BIRD IMPACT SCOPING STUDY

Proposed Solafrica CSP and PV plant

October 2014

Prepared by:

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DECLARATION OF INDEPENDENCE

I, Chris van Rooyen as duly authorised representative of Chris van Rooyen Consulting, and working under the supervision of and in association with Albert Froneman (SACNASP Zoological Science Registration number 400177/09) as stipulated by the Natural Scientific Professions Act 27 of 2003, hereby confirm my independence (as well as that of Chris van Rooyen Consulting) as a specialist and declare that neither I nor Chris van Rooyen Consulting have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Royal Haskoning DHV was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed Solafrica CSP and PV plant.

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Full Name: Chris van Rooyen
Title / Position: Director

RELEVANT EXPERTISE

Chris van Rooyen

Chris has seventeen years' experience in the management of wildlife interactions with electricity infrastructure. He was head of the Eskom-Endangered Wildlife Trust (EWT) Strategic Partnership from 1996 to 2007, which has received international acclaim as a model of co-operative management between industry and natural resource conservation. He is an acknowledged global expert in this field and has worked in South Africa, Namibia, Botswana, Lesotho, New Zealand, Texas, New Mexico and Florida. Chris also has extensive project management experience and has received several management awards from Eskom for his work in the Eskom-EWT Strategic Partnership. He is the author of 15 academic papers (some with co-authors), co-author of two book chapters and several research reports. He has been involved as ornithological consultant in more than 160 power line and 30 renewable energy projects. Chris is also co-author of the Best Practice for Avian Monitoring and Impact Mitigation at Wind Development Sites in Southern Africa, which is currently (2013) accepted as the industry standard. Chris also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

Albert Froneman (Pr.Sci.Nat)

Albert has an M. Sc. in Conservation Biology from the University of Cape Town, and started his career in the natural sciences as a Geographic Information Systems (GIS) specialist at Council for Scientific and Industrial Research (CSIR). He is a registered Professional Natural Scientist in the field of zoological science with the South African Council of Natural Scientific Professionals (SACNASP). In 1998, he joined the Endangered Wildlife Trust where he headed up the Airports Company South Africa – EWT Strategic Partnership, a position he held until he resigned in 2008 to work as a private ornithological consultant. Albert's specialist field is the management of wildlife, especially bird related hazards at airports. His expertise is recognized internationally; in 2005 he was elected as Vice Chairman of the International Bird Strike Committee. Since 2010, Albert has worked closely with Chris van Rooyen in developing a protocol for pre-construction monitoring at wind energy facilities, and they are currently jointly coordinating pre-construction monitoring programmes at several wind farm facilities. Albert also works outside the electricity industry and had done a wide range of bird impact assessment studies associated with various residential and industrial developments.

EXECUTIVE SUMMARY

BACKGROUND

Solafrica Photovoltaic Energy (Proprietary) Limited ("Solafrica") proposes a 150 MW CSP central receiver plant in the Northern Cape Province of South Africa. The project site is located on the north-east end of an existing farm named Sand Draai near the town of Groblershoop. An additional 150 MW parabolic trough CSP plant and 125 MW PV facility in build-out of the project site is also being considered. The existing road infrastructure will be utilised for the construction of the plant. The Eskom Garona transmission and Distribution substation is located on the neighbouring farm property. A ±6km overhead power line will be required for interconnection. Water will be accessible from the Orange River. A ±15km pipeline, and associated pumping and storage infrastructure, will be constructed to transport raw water to the project site.

AVIFAUNA

An estimated 113 species could potentially occur in the study area. Of these, 9 are South African Red Data species, 14 are southern African endemics and 23 are near-endemics. This means that 8% of the species that occur could potentially occur in the study area are Red Data species, and almost 33% are southern African endemics of near-endemics. Overall, the study area potentially contains a total of 37 endemics and near-endemics, which is 23% of the total southern African endemics and near-endemics.

IMPACTS

Potential impacts an avifauna are the following:

- Collisions with the heliostats and/or solar panels and burning due to solar flux (CSP only)
- Temporary displacement due to disturbance associated with the construction of the plant
- Permanent displacement due to habitat transformation
- Collisions with the associated power lines

Sociable Weavers may try to nest on the plant infrastructure e.g. heliostats and electricity poles. Experience in this arid region has shown that Sociable Weavers are quick to nest on any man-made infrastructure.

SENSITIVITY MAP

The study area is located in Western Arid, which is the endemic region with the highest number of endemics in southern Africa. With almost a quarter of all southern African endemics or near endemics potentially occurring in the study area, the study area as a whole should be regarded as moderately sensitive from an avifaunal perspective. Within the study area, potential high sensitive areas are surface water (water troughs) and high voltage lines, as both these micro-habitats are potential focal points of bird activity. Figure 13 indicates areas of moderate and high sensitivity. It is important to note that the sensitivity of the study area will be influenced by the development itself, in that the construction of the power line and evaporation ponds will potentially create new areas of high sensitivity. The sensitivity map in Figure 13 is based on the current status quo.

RECOMMENDATIONS

It is recommended that a pre-construction monitoring programme is implemented at the site as soon as possible to gather baseline data over a period of 12 months on the following aspects pertaining to avifauna:

- The abundance and diversity of birds at the solar facility and a suitable control site.
- Flight patterns of priority species at the solar facility.

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1. INTRODUCTION & BACKGROUND

Solafrica Photovoltaic Energy (Proprietary) Limited ("Solafrica") proposes a 150 MW CSP central receiver plant in the Northern Cape Province of South Africa. The project site is located on the north-east end of an existing farm named Sand Draai near the town of Groblershoop. An additional 150 MW parabolic trough CSP plant and 125 MW PV facility in build-out of the project site is also being considered. The existing road infrastructure will be utilised for the construction of the plant. The Eskom Garona transmission and Distribution substation is located on the neighbouring farm property. A ±6km overhead power line will be required for interconnection. Water will be accessible from the Orange River. A ±15km pipeline, and associated pumping and storage infrastructure, will be constructed to transport raw water to the project site.

See Figures 1 - 4 below for maps of the study area:

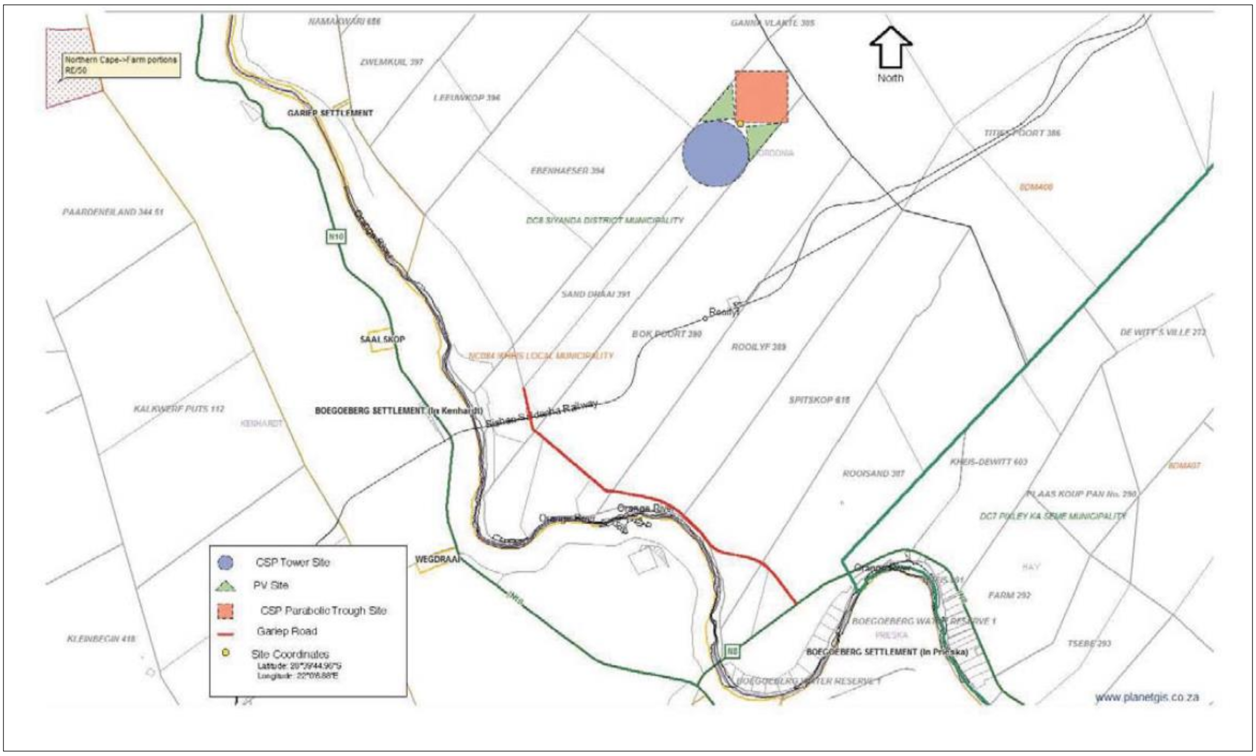

Figure 1: Map of proposed Sand Draai CSP site.

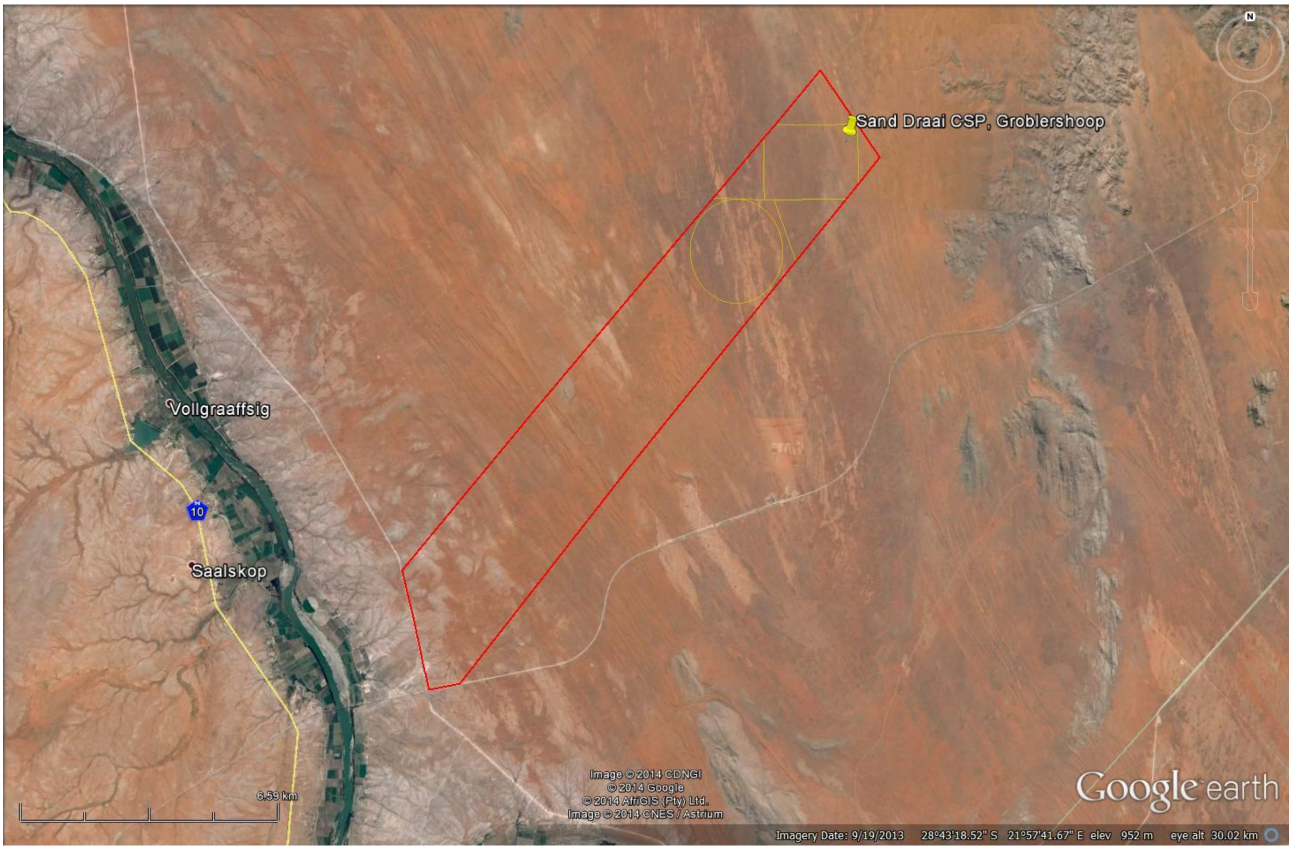

Figure 2: Map of proposed Sand Draai CSP site on a background of satellite imagery.

