during and after construction: seven red-data bustards will be affected. For the non-threatened korhaans, raptor and wetland birds, probability of occurrence is medium **(3)**, and for wetland birds **(1).**

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) CSP site due to displacement or avoidance and (ii) collision after construction.

Table 4. A summary of the quantified impacts to the collision-prone bustards, raptors and wetland bird species likely to be impacted by **(i) displacement and avoidance**, **(ii) collision** or **(iii) feather singeing or incineration** with the CSP tower or associated infra-structure. The significance scale varies from 0 (no significance) to 100 (highly significant and unacceptable). A score above 50 is considered high and mitigation is required.

(i) Within the CSP site itself (DISPLACEMENT AND AVOIDANCE)
Nature: Mostly negative due to direct impact mortality (or displacement /avoidance of area) around the **CSP TOWER 7** for the Red-listed bird groups identified as at risk above.
(**Bust** = Bustards, **Rapt** = Raptors, **Korh** = Korhaans, **WetB** = Wetland birds):

	Without mitigation	**With mitigation**
Extent	**2**	**1**
Duration	**4**	**4**
Magnitude	**8 (Bust)** high **8 (Rapt)** high **1 (WetB)** low **2 (Korh)** low	**6 (Bust)** medium-high **6 (Rapt)** medium-high **1 (WetB)** low **1 (Korh)** low
Probability	**5 (Bust)** high **5 (Rapt)** high **1 (WetB)** low **3 (Korh)** medium-low	**4 (Bust)** medium-high **4 (Rapt)** medium-high **1 (WetB)** low **2 (Korh)** low

Significance (E+D+M)P	**70 (Bust)** high **70 (Rapt)** high **7 (WetB),** low **24 (Korh)** medium-low	**44 (Bust)** medium **44 (Rapt)** medium **6 (WetB)** low **12 (Korh)** low
Status (+ve or –ve)	Negative	Negativ
Reversibility	Medium	medium
Irreplaceable loss of species?	Yes, two red-data species (2 bustards) will lose foraging and breeding habitat with up to 8 birds being impacted.	
Can impacts be mitigated?	Probably yes: but only if the constructions avoids the areas of high sensitivity .	

Mitigation for impacts through displacement and avoidance at the CSP tower

There are only two mitigations for displacement or avoidance of the CSP towers by red data birds: (i) move the development away from highly sensitive bird area (especially feeding/nesting areas or roosts), and (ii) reduce disturbance post-construction to allow birds to re-settle.

Cumulative impacts:

For the CSP itself the mortality and displacement impact on birds is poorly known, but at least 13 other solar farms are now being constructed within 50 km of Karoshoek site: thus more research and monitoring of the combined impacts is required. This will require data sharing to a central authority to allow a meta –analysis of multiple data sets. See section 7.1 below for details.

Residual impacts:

After mitigation, displacement or avoidance by the species identified above may still occur. An environmental management programme will assess and highlight the efficacy of the mitigations to reduce avoidance by the red data birds. Further research and mitigation can then be suggested and tested as the need arises.

(ii) Within the CSP site itself – COLLISIONS (post construction)

Nature: Mostly negative due to direct impact mortality from impacting the heliostat mirrored surfaces around the **CSP Tower 7** for the Red-listed bird groups identified as at risk above. (**Bust** = Bustards, **Rapt** = Raptors, **Korh** = Korhaans, **WetB** = Wetland birds):

	Without mitigation	**With mitigation**
Extent	**1**	**1**
Duration	**4**	**4**

Magnitude	**3 (Bust)** low **3 (Rapt)** low **4 (WetB)** medium **2 (Korh)** low	**2 (Bust)** low **2 (Rapt)** low **3 (WetB)** low **1 (Korh)** low
Probability	**2 (Bust)** low **2 (Rapt)** low **1 (WetB)** low **2 (Korh)** low	**1 (Bust)** **1 (Rapt)** **1 (WetB)** **1 (Korh)**
Significance (E+D+M)P	**16 (Bust)** low **16 (Rapt)** low **9 (WetB),** low **14 (Korh)** low	**7 (Bust)** low **7 (Rapt)** low **8 (WetB)** low **6 (Korh)** low
Status (+ve or –ve)	Negative	Neutral
Reversibility	Medium	(mitigations untested)
Irreplaceable loss of species?	No, few red data species expected to collide with mirrors. It depends entirely whether wetland species (or other African species) are attracted to and collide with the mirrors.	
Can impacts be mitigated?	Probably yes: the use of bird scaring strategies on the site will probably deter species from interacting negatively.	

Mitigation for impacts for the heliostat mirrors

There are two classes of mitigation for the heliostat mirrors: (i) move them away from highly sensitive bird area (especially fly-ways to flooded pans or other nests or roosts), or (ii) employ bird-diverters to deter birds mistaking the mirrors for open water.

We recommend that Emvelo install video cameras above some mirrors 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 CSP itself the collision-mortality of birds is poorly known, but many solar farms are now being constructed in the Kalahari/Karoo region and more will occur in the future: thus more research and monitoring of the combined impacts is required. See 7.1 below.

Residual impacts:

After mitigation, direct mortality through collision 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 sandgrouse, or the aerial swallows/swifts impacting panels. Further research and mitigation can then be suggested and tested as the need arises.

(iii) Within the CSP solar flux– FEATHER SINGEING and INCINERATION (post construction) **Nature:** Mostly negative due to direct impact mortality from flying through the solar flux around or above the **CSP tower** for the Red-listed bird groups and highly aerial species. (**Bust** = Bustards, **Rapt** = Raptors, **Korh** = Korhaans, **Sandgrouse+ Hirundines** = Sand/Hiru):		
	Without mitigation	**With mitigation**
Extent	**2**	**1**
Duration	**4**	**4**
Magnitude	**3 (Bust)** low **7(Rapt)** high **7 (Sand/Hiru)** high **2 (Korh)** low	**2 (Bust)** low **6 (Rapt)** medium-high **6 (WetB)** medium -high **1 (Korh)** low
Probability	**2 (Bust)** low **4 (Rapt)** medium-high **4 (Sand/Hiru)**medium-high **2 (Korh)** low	**1 (Bust)** **3 (Rapt)** **3 (Sand/Hiru)** **1 (Korh)**
Significance (E+D+M)P	**16 (Bust)** low **53 (Rapt)** high **53 (Sand/Hiru)** high **16 (Korh)** low	**7 (Bust)** low **33 (Rapt)** medium **33 (Sand/Hiru)** medium **6 (Korh)** low
Status (+ve or –ve)	Negative	Negative-neutral
Reversibility	Medium	(mitigations untested)
Irreplaceable loss of species?	Yes, red data species and large numbers of sandgrouse and swifts and swallows have the potential to be incinerated or suffer feather singeing. The risk depends entirely whether aerial species such as sandgrouse and raptors are attracted to or fly through the solar flux.	
Can impacts be mitigated?	Probably yes: moving the site away from the high sensitivity areas and avoiding all flyways to pans (or closing them down) may deter species from flying through the solar flux.	
Mitigation for impacts from the solar flux There are three classes of mitigation to avoid deaths from incineration and singeing: (i) move the site		

