BIRD IMPACT ASSESSMENT

BASELINE REPORT

BOTSWANA-SOUTH AFRICA (BOSA)

TRANSMISSION INTERCONNECTION PROJECT

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PROFESSIONAL EXPERIENCE

Chris van Rooyen

Chris has 20 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 100 power line and 25 wind generation 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 (2015) 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.

Megan Diamond

Megan completed a Bachelor of Science degree in Environmental Management from the University of South Africa and has been involved in conservation for 18 years. She has ten years' experience in the field of bird interactions with electrical infrastructure (both linear and footprint) and during this time has completed impact assessments for at least 80 projects. In various roles (including Programme Manager) with the Endangered Wildlife Trust's Wildlife & Energy Programme and the Programme's primary project (Eskom-EWT Partnership) from 2006 to 2013, Megan was responsible for assisting the energy industry and the national utility in minimising the negative impacts (associated with electrical infrastructure) on wildlife through the provision of strategic guidance, risk and impact assessments, training and research. Megan currently owns and manages *Feathers Environmental Services* and is tasked with providing strategic guidance to industry through the development of best practice procedures and guidelines, reviewing and commenting on methodologies, specialist studies and EIA reports for Renewable Energy projects as well as providing specialist avifaunal input into renewable energy and power line developments within South Africa, elsewhere in Africa and across the globe. In addition, Megan has attended and presented at several conferences and facilitated workshops, as a subject expert, since 2007. Megan is a co-author of the *BirdLife South Africa / Endangered Wildlife Trust best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa* and the *Avian Wind Farm Sensitivity Map for South Africa* (2015) and played an instrumental role in facilitating the endorsement of these two products by the South African Wind Energy Association (SAWEA), IAIAsa (International Association for Impact Assessment South Africa) and Eskom. In 2011/2012, she chaired the Birds and Wind Energy Specialist Group in South Africa. From 2013 to 2015, Megan chaired the IUCN/SSC Crane Specialist Group's Crane and Powerline Network, a working group comprised of subject matter experts from across the world, working in partnership to share lessons, develop capacity, pool resources, and accelerate collective learning towards finding innovative solutions to mitigate this impact on threatened crane populations.

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 the Environmental Impact Assessment for the proposed Botswana-South Africa (BOSA) Transmission Interconnection Project, other than fair remuneration for the specialist investigations completed in a professional capacity as specified by the Environmental Impact Assessment Regulations, 2014.

Full Name: Chris van Rooyen
Title / Position: Director

EXECUTIVE SUMMARY

This baseline report discusses the potential interactions between avifauna and the proposed Botswana-South Africa (BOSA) Transmission Interconnection Project which requires the construction of approximately 220 km of 400kV transmission power line between the existing Isang substation, located approximately 40km north of Gaborone in Botswana and the proposed Watershed B substation in South Africa's North-West Province.

During the inception phase, the project team followed a structured, systematic and comprehensive process that would enable the identification of the most viable corridors, to be evaluated by means of a Multi Criteria Decision Making process. Based on the evaluation of several criteria, the resultant combined relative priority score and the preference ranking assigned to each of the identified five corridor options, corridor Option C emerged as the preferred alternative for more detailed assessment.

A combined total of at least 462 bird species have been recorded within the relevant SABAP2 pentads covering the broader area in both countries. The presence of these species in the broader area provides an indication of the diversity of species that could potentially occur along the proposed power line route. A total of 97 power line sensitive species have been recorded in the broader area during the SABAP2 atlassing period to date. In general, the habitat in which the proposed BOSA 400kV power line corridor (Option C) is located is moderately sensitive from a potential bird impact perspective. The intact natural habitats are likely to support a diversity of Red List power line sensitive species. However, there is evidence of anthropogenic impacts in some parts of the broader area, particularly in the form of urbanisation, cultivation and pastoral activities which is visible in the disturbed state of the natural habitat. The levels of disturbance associated with these land use practices are likely to be high and have therefore had a negative impact on avifaunal diversity and abundance reflected in the low reporting rates for the majority of the power line sensitive Red List species.

Potential impacts that were identified related to the construction and operation of the proposed power line include collision of large terrestrial birds, vultures and raptors with overhead power line and displacement as a result of habitat transformation and disturbance.

At this early stage of the assessment process, the confidence with which the potential impacts have been predicted is moderate given the absence of primary data which still has to be gathered by means of a field visit. The following impacts needs further investigation:

- Collisions of Red List species with the earthwire of the proposed powerline;
- Displacement of Red List species due to disturbance and habitat transformation associated with the construction of the powerline

The investigations will take the form of a site visit to record data at selected areas identified beforehand through the study of aerial imagery of the entire 2km corridor, which is currently being collected by means of an aerial survey.

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1 INTRODUCTION

1.1 Background

Over the last decade, excess electricity generation across the Southern African Development Community (SADC) region has diminished quite substantially and many regional transmission lines are now congested. In order to provide a high-quality supply of electricity to meet the ever-increasing needs of its end users and stimulate regional development and economic growth, the Southern African Power Pool (SAPP) is tasked with coordinating the activities of power utilities in the SADC region and facilitating the development of new generation and transmission facilities.

One of the identified and planned initiatives is the Botswana-South Africa (BOSA) Transmission Interconnection Project, which requires the construction of approximately 220 km of 400kV transmission power line between the existing Isang substation, located approximately 40km north of Gaborone in Botswana and the proposed Watershed B substation in South Africa's North-West Province. The construction of the proposed power line will support the restructuring and strengthening of a high voltage transmission system to improve and intensify power transfers, stability and regional trade within the SAPP network.

The SAPP Coordination Centre (on behalf of Eskom of South Africa and Botswana Power Corporation of Botswana), as the designated project coordinator and contracting authority, has appointed Aurecon South Africa (Pty) Ltd (hereinafter referred to as Aurecon) as the lead consultant to provide advisory services that will encompass the project development cycle, including the necessary Environmental and Social Impact Assessments for the proposed BOSA Transmission Interconnection Project. Aurecon has appointed Chris van Rooyen Consulting to compile this specialist avifaunal baseline report that details the sensitive bird habitats within the study area and the potential bird related impacts associated with the proposed power line project.

1.2 Selection of a Preferred Power Line Alternative

Identifying suitable power line route alternatives from one point to another is an essential component of any power line development project. Ideally, the routing for an overhead electricity transmission line should follow a straight line, traverse over flat terrain with no obstacles and avoid sensitive areas or other constraints. Since meeting all these criteria is seldom possible, selecting the best route must aim to minimise the impacts on the environment and people, while accommodating the technical and financial challenges.

During the inception phase, the project team followed a structured, systematic and comprehensive process that would enable the identification of a range of potential route alignment corridors. Several factors that typically influence the selection of potential transmission line routes (i.e. the presence of towns, settlements, other infrastructure, protected areas, waterbodies, land cover, places of interest, contours and environmental and heritage constraints) were considered and used to inform potential route alignment corridors. Nineteen potential sites were identified. Further analysis resulted in five corridors (Figure 1) being selected as the most viable corridors, that were evaluated during a Multi Criteria Decision Making (MCDM) workshop, held on 25 May 2016. The MCDM process prioritised the five corridor options against a set of criteria, considered to have most relevance to the selection of the route alignment corridors based on specialist input. The criteria were grouped into four main categories (i.e. Technical, Environmental, Social and Strategic) and weighted accordingly to ensure that those criteria considered to be more important in terms of site selection were given more significance in the site selection process.