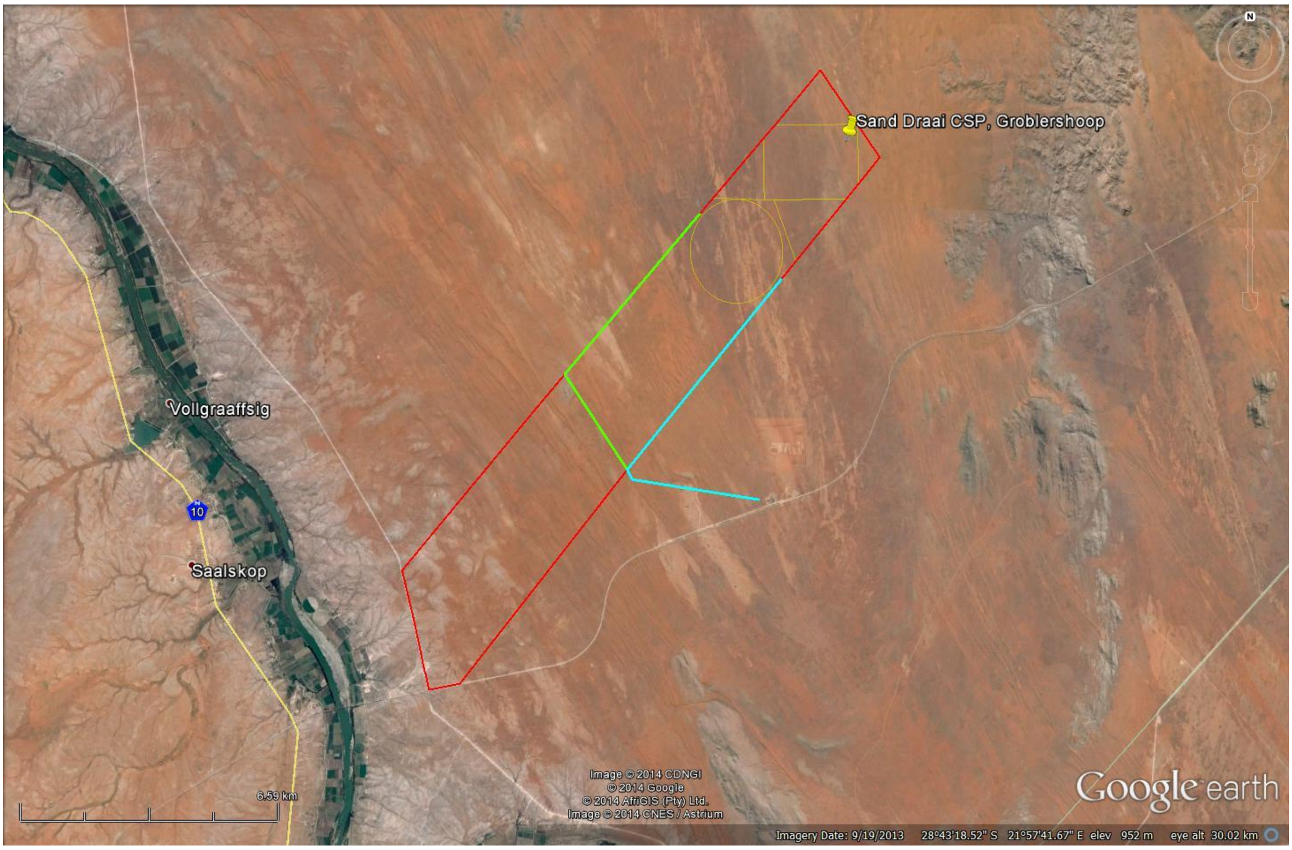

Figure 3: Map of proposed Sand Draai CSP site showing the potential power line alternatives.

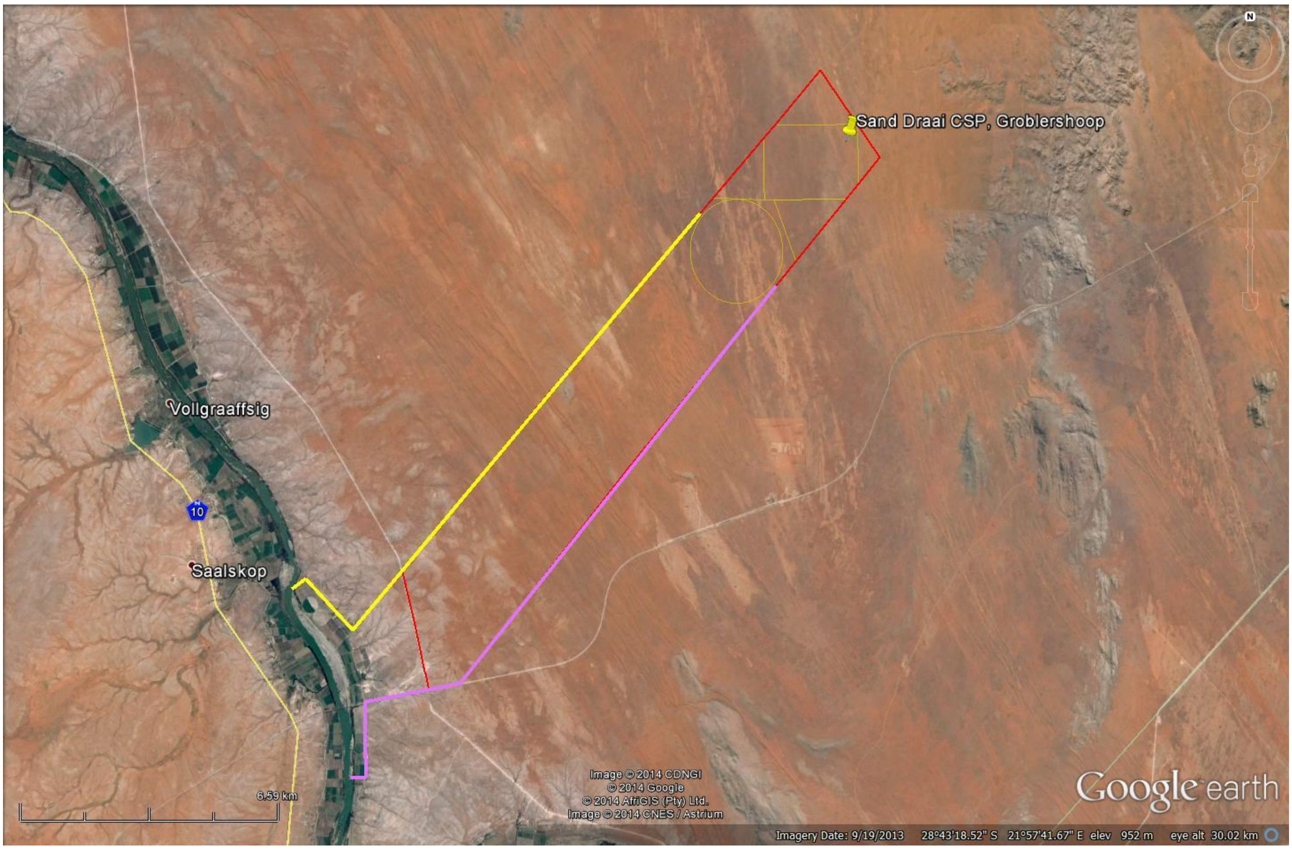

Figure 4: Map of proposed Sand Draai CSP site showing the potential pipe line alternatives.

The technological options which are currently being considered are the following:

- Parabolic trough

Parabolic trough-shaped mirror reflectors are used to concentrate sunlight on to thermally efficient receiver tubes placed in the trough's focal line. The troughs are usually designed to track the sun along one axis, predominantly north-south. A thermal transfer fluid, such as synthetics thermal oil, is circulated in these tubes. The fluid is heated to approximately 400°C by the sun's concentrated rays and then pumped through a series of heat exchangers to produce superheated steam. The steam is converted to electrical energy.

Figure 5: Example of parabolic troughs.

- Central Receiver

A circular array of heliostats (large mirrors with sun-tracking motion) concentrates sunlight on to a central receiver mounted at the top of a tower. A heat transfer medium in this central receiver absorbs the highly concentrated radiation reflected by the heliostats and converts it into thermal energy, which is used to generate superheated steam for the turbine. Some commercial tower plants now in operation use direct steam generation in the receiver; others use molten salts as both the heat transfer fluid and storage medium.

Figure 6: Example of central receiver.

- Linear Fresnel reflector

Linear Fresnel reflector approximate the parabolic shape of trough systems but by using long rows of flat or slightly curved mirrors to reflect the sun’s rays onto a downward-facing linear, fixed receiver. A more recent design, known as compact linear Fresnel reflectors (CLFRs), uses two parallel receivers for each row of mirrors and thus needs less land than parabolic troughs to produce a given output. The receiver consists of a long, selectively-coated absorber tube. Unlike parabolic trough collectors, the focal line of Fresnel collectors is distorted by astigmatism. This requires a mirror above the tube (a secondary reflector) to refocus the rays missing the tube, or several parallel tubes forming a multi-tube receiver that is wide enough to capture most of the focused sunlight without a secondary reflector

Figure 7: Example of Linear Fresnel Reflector.

2. TERMS OF REFERENCE

The terms of reference for this desk top scoping study are as follows:

- Describe the affected environment.
- Discuss gaps in baseline data and provide recommendations on how it can be addressed .
- List and describe the expected impacts.
- Provide a sensitivity map of the Sand Draai farm from an avifaunal perspective.

3. SOURCES OF INFORMATION

The following information sources were consulted in order to conduct this study:

- Bird distribution data of the Southern African Bird Atlas Project2 (SABAP 2) was obtained (http://sabap2.adu.org.za/), in order to ascertain which species occur in the pentads where the proposed line is located. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is approximately 8 × 7.6 km. In order to get a more representative impression of the birdlife, a consolidated data set was obtained for the 9 pentads which overlaps substantially with the proposed development.
- The power line bird mortality incident database of the Endangered Wildlife Trust (1996 to 2008) was consulted to determine which of the species occurring in the study area are typically impacted upon by power lines (Jenkins *et al.* 2010).
- A classification of the vegetation types in the study area was obtained from the Atlas of Southern African Birds 1 (SABAP1) and the National Vegetation Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford 2006).

- Data on the location of large raptor nests in the Northern Cape for the period 1994 – 2009 was obtained from the Kalahari Raptor Project (Maritz 2009).
- Data on the alignment of existing high voltage lines were obtained from Eskom.
- The national threatened status of all priority species was determined with the use of the most recent edition of the Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor 2014), and the latest authoritative summary of southern African bird biology (Hockey *et al.* 2005).
- The global threatened status of all priority species was determined by consulting the latest (2014.1) IUCN Red List of Threatened Species (http://www.iucnredlist.org/).
- The Important Bird Areas of Southern Africa was consulted for information on relevant Important Bird Areas (IBAs) (http://www.birdlife.org.za/conservation/important-bird-areas).
- Satellite imagery from Google Earth was used in order to view the broader area on a landscape level and to help identify bird habitat on the ground.
- An intensive internet search was conducted to source information on the impacts of solar facilities on avifauna.