away from highly sensitive bird area (especially fly-ways to flooded pans or other nests or roosts), or (ii) shutting down and covering all sources of water within 1 km of the solar site (this includes settling ponds) or (iii) employ bird-diverters to deter birds from flying through the high energy end of the solar flux. At the operational Khei CSP tower site 40 km from Karoshoek, four evaporation ponds covering 4 ha are located on the boundary edge of the heliostat mirrors. These will act as a magnet for both wetland birds and arid-adapted species seeking water on hot or dry days. Such ponds should be completely covered so birds do not perceive them from above or they should be constructed more than 1 km from the edge of the heliostat field. Positioning them so that birds do not fly through the solar flux from a known roost or already existing water source will further reduce any possible impacts. We recommend that Emvelo install video cameras above some mirrors or on the tower itself for post-construction monitoring of any mortality of birds in the vicinity, through direct observation and carcass searches in a systematic and regular fashion. Standby mode for the heliostats often involves the mirrors focusing light above the 270 m tower. This can also kill birds flying through the intense flux. Thus mirrors vertically orientated in standby (to produce no focussed flux) or a series of 10 or more focal points at tower height, none of which are intense enough to kill birds flying through them, will reduce this form of mortality to close to zero. Vertically orientated mirrors are the best solution given that they also will not form a reflective surface that birds may attempt to land on.
Cumulative impacts: For any CSP facility the incineration-mortality of birds is very poorly known, but many solar farms are now being constructed in the Kalahari/Karoo region and more will occur in the future: thus more research and monitoring of the combined impacts is required. See 7.1 below.
Residual impacts: After mitigation, direct mortality through singeing or incineration collision 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 sandgrouse, or the aerial swallows/swifts being killed in any numbers. Further research and mitigation can then be suggested and tested as the need arises.

7.1 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 Karoshoek solar development, mainly by other solar farms and associated infrastructure. This will happen via the same factors identified here viz: collision, avoidance, displacement and incineration. Therefore, we need to know as a starting point the number of solar farms around the region within 50 km, and secondly, to know their impact on avifauna.

There are 20 proposed or approved solar farms of various sizes within 50 km of Karoshoek (Figure 5) and an operational CSP Tower (Khei Solar One) 40 km north-west of Karoshoek solar valley. Given the general assumption that footprint size and bird impacts are linearly related for CSP solar farms, a starting point in determining cumulative impacts is to determine:

- the number of bird displaced per unit area, by habitat destruction, disturbance, or displacement;
- 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.

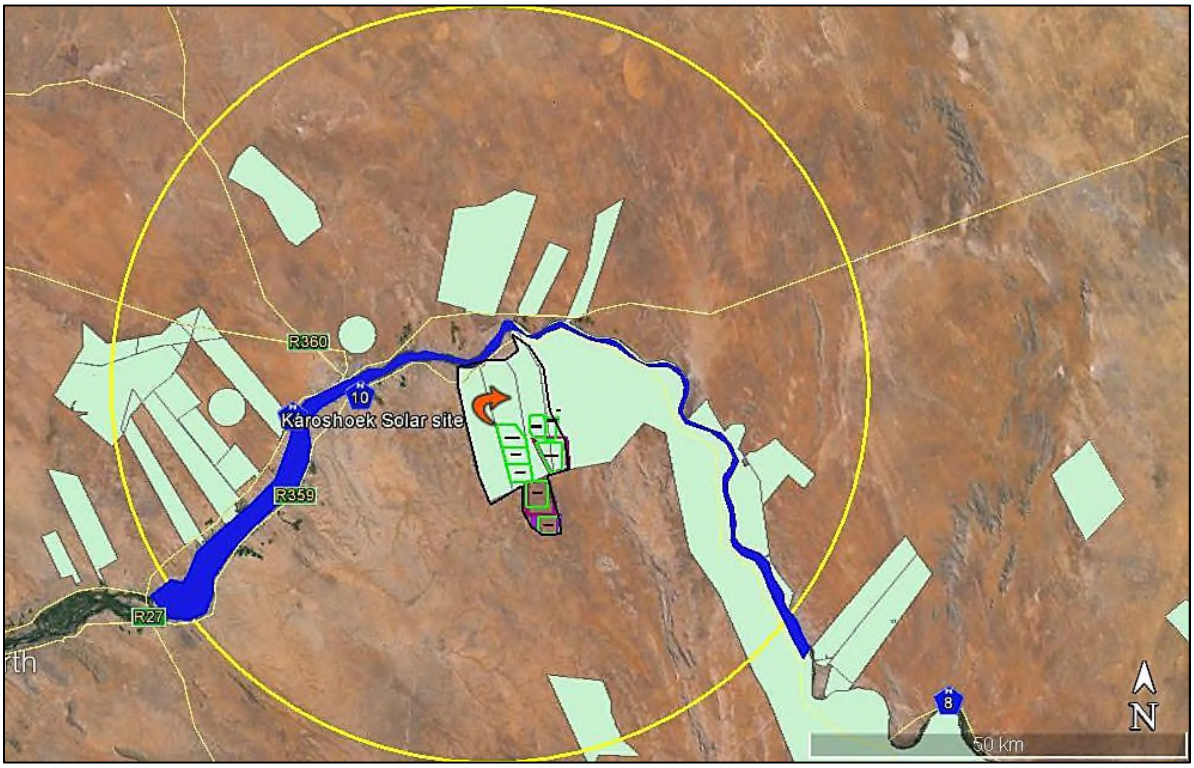

Figure 5: The location and extent of all other proposed or existing solar farm developments within 50 km of the Karos/Upington area (Source: http://egis.environment.gov.za/frontpage.aspx?m=27 Directorate of Environmental Affairs) in 2016.