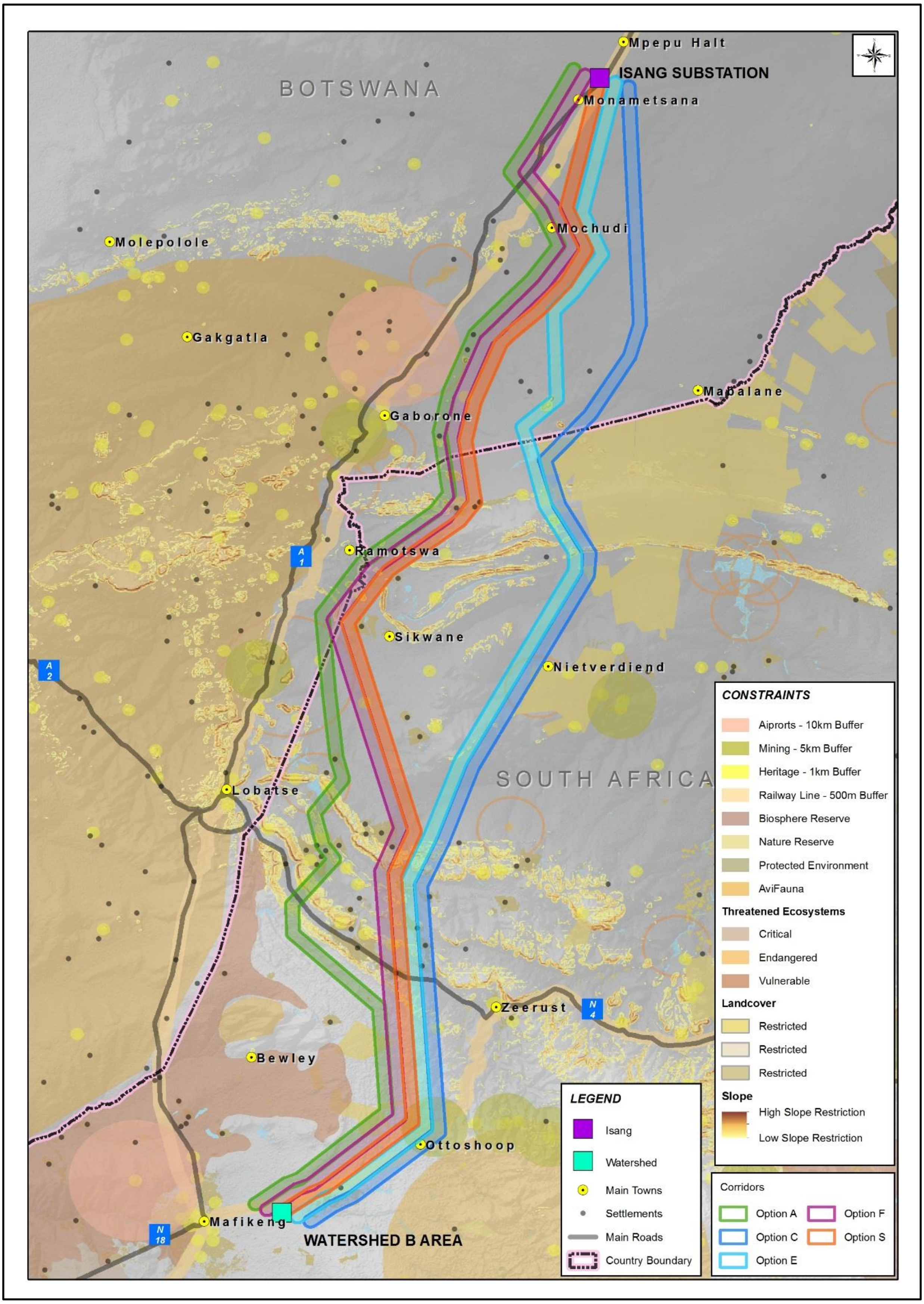

Figure 1. Regional map detailing the location of the five corridor options evaluated in the MCDM process (Aurecon, 2016)

One of the main considerations for high voltage lines is possible bird collision impact with the overhead conductors and earth wires. Breeding, roosting and feeding areas and migration routes all influence where high avifaunal activity is likely to occur and which areas will be most sensitive in terms of avifauna. An avian sensitivity map was compiled prior to the MCDM workshop detailing 1) no-go areas which should be avoided i.e. vulture colonies, nest locations, Important Bird Areas, vulture restaurants and water bodies and 2) areas of high sensitivity which should be avoided if possible i.e. protected areas and high vulture flight activity. These areas are delineated in Figure 1, in addition to other environmental, technical and social constraints. During the MCDM workshop, the following areas of high avifaunal activity were considered when ranking the corridor options in their order of preference (Table 1.1):

- Proximity to vulture breeding areas
- Proximity to Important Bird Areas (IBAs)
- Proximity to dams (avifaunal focal points)
- Proximity to vulture restaurants (avifaunal focal points)
- Proximity to protected areas

Table 1.1: Preference ratings per category and criterion 1=most favoured and 5=least favoured (Aurecon, 2016)

Category	Criteria	A	C	E	F	S
Technical (Inc. Financial)	Te1. Slope	3	1	1	2	2
	Te2. Access	3	1	1	2	2
	Te3. Length	5	1	2	4	3
	Te4. Width	1	2	2	3	3
Environmental	En1. Biodiversity	4	2	1	3	3
	En3. Avifauna	3	1	1	2	2
Social	So1. Heritage	5	4	1	3	2
	So2. Compensation	5	1	2	4	3
	So3. Social	5	1	2	4	3
	So4. Visual	5	1	2	4	3
Strategic	St1. Proximity	2	1	1	2	2

Based on the evaluation of each of the abovementioned criteria, the resultant combined relative priority score and the preference ranking assigned to each of the five corridor options, corridor Option C emerged as the preferred alternative for more detailed assessment.

2 BRIEF

The terms of reference for this baseline report are as follows:

- Describe the affected environment and avifauna in the broader area, with a particular focus on regionally and globally Red List species.
- Identify and discuss potential impacts of the proposed project on regionally and globally Red List avifauna during construction and operation.
- Identify information gaps and limitations.

- Identify those impacts that will require detailed investigation in the assessment phase.