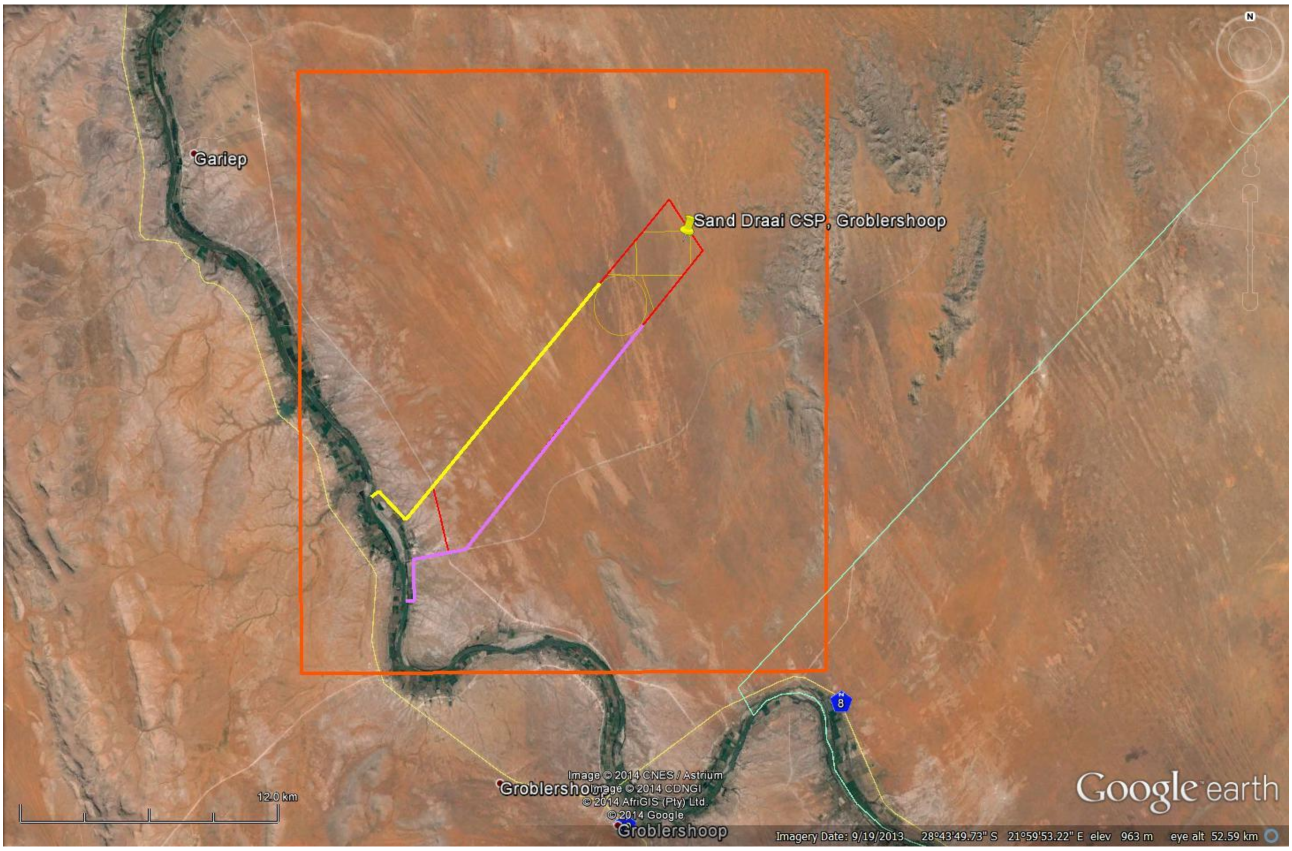

Figure 8: Area covered by the SABAP2 data.

4. ASSUMPTIONS & LIMITATIONS

The following assumptions and limitations are applicable in this study:

- A total of 11 full protocol lists have been completed to date to date for the 9 pentads where the study area is located (i.e. lists surveys lasting a minimum of two hours each). The SABAP2 data was therefore not regarded as a conclusive snapshot of the avifauna, but merely as a guideline. For purposes of completeness, the list of species that could be encountered was supplemented with personal observations and general knowledge of the area.

- Conclusions in this study are based on experience of these and similar species in different parts of South Africa. Bird behaviour can never be entirely reduced to formulas that will be valid under all circumstances. However, power line and substation impacts can be predicted with a fair amount of certainty (see References Section 9).
- It should be noted that the raptor nest data should be viewed only as a rough indication of the species that may breed in the study area because (a) the nest data is not the result of a systematic survey which is repeated regularly and (b) some species, e.g. Secretarybird, generally build a new nest in a different location every year (Hockey *et al.* 2005).
- The focus of the study is on Red Data species, endemics and near-endemics.
- The impact of solar installations on avifauna is a new field of study, with only one scientific study published to date (McCrary *et al*. 1986). Strong reliance was therefore placed on the opinions of experts and the pre-cautionary principle was applied throughout.
- The study area was defined as the area within the boundaries of the farm Sand Draai.

5. DESCRIPTION OF AFFECTED ENVIRONMENT

5.1 Biomes and vegetation types

The study area is located in an ecotonal zone between two biomes, namely Savanna and Nama Karoo (Mucina & Rutherford 2006). The study area contains three vegetation types, namely Bushmanland Arid Grassland, Kalahari Karroid Shrubland and Gordonia Duneveld. The first two are associated with Nama Karoo, and the latter with Savanna (see Figure 9 below).

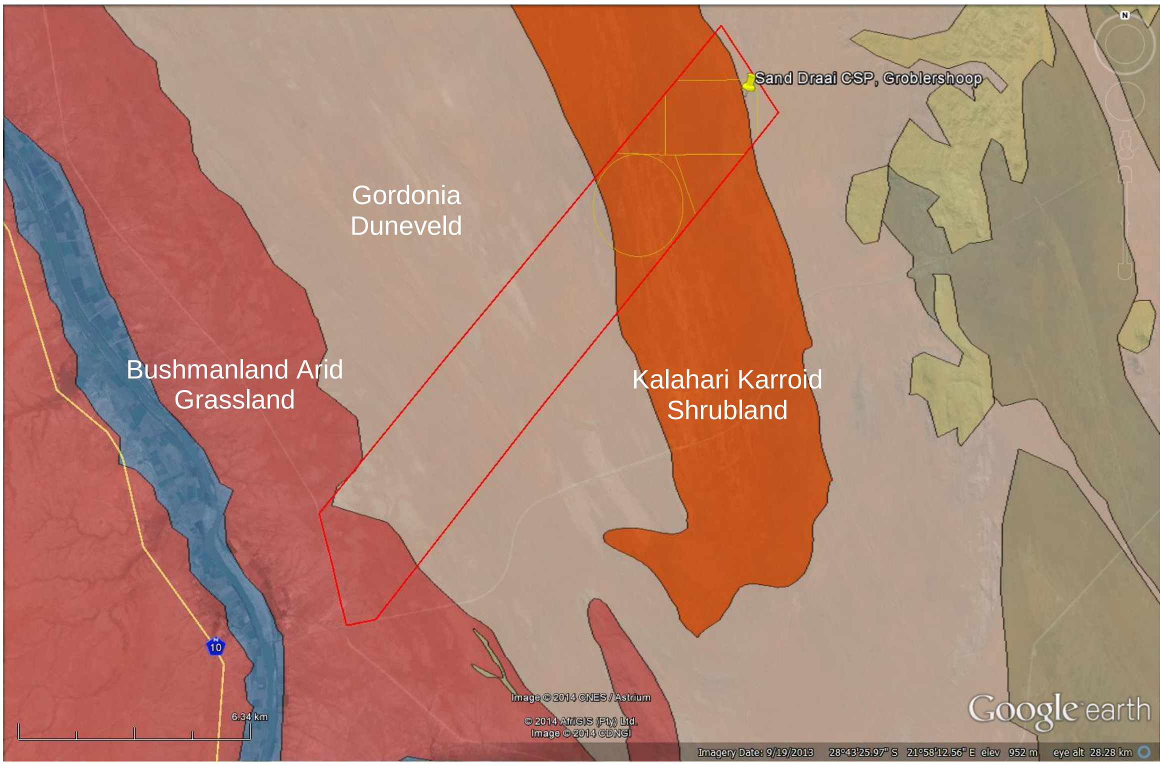

Figure 9: Vegetation types in the study area

Vegetation structure, rather than the actual plant species, is more significant for bird species distribution and abundance (in Harrison *et al.* 1997). Therefore, the vegetation description below does not focus on lists of plant species, but rather on factors which are relevant to bird distribution. The description of the vegetation types occurring in the study area largely follows the classification system presented in the Atlas of southern African birds (Harrison *et al.* 1997). The criteria used to amalgamate botanically defined vegetation units, or to keep them separate were (1) the existence of clear differences in vegetation structure, likely to be relevant to birds, and (2) the results of published community studies on bird/vegetation associations. It is important to note that no new vegetation unit boundaries were created, with use being made only of previously published data. The description of vegetation presented in this study therefore concentrates on factors relevant to the bird species present, and is not an exhaustive list of plant species present.

Savanna (or woodland) is defined as having a grassy under-storey and a distinct woody upper-storey of trees and tall shrubs. Soil types are varied but are generally nutrient poor. The savanna biome contains a large variety of bird species (it is the most species-rich community in southern Africa) but very few bird species are restricted to this biome. In the study area, the savannah biome contains one vegetation type, namely Gordonia Duneveld, which is classified with Southern Kalahari in Harrison *et al.* 1997. Southern Kalahari vegetation occurs on deep Kalahari sands with rolling dunes, and consists of open shrubland with ridges of grassland and semi-deciduous *Acacia* and *Boscia albitrunca* trees along intermittent fossil watercourses and interdunal valleys. Tall trees are generally absent, except along some fossil rivers. Grass cover is highly variable dependent on rain and grazing. Summers are hot, winters cold, rainfall variable averaging <250mm and mostly in summer.

The **Nama Karoo** vegetation largely comprises low shrubs and grasses; peak rainfall occurs in summer. Trees e.g. *Acacia karroo* and alien species such as Mesquite *Prosopis glandulosa* are mainly restricted to watercourses where fairly luxurious stands can develop, especially along the Orange River. In the study area, the Nama Karoo contains two vegetation types, namely Kalahari Karroid Shrubland and Bushmanland Arid Grassland. Bushmanland Arid Grassland consists mainly of extensive to irregular plains sparely vegetated by grassland dominated by white grasses (*Stipagrostis* species) giving the landscape the character of semi-desert "steppe", with a few low shrubs in places. Large trees are almost absent, but present in some fossil water courses. Kalahari Karroid Shrubland, where the proposed plant is currently located, consists of low, karroid shrubland on flat, gravel plains and constitutes a transitional phase between Savanna (Southern Kalahari) and Nama Karoo with bird communities typical of both biomes.

5.2 Avifauna and habitat classes in the study area

Whilst much of the distribution and abundance of the bird species in the study area can be explained by the description of the biomes and vegetation types above, it is as important to examine the modifications which have changed the natural landscape, and which may have an effect on the distribution of avifauna. These are sometimes evident at a much smaller spatial scale than the biome or vegetation types, and are determined by a host of factors such as topography, land use and man-made infrastructure.