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 Orange River's solar farms. Once the data is collected and published (or released to other specialists), covering a minimum of 12 months, we can quantify this aspect.

Orange River water off–take rates are considerations already under investigation by hydrologists. However, the influence on the Orange River's wetland birds, which use the river as a linear oasis (Simmons & Allan 2002), needs to be assessed. This arises because the Orange River flow is reduced at certain times of year to very low rates. But at all times no less than 20% of the flow is required as an ecological reserve to maintain ecological functioning of the river (http://orangesenqurak.com/challenge/water+demand/environmental+flows.aspx). Further off-take amounting to over 1.1 million m^3, (3 CSP tower sites x 250 000 m^3 and 5 CSP trough sites x 80 000m^3) particularly at low flow (November-December) may force some wetland species to seek other water sources. With 20 other solar farm applications within 50 km, all potentially using the Orange River as a source of water, approximately 20 million m^3 of water per annum may be drawn in future. Given that 5 500 million m^3 is the average run-off to the mouth (ORESACOM 2007), this represents only 0.4% of the annual flow. At high flow this will make little difference to the river ecology, but at low flow it may have a more major impact.

This may become an issue for the CSPs and the bank of mirrored surfaces that will be in the environment surrounding the river environs. If the evaporation ponds or the Lake Effect of Kagen et al. (2014) attracts such water-seeking wetland birds then the off-take of water from the Orange River may exacerbate this effect. We would predict:

- a seasonal influx of wetland birds attracted to the CSP Tower 7 site in the low-flow season and an increase in mortality;
- greater mortality with time, as more and more solar developments take increasing amounts of water away at low-flow periods, reducing wetland habitat in the Orange River.

A simple calculation of the Cumulative Impact of this would be related to:

- the *rate* of avian mortality per surface area of the mirrored surfaces of the CSPs per year;
- the total surface area of the mirrored surfaces of each CSP in the area;
- the number of solar farms within 50 km of the Karoshoek site; and
- the reduction in flow of the Orange River causing more birds to seek other water sources; and
- the number of solar farms within 50 km of the Karoshoek site.

In 2016 we cannot yet quantify all of these variables, so a prediction of Cumulative Impact is not possible. Data gathering and sharing over even just one 12-month period, of one or more solar farms, will allow us to determine impacts on Orange River avifauna.

8 ENVIRONMENTAL MANAGEMENT PLAN

Given the size and number of the CSP plants proposed for the total Karoshoek Solar Valley Development, the overall impact on the avifauna species requires systematic monitoring at both the construction and post-construction phases. This is a recommendation of the draft BARESG guidelines (Jenkins et al. 2015).

The guidelines suggest an adaptive and systematic monitoring of bird displacement (comparing avian densities before and after construction, particularly for collision-prone and red data species) and all fatalities. The latter must take account of biases introduced by scavengers removing carcasses and observers not detecting bird remains.

The monitoring should include the following (after Jenkins et al. 2015):

- Post-construction monitoring should begin as the facility becomes operational, given that the effects of the CSP facility may change over time;
- Post-construction monitoring can be divided into two categories: a) quantifying bird numbers and movements (replicating baseline data collection), and b) estimating bird mortalities;
- Estimating bird fatality rates includes: a) estimation of the number of birds incinerated in the solar flux with video cameras (because incineration leaves little or no remains to be located) b) carcass searches (c) estimation of searcher efficiency and scavenger removal rates, and d) data analysis incorporating systematically collected data from *a* and *b*;
- A minimum of 20-30% of the CSP solar footprint 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 recorded and included in reports as incidental finds;
- The search area and video field of view should be defined and consistently applied throughout monitoring;
- Observed mortality rates must be adjusted to account for searcher efficiency (which could change seasonally depending on vegetative condition of the site),

scavenger removal and the proportion of the facility or air-space covered by the monitoring effort. Some of these factors may change seasonally due to the breeding season of scavengers and the visibility of the survey area;

- The duration and scope of post-construction monitoring should be informed by the outcomes of the previous year's monitoring, and 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;
- If significant problems are found or suspected, the post-construction monitoring should continue as needed in conjunction with adaptive management and mitigations, taking into account the risks related to the particular site and species involved.

Determining the number of birds killed by flying through the solar flux is traditionally undertaken by carcass searching. This is an inefficient way of doing so because some birds leave no remains. Therefore, we recommend that video cameras are used to determine the number of birds flying through the airspace around the tower and the number which are killed as evidenced by "streamers" of incinerated birds as observed at the Ivanpah and Crescent Dunes Solar towers that leave few remains http://www.basinandrangewatch. org/Crescent-Dunes-Solar-Flux.html

An assessment guided by the principles above is required not only to enact and experiment with different mitigation measures where significant mortality is found, but to allow data to be collected that will benefit the welfare of avifauna at other solar farms. This will also be important for a study of cumulative avian impacts for the large number of solar farms planned for the Northern Cape of South Africa.

Management interventions: Where avian fatalities are found to occur (i) to red-data species, or (ii) at unacceptably high levels, to these or other species, then mitigation measures should be brought into play. Thus, experiments with bird deterrent techniques such as bird-scaring prisms, auditory bird-scaring sounds (of birds' distress calls) and Torri Lines, (successfully used to prevent albatrosses and petrels descending onto baited hooks behind trawlers at sea), can be tried and tested (http://www.birdlife.org.za/conservation/seabird-conservation/albatross-task-force).

Where natural or artificial pans occur and attract wetland species that are then killed by the solar flux, action to close down the pan or dam will then be required.

The settling/evaporation ponds associated with the CSP tower technology must also be covered so that birds are not attracted to them. If they cannot be covered then we recommend that they are constructed more than 1km from the boundary of the heliostat field to prevent arid-adapted birds, especially sandgrouse, being drawn to them.

9 CONCLUSIONS AND RECOMMENDATIONS

The proposed CSP Tower 7 plant in the Karoshoek Solar Valley Development, near Upington, is one of many such renewable energy initiatives being proposed for this high-flux solar radiation region of South Africa.