3 STUDY APPROACH

3.1 Sources of information

This study made use of the following data sources:

- Bird distribution data of the South African Bird Atlas 2 (SABAP 2) was obtained from the Animal Demography Unit of the University of Cape Town, as a means to ascertain which species occur within the broader area i.e. within a block consisting of 189 pentad grid cells within which the study area is situated. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is approximately 8 × 7.6 km. Between 2007 and 2015, a total of 725 full protocol cards (i.e. 725 bird surveys lasting a minimum of two hours each) have been completed for the study area and its immediate surrounds;
- The Southern African Bird Atlas 1 (SABAP1) (Harrison *et al.* 1997) was used as a supplementary source of information in that it provided information on the historical occurrence of birds in the study area;
- Bird Atlas of Botswana (Penry, 1994) was consulted as a supplementary source of information in that it provided information on the historical occurrence of birds in the study area;
- The Important Bird Areas project data was consulted to get an overview of important bird areas (IBAs) and species diversity in the South African portion of the study area (Marnewick *et al*. 2015 and Barnes, 1998);
- The BirdLife International (2017) Country profile: Botswana was consulted for information on Important Bird Areas in the Botswana portion of the study area.
- The Co-ordinated Waterbird Count (CWAC) data was consulted determine if large concentrations of water birds, associated with South African wetlands, may occur within the study area (http://cwac.adu.org.za/).
- The conservation status of all species considered likely to occur in the area was determined as per the most recent iteration of the 2015 Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor *et al*. 2015) and the IUCN Red List of Threatened Species (http://www.iucnredlist.org/) and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005). This information was further supplemented with the draft Red Data List of Birds in Botswana, compiled by the Botswana Bird Club (Tyler & Borello 2000).
- Vulture movement data for the area, received from VULPRO, dated 2013 to 2016;
- The power line bird mortality incident database of the Endangered Wildlife Trust (1996 to 2007) was consulted to determine which of the species occurring in the study area are typically impacted upon by power lines (Jenkins *et al.* 2010);
- Data on vegetation types in the study area was obtained from the Vegetation Map of South Africa, (Mucina & Rutherford 2006) and the Provisional Vegetation Map of Botswana (Weare & Yalala, 2009);
- High resolution Google Earth ©2016 imagery was used to further examine the micro habitats within the study area;
- The status of biodiversity in Botswana was obtained from the Selected Botswana Biodiversity Indicators 2011 (Botswana Government, 2012);
- Personal observations, especially experience from other projects which the authors have completed in both South Africa and Botswana since 1996, have also been used to supplement the data that is available from SABAP2, and has been used extensively in forming a professional opinion of likely bird/habitat associations; and
- Maps and shapefiles detailing the location of the proposed power line corridor option C were obtained from Aurecon.

3.2 Methods

The following methodology was employed to compile this report:

- The study area was defined as a 2km buffer around the proposed corridor (Figure 2). The broader area refers to an area of approximately 50km around the proposed alignment.
- The various data sets listed above were collected and examined at a desktop level to determine the location and abundance of sensitive avifauna that may be vulnerable to the impacts associated with the proposed power line development, with particular focus on threatened species.
- Bird habitat classes, particularly those areas where high avifaunal activity is likely to occur, were identified using various GIS (Geographic Information System) layers and Google Earth ©2016 imagery.
- The impacts of the proposed development on birds were predicted on the basis of experience in gathering and analysing data on avian impacts with various forms of linear infrastructure and developments in southern Africa since 1996.

3.3 Assumptions & limitations

- This baseline study is based on a **desktop assessment** of the proposed development area. No site visit or long-term monitoring was conducted by the avifaunal specialist and it therefore relies heavily upon secondary data sources with regards to bird abundances.
- Coverage by SABAP2 has not been extensive, for the majority of the pentads through which the proposed corridor traverses. Only two pentads have been surveyed on multiple occasions with a total of 125 and 134 full protocol data cards being completed for each pentad respectively. Although an additional seven pentads have been surveyed on 15 or more occasions, sufficient data is not yet readily available for the remainder of the 180 pentads. During the EIA phase a site visit will be conducted whereby the status of the available avifaunal habitats will be confirmed and primary data on bird species presence will be collected on site as far as possible.
- The authors have worked extensively on avifaunal impact assessments in various parts of southern Africa since 1996. Personal observations and past experience have therefore been used to supplement the secondary data sources and in identifying likely bird/habitat associations related to the proposed BOSA Transmission Interconnection Project.
- Predictions in this study are based on experience of these and similar species in different parts of southern Africa. Bird behaviour can never be entirely reduced to formulas that will hold true under all circumstances. Therefore, professional judgment based on extensive field experience, played an important role in this assessment. It should also be noted that the impact of power lines on birds has been well researched with a robust body of published research stretching over thirty years.

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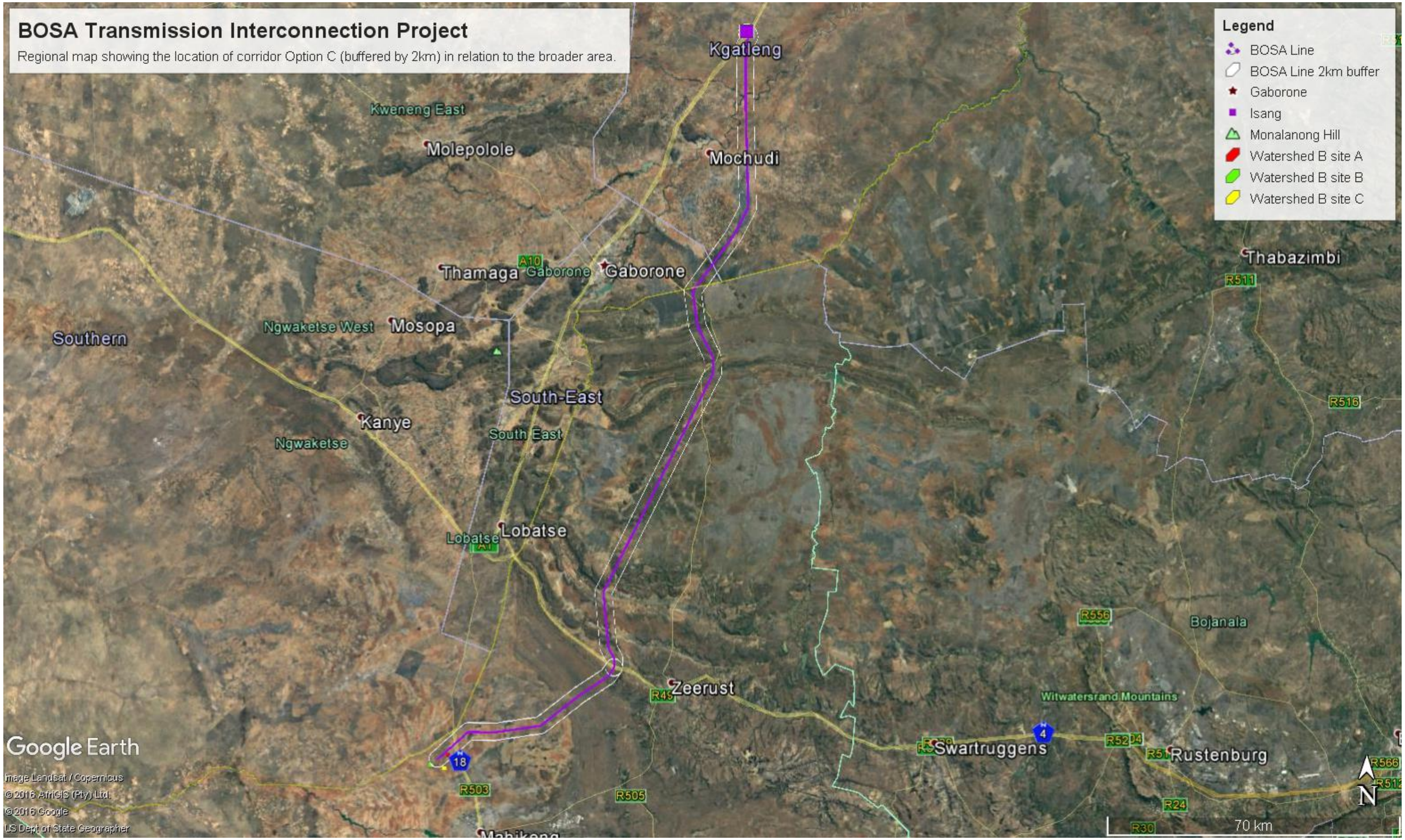