The following bird habitat classes have been identified in the study area, subject to field investigations:

5.2.2 Savanna

This habitat class is described above under 5.1 and is of importance for a suite of Red Data species which could potentially occur in the study area. These could include White-backed Vulture[1], Martial Eagle, Tawny Eagle, Lappet-faced Vulture and Lanner Falcon. Apart from Red Data species, it also supports non-Red Data large raptor species which could occur in the study area, e.g. Brown Snake Eagle *Circaetus cinereus* and Black-chested Snake Eagle *Circaetus pectoralis.* A multitude of smaller non-Red Data raptor species could also occur in Kalahari Savanna in the study area e.g. the near-endemic Southern Pale Chanting Goshawk, Gabar Goshawk *Melierax gabar* and Pygmy Falcon (which breeds exclusively in Sociable Weaver nests) as well as the large terrestrial Red Data Secretarybird and Kori Bustard. However, the scarcity of large trees means that large raptors and vultures are unlikely to breed in the study area. The habitat is very suitable for Secretarybird, as the species generally breeds in small trees and forages in open duneveld. Kori Bustard is also common in this habitat, while Ludwig's Bustard occurs sporadically. Apart from Red Data species, Kalahari Savanna in the study area is also suitable for several non-Red Data endemic species i.e. African Red-eyed Bulbul, Ant-eating Chat, Fairy Flycatcher, Fiscal Flycatcher, Northern Black Korhaan, White-backed Mousebird, Rufous-eared Warbler, Sociable Weaver, and many near endemics namely Cape Bunting, Lark-like Bunting, White-throated Canary, Yellow Canary, Red-headed Finch, Scaly-feathered Finch, Chat Flycatcher, Sabota Lark, Spike-heeled Lark, Black-chested Prinia, Burchell's Sandgrouse, Namaqua Sandgrouse, Kalahari Scrub-Robin, Crimson-breasted Shrike, Cape Sparrow, Grey-backed Sparrowlark and Ashy Tit (see Table 1 below).

5.2.3 Nama Karoo

This habitat class is described above under 5.1. The Karoo vegetation types support a particularly high diversity of bird species endemic to Southern Africa, particularly in the family *Alaudidae* (Larks)(Harrison *et al.* 1997). Its avifauna typically comprises ground-dwelling species of open habitats. Many typical karroid species are nomads, able to use resources that are patchy in time and space, especially enhanced conditions associated with rainfall (Barnes 1998). Red Data species specifically associated with Nama Karoo which could potentially occur in the study area are in particular the nomadic Ludwig's Bustard, which may occur in flocks following rainfall events, Karoo Korhaan, Double-banded Courser and to a lesser extent Kori Bustard. However, the predominant Nama Karoo habitat in the study area (Kalahari Karroid Shrubland) exhibits many features of the surrounding Kalahari Savanna, with the result that the Red Data species mentioned in 5.2.2 above could also occur in the Nama Karoo which occurs on the site, but probably at lower densities. Non-Red Data large raptors are generally less common in Nama Karoo than in Kalahari Savanna, but Black-chested Snake-Eagle *Circaetus pectoralis* could occur regularly. Verreaux's Eagle would generally be confined to rocky outcrops to the east of the study area, but excursions into the study area could be a regular event, with potential attractants being surface water or the carcasses of dead livestock.

[1] For scientific names of all Red Data, endemic and near-endemic species see Table 1.

Carcasses and water troughs could also attract vultures and large raptors. Endemic species that could occur in Nama Karoo on the site are African Red-eyed Bulbul, Ant-eating Chat, Fairy Flycatcher, Fiscal Flycatcher, White-backed Mousebird, Rufous-eared Warbler, Sociable Weaver, Karoo Long-billed Lark, Karoo Scrub-Robin, Layard's Warbler, Namaqua Warbler, and several near endemics i.e. Cape Bunting, Lark-like Bunting, White-throated Canary, Yellow Canary, Red-headed Finch, Scaly-feathered Finch, Chat Flycatcher, Spike-heeled Lark, Black-chested Prinia, Namaqua Sandgrouse, Cape Sparrow, Grey-backed Sparrowlark, Karoo Chat, Tratrac Chat, Southern Pale Chanting Goshawk, Dusky Sunbird and Bokmakierie.

5.2.4 Waterbodies and rivers

Surface water is of specific importance avifauna in this arid study area. The perennial Orange River is located approximately 2km south the study area, and the river channel, pools of water and riverine islands with riparian thickets, reed beds, flooded grasslands and sandbanks provide habitat for a multitude of waterbirds. However, based on the inspection of satellite imagery of the study area, there are no permanent or ephemeral rivers in the study area itself, except for a few small drainage lines in the extreme south of the study area, which drains into the Orange River. The study area does contain boreholes. Four suspected boreholes have been identified from satellite imagery, which would need to be confirmed through site investigations. Boreholes with open water troughs are important sources of surface water and are used extensively by various species, including large raptors and vultures, to drink and bath. Apart from raptors, smaller species, including endemics and near-endemics such as Sociable Weaver, Cape Sparrow, Red-headed Finch, Scaly-feathered Finch, Yellow Canary, White-throated Canary, Burchell's Sandgrouse and Namaqua Sandgrouse congregate in large numbers around water troughs which in turn attracts raptors such as Lanner Falcon and Southern Pale Chanting Goshawk.

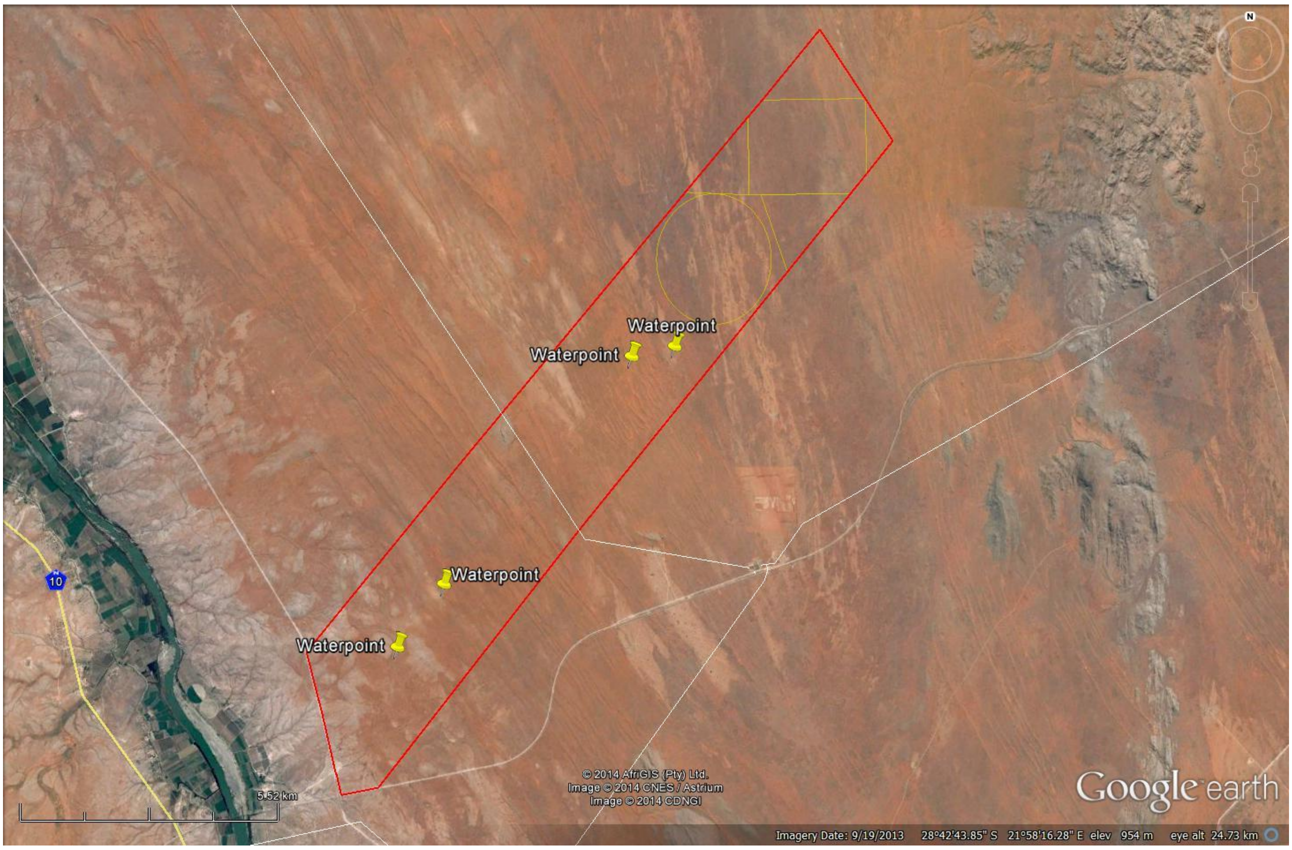

Figure 10: Suspected boreholes which need to be confirmed through physical inspections

5.2.5 High voltage lines

High voltage lines are an important potential roosting and breeding substrate for large raptors in the study area. Existing high-voltage lines are used extensively by large raptors e.g. in 2005 the author did an aerial survey of the Ferrum – Garona 275kV line which starts at Kathu and terminates at Garona Substation approximately 16km north of Groblershoop, and found a total of 19 Martial Eagle and 7 Tawny Eagle nests on transmission line towers (Van Rooyen 2007). High voltage lines therefore hold a special importance for large raptors, but also for Sociable Weavers which often construct their giant nests within the lattice work or cross-arms of high voltage structures. One high-voltage line, the Garona – Gordonia 132kV line was identified from satellite imagery, running in an east – west direction through the study area, which will require further investigation.

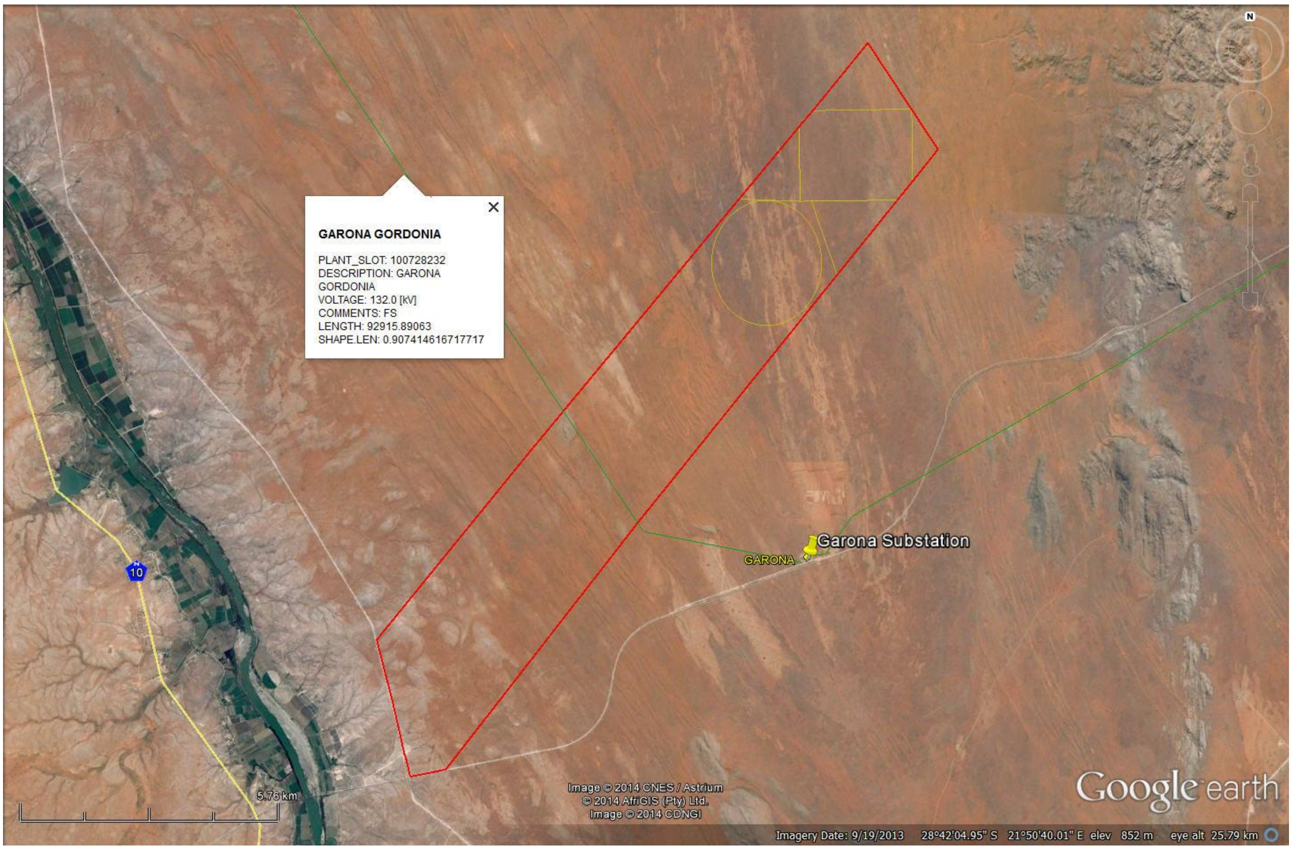

Figure 11: The location of the Garona Gordonia 132kV line in the study area.