The avifauna of the area may be affected by the infrastructure of the CSP plant and our analysis of the number of collision-prone birds on CSP Tower 7 suggests that:

- Two threatened bustard species will be impacted by habitat destruction. The significance for displacement and avoidance will be high for these red data species;
- mitigation measures include avoiding construction near the two high sensitivity areas identified;
- for any wetland birds, the raptors and the korhaans, the significance is lower because they are less collision-prone and less threatened;
- sandgrouse and other aerial species such as swifts and swallows, which were numerous on site, are likely to be at risk from traversing the solar flux;
- a structured and systematic construction and post-construction assessment, as laid out in the Environmental Management Programme (above) by trained ornithologists will determine the impacts and provide appropriate mitigations.

Virtually no research in South Africa is presently available to determine the impact of CSP tower technology on the South African avian community, so a minimum of 24 months' post-construction monitoring at this site by trained ornithologists is recommended.

We also recommend that all available precautions are taken to avoid threatened species and wetland birds being attracted to the site. If species are attracted and collide with, or are incinerated by, the CSP Tower technology then we recommend that innovative bird deterrent techniques are used, such as auditory bird scarers on the tower or the Torri lines mentioned above and in the avian Scoping Report (Simmons and Martins 2015).

If these recommendations can be followed and prove effective, we believe that the CSP

Tower 7 development can be allowed to proceed with minimal impact to the avifauna of the area.

10 REFERENCES

Allan DG. 2005. Ludwig's Bustard *Neotis ludwigii* In: Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town

Allan DG Osborne TE. 2005. Kori Bustard *Ardeotis kori* In: Hockey, P.A.R., Dean, W.R.J., Ryan, P.G. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

BARESG 2014. Ranking of top collision-prone species in South Africa. Birdlife South Africa, unpubl report.

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

Birds Unlimited 2014. Avian assessment of proposed 30 km power line from Upington to the Ilanga CSP facility, Northern Cape. Unpubl report to Savannah Environmental, Johannesburg.

Dean W.R.J. 2004. Nomadic Desert Birds. Adaptations of Desert Organisms series. Springer Verlag, Berlin, Heidelberg,

Dean WRJ, Barnard PE Anderson MD 2009. When to stay, when to go: trade-offs for southern African arid-zone birds in times of drought. S Af J Science 105:24-28.

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

Harvey HT and Associates 2015. Ivanpah solar electric generating system. Avian & bat monitoring plan, 2013-2014 annual report (revised)(29 october 2013 – 20 october 2014). Unpublished report to California Energy Commission.

Henry DAW, Ament JM Cumming GS. 2016. Exploring the environmental drivers of waterfowl movement in arid landscapes using first-passage time analysis. Movement Ecology 4:8 DOI 10.1186/s40462-016-0073-x

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

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 Conservation International 20: 263 – 278.

Jenkins AR, Ralston S, Smit-Robinson HA. 2015. Birds and Solar Energy: Best Practice Guidelines for assessing and monitoring the impact of solar energy facilities on birds in southern Africa. Birdlife South Africa, Johannesburg

Kagan RA, Verner TC, Trail PW, Espinoza EO. 2014. Avian mortality at solar energy facilities in southern California: a preliminary analysis. Unpublished report National Fish & Wildlife Forensics Laboratory, USA **.**

Lloyd P. 2005. Namaqua Sandgrouse. In: Hockey, PAR, Dean, WRJ, Ryan, PG. (Eds) 2005. Roberts – Birds of Southern Africa, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Lloyd P. 1999. Rainfall as a breeding stimulus and clutch size determinant in South African arid-zone birds. Ibis 141, 637–643.

Martin GR, Shaw JM 2010. Bird collisions with power lines: Failing to see the way ahead? Biological Conservation 143: 2695–2702.

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

ORASECOM 2007. Orange River Integrated Water Resources Management Plan. http://www.orasecom.org/_system/writable/DMSStorage/1941SURFACE_HYDROLOGY.PDF

Retief E. et al. 2012. Birds and wind farm map. http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy/wind-farm-map

Shaw, J., Jenkins, A.R. Allan D & Ryan, P.G. 2015. Population size and trends of Ludwig's Bustard*Neotis ludwigii* and other large terrestrial birds. in the Karoo, South Africa. Bird Conservation International, page 1 of 18.

Simmons RE, Martins M. 2015. Avian Impact Assessment for the proposed Savannah Environmental Emvelo Solar Power CSP Plant at Karoshoek, near Upington, Northern Cape- Scoping Report. Unpubl report to Savannah Environmental, Birds & Bats Unlimited, Cape Town.

Simmons R.E., Barnard P. and Jamieson I.G. 1999. What precipitates influxes of wetland birds to ephemeral pans in arid landscapes? Observations from Namibia. Ostrich 70, 145–148. African National Biodiversity Institute, Pretoria, RSA.

Taylor M, Peacock F, Wanless R. (eds.) 2015. The Eskom red data book of birds of South Africa, Lesotho and Swaziland. Birdlife South Africa.

Todd, S. 2012 Proposed Karoshoek Solar Valley Development: Fauna and Flora Specialist Impact Assessment Report. Unpubl report to Savannah Environmental, Johannesburg

Walston, LJ., Rollins KE, Smith KP, LaGory KE, Sinclair K, Turchi C, Wendelin T Souder H. 2014. A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities Unpublished report by Argonne National Laboratory, USA for U.S. Department of Energy, SunShot Initiative and Office of Energy Efficiency & Renewable Energy.

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21 April 2016

11 APPENDICES

Appendix 1: All bird species recorded around the Karoshoek Solar development

All bird species and their likelihood of occurrence in the greater Karoshoek solar development area, from the bird atlas pentads that run along the Ilanga power line to the CSP site. These pentads are: 2825_2115, 2825_2120, 2825_2125, 2825_2130 from the period 2007 to 2013. Extracted from the Animal Demography Unit, University of Cape Town website http://sabap2.adu.org.za and based on 17 cards. **Red data species are given in red,** **collision-prone species in bold.** Blue shading indicates wetland species that may be attracted to the parabolic mirrors.

Note: this list includes pentads that overlap the Orange River inflating the number of species that will occur in the drier footprint of the Karoshoek solar development. We have added our (92) species records in the last column, which includes no Orange River areas.