Figure 2: Regional map showing the location of corridor Option C (buffered by 2km) in relation to the broader area.

Proposed BOSA 400kV power line corridor Option C = purple line

2km Buffer = white polygon

4 STUDY AREA

4.1 Important Bird Areas (IBAs)

Some sites are exceptionally important for maintaining the taxa dependent upon the habitats and ecosystems in which they occur. Vigorous protection of the most critical sites is one important approach to conservation. Many species may be effectively conserved by this means. Patterns of bird distribution are such that, in most cases, it is possible to select sites that support many species. These sites, carefully identified on the basis of the bird numbers and species complements they hold, are termed Important Bird Areas (IBAs). IBAs are selected such that, taken together, they form a network throughout the species' biogeographic distributions. IBAs are key sites for conservation – small enough to be conserved in their entirety and often already part of a protected-area network.

4.1.1 South Africa

The proposed BOSA 400kV power line does not traverse across an IBA. However, one IBA does occur within the broader area i.e. the Botsalano Nature Reserve (SA024).

Botsalano Nature Reserve is located approximately 40km north of central Mahikeng, near the border with Botswana and is the closest IBA to the proposed power line (approximately 15km). Habitat within the reserve consists of elements of both the Grassland and the Savanna biomes and consequently support both grassland and woodland dependent bird species. The area is of particular interest from an ornithological point of view as it is one of very few reserves in South Africa that holds the western population of the Short-clawed Lark *Certhilauda chuana*. It is also one of the few reserves in which Melodious Lark *Mirafra cheniana* can be found. The open grassland flats are also known to periodically support Yellow-throated Sandgrouse *Pterocles gutturalis*. The surrounding woodland–grassland mosaic is known to hold Secretarybird *Sagittarius serpentarius*, Kori Bustard *Ardeotis kori* and a diversity of small woodland passerines e.g. Monotonous Lark *Mirafra passerina*, Pied Babbler *Turdoides bicolor*, White-throated Robin-chat *Cossypha humeralis*, Kalahari Scrub Robin *Erythropygia paena*, Burnt-necked Eremomela *Eremomela usticollis*, Barred Wren-Warbler *Calamonastes fasciolatus*, Marico Flycatcher *Melaenornis mariquensis*, Crimson-breasted Shrike *Laniarius atrococcineus*, Southern White-crowned Shrike *Eurocephalus anguitimens*, Burchell's Starling *Lamprotornis australis*, Scaly-feathered Finch *Sporopipes squamifrons*, Violet-eared Waxbill *Uraeginthus granatinus*, Black-faced Waxbill *Estrilda erythronotos*, Shaft-tailed Whydah *Vidua regia*. Dusky Lark *Pinarocorys nigricans* and Tinkling Cisticola *Cisticola rufilatus*. The reserve's proximity to Botswana, with its extensive rural landscape management, means that a number of globally threatened species regularly occur within the reserve i.e. Lappet-faced Vulture *Torgos tracheliotus* (five active nests were spotted during the aerial count in mid-August 2014), breeding White-backed Vulture *Gyps africanus,* as well as Cape Vulture *Gyps coprotheres*. raptors feature prominently, with Martial Eagle *Polemaetus bellicosus*, Bateleur *Terathopius ecaudatus*, Tawny Eagle *Aquila rapax*, Wahlberg's Eagle *Aquila wahlbergi*, African Hawk Eagle *Aquila spilogaster*, Brown Snake Eagle *Circaetus cinereus*, Black-chested Snake Eagle *Circaetus pectoralis* and Lanner Falcon *Falco biarmicus* all occurring in good numbers (Marnewick *et al.* 2015).

4.1.2 Botswana

The proposed BOSA 400kV power line does not traverse across an IBA. However, two IBAs do occur within the broader area i.e. Mannyelanong Hill (BW007) and the southeast Botswana site (BW011) located between 15km and 50km west of the proposed BOSA 400kV power line.

Mannyelanong Hill lies south-east of the village of Otse in the hardveld of south-east Botswana, with its undulating plains and scattered rocky hill ranges. The cliff and its lower wooded slope is fenced off to serve as a sanctuary for the important nesting population of Cape Vulture, one of only two localities currently used by this species in Botswana. Despite significant declines (45%) in breeding population numbers between 1963 and 1982, the following decade saw this population stabilise at around 50 pairs breeding per season. The current population consists of about 70 breeding pairs, and is now one of Botswana's largest vulture colonies. One pair of Black Stork *Ciconia nigra* nests on the cliffs; the nest-site has been used in most seasons since 1941. Verreaux's Eagle *Aquila verreauxi* also breeds on the Mannyelanong cliffs, together with Lanner Falcon and Rock Kestrel *Falco rupicolus* (BirdLife International, 2017).

The South-east Botswana IBA is an extensive 750 000ha area that is comprised of Pitsane grasslands as well as mixed savanna, low rolling hills and farmland. This IBA was established on the occurrence of an important population of the restricted-range Short-clawed Lark *Certhilauda chuana*, which is prevalent and locally abundant in the area (approximately 70% of the Botswanan population, comprising 8,000–10,000 birds). In addition, Blue Crane *Anthropoides paradisea* are regularly seen at or near Kgoro Pan and may breed nearby, whilst Lesser Kestrel *Falco naumanni* and Pallid Harrier *Circus macrourus* frequently hunt over the grasslands in the austral summer. Cape Vultures from the breeding colony at Mannyelanong Hill, Kori Bustard, Secretarybird and Black Stork all forage over this area. The site also supports a number of species which occur in Botswana only, or mainly, in this south-east corner; these include Orange River Francolin *Francolinus levaillantoides*, White-bellied Korhaan *Eupodotis cafra* (two records only), Cape Longclaw *Macronyx capensis* and Long-tailed Widowbird *Euplectes progne*. There are a few records of Burchell's Courser *Cursorius rufus*, now rare in Botswana. A wide range of species restricted to the Kalahari–Highveld biome occur, including Sociable Weaver *Philetairus socius* which breeds, other than in the Kalahari in south-west Botswana, only in an isolated population in the Pitsane grasslands. The Palearctic migrant Olivetree Warbler *Hippolais olivetorum* is not uncommon throughout much of the site (BirdLife International 2017).