5.2.6 Avifauna

The study area does not overlap with any Important Bird Areas, the closest IBA is the Augrabies Falls National Park (SA029), which is situated approximately 160km north-west from the study area.

An estimated 113 species could potentially occur in the study area. Of these, 9 are South African Red Data species, 14 are southern African endemics and 23 are near-endemics. This means that 8% of the species that occur could potentially occur in the study area are Red Data species, and almost 33% are southern African endemics of near-endemics. Southern Africa contains 13 avifaunal endemic regions, namely Western Arid, Woodland, Evergreen Forest, Grassland, Montane, Rocky slopes and cliffs, Fynbos, Marine and Inland Waters (MacLean 1999). Of these regions, Western Arid, where the study area is located, contains the highest number of endemics. Overall, the study area potentially contains a total of 37 endemics and near-endemics, which is 23% of the total southern African endemics and near-endemics (Hockey *et al.* 2005).

See Appendix 1 and Table 1 for a list of species potentially occurring in the study area. Potential impacts on these species are also listed in Table 1.

Table 1: Red Data species potentially occurring in the study area

En = Endangered

Vu = Vulnerable

NT = Near-threatened

LC = Least concern

End = Southern African Endemic

N-End = Southern African near endemic

Name	Scientific name	Status National	Status International	Savanna	Nama Karoo	Waterbodies	Transmission lines	Solar flux	Collisions	Displacement through disturbance	Displacement through habitat transformation*
Kori Bustard	*Ardeatis kori*	NT	NT	x	x				x	x	x
Lanner Falcon	*Falco biarmicus*	Vu	LC	x	x	x	x	x	x	x	
Lappet-faced Vulture	*Torgos tracheliotis*	En	Vu	x	x	x	x	x		x	x
Ludwig's Bustard	*Neotos ludwigii*	En	En	x	x			x	x	x	x
Martial Eagle	*Polemaetus bellicosus*	En	Vu	x	x	x	x	x		x	x
Karoo Korhaan	*Eupodotis vigorsii*	NT, End	LC		x				x	x	x
Secretarybird	*Sagittarius serpentarius*	Vu	Vu	x		x			x	x	x
Tawny Eagle	*Aquila rapax*	En	LC	x	x	x	x	x		x	x
White-backed Vulture	*Gyps africanus*	En	En	x		x	x	x			x
Double-banded Courser	*Rhinoptilus africanus*	NT	LC		x				x	x	x
Verreaux's Eagle	*Aquila verreauxii*	VU	LC	x	x	x		x			x

Name	Scientific name	Status National	Status International	Savanna	Nama Karoo	Waterbodies	Transmission lines	Solar flux	Collisions	Displacement through disturbance	Displacement through habitat transformation*
African Red-eyed Bulbul	*Pycnonotus nigricans*	End	LC	x	x			x	x	x	x
Anteating Chat	*Myrmecocichla formicivora*	End	LC	x	x			x	x	x	x
Fairy Flycatcher	*Stenostira scita*	End	LC	x	x			x	x	x	x
Fiscal Flycatcher	*Sigelus silens*	End	LC	x	x			x	x	x	x
Northern Black Korhaan	*Afrotis afraoides*	End	LC	x	x			x	x	x	x
Karoo Long-billed Lark	*Certhilauda subcoronata*	End	LC		x			x	x	x	x
White-backed Mousebird	*Colius colius*	End	LC	x	x				x	x	x
Karoo Scrub-Robin	*Cercotrichas coryphoeus*	End	LC		x			x	x	x	x
Layard’s Warbler	*Sylvia layardi*	End	LC	x	x			x	x	x	x
Namaqua Warbler	*Phragmacia substriata*	End	LC		x			x	x	x	x
Rufous-eared Warbler	*Malcorus pectoralis*	End	LC	x	x			x	x	x	x
Sociable Weaver	*Philetairus socius*	End	LC	x	x	x		x	x	x	x
Cape Bunting	*Emberiza capensis*	N-End	LC	x	x	x		x	x	x	x
Lark-like Bunting	*Emberiza impetuani*	N-End	LC	x	x	x		x	x	x	x
White-throated Canary	*Crithagra albogularis*	N-End	LC	x	x	x		x	x	x	x
Yellow Canary	*Crithagra flaviventris*	N-End	LC	x	x	x		x	x	x	x
Karoo Chat	*Cercomela schlegelii*	N-End	LC		x			x	x	x	x
Tratrac Chat	*Cercomela tractrac*	N-End	LC		x			x	x	x	x
Red-headed Finch	*Amadina erythrocephala*	N-End	LC	x	x	x		x	x	x	x

Name	Scientific name	Status National	Status International	Savanna	Nama Karoo	Waterbodies	Transmission lines	Solar flux	Collisions	Displacement through disturbance	Displacement through habitat transformation*
Scaly-feathered Finch	*Sporopipes squamifrons*	N-End	LC	x	x	x		x	x	x	x
Chat Flycatcher	*Bradornis infuscatus*	N-End	LC	x	x			x	x	x	x
Southern Pale Chanting Goshawk	*Melierax canorus*	N-End	LC	x	x	x	x	x	x	x	x
Sabota Lark	*Calendulauda sabota*	N-End	LC	x	x			x	x	x	x
Lark, Spike-heeled	*Chersomanes albofasciata*	N-End	LC	x	x			x	x	x	x
Prinia, Black-chested	*Prinia flavicans*	N-End	LC	x	x			x	x	x	x
Sandgrouse, Burchell's	*Pterocles burchelli*	N-End	LC	x		x		x	x	x	x
Sandgrouse, Namaqua	*Pterocles namaqua*	N-End	LC	x	x	x		x	x	x	x
Scrub-Robin, Kalahari	*Cercotrichas paena*	N-End	LC	x				x	x	x	x
Shrike, Crimson-breasted	*Laniarius atrococcineus*	N-End	LC	x				x	x	x	x
Sparrow, Cape	*Passer melanurus*	N-End	LC	x	x	x		x	x	x	x
Sparrowlark, Grey-backed	*Eremopterix verticalis*	N-End	LC	x	x			x	x	x	x
Sunbird, Dusky	*Cinnyris fuscus*	N-End	LC		x			x	x	x	x
Tit, Ashy	*Parus cinerascens*	N-End	LC	x				x	x	x	x
Batis, Pririt	*Batis pririt*	N-End	LC	x	x			x	x	x	x
Bokmakierie	*Telophorus zeylonus*	N-End	LC		x			x	x	x	x

- With smaller species this impact might result in partial but not total exclusion from the site, depending on the level of vegetation transformation

6. DESCRIPTION OF EXPECTED IMPACTS

To date, only one published scientific study has been conducted on the direct impacts of solar facilities on avifauna, namely "Avian mortality at a solar energy power plant" by McCrary, McKernan, Schreiber, Wagner & Sciarrotta 1986. This describes the results of monitoring at the experimental Solar One solar power plant in southern California (now de-commissioned), which is a 10 megawatt, central receiver solar power plant consisting of a 32-ha field of 1818, 6.9 x 6.9 m mirrors (heliostats) which concentrates sunlight on a centrally located, tower-mounted boiler, 86m in height. Since then, several much larger plants have been constructed in the Desert Southwest of the USA namely the 250MW, 1300ha California Valley Solar Ranch PV plant, the 377 MW, 1600ha Ivanpah central receiver CSP plant, the 550MW, 1600ha Desert Sunlight PV plant and the 250MW, 1880ha Genesis Solar Energy parabolic trough CSP plant. The full spectrum of impacts of solar facilities on birds is only now starting to emerge from compliance reports at these solar facilities. These can be summarised as follows:

- Collisions with the heliostats and/or solar panels and burning due to solar flux (CSP only)
- Temporary displacement due to disturbance associated with the construction of the plant
- Permanent displacement due to habitat transformation
- Collisions with the associated power lines

6.1 Collisions with heliostats/solar panels and burning due to solar flux

From existing evidence, it seems that these impacts are responsible for most mortalities at solar plants.

McCrary *et al*. (1986) searched for dead birds amongst the heliostat mirrors and around the central receiver tower, and they estimated a bird fatality rate caused by bird collisions with heliostat mirrors and the tower, and by heat encountered when birds flew through the concentrated sunlight reflected toward the tower. Their forty visits (one week apart) to the facility over a two year period revealed 70 bird carcasses involving 26 species. It was estimated that between 10% and 30% of carcasses were removed by scavengers in between visits, so the actual mortality figure may have been slightly higher. They estimated that fifty seven (81%) of these birds died through collision with infrastructure, mostly the heliostats. Species killed in this manner included waterbirds, small raptors, gulls, doves, sparrows and warblers. Thirteen (19%) of the birds died through burning in the standby points. Species killed in this manner were mostly swallows and swifts. However, they appeared to have under-appreciated the magnitude of the impacts caused by Solar One, likely because they did not know as much as scientists know today about scavenger removal rates and searcher detection error (Smallwood 2014). Their search pattern was not fixed, so it was not as rigorous as modern searches at wind energy projects and other energy generation and transmission facilities. They placed 19 bird carcasses to estimate the proportion remaining over the average time span between their visits to the project site, though they provided few details about their scavenger removal trial. It is known today that the results of removal trials can vary substantially for many reasons, including the species used, time since death, and the number of carcasses placed in one place at one time, and etc. (Smallwood 2007). They also performed no searcher detection trials, because they concluded that the ground was sufficiently exposed that all available bird carcasses would have been found. This conclusion would not be accepted today, based on modern fatality search protocols. Smallwood (2014) recalculated the estimated fatality rate at Solar One, but this time using US national averages to represent scavenger removal rates and searcher detection rates (see Smallwood 2007, 2013). He re-calculated it as 87.4 mortalities per year with an 80% confidence interval (CI) of 69.6 to 105.5.