Species	Pentads/4	Records	Total cards	Reporting Rate %	Recorded in our site visits in Karos solar park
Ostrich, Common	1	1	17	5.9	√
Grebe, Little	1	2	17	11.8	
Cormorant, White-breasted	2	6	17	35.3	
Cormorant, Reed	3	6	17	35.3	
Darter, African	2	7	17	41.2	
Heron, Grey	1	4	17	23.5	
Heron, Black-headed	1	1	17	5.9	
Heron, Goliath	1	1	17	5.9	√
Egret, Little	1	4	17	23.5	
Egret, Cattle	3	10	17	58.8	
Bittern, Little	1	1	17	5.9	
Hamerkop	2	8	17	47.1	
Stork, Abdim's	1	1	17	5.9	
Ibis, African Sacred	3	5	17	29.4	√
Ibis, Hadeda	3	16	17	94.1	
Goose, Egyptian	2	11	17	64.7	√
Shelduck, South African	2	2	17	11.8	
Duck, African Black	1	1	17	5.9	
Duck, Yellow-billed	1	1	17	5.9	
Teal, Cape	1	1	17	5.9	

Red-billed Teal					√
Harrier, Black					√
Eagle, Verreaux's					√
Eagle, Booted					√
Falcon, Lanner	**1**	**1**	**17**	**5.9**	√
Kestrel, Rock					√
Falcon, Pygmy	1	1	17	5.9	√
Kite, Black-shouldered	2	4	17	23.5	
Fish-Eagle, African	**2**	**6**	**17**	**35.3**	
Pale-chanting Goshawk	**1**	**1**	**17**	**5.9**	√
Guineafowl, Helmeted	2	8	17	47.1	
Common Quail					√
Crake, Black	1	1	17	5.9	
Moorhen, Common	1	1	17	5.9	
Bustard, Kori	**1**	**1**	**17**	**5.9**	√
Bustard, Ludwig's					√
Korhaan, Karoo	**1**	**1**	**17**	**5.9**	√
Northern Black Korhaan	**1**	**2**	**17**	**11.8**	√
Plover, Three-banded	2	4	17	23.5	
Lapwing, Crowned	1	5	17	29.4	
Lapwing, Blacksmith	3	9	17	52.9	√
Sandgrouse, Namaqua	2	2	17	11.8	√
Double-banded Courser					√
Pigeon, Speckled	3	16	17	94.1	
Dove, Red-eyed	3	13	17	76.5	
Turtle-Dove, Cape	3	14	17	82.4	√
Dove, Laughing	3	15	17	88.2	√
Dove, Namaqua	1	3	17	17.6	√
Cuckoo, Diderick	1	3	17	17.6	
Owl, Barn	1	3	17	17.6	
Owlet, Pearl-spotted	1	1	17	5.9	
Eagle-Owl, Spotted	1	1	17	5.9	√
Common Swift					√
Swift, White-rumped	2	3	17	17.6	
Swift, Little	3	12	17	70.6	√
Palm-Swift, African	2	12	17	70.6	
Mousebird, White-backed	3	14	17	82.4	√
Mousebird, Red-faced	1	8	17	47.1	√
Kingfisher, Pied	2	5	17	29.4	
Kingfisher, Giant	2	4	17	23.5	
Kingfisher, Malachite	2	3	17	17.6	
Kingfisher, Striped	1	1	17	5.9	
Bee-eater, European	1	2	17	11.8	
Bee-eater, Swallow-tailed	3	4	17	23.5	

Hoopoe, African	2	10	17	58.8	
Barbet, Black-collared	1	1	17	5.9	
Barbet, Acacia Pied	3	4	17	23.5	√
Barbet, Crested	3	9	17	52.9	
Honeyguide, Lesser	1	2	17	11.8	
Shrike, Lesser Grey					√
Woodpecker, Golden-tailed	1	3	17	17.6	
Lark, Fawn-coloured	1	2	17	11.8	√
Lark, Sabota	3	4	17	23.5	√
Lark, Spike-heeled	2	2	17	11.8	√
Stark’s Lark					√
Swallow, Barn	2	4	17	23.5	√
Swallow, White-throated	1	6	17	35.3	
Swallow, Greater Striped	2	10	17	58.8	√
Martin, Rock	3	6	17	35.3	√
Martin, Brown-throated	3	8	17	47.1	
Tit, Ashy	1	1	17	5.9	
Crow, Pied	1	4	17	23.5	√
Bulbul, African Red-eyed	3	16	17	94.1	
Rock-Thrush, Short-toed	1	1	17	5.9	
Wheatear, Capped	1	1	17	5.9	√
Chat, Ant-eating					√
Chat, Karoo					√
Chat, Familiar	3	3	17	17.6	
Robin-Chat, Cape	3	12	17	70.6	
Scrub-Robin, Karoo	3	5	17	29.4	√
Kalahari Scrub Robin					√
Swamp-Warbler, Lesser	2	5	17	29.4	
Reed-Warbler, African	2	3	17	17.6	
Eremomela, Yellow-bellied					√
Warbler, Rufous-eared	1	4	17	23.5	√
Cisticola, Zitting	3	6	17	35.3	
Cisticola, Levaillant's	3	4	17	23.5	
Cisticola, Desert					√
Prinia, Black-chested	3	8	17	47.1	√
Warbler, Namaqua	1	1	17	5.9	√
Tit-Babbler, Chestnut-vented	2	2	17	11.8	√
Tit-babbler, Layard’s					√
Flycatcher, Chat					√
Flycatcher, Fiscal	3	3	17	17.6	
Batis, Pririt	3	4	17	23.5	
Wagtail, African Pied	1	1	17	5.9	
Wagtail, Cape	2	13	17	76.5	√
Pipit, African	2	3	17	17.6	

Fiscal, Common	2	11	17	64.7	√
Bokmakierie,	2	4	17	23.5	√
Brubru	1	3	17	17.6	
Starling, Wattled	2	9	17	52.9	
Starling, Cape Glossy	3	4	17	23.5	
Sunbird, Dusky	3	5	17	29.4	√
Sparrow-Lark, Grey-backed					√
Sparrow-Lark, Black-eared					√
Sparrow-Weaver, White-browed	2	9	17	52.9	√
Weaver, Sociable	3	5	17	29.4	√
Sparrow, House	3	13	17	76.5	
Sparrow, Cape	3	13	17	76.5	√
Masked-Weaver, Southern	3	15	17	88.2	√
Quelea, Red-billed	3	6	17	35.3	√
Bishop, Southern Red	2	9	17	52.9	
Firefinch, Red-billed	2	4	17	23.5	
Finch, Scaly-feathered					√
Waxbill, Common	2	2	17	11.8	
Whydah, Pin-tailed	1	4	17	23.5	
Canary, Black-headed					√
Canary, Black-throated	2	6	17	35.3	
Canary, Yellow	2	3	17	17.6	√
White-throated Canary					√
Dove, Rock	3	8	17	47.1	
Thrush, Karoo	1	13	17	76.5	
White-eye, Orange River	3	15	17	88.2	
Lark, Eastern Clapper	1	1	17	5.9	√
Coucal, Burchell's	1	3	17	17.6	
Sparrow, Southern Grey-headed	2	3	17	17.6	
Bunting, Lark-like					√

APPENDIX 2: BIRD DENSITIES BY HABITAT

Species recorded on site in 1-km transects on the Karoshoek Solar Valley Development CSP Tower 7 in November 2015 and March 2016.