The aforementioned IBAs are located within close proximity to the study area, particularly for wide ranging species like vultures. Although the proposed BOSA 400kV power line will not have any direct impact on the IBAs and the species they support in terms displacement through habitat transformation and/or disturbance, species that may engage in nomadic movements (i.e. Kori Bustard and Secretarybird) and vultures that are likely to forage within the study area and in close proximity to the proposed power line, may be susceptible to the collision impact. In a recent publication, Cape Vulture movement patterns and core foraging ranges were found to be closely associated with the spatial distribution of transmission power lines (Figure 3) and that the construction of power lines may contribute to the range expansion of the species to areas that lack suitable perching substrates (Phipps *et al.*, 2013). The vultures' ability to traverse vast distances and the high proportion of time they spend foraging outside protected areas and particularly in the vicinity of power lines makes them especially vulnerable to negative interactions with the expanding power line network across the region. VulPro, a South African NGO dedicated to the conservation of vultures, regularly deploys tracking devices on vultures to ascertain the foraging ranges of the species. Tracking data from five Cape Vultures over the period 2012 to date confirms that they regularly forage and roost in the study area, both in South Africa and Botswana (Figure 4).

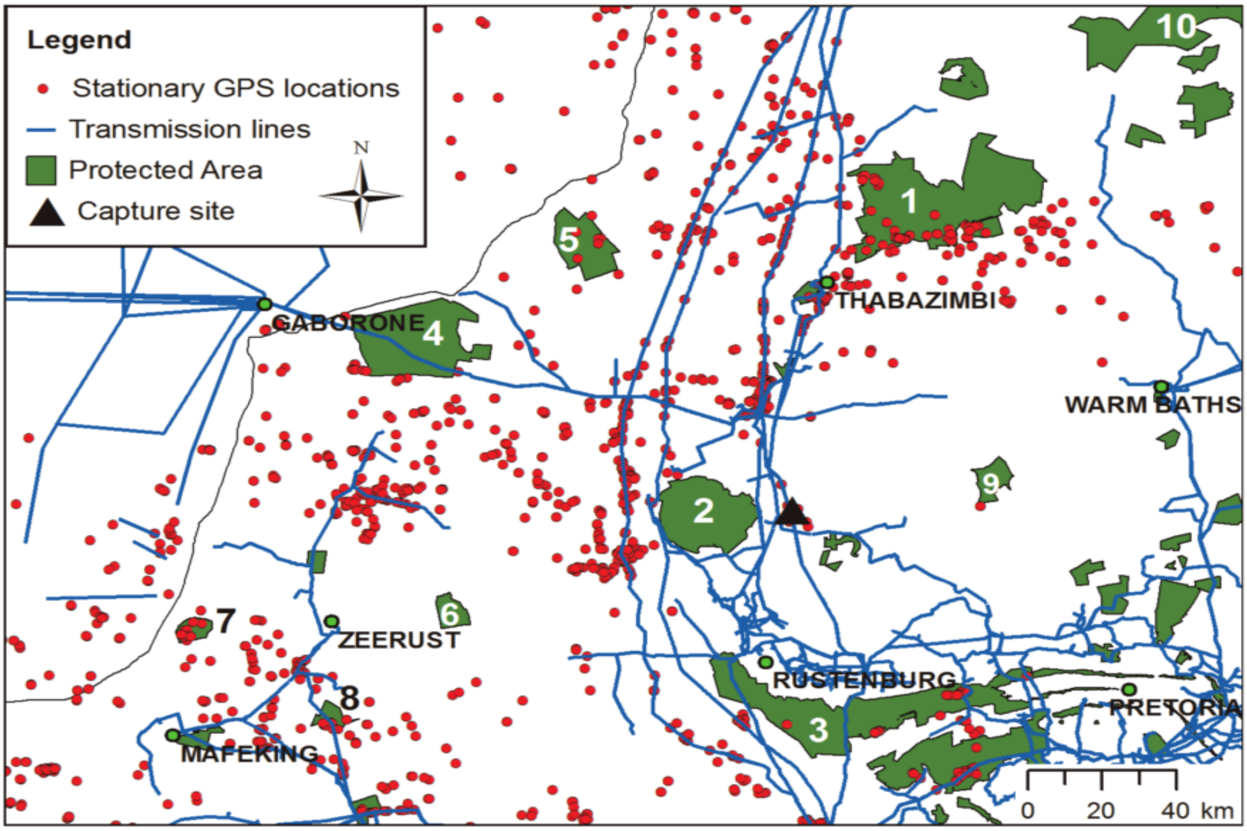

Figure 3. Stationary GPS locations of satellite tracked Cape Vultures in relation to protected areas and transmission power lines in the northern provinces of South Africa (Phipps *et al*, 2013).