Avian monitoring surveys were conducted from 29 October 2013 to 21 March 2014 (the winter season) at the Ivanpah Solar Electric Generating System (Ivanpah) facility in accordance with the Project's Avian & Bat Monitoring and Management Plan (Harvey & Associates 2014a). Searches were conducted within the winter season at intervals averaging 26-27 days (range 24-29 days, median = 26 days). The timing of searches was phased in accordance with commencement of operation of the units, with Unit 1 becoming operational first, followed by Unit 3, and then Unit 2. By 27 January 2014, the standardized searches were being conducted at all three units. The area that was searched amounts to 30.1% of the total area taken up by the facility. In addition, throughout operations, the facility implemented its required Wildlife Incident Reporting System, through which site workers report "incidental detections" which comprise bird or bat injuries or fatalities that were observed spatially or temporally outside of the formal search protocol used to determine a fatality estimate. During the period 29 October 2013 – 21 March 2014, a total of five injured birds, and five bat fatalities and 91 avian fatalities (38 of which were feather spots), were detected. Of the 96 avian detections during the 2013-2014 winter season, 24 fatalities (13 carcasses and 11 feather spots, together 25%) and three injured birds showed signs of singed feather damage from flux effects. Twenty-three of 27 detections (85.2%) showing signs of flux occurred in the tower area. Evidence of collision (primarily with heliostats) was observed in the case of 14 detections (14.6%). The cause of injury or mortality for the remaining 55 detections (57.3%) could not be confirmed, mainly because the evidence of mortality was limited to feather spots; however, none of these detections with unknown causes of mortality displayed evidence of flux effects or observable evidence of collision. Thirty-eight (39.6%) of the 96 detections consisted only of feather spots. Because singed feathers are readily observable, fatalities for which the cause of death is unconfirmed are likely to have resulted from predation, collision, or illness. During the period 29 October 2013 to 21 March 2014, total **estimated** numbers of fatalities attributable to the project, which are those with evidence of flux or collision effects, were 81 (90% confidence interval estimates 47-180) in the tower area; 111 (90% confidence interval estimates 49-272) in the heliostat area; and eight (90% confidence interval estimates 4-14) in the fenceline area, which translates into a total estimated number of fatalities directly attributable to the project of 200 (90% confidence interval estimates 100 – 466). Estimates of fatalities from unknown causes, which cannot be directly attributed to the facility, were 35 (90% confidence interval estimates 14-84) in the tower area; 153 fatalities (90% confidence interval estimates 57-406) in the heliostat area; and 13 (90% confidence interval estimates 7-25) in the fenceline area, which translates into a total estimated number of fatalities due to unknown causes of 201 (90% confidence interval estimates 78 – 515). Overall, the estimated number of fatalities from both project related causes and unknown causes for the period 29 October 2013 to 21 March 2014 comes to 401 (90% confidence interval estimates 178 – 981) which amounts to approximately 80 estimated bird mortalities per month. However, subsequent monitoring in April and May 2014 yielded **actual** mortality figures of 101 and 82 birds respectively, which is more than double the actual monthly mortalities for the previous monitoring period of 29 October 2013 to 21 March 2014 (Ivanpah 2014a and 2014b). Based on the latter two reports, Smallwood (2014) calculated the estimated annual mortality at Ivanpah to be potentially as high as 28 380 birds per year. In his testimony to the California Energy Commision he explains as follows: "The April searches turned up 101 fatalities and the May searches discovered another 82 fatalities. If the searches were performed according to document TB201315, which summarized a monitoring plan for Ivanpah, then weekly searches were performed at 20% of the heliostat mirrors at Ivanpah during April and May 2014. Given the size range of the birds found, including many hummingbirds, swallows and warblers, I would predict that the overall adjustment rate for searcher detection and carcass persistence would be no greater than 20%. That means thenumber of fatalities found would be divided by 0.2 to arrive at an adjusted estimate of 473 fatalities per month within the search areas. This number then would be divided by 0.2 (corresponding with 20% of the project being searched) to extrapolate the fatality estimate to the rest of Ivanpah, yielding 2,365 birds per month during April and May 2014. If this rate persisted yearlong, then Ivanpah might be killing 28,380 birds, which would be 3.6 times greater than the fatality rate I predicted." This extremely high estimate is a cause for concern.

Weekly mortality searches at 20% coverage are also being conducted at the California Valley Solar Ranch (Harvey & Associates 2014b and 2014c). According to the information that could be sourced from the internet (two quarterly reports), 152 avian mortalities were reported for the period 16 November 2013 – 15 February 2014, and 54 for the period 16 February 2014 – 15 May 2014, of which approximately 90% were based on feathers spots which precluded a finding on the cause of death. These figures give an estimated unadjusted 1030 mortalities per year, which is obviously an underestimate as it does not include adjustments for carcasses removed by scavengers and missed by searchers. The authors stated clearly that these quarterly reports do not include the results of searcher efficiency trials, carcass removal trials, or data analyses, nor does it include detailed discussions.

In a report by the National Fish and Wildlife Forensic Laboratory (Kagan *et al.* 2014), the cause of avian mortalities was estimated based on opportunistic avian carcass collections at Ivanpah, Desert Sunlight and Genesis solar plants. The results of the investigation are tabled below:

Cause of Death	Ivanpah	Genesis	Desert Sunlight	Total
Solar Flux	47	0	0	47
Impact trauma	24	6	19	49
Predation trauma	5	2	15	22
Trauma of undetermined cause	14	0	0	14
Electrocution	1	0	0	1
Emaciation	1	0	0	1
Undetermined (remains in poor condition)	46	17	22	85
No evident cause of death	3	6	5	14
Total	141	31	61	233

Sheet glass used in commercial and residential buildings has been well established as a hazard for birds. A recent comprehensive review estimated between 365 – 988 million birds are killed annually in the USA due to collisions with glass panels (Loss *et al.* 2014). It is therefore to be expected that the solar panels and heliostats will constitute a similar risk to avifauna. A related problem is the so-called "lake effect" i.e. it seems very likely that reflections from solar facilities' infrastructure, particularly large sheets of dark blue photovoltaic panels, may well be attracting birds in flight across the open desert, who mistake the broad reflective surfaces for water (Kagan *et al.* 2014). This could either result in birds colliding directly with the solar panels, or getting stranded and unable to take off again because many aquatic species find it very difficult and sometimes impossible to take off from dry land e.g. grebes and cormorants. This exposes them to predation, even when if they do not get injured through direct collisions with the panels. The unusually high number of waterbird mortalities at all three facilities, which are all situated in extremely arid environments e.g. Desert Sunlight facility (44%), Genesis (19%) and Ivanpah (10%) seems to support this hypothesis. The proximity of the Orange River with its large populations of waterbirds to the Sand Draai site means that this might potentially turn out to be a problem, especially as far as the proposed PV site is concerned. Evaporative ponds would also likely increase the fatality rates as these ponds might attract birds, particularly waterbirds and sandgrouse which would in turn attract raptors such as Lanner Falcons and Southern Pale Chanting Goshawks, which would then come into proximity of the heliostat mirrors and the zone of solar flux.

Avian mortality due to solar flux has been previously reported by McCrary et al (1986) at the experimental Solar One facility. Solar flux related injuries to birds have so far only been reported at CSP plants with central receiver technology. From the evidence examined by Kagan *et al.* 2014, it seems that the mortality associated with solar flux results from the singeing of feathers. Severe singeing of flight feathers causes catastrophic loss of flight ability, leading to death by impact on the ground or other objects. Less severe singeing leads to impairment of flight abilities, reducing ability to forage, thermoregulate and evade predators, resulting in death by predation or starvation. Limited evidence of severe tissue burns were found and no eye damage was recorded (Kagan *et al.* 2014), indicating that death by acute hyperthermia is a relatively rare occurrence. It has been postulated that CSP plants with central receiver technology might be functioning as an ecological mega-traps in that they attract and kill species of multiple trophic layers. The strong light emitted by these facilities attract insects, which in turn attracts insect eating birds, which are incapacitated by solar flux injury, thus attracting predators and thus creating an entire food chain vulnerable to injury and death (Kagan *et al*. 2014). The latter scenario is a distinct possibility at the Sand Draai facility, which could impact on several endemic and near-endemic species.

6.2 Displacement due to habitat transformation and disturbance associated with the construction of the plant

The activities listed below are typically associated with the construction and operation of solar facilities and could have direct impacts on avifauna (County of Merced 2014):

- Preparation of solar panel areas for installation, including vegetation clearing, grading, cut and fill.
- Excavation/trenching for water pipelines, cables, fibre-optic lines, and the septic system.
- Construction of piers and building foundations.
- Construction of new dirt or gravel roads and improvement of existing roads.
- Temporary stockpiling and side-casting of soil, construction materials, or other construction
- wastes.
- Soil compaction, dust, and water runoff from construction sites.
- Increased vehicle traffic.
- Short-term construction-related noise (from equipment) and visual disturbance.
- Degradation of water quality in drainages and other water bodies resulting from project runoff.
- Maintenance of fire breaks and roads.
- Weed removal, brush clearing, and similar land management activities related to ongoing operation of the project.

These activities have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through disturbance and transformation of habitat, which could result in temporary or permanent displacement.

At Ivanpah solar plant, in addition to the facility monitoring, avian point count surveys and large raptor surveys were conducted. Seven avian use surveys were conducted using variable-radius point counts at each of 80 survey points, including 40 points in heliostat arrays and 40 points in desert bajada habitats. Estimated avian densities were 2.1 birds/hectare in the heliostat units and 10.2 birds/hectare in the offsite desert bajada habitats. Thus, while the vegetation in the heliostat arrays does provide habitat for some birds, it is evidently not as suitable or preferable to birds as the surrounding desert vegetation (Harvey *et al.* 2014 a). However, small birds are often capable of surviving in small pockets of suitable habitat, and are therefore generally less affected by habitat fragmentation than larger species. It is therefore likely that many smaller species will continue to use the habitat available within the solar facility albeit at lower densities. However, larger species which require contiguous, un-fragmented tracts of suitable habitat (e.g. large raptors, korhaans and bustards) are likely to be displaced in the area of the proposed plant.

6.3 Mortality on associated power line infrastructure

Negative impacts on birds by electricity infrastructure generally take two forms namely electrocution and collisions (Ledger and Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs and Ledger 1986a; Hobbs and Ledger 1986b; Ledger, Hobbs and Smith, 1992; Verdoorn 1996; Kruger and Van Rooyen 1998; Van Rooyen 1998; Kruger 1999; Van Rooyen 1999; Van Rooyen 2000; Van Rooyen 2004; Jenkins *et al* 2010). Birds also impact on the infrastructure through nesting and streamers, which can cause interruptions in the electricity supply (Van Rooyen *et al* 2002).

Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004). The electrocution risk is largely determined by the pole/tower design.

Collisions are probably the bigger threat posed by transmission lines to birds in southern Africa (van Rooyen 2004). Most heavily impacted upon are bustards, storks, cranes and various species of waterbirds. These species are mostly heavy-bodied birds with limited manoeuvrability, which makes it difficult for them to take the necessary evasive action to avoid colliding with power lines (van Rooyen 2004, Anderson 2001). In a recent PhD study, Shaw (2013) provides a concise summary of the phenomenon of avian collisions with power lines:

"The collision risk posed by power lines is complex and problems are often localised. While any bird flying near a power line is at risk of collision, this risk varies greatly between different groups of birds, and depends on the interplay of a wide range of factors (APLIC 1994). Bevanger (1994) described these factors in four main groups – biological, topographical, meteorological and technical. Birds at highest risk are those that are both susceptible to collisions and frequently exposed to power lines, with waterbirds, gamebirds, rails, cranes and bustards usually the most numerous reported victims (Bevanger 1998, Rubolini *et al*. 2005, Jenkins *et al*. 2010).