NOVEMBER 2015 (Dry season)	Number	PerpDist	Date	Transect	Habitat
Fawn-coloured lark	1	55	06/11/2015	KT7-1	Sandy, Rhigozum
Namaqua sandgrouse	4	25	06/11/2015	KT7-1	Sandy, Rhigozum
Grey-backed sparrowlark	5	65	06/11/2015	KT7-1	Sandy, Rhigozum
Black-chested prinia	1	55	06/11/2015	KT7-1	Sandy, Rhigozum
Fawn-coloured lark	1	40	06/11/2015	KT7-1	Sandy, Rhigozum
Fawn-coloured lark	1	60	06/11/2015	KT7-1	Sandy, Rhigozum
Yellow canary	1	5	06/11/2015	KT7-1	Sandy, Rhigozum
Barn swallow	1	5	06/11/2015	KT7-1	Sandy, Rhigozum

6 species	**15**	**birds**	**In this trans: Red Data species = 0**		**Collision-prone species = 0**
Grey-backed sparrowlark	6	5	07/11/2015	KT7-2	Grass, sand, Rhigozum
Fawn-coloured lark	1	45(60)	07/11/2015	KT7-2	Grass, sand, Rhigozum
Cape turtle dove	1	110	07/11/2015	KT7-2	Grass, sand, Rhigozum
Northern black korhaan	1	300	07/11/2015	KT7-2	Grass, sand, Rhigozum
Clapper lark	1	100	07/11/2015	KT7-2	Grass, sand, Rhigozum
Northern black korhaan	1	150	07/11/2015	KT7-2	Grass, sand, Rhigozum
Acacia pied barbet	2	80	07/11/2015	KT7-2	Grass, sand, Rhigozum
Fawn-coloured lark	1	50	07/11/2015	KT7-2	Grass, sand, Rhigozum
Ant-eating chat	2	105	07/11/2015	KT7-2	Grass, sand, Rhigozum
Spike-heeled lark	2	30	07/11/2015	KT7-2	Grass, sand, Rhigozum
Cape turtle dove	2	110	07/11/2015	KT7-2	Grass, sand, Rhigozum
Black-chested prinia	1	70	07/11/2015	KT7-2	Grass, sand, Rhigozum
Chat flycatcher	1	20	07/11/2015	KT7-2	Grass, sand, Rhigozum
Sabota lark	1	70	07/11/2015	KT7-2	Grass, sand, Rhigozum
Cape turtle dove	2	90	07/11/2015	KT7-2	Grass, sand, Rhigozum
Little swift	1	30	07/11/2015	KT7-2	Grass, sand, Rhigozum
Fawn-coloured lark	1	30	07/11/2015	KT7-2	Grass, sand, Rhigozum
Little swift	1	40	07/11/2015	KT7-2	Grass, sand, Rhigozum
Fawn-coloured lark	1	60	07/11/2015	KT7-2	Grass, sand, Rhigozum
Cape turtle dove	1	150	07/11/2015	KT7-2	Grass, sand, Rhigozum
Namaqua sandgrouse	3	120	07/11/2015	KT7-2	Grass, sand, Rhigozum
Rufous-eared warbler	2	50	07/11/2015	KT7-2	Grass, sand, Rhigozum
Kalahari scrub-robin	1	40	07/11/2015	KT7-2	Grass, sand, Rhigozum
14 species	**36**	**birds**	**In this trans: Red Data species = 0**		**Collision-prone species = 1**
Total Birds	**51**				
Total Species	**10**				
Total Collision-prone sp	**1**	Northern Black Korhaan			
Total Red-data Species	**0**				
Summary (DRY)	**Species**	**Birds**	**Habitat**		
KT7-1	6	15	Sandy, Rhigozum		
KT7-2	14	36	Grass, sand, Rhigozum		
Means	**10.00**	**25.50**			

MARCH 2016 (Wet season)	Number	PerpDist	Date	Transect	Habitat
Namaqua sandgrouse	1	150	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Fawn-coloured lark	2	70	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Grey-backed sparrowlark	2	20	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Spike-heeled lark	2	50	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape clapper lark	2	90	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Grey-backed sparrowlark	3	25	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Northern black Korhaan	1	90	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Larklike bunting	1	25	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Black-chested prinia	1	100	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Namaqua sandgrouse	1	120	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Ant-eating chat	1	100	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Fawn-coloured lark	1	30	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Fawn-coloured lark	1	80	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Northern black Korhaan	1	180	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees

Grey-backed sparrowlark	1	50	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Quelea spp	10	180	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape turtle dove	1	160	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Spike-heeled lark	2	90	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Namaqua dove	2	130	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Namaqua sandgrouse	3	130(25)	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Fawn-coloured lark	1	35	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Grey-backed sparrowlark	1	3	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Grey-backed sparrowlark	2	40	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Larklike bunting	2	12	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Rufous-eared warbler	1	40	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape turtle dove	2	200	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Black-eared sparrowlark	1	5	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Grey-backed sparrowlark	3	20	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Northern black Korhaan	1	50	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Kori bustard	1	200 (10)	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Northern black Korhaan	1	(20-50)	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape turtle dove	1	150	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape clapper lark	1	100	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Yellow canary	2	45	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Cape clapper lark	2	25(50-60)	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
Larklike bunting	1	40	07/03/2016	KT7-2	Rhigozum, grasses, Boscia trees
16 species	**62**	**birds**	**In this trans: Red Data species = 1, Collision-prone species = 2**		
Cape clapper lark	1	0	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Grey-backed sparrowlark	10	30	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Northern black korhaan	2	110	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Cape clapper lark	1	10	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Scaly-feathered finch	3	50	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Laughing dove	1	50	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Namaqua dove	1	30	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Black-chesterd prinia	1	10	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Larklike bunting	2	15	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Cape clapper lark	1	0	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Larklike bunting	15	12	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Grey-backed sparrowlark	2	5	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Sabota lark	1	45	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Cape clapper lark	2	60	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Spike-heeled lark	5	35	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Sabota lark	1	15	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Cape turtle dove	1	120	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Cape clapper lark	1	70	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Larklike bunting	1	5	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Northern black korhaan	1	75(20)	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Scaly-feathered finch	3	35	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Sabota lark	1	35	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Namaqua sandgrouse	1	60(30)	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Grey-backed sparrowlark	3	55	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
Namaqua dove	2	38	08/03/2016	KT7-3	Grass, sand, Rhigozum, Boscia, bare ground
12 species	**63**	**birds**	**In this trans: Red Data species = 0**		**Collision-prone species = 1**