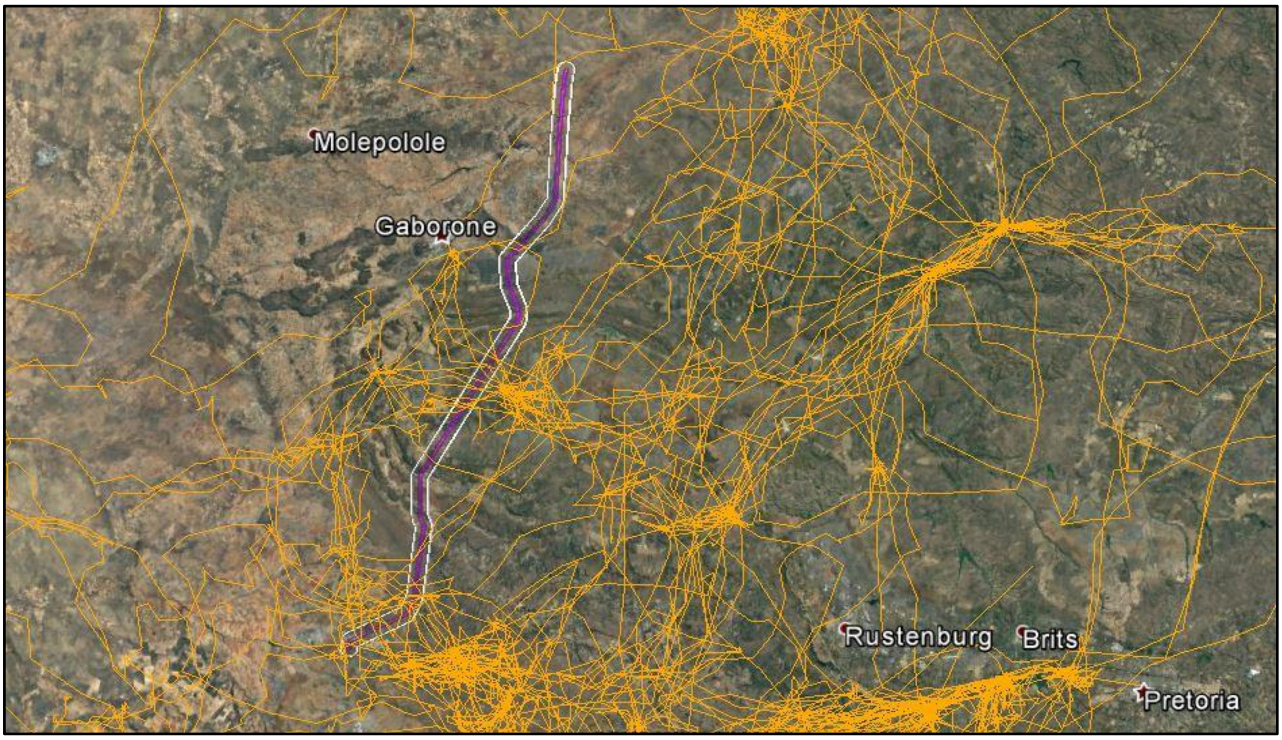

Figure 4. Flight activity of five Cape Vultures tracked with satellite devices between 2012 and 2016.
Vulture flight activity = orange lines
Proposed BOSA 400kV power line corridor Option C = purple line
2km Buffer = white polygon

4.2 Coordinated Waterbird Count (CWAC) Data (South Africa only)

A CWAC site is any body of water, other than the oceans, which supports a significant number (set at approximately 500 individual waterbirds, irrespective of the number of species) of birds which use the site for feeding, and/or breeding and roosting (Harrison *et al*. 2004). This definition includes natural pans, vleis, marshes, lakes, rivers, as well as a range of manmade impoundments (i.e. sewage works). The presence of a CWAC site within the study area is an indication of a large number of bird species occurring there and the overall sensitivity of the area.

There are no CWAC sites within the broader area. The closest sites are Leeupan and Barberspan which are approximately 75km south of the study area. Although these sites constitute one of the largest water fowl sanctuaries in Southern Africa, that can at times support an abundance (c.40,000) and diversity of bird species, the distance between these sites and the study area will result in little to no direct impact on these sites or the species that these areas support.

4.3 Description of bird habitat classes

The study area extends over two primary vegetation divisions, namely the Savanna and Grassland biomes in addition to small pockets of Azonal vegetation in the form of Highveld Salt Pans (Mucina & Rutherford 2006). It is generally accepted that vegetation structure, rather than the actual plant species, influences bird species distribution and abundance (Harrison *et al.* 1997). From an avifaunal perspective, the Atlas of southern African Birds (SABAP1) recognises six primary vegetation divisions or biomes within South Africa, namely (1) Fynbos (2) Succulent Karoo (3) Nama Karoo (4) Grassland (5) Savanna and (6) Forest (Harrison *et al.* 1997). These vegetation descriptions do not focus on lists of plant species, but rather on factors which are relevant to bird distribution.

The following bird habitat classes were identified within the study area. Habitat descriptions are based largely on the available vegetation maps as well as, those habitats identified using high resolution Google Earth ©2016 imagery:

4.3.1 Woodland/Savanna

4.3.1.1 South Africa

The greatest proportion of the study area is situated in the Savanna biome which is characterised by a grassy under-storey and a distinct woody upper-storey of trees and tall shrubs (Harrison *et al.* 1997). Natural woodland occurring in the study area consists of the following vegetation units, namely Dwaalboom Thornveld, Zeerust Thornveld, Dwarsberg-Swartruggens Mountain Bushveld and Madikwe Dolomite Bushveld. Tree Savanna comprised of mixed *Vachellia sp*. and *Combretum apiculatum* woodland in Botswana.

The floristic and structural attributes of Dwaalboom Thornveld is fairly homogenous and consists of low to medium high microphyllous bushveld that is dominated by taxa of the genus *Vachellia*. The herbaceous layer is dominated by graminoid taxa as opposed to forb species. The Zeerust Thornveld woodland type is characterised as a deciduous, open to dense short thorny woodland, dominated by *Vachellia* species with herbaceous layer of mainly grasses on deep, high base-status and some clay soils on plains and lowlands. The Dwarsberg-Swartruggens Mountain Bushveld is comprised of a highly variable vegetation structure that is differentiated by diverse tree and shrub layers. Similarly, this vegetation unit is also dominated by *Vachellia* species. In some places, the woody layer may occur as bush clumps and the grass layer is generally very dense with a great variety of grass species. Madikwe Dolomite Bushveld has tree and shrub layers that are often not clearly distinct, especially on steeper slopes. They are dominated by deciduous trees, particularly *Combretum apiculatum* and *Kirkia wilmsii* with a continuous herbaceous layer, dominated by grasses. These vegetation units are not considered threatened, with only small percentages having been transformed by cultivation, urbanisation, spread of alien species and bush encroachment due to overgrazing by cattle.

Woodland supports 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. Woodland is particularly rich in raptors, and forms the stronghold for Red List species (recorded in the greater area) such as Bateleur, Martial Eagle, Tawny Eagle, Lanner Flacon, Red-footed Falcon *Falco vespertinus*, Lappet-faced Vulture and African White-backed Vulture *Gyps africanus*. It also supports several non-Red List raptor species, such as the Booted Eagle *Aquila pennatus*, Wahlberg's Eagle *Aquila wahlbergi*, Lesser Spotted Eagle *Aquila pomarina*, Steppe Eagle *Aquila nipalensis,* Brown Snake-Eagle, African Fish-Eagle *Haliaeetus vocifer*, Black-chested Snake-Eagle and a multitude of medium-sized raptors, for example the migratory Steppe Buzzard *Buteo vulpinus*, Lizzard Buzzard *Kaupifalco monogrammicus*, Jackal Buzzard *Buteo rufofuscus,* African Harrier Hawk (Gymnogene) *Polyboroides typus,* Gabar Goshawk *Melierax gabar*, Shikra *Accipiter badius*, African Hawk-Eagle *Aquila spilogaster*, European Honey-Buzzard *Pernis apivorus*, Lesser Kestrel, Greater Kestrel *Falco rupicoloides,* Rock Kestrel *Falco rupicolus* and Pearl-spotted Owlet *Glaucidium perlatum*. Apart from raptors, open woodland and savanna areas are suitable for a wide range of other power line sensitive Red List species, i.e. Kori Bustard, Southern Ground Hornbill *Bucorvus leadbeateri*, White-bellied Korhaan, Short-clawed Lark, European Roller *Coracias garrulus*, Secretarybird and Abdim's Stork *Ciconia abdimii.*

4.3.1.3 Botswana

The entire study area in Botswana is located in the Savanna biome. The woodland consists of Tree Savanna comprised of mixed *Vachellia sp*. and *Combretum apiculatum* woodland. The same complement of species which could potentially occur in woodland on the South African portion of the study area could also be encountered in woodland in the Botswana portion of the study area.