The proliferation of man-made structures in the landscape is relatively recent, and birds are not evolved to avoid them. Body size and morphology are key predictive factors of collision risk, with large-bodied birds with high wing loadings (the ratio of body weight to wing area) most at risk (Bevanger 1998, Janss 2000). These birds must fly fast to remain airborne, and do not have sufficient manoeuvrability to avoid unexpected obstacles. Vision is another key biological factor, with many collision-prone birds principally using lateral vision to navigate in flight, when it is the lower-resolution, and often restricted, forward vision that is useful to detect obstacles (Martin &

Shaw 2010, Martin 2011, Martin *et al*. 2012). Behaviour is important, with birds flying in flocks, at low levels and in crepuscular or nocturnal conditions at higher risk of collision (Bevanger 1994). Experience affects risk, with migratory and nomadic species that spend much of their time in unfamiliar locations also expected to collide more often (Anderson 1978, Anderson 2002). Juvenile birds have often been reported as being more collision-prone than adults (e.g. Brown *et al.* 1987, Henderson *et al.* 1996).

Topography and weather conditions affect how birds use the landscape. Power lines in sensitive bird areas (e.g. those that separate feeding and roosting areas, or cross flyways) can be very dangerous (APLIC 1994, Bevanger 1994). Lines crossing the prevailing wind conditions can pose a problem for large birds that use the wind to aid take-off and landing (Bevanger 1994). Inclement weather can disorient birds and reduce their flight altitude, and strong winds can result in birds colliding with power lines that they can see but do not have enough flight control to avoid (Brown *et al*. 1987, APLIC 1994).

The technical aspects of power line design and siting also play a big part in collision risk. Grouping similar power lines on a common servitude, or locating them along other features such as tree lines, are both approaches thought to reduce risk (Bevanger 1994). In general, low lines with short span lengths (i.e. the distance between two adjacent pylons) and flat conductor configurations are thought to be the least dangerous (Bevanger 1994, Jenkins et al. 2010). On many higher voltage lines, there is a thin earth (or ground) wire above the conductors, protecting the system from lightning strikes. Earth wires are widely accepted to cause the majority of collisions on power lines with this configuration because they are difficult to see, and birds flaring to avoid hitting the conductors often put themselves directly in the path of these wires (Brown *et al.* 1987, Faanes 1987, Alonso *et al*. 1994a, Bevanger 1994)."

A potential impact that is foreseen is collisions with the proposed overhead line. Quantifying this impact in terms of the likely number of birds that will be impacted, is very difficult because such a huge number of variables play a role in determining the risk, for example weather, rainfall, wind, age, flocking behaviour, power line height, light conditions, topography, population density and so forth. However, from incidental record keeping by the Endangered Wildlife Trust, it is possible to give a measure of what species are likely to be impacted upon (see Figure 2 below - Jenkins *et al* 2010). This only gives a measure of the general susceptibility of the species to power line collisions, and not an absolute measurement for any specific line.

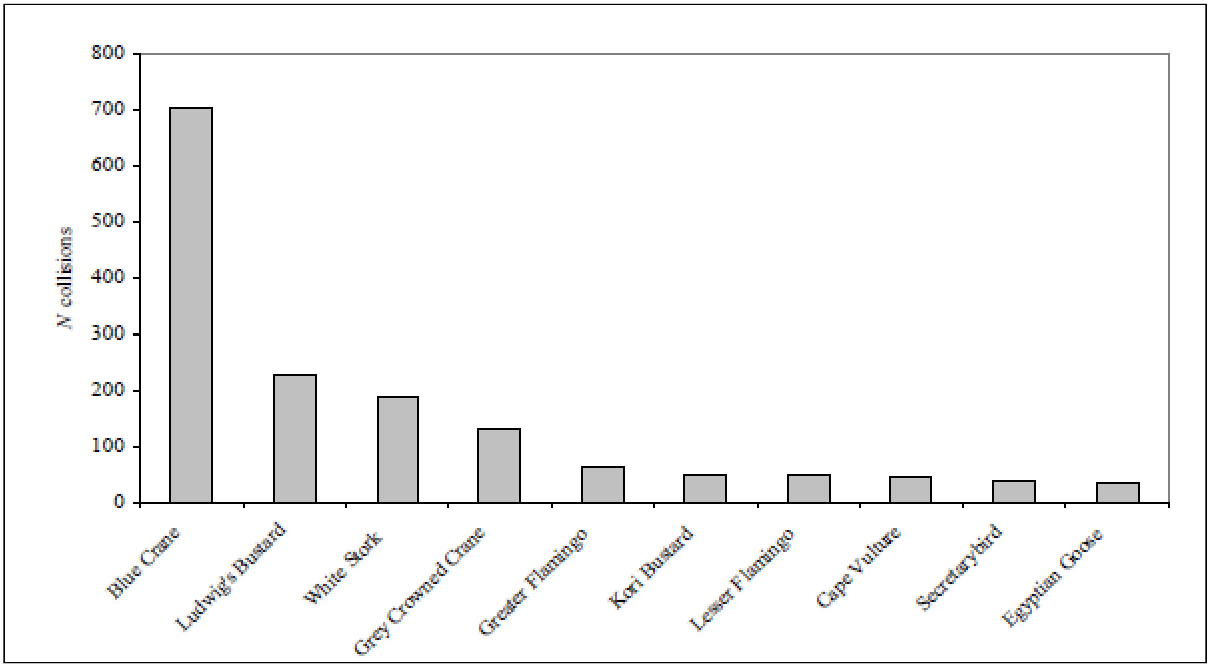

Figure 12: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins *et al* 2010)

The most likely candidates for collision mortality on the proposed power line are Ludwig's Bustards followed by Kori Bustards. Power line collisions are generally accepted as a key threat to bustards (Raab *et al.* 2009; Raab *et al.* 2010; Jenkins & Smallie 2009; Barrientos *et al.* 2012, Shaw 2013). In a recent study, carcass surveys were performed under high voltage transmission power lines in the Karoo for two years, and low voltage distribution lines for one year (Shaw 2013). Ludwig's Bustard was the most common collision victim (69% of carcasses), with bustards generally comprising 87% of mortalities recovered. Total annual mortality was estimated at 41% of the Ludwig's Bustard population, with Kori Bustards also dying in large numbers (at least 14% of the South African population killed in the Karoo alone). Karoo Korhaan was also recorded, but to a much lesser extent than Ludwig's Bustard. The reasons for the relatively low collision risk of this species probably include their smaller size (and hence greater agility in flight) as well as their more sedentary lifestyles, as local birds are familiar with their territory and are less likely to collide with power lines (Shaw 2013). Several factors are thought to influence avian collisions, including the manoeuvrability of the bird, topography, weather conditions and power line configuration. An important additional factor that previously has received little attention is the visual capacity of birds; i.e. whether they are able to see obstacles such as power lines, and whether they are they looking ahead to see obstacles with enough time to avoid a collision. In addition to helping explain the susceptibility of some species to collision, this factor is key to planning effective mitigation measures. Recent research provides the first evidence that birds can render themselves blind in the direction of travel during flight through voluntary head movements (Martin & Shaw 2010). Visual fields were determined in three bird species representative of families known to be subject to high levels of mortality associated with power lines i.e. Kori Bustards, Blue Cranes *Anthropoides paradiseus* and White Storks *Ciconia ciconia.* In all species the frontal visual fields showed narrow and vertically long binocular fields typical of birds that take food items directly in the bill under visual guidance. However, these species differed markedly in the vertical extent of their binocular fields and in the extent of the blind areas which project above and below the binocular fields in the forward facing hemisphere. The importance of these blind areas is that when in flight, head movements in the vertical plane (pitching the head to look downwards) will render the bird blind in the direction of travel. Such movements may frequently occur when birds are scanning below them (for foraging or roost sites, or for conspecifics). In bustards and cranes pitch movements of only 25° and 35° respectively are sufficient to render the birds blind in the direction of travel; in storks head movements of 55° are necessary. That flying birds can render themselves blind in the direction of travel has not been previously recognised and has important implications for the effective mitigation of collisions with human artefacts including wind turbines and power lines. These findings have applicability to species outside of these families especially raptors (Accipitridae) which are known to have small binocular fields and large blind areas similar to those of bustards and cranes, and are also known to be vulnerable to power line collisions.

Despite doubts about the efficacy of line marking to reduce the collision risk for bustards (Jenkins *et al.* 2010; Martin *et al.* 2010), there are numerous studies which prove that marking a line with PVC spiral type Bird Flight Diverters (BFDs) generally reduce mortality rates (e.g. Barrientos *et al.* 2011; Jenkins *et al.* 2010; Alonso & Alonso 1999; Koops & De Jong 1982), also to some extent for bustards (Barrientos *et al.* 2012). Beaulaurier (1981) summarised the results of 17 studies that involved the marking of earth wires and found an average reduction in mortality of 45%. A recent study (Barrientos *et al.* 2011) reviewed the results of 15 wire marking experiments in which transmission or distribution wires were marked to examine the effectiveness of flight diverters in reducing bird mortality. The presence of flight diverters was associated with a decrease in bird collisions. At unmarked lines, there were 0.21 deaths/1000 birds (n = 339,830) that flew among lines or over lines. At marked lines, the mortality rate was 78% lower (n = 1,060,746). Koops and De Jong (1982) found that the spacing of the BFDs were critical in reducing the mortality rates - mortality rates are reduced up to 86% with a spacing of 5 metres, whereas using the same devices at 10 metre intervals only reduces the mortality by 57%. Barrientos *et al.* (2012) found that larger BFDs were more effective in reducing Great Bustard collisions than smaller ones. Line markers should be as large as possible, and highly contrasting with the background. Colour is probably less important as during the day the background will be brighter than the obstacle with the reverse true at lower light levels (e.g. at twilight, or during overcast conditions). Black and white interspersed patterns are likely to maximise the probability of detection (Martin *et al.* 2010).

For Ludwig's Bustard, this risk is particularly relevant in Nama Karoo as it is the preferred habitat for the species in the study area. Ludwig's Bustard is highly vulnerable to power line collisions based on the species flight characteristics and tendency to fly long distances between foraging and roosting areas and when migrating. Movements by this species are triggered by rainfall (Allan 1994), and so are inherently erratic and unpredictable in this arid environment, where the quantity and timing of rains are highly variable between years. Hence, it is difficult to anticipate the extent to which Ludwig's Bustard may be exposed to collision risk, but the proposed alignments cross suitable habitat and the species is likely to be present in varying numbers, depending on foraging conditions. Kori Bustards could be at risk mostly in the Kalahari Savanna but also in Nama Karoo. Secretarybirds are also highly vulnerable to collisions. Water reservoirs are draw cards for a variety of birds, including raptors and vultures, and may therefore expose Red Data species i.e. Martial Eagles, Tawny Eagles and Lanner Falcons to collision risk if it is situated close to an alignment.

6.4 Other impacts

Sociable Weavers may try to nest on the plant infrastructure e.g. heliostats and electricity poles. Experience in this arid region has shown that Sociable Weavers are quick to nest on any man-made infrastructure. It is hoped that the constant movement of the heliostats and regular cleaning and maintenance activities will prevent this from becoming a problem – but close monitoring will still be required. Cape Sparrows will very likely attempt to nest underneath heliostats and solar panels to take advantage of the shade, but this should not adversely affect the operation of the equipment.

7. SENSITIVITY MAP

The study area is located in Western Arid, which is the endemic region with the highest number of endemics in southern Africa. With almost a quarter of all southern African endemics or near endemics potentially occurring in the study area, the study area as a whole should be regarded as moderately sensitive from an avifaunal perspective. Within the study area, potential high sensitive areas are surface water (water troughs) and high voltage lines, as both these micro-habitats are potential focal points of bird activity. Figure 13 below indicates areas of moderate and high sensitivity. It is important to note that the sensitivity of the study area will be influenced by the development itself, in that the construction of the power line and evaporation ponds will potentially create new areas of high sensitivity. The sensitivity map in Figure 13 is based on the current status quo.