Namaqua dove	2	15	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Sociable weaver	30	0	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	2	15	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	2	25	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	4	30	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Fawn-coloured lark	1	55	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Black-chested prinia	1	20	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	3	70	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Black-chested prinia	1	38	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Karoo prinia	1	20	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	1	5	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Northern black korhaan	1	220	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Grey-backed sparrowlark	18	50	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Acacia pied barbet	1	65	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	3	45	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Cape turtle dove	2	80	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Lesser grey shrike	1	24	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Grey-backed sparrowlark	4	15	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Desert cisticola?	1	10	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua dove	3	20	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Larklike bunting	1	10	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Cape clapper lark	1	60	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Northern black korhaan	1	140	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Grey-backed sparrowlark	10	35	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Scaly-feathered finch	1	20	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Namaqua sandgrouse	1	120	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Sabota lark	1	20	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Cape sparrow	1	15	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
Yellow canary	1	7	08/03/2016	KT7-4	Grasses, Boscia, Rhigozum, bare ground
18 species	**100**	**birds**	**In this trans: Red Data species = 0, Collision-prone species = 1**		
Total Birds	**225**				
Total Species	**25**				
Total Collision-prone sp	**2**	Kori Bustard; Northern Black Korhaan			
Total Red-data Species	**1**	**Kori Bustard**			
Summary (WET)	**Species**	**Birds**	**Habitat**		
KT4-2	16	62	0		
KT4-3	12	63	Grass, sand, Rhigozum, Boscia, bare ground		
KT4-4	18	100	Grasses, Boscia, Rhigozum, bare ground		
Means	**15.33**	**75.00**	**Wet season**		
Means	**10.00**	**25.50**	**Dry season**		
Combined	**13.20**	**55.20**			

Appendix 3: Passage rates of Collision-prone species

Date	Time	Obsv period	Hrs	Vantage Point	No.	Species	GPS pos on map	Height
06/11/2015	06h52	06h45-12h45	6	**VP7-1**	**1**	**Northern black korhaan**	NBK4	15m-20m
	09h05				2	Namaqua sandgrouse	NS72-73	20m

	09h16				6	Namaqua sandgrouse	NS74-79	15m-20m
	09h15				1	Namaqua sandgrouse	NS80	50m-53m
	10h20				**1**	**Northern black korhaan**	NBK5	10m-30m-20m
07/11/2015	06h48	06h40-12h40	6	**VP7-2**	**1**	**Northern black korhaan**	NBK2	10m-20m-25m-30
	07h31				9	Namaqua sandgrouse	NS44-52	30m-35m-40m-35m
	07h51				3	Namaqua sandgrouse	NS53-55	50m-55m-50m
	08h04				**1**	**Northern black korhaan**	NBK3	10-20-30-35-30-10m
	08h17				1	Namaqua sandgrouse	NS56	60m-65m
	08h19				1	Namaqua sandgrouse	NS57	55m
	08h30				5	Namaqua sandgrouse	NS58-62	50m
	08h35				3	Namaqua sandgrouse	NS63-65	60m-65m
	08h35				3	Namaqua sandgrouse	NS66-68	50m-55m-50m
	08h39				1	Namaqua sandgrouse	NS69	60m-65m
	08h43				1	Namaqua sandgrouse	NS70	40m
	08h50				1	Namaqua sandgrouse	NS71	10m
			12	**TOTALS**	**41**	Birds	2	Species
					4	**Collision-prone birds**	**1**	**Species**
Passage rate:		41birds in		12	hr	3.42	birds/hr	**all birds**
Passage rate:		**4**		**12**		**0.33**	**birds/h**	**collision-prone**
Passage Rate		37		12		3.08		Sandgrouse

Date	Time	Obsv period	Hrs	Vantage Point	No.	Species	GPS pos on map	Height
07/03/2016	7h05	06h50-12h50	6	**VP7-1**	1	Namaqua sandgrouse	NS475-480	30-30-30m
	7h14				1	Namaqua sandgrouse	NS475-480	40-40-40m
	7h20				4	Namaqua sandgrouse	NS475-480	25025025m
	7h30				**1**	**Kori bustard**	Kori3	10-10-10-10-10m
	7h31				**1**	**Northern black korhaan**	NBK26	20-20-20-30-40-45-50-50m
	8h48				6	Namaqua sandgrouse	NS481-486	25-35-35-40-45-50-55-60m
	9h04				12	Namaqua sandgrouse	NS488-498	20-20-5m
08/03/2016	9h23	09h00-15h00	6	**VP7-2**	4	Namaqua sandgrouse	NS499-502	10-5-5-2m
	9h37				**1**	**Northern black korhaan**	NBK27	10-10-10-10-7-1m
	9h14				**1**	**Northern black korhaan**	NBK28	10-15-15-15-10-5-0m
	9h14				**1**	**Northern black korhaan**	NBK29	10-10-10-10-10-5-0m
	10h16				1	Namaqua sandgrouse	NS503	60-60-60m
	11h01				**1**	**Northern black korhaan**	NBK30	20-20-20-5m
	11h33				1	UnID Raptor	UnIDRapt3	60-60-70-70-80-80-90-90-60-40-30-20-0m
	12h01				1	UnID Raptor	UnIDRapt4	60-60-60-50-50-30-20-30-40-40-50-30-20m
08/03/2016	18h05	17h30-19h30	2	**VP7-3**	2	Namaqua sandgrouse	NS509-510	20-20m
	18h44				**1**	**Kori bustard**	Kori4	10-10-10-20-20-20-30-30-30-20-20-20-20m
			14	**TOTALS**	40	Birds	**3**	**Species**
		7	**14**		**7**	**0.5**		**collision-prone (wet)**