4.3.2 Grassland

4.3.2.1 South Africa

A smaller proportion of the study area is situated in the Grassland biome and consists predominantly of the Carltonville Dolomite Grassland and Klerksdorp Thornveld vegetation types (Mucina & Rutherford 2006). The Carltonville Dolomite Grassland is a species-rich mosaic of plant community types occurring on undulating plains dissected by hard and compact sedimentary rock ridges. It is characterized by the presence of the following species, *Aristida congesta, Brachiaria serrata, Cynodon dactylon, Digitaria tricholaenoides, Diheteropogon amplectens, Eragrostis chloromelas, Eragrostis racemosa, Heteropogon contortus, Loudetia simplex, Schizachyrium sanguineum, Setaria sphacelata, Themeda triandra,* and a wide variety of herbaceous forbs and other grasses. Klerksdorp Thornveld occurs in two regions, the first in the Wolmaransstad, Ottosdal and Hartebeestfontein region and the other from the Botsolano Game Park north of Mafikeng to the vicinity of Madibogo in the south. Mucina & Rutherford describe the vegetation type as consisting of plains or slightly undulating plains with open to dense *Vachellia karoo* bush clumps in dry grassland. Fairly significant proportions of these vegetation types have been transformed, mostly by cultivation and urbanisation.

Grasslands represent a significant foraging area for many bird species. Specifically, open grassland in the greater area typically attract the Red List, Lanner Falcon, Red-footed Falcon, White-bellied Korhaan, Black-winged Pratincole *Glareola nordmanni*, European Roller, Yellow-throated Sandgrouse, Secretarybird and Abdim's Stork, the majority of which are power line sensitive species. The grassland patches are also a favourite foraging area for game birds such as francolins and Helmeted Guineafowl *Numida meleagris.* This in turn attracts large raptors e.g. Martial Eagle, because of both the presence and accessibility of prey.

4.3.2.2 Botswana

The Grassland biome does not extend into the Botswana portion of the study area.

4.3.3 Rivers

4.3.3.1 South Africa

The main river system in the South African portion of the broader area is the Marico River, with several tributaries including the Brakfonteinspruit, Kgolane, Pitsedisulejang, Tholwane, Springboklaagte, Lethlakane, Klein-Marico and many associated unnamed ephemeral drainage lines. The proposed alignment does not actually cross any of these rivers, but it does cross some ephemeral drainage lines. Rivers and drainage lines are important habitat for birds in that they act as corridors of microhabitat for waterbirds, while the riparian vegetation on the banks provide potential cover for skulking non-Red List species such as Black Crake *Amaurornis flavirostris*, Dwarf Bittern *Ixobrychus sturmii* and Green-backed Heron *Butorides striata*. Ephemeral rivers and drainage lines generally only flow for short periods in the rainy season, but pools of water can persist for many months and aquatic organisms that are trapped in those pools could provide potential sources of food for various species. Relevant to this study and the rivers, drainage lines and surrounding riparian habitat could attract Red List species such as Black Stork, Yellow-billed Stork *Mycteria ibis*, Marabou Stork *Leptoptilos crumeniferus*, Half-collared Kingfisher *Alcedo semitorquata*, as well as many other non-Red List waterbirds including Reed Cormorant *Phalacrocorax africanus*, White-breasted Cormorant *Phalacrocorax crbo*, African Darter *Anhinga rufa*, African Black Duck *Anas sparsa*, Comb Duck *Sarkidiornis melanotos*, White-faced Duck *Dendrocygna viduata*, African Fish-Eagle *Haliaeetus vocifer*, Egyptian Goose *Alopochen aegyptiacus*, Spur-winged Goose *Plectropterus gambensis*, several heron, egret, ibis and stork species, African Openbill *Anastomus lamelligerus*, Osprey *Pandion haliaetus*, and African Spoonbill *Platalea alba*.

4.3.3.2 Botswana

The main river system in the Botswana portion of the study area is the Ngotwane River, with tributaries Dikolakolane, Metsemothlaba, Taung and several unnamed associated ephemeral drainage lines. The characteristics of these rivers, and the avifauna associated with them, are similar to those in the South African portion of the study area. The proposed alignment crosses the Ngotwane River near Isang.

4.3.4 Wetlands

4.3.4.1 South Africa

Wetlands are characterized by slow flowing seasonal water (or permanently wet) and tall emergent vegetation (rooted or floating) and provide habitat for many water birds. The precarious conservation status of many of the bird species that are dependent on wetlands reflects the critical status of wetlands worldwide, with many having already been destroyed. There are several localized wetlands occurring in the broader area, especially in the southern grassland section which are likely to represent attractive roosting and foraging areas for certain species year-round – not only after rainfall. Of the collision-sensitive Red List species found within the broader area, Pallid Harrier *Circus macrourus,* Greater Painted-snipe *Rostratula benghalensis*, Yellow-billed Stork and Marabou Stork could potentially use these wetlands.

4.3.4.2 Botswana

The broader area in Botswana is quite arid, but there are small seasonal wetlands and pans present, as well as wetland areas associated with the ephemeral rivers and sewage works. Species that could be attracted to these wetland areas are listed in the previous paragraph.

4.3.5 Dams

4.3.5.1 South Africa

Many thousands of earthen and other dams exist in the southern African landscape. The South African portion of the broader area contains many dams, including some large ones e.g. the Molatedi Dam, Marico Bosveld Dam and the Kromellenboog Dam. Whilst dams have altered flow patterns of streams and rivers, and affected many bird species detrimentally, a number of species have benefited from their construction. The construction of these dams has probably resulted in a range expansion for many water bird species that were formerly restricted to areas of higher rainfall. Man-made impoundments, although artificial in nature, can be very important for variety of birds, particularly water birds. Apart from the water quality, the structure of the dam, and specifically the margins and the associated shoreline and vegetation, plays a big role in determining the species that will be attracted to the dam. Common species in the study area that could use dams and dam edges (including sewage ponds) include Reed Cormorant, White-breasted Cormorant, African Darter, African Black Duck, Comb Duck, White-backed Duck, White-faced Duck, Egyptian Goose, Spur-winged Goose, several heron, egret, ibis and stork species, African Openbill, Osprey, African Spoonbill and Red-billed Teal *Anas erythrorhyncha*. Red List species recorded in the study area by SABAP2 that are likely to be attracted to dams include Lesser Flamingo *Phoenicopterus minor*, Greater Flamingo *Phoenicopterus ruber*, Pink-backed Pelican, Greater Painted-snipe, Black Stork, Marabou Stork and Yellow-billed Stork. The proposed alignment itself is not situated close to any major dams.

4.3.5.2 Botswana

The Botswana portion of the broader area contains a number of important large dams, namely the Bokaa Dam, Gaborone Dam and Ngotwane Dam. The same complement of species could be present at these and other smaller dams and sewage ponds as discussed in the previous paragraph. The proposed alignment itself is not situated close to any major dams.

4.3.6 Agricultural clearings and old lands

4.3.6.1 South Africa

The tilling of soil is one of the most drastic and irrevocable transformations brought on the environment. It completely destroys the structure and species composition of the natural vegetation, either temporarily or permanently. However, arable or cultivated land may represent a significant feeding area for many bird species in any landscape for the following reasons: through opening up the soil surface, land preparation makes many insects, seeds, bulbs and other food sources suddenly accessible to birds and other predators; the crop or pasture plants cultivated are often eaten themselves by birds, or attract insects which are in turn eaten by birds; during the dry season arable lands often represent the only green or attractive food sources in an otherwise dry landscape. The South African portion of the study area contains extensive agricultural clearings mostly in the form commercial dryland cultivation, irrigated pivots and dryland subsistence cultivation that features prominently in those areas surrounding towns and settlements.