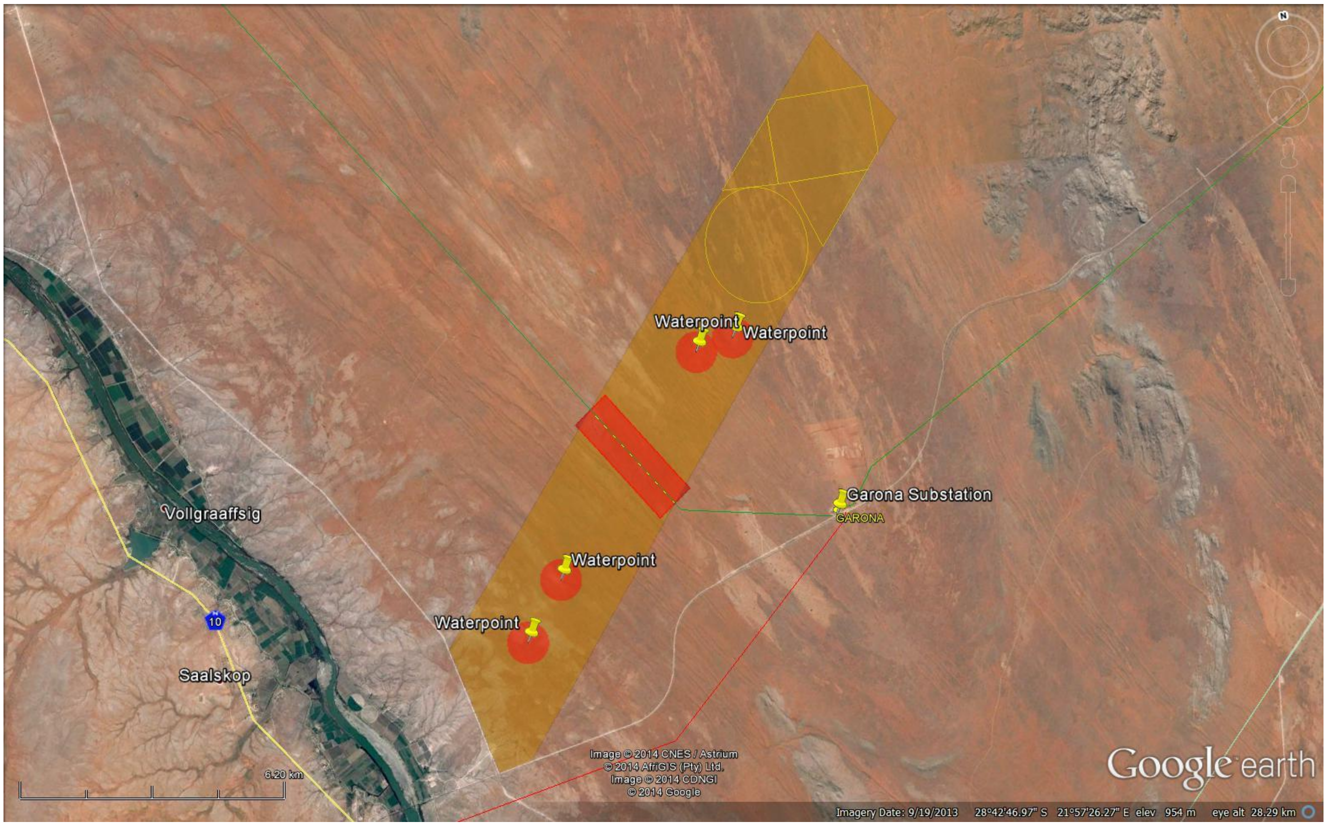

Figure 13: Sensitivity map of the study area. Yellow area indicates moderate sensitivity. Orange areas indicate potential high sensitivity subject to further investigations.

8. RECOMMENDATIONS

It is recommended that a pre-construction monitoring programme is implemented at the site as soon as possible to gather baseline data over a period of 12 months on the following aspects pertaining to avifauna:

- The abundance and diversity of birds at the solar facility and a suitable control site.
- Flight patterns of priority species at the solar facility.

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APPENDIX 1: SPECIES LISTS

Species	Scientific name	National Status	IUCN Red List	Endemic status
Barbet, Acacia Pied	*Tricholaema leucomelas*			
Barbet, Crested	*Trachyphonus vaillantii*			
Batis, Pririt	*Batis pririt*			*Near-endemic*
Bee-eater, Swallow-tailed	*Merops hirundineus*			
Bokmakierie	*Telophorus zeylonus*			*Near-endemic*
Brubru	*Nilaus afer*			
Bulbul, African Red-eyed	*Pycnonotus nigricans*			*Endemic*
Bunting, Cape	*Emberiza capensis*			*Near-endemic*
Bunting, Lark-like	*Emberiza impetuani*			*Near-endemic*
Bustard, Kori	*Ardeotis kori*	*NT*	*NT*	
Buttonquail, Kurrichane	*Turnix sylvaticus*			
Canary, Black-throated	*Crithagra atrogularis*			
Canary, White-throated	*Crithagra albogularis*			*Near-endemic*
Canary, Yellow	*Crithagra flaviventris*			*Near-endemic*
Chat, Anteating	*Myrmecocichla formicivora*			*Endemic*
Chat, Familiar	*Cercomela familiaris*			
Chat, Karoo	*Cercomela schlegelii*			*Near-endemic*
Chat, Tractrac	*Cercomela tractrac*			*Near-endemic*
Cisticola, Desert	*Cisticola aridulus*			
Cisticola, Grey-backed	*Cisticola subruficapilla*			
Courser, Double-banded	*Rhinoptilus africanus*	*NT*	*LC*	
Crombec, Long-billed	*Sylvietta rufescens*			
Crow, Cape	*Corvus capensis*			
Crow, Pied	*Corvus albus*			
Cuckoo, Diderick	*Chrysococcyx caprius*			
Dove, Laughing	*Streptopelia senegalensis*			
Dove, Namaqua	*Oena capensis*			
Dove, Red-eyed	*Streptopelia semitorquata*			
Eagle, Booted	*Aquila pennatus*			
Eagle, Martial	*Polemaetus bellicosus*	*EN*	*VU*	
Eagle, Verreaux's	*Aquila verreauxii*	*VU*	*LC*	
Eagle-Owl, Spotted	*Bubo africanus*			
Eremomela, Yellow-bellied	*Eremomela icteropygialis*			
Falcon, Lanner	*Falco biarmicus*	*VU*	*LC*	
Falcon, Pygmy	*Polihierax semitorquatus*			
Finch, Red-headed	*Amadina erythrocephala*			*Near-endemic*
Finch, Scaly-feathered	*Sporopipes squamifrons*			*Near-endemic*

Species	Scientific name	National Status	IUCN Red List	Endemic status
Fiscal, Common	*Lanius collaris*			
Flycatcher, Chat	*Bradornis infuscatus*			*Near-endemic*
Flycatcher, Fairy	*Stenostira scita*			*Endemic*
Flycatcher, Fiscal	*Sigelus silens*			*Endemic*
Goose, Egyptian	*Alopochen aegyptiacus*			
Goshawk, Southern Pale Chanting	*Melierax canorus*			*Near-endemic*
Guineafowl, Helmeted	*Numida meleagris*			
Heron, Black-headed	*Ardea melanocephala*			
Honeyguide, Lesser	*Indicator minor*			
Hoopoe, African	*Upupa africana*			
Kestrel, Greater	*Falco rupicoloides*			
Kestrel, Rock	*Falco rupicolus*			
Kingfisher, Brown-hooded	*Halcyon albiventris*			
Kite, Black-shouldered	*Elanus caeruleus*			
Korhaan, Karoo	*Eupodotis vigorsii*	*NT*	*LC*	*Endemic*
Korhaan, Northern Black	*Afrotis afraoides*			*Endemic*
Korhaan, Red-crested	*Lophotis ruficrista*			
Lapwing, Crowned	*Vanellus coronatus*			
Lark, Eastern Clapper	*Mirafra fasciolata*			
Lark, Fawn-coloured	*Calendulauda africanoides*			
Lark, Karoo Long-billed	*Certhilauda subcoronata*			*Endemic*
Lark, Sabota	*Calendulauda sabota*			*Near-endemic*
Lark, Spike-heeled	*Chersomanes albofasciata*			*Near-endemic*
Martin, Rock	*Hirundo fuligula*			
Mousebird, Red-faced	*Urocolius indicus*			
Mousebird, White-backed	*Colius colius*			*Endemic*
Nightjar, Rufous-cheeked	*Caprimulgus rufigena*			
Ostrich, Common	*Struthio camelus*			
Owl, Barn	*Tyto alba*			
Owlet, Pearl-spotted	*Glaucidium perlatum*			
Pigeon, Speckled	*Columba guinea*			
Pipit, African	*Anthus cinnamomeus*			
Prinia, Black-chested	*Prinia flavicans*			*Near-endemic*
Quail, Common	*Coturnix coturnix*			
Quelea, Red-billed	*Quelea quelea*			
Sandgrouse, Burchell's	*Pterocles burchelli*			*Near-endemic*
Sandgrouse, Namaqua	*Pterocles namaqua*			*Near-endemic*
Scimitarbill, Common	*Rhinopomastus cyanomelas*			
Scrub-Robin, Kalahari	*Cercotrichas paena*			*Near-endemic*

Species	Scientific name	National Status	IUCN Red List	Endemic status
Scrub-Robin, Karoo	*Cercotrichas coryphoeus*			*Endemic*
Secretarybird	*Sagittarius serpentarius*	*VU*	*VU*	
Shrike, Crimson-breasted	*Laniarius atrococcineus*			*Near-endemic*
Sparrow, Cape	*Passer melanurus*			*Near-endemic*
Sparrow, House	*Passer domesticus*			
Sparrow, Southern Grey-headed	*Passer diffusus*			
Sparrowlark, Grey-backed	*Eremopterix verticalis*			*Near-endemic*
Sparrow-Weaver, White-browed	*Plocepasser mahali*			
Starling, Cape Glossy	*Lamprotornis nitens*			
Starling, Wattled	*Creatophora cinerea*			
Sunbird, Dusky	*Cinnyris fuscus*			*Near-endemic*
Swallow, Barn	*Hirundo rustica*			
Swallow, Red-breasted	*Hirundo semirufa*			
Swift, Alpine	*Tachymarptis melba*			
Swift, Bradfield's	*Apus bradfieldi*			
Swift, Horus	*Apus horus*			
Swift, Little	*Apus affinis*			
Swift, White-rumped	*Apus caffer*			
Tchagra, Brown-crowned	*Tchagra australis*			
Thick-knee, Spotted	*Burhinus capensis*			
Tit, Ashy	*Parus cinerascens*			*Near-endemic*
Tit-Babbler, Chestnut-vented	*Parisoma subcaeruleum*			
Tit-Babbler, Layard's	*Parisoma layardi*			*Endemic*
Turtle-Dove, Cape	*Streptopelia capicola*			
Vulture, Lappet-faced	*Torgos tracheliotus*	*EN*	*VU*	
Vulture, White-backed	*Gyps africanus*	*EN*	*EN*	
Wagtail, Cape	*Motacilla capensis*			
Warbler, Namaqua	*Phragmacia substriata*			*Endemic*
Warbler, Rufous-eared	*Malcorus pectoralis*			*Endemic*
Waxbill, Black-faced	*Estrilda erythronotos*			
Waxbill, Common	*Estrilda astrild*			
Waxbill, Violet-eared	*Granatina granatina*			
Weaver, Sociable	*Philetairus socius*			*Endemic*
Wheatear, Capped	*Oenanthe pileata*			
Whydah, Pin-tailed	*Vidua macroura*			
Woodpecker, Cardinal	*Dendropicos fuscescens*			
Woodpecker, Golden-tailed	*Campethera abingoni*			