Passage rate:	40 birds in		14	hr	2.86	birds/hr	all birds
Passage rate:	**4**		**12**		**0.33**	**birds/h**	**collision-prone (dry)**
Passage rate:	**11**		**26**		**0.42**		**wet+dry**
Passage rate:	37		12		3.08		Sandgrouse
Passage rate:	33		14		2.36		Sandgrouse
Passage rate:	70		26		2.69		Sandgrouse

Appendix E1:

Dry & Wet Season Motivation

AVIFAUNAL MOTIVATION LETTER FOR CONDUCTING A DRY AND WET SEASON ASSESSMENT OF THE ILANGA CSP 7 FACILITY, NEAR UPINGTON, NORTHERN CAPE

Prepared for:

Savannah Environmental (PTY) LTD

On behalf of:

EMVELO ECO PROJECTS (PTY) Ltd

Prepared by:

BIRDS & BATS UNLIMITED Environmental Consultants www.birds-and-bats-unlimited.com

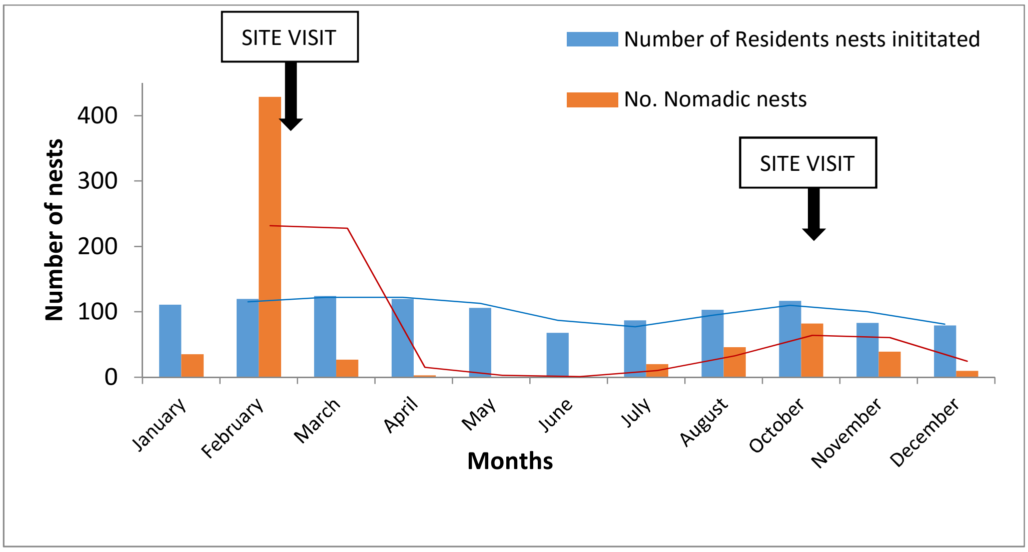
Timing of site visits to survey birds at Ilanga (Karoshoek) solar development

Reply to: *It must be noted that this Department [DEA] in its acceptance of the SR letter, requested that the avifaunal assessment cover the summer and winter seasons. Upon review of this report, the specialist conducted a site visit from the 31 October – 7 November 2015 and 29 February – 09 March 2016 which is deemed as spring and autumn. As such the study must be conducted within the seasons as requested by the DEA. Furthermore, no reason or motivation was provided for the deviation from the acceptance of the SR.*

We, Birds & Bats Unlimited Environmental Consultants, undertook the avian surveys for the Ilanga solar site. We undertook two visits and timed them to maximise the chances of seeing as many resident birds and nomadic birds as possible present on site. Such visits were timed therefore to :

- capture the first breeding peak of resident arid-adapted birds in October-November
- capture the influx of nomadic birds that arrive with the rains and breed 2-4 weeks later.

The graph below indicates the timing of breeding in s-w Kalahari birds drawn from Maclean (1969). Our visits (shown) indicate how they coincide with the main breeding events in arid areas.



So our site visit in October-November 2015 coincided with late spring when many resident arid-species first start to breed (blue above). Furthermore, according to Lepage and Lloyd (2004) who analysed the breeding seasons of all South Africa's birds (with an emphasis on arid-breeding birds), the top breeding month is October (even for areas which have late-summer rains). Ilanga fits into the latter category. Most breeding is finished by the winter (June-July).

For really arid areas like Ilanga which have late summer (March) rains, nomadic birds respond to (fly into) areas with rains and breed within 14 days (insectivores) or 32 d (granivores) (Maclean 1969). So both our visits were timed perfectly to record resident (October) and nomadic (March) birds present and breeding in the Ilanga area. A summer and winter visit would miss both peaks.

Lepage D, Lloyd P. (2004). Avian clutch size in relation to rainfall seasonality and stochasticity along an aridity gradient across South Africa. *Ostrich 75(4): 259–268.*

Maclean, G .(1969). The Breeding seasons of birds In the Southwestern Kalahari. *Ostrich (supplement)* 40:179-192.

Environmental Emvelo Solar Power CSP Plant at Karoshoek, near Upington, Northern Cape- Scoping Report. Unpubl report to Savannah Environmental, Birds & Bats Unlimited, Cape Town.

Simmons R.E., Barnard P. and Jamieson I.G. 1999. What precipitates influxes of wetland birds to ephemeral pans in arid landscapes? Observations from Namibia. Ostrich 70, 145–148. African National Biodiversity Institute, Pretoria, RSA.

Taylor M, Peacock F, Wanless R. (eds.) 2015. The Eskom red data book of birds of South Africa, Lesotho and Swaziland. Birdlife South Africa.

Todd, S. 2012 Proposed Karoshoek Solar Valley Development: Fauna and Flora Specialist Impact Assessment Report. Unpubl report to Savannah Environmental, Johannesburg

Walston, LJ., Rollins KE, Smith KP, LaGory KE, Sinclair K, Turchi C, Wendelin T Souder H. 2014. A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities Unpublished report by Argonne National Laboratory, USA for U.S. Department of Energy, SunShot Initiative and Office of Energy Efficiency & Renewable Energy.

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18 April 2016