In general, agricultural areas are of lesser importance for the majority of Red List species recorded in the study area, compared to the natural habitats (i.e. woodland, rivers and wetlands). The Red List species recorded in the study area that are most likely to utilise agricultural lands and clearings in the study area are Pallid Harrier, Black-winged Pratincole, Abdim's Stork and Red-footed Falcon. The clearings, including those areas of abandoned old lands could also be utilised by Kori Bustard, Lanner Falcon and Secretarybird and other large, non-Red List power line sensitive species such as White Stork *Ciconia ciconia* and Spur-winged Goose may also use freshly ploughed in the study area to feed in.

4.3.6.2 Botswana

Dryland subsistence cultivation is dominant form of agricultural activity in the Botswana portion of the study area. The agricultural activity is largely centred around villages and towns. The same complement of species is likely to be found in this habitat as discussed in the previous paragraph.

4.3.7 Mountains

4.3.7.1 South Africa

Topographically, the majority of the study area is flat. However, mountainous areas and examples of ridges and rocky outcrops are found within the study area and are potentially suitable roosting and breeding habitat for the Red List Lanner Falcon, Verreaux's Eagle and non-Red List Peregrine Falcon *Falco peregrinus* and Rock Kestrel. Lanner Falcon could be attracted to poultry in the settlements.

4.3.7.2 Botswana

There are no mountains or rocky outcrops in the Botswana portion of the study area, except for one rocky outcrop.

4.3.8 Exotic/Alien Trees

4.3.8.1 South Africa

Although stands of *Eucalyptus* are strictly speaking invader species, they have become important refuges for certain species of raptors, including Martial Eagle and Verreaux's Eagle (*pers.obs.* Chris van Rooyen). Amur Falcon *Falco amurensis*, a non-Red List Palearctic migrant, will commonly roost in small stands of *Eucalyptus*, in addition, other non-Red List species e.g. Black Sparrowhawk *Accipiter melanoleucus*, Ovambo Sparrowhawk *Accipiter ovampensis,* Little Sparrowhawk *Accipiter minullus* and African Cuckoo Hawk *Aviceda cuculoides* that may also utilise these trees for roosting and breeding purposes. Stands of alien trees are found all over the broader area.

4.3.8.2 Botswana

There are also stands of alien trees found within the broader area in Botswana, although to a lesser extent than in South Africa.

4.3.9 Towns and Settlements

4.3.9.1 South Africa

The broader area in South Africa contains many villages and towns. These areas include surface infrastructure such as roads and buildings. Built-up areas generally are of little value to sensitive Red List bird species due to their degraded nature and the associated disturbance factor. They do however play an important role in providing safe refuge and foraging opportunities for small passerine species that have become common in urban environments.

4.3.9.2 Botswana

The broader area in Botswana contains numerous villages. As is the case across the border in South Africa, built-up areas generally are of little value to sensitive Red List bird species due to their degraded nature and the associated disturbance factor.

4.3.10 General

SABAP2 reporting rates for the majority of the abovementioned Red List avifauna potentially occurring in the nine habitat classes discussed above are relatively low (see Table 4-1), indicating that human activity has impacted on the avifauna and that levels of habitat transformation and disturbance are high. Table 4-1 details the micro habitats that each Red List bird species typically frequents in the broader study area.

4.4 Power line sensitive species potentially occurring in the study area

A combined total of at least 462 bird species have been recorded within the relevant SABAP2 pentads within the combined broader area of South Africa and Botswana. The presence of these species in the combined broader area provides an indication of the diversity of species that could potentially occur along the proposed power line route. A total of 97 power line sensitive species have been recorded in the combined broader area during the SABAP2 atlassing period to date. Thirty of these are considered to be of conservation concern according to the 2015 Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (Taylor *et al*, 2015) and the IUCN Red List (2016). For each of these threatened species, the potential for occurring in a specific habitat class is indicated in Table 4.1, in addition to the type of impact that could potentially affect each species as a result of the construction and operation of the BOSA 400kV power line and its associated substations.

Twenty-three globally threatened bird species occur in Botswana, 15 of which have been recorded within the broader area during the SABAP1 and SABAP2 atlassing periods. Although there has been an increase in the number of globally threatened birds in Botswana since 2000, generally the status of birds throughout the country is relatively good (Kootsositse *et al*. in press). This increase in species of conservation concern can be attributed to these species being listed as globally threatened, following declines elsewhere in the world and not necessarily a deterioration of the status of birds in Botswana (Hancock, 2008). The Egyptian Vulture, Basra Reed Warbler, Black Harrier, Blue Crane and Denham's Bustard are all in the IUCN Red List, but have not been listed by BirdLife Botswana as species of conservation concern (Botswana Government, 2009). However, some species like the Wattled Crane, Short-clawed Lark (>90% of its global population in South-eastern Botswana) and Slaty Egret (85% of its global population in the Okavango Delta) have their core populations in Botswana. They, therefore, require special consideration to ensure that their populations remain stable and secure. It has been found that densities for most species, such as large raptors, are considerably higher in protected areas than in unprotected areas (Herremans, 1998; Herremans-Tonnoeyr, 2000). Most species are highly sensitive to human disturbance, particularly when nesting. Other species like game birds and bustards are susceptible to hunting and snaring for food and, are therefore good indicators of human pressure on birds as food resources.

Although this assessment focuses on the impacts on regionally and globally theratened species, as these are the species of highest conservation concern, the impact on the more common species has also been considered, although not on an individual species basis. It is worth noting that since the impacts are usually the same across various species, threatened species can often be used as surrogate species for the others in terms of impacts and the necessary mitigation.

Table 4-1: Red List species that could potentially occur in the study area

Name	Regional status SA (2015)	Regional status Botswana (2000)	Global status (IUCN, 2016)	SABAP2 Av. reporting rate (%)	Savanna/ Woodland	Rivers, Wetlands & Dams	Grassland (SA only)	Agricultural Lands	Mountains/ Ridges	Exotic tree stands (*Eucalyptus*)	Collisions	Displacement through disturbance	Displacement through habitat destruction
Bateleur *Terathopius ecaudatus*	EN	BOC	NT	0.55	x	-	-	-	-	-	x	x	x
Bustard, Kori *Ardeotis kori*	NT	Threatened or declining	NT	8.55	Open savanna	-	-	Old agric. lands	-	-	x	x	-
Duck, Maccoa *Oxyura maccoa*	NT	-	NT	1.10	-	x	-	-	-	-	x	x	-
Eagle, Martial *Polemaetus bellicosus*	EN	BOC	VU	2.34	x	-	-	-	-	x	x	x	x
Eagle, Tawny *Aquila rapax*	EN	-	LC	2.76	x	-	-	-	-	-	x	x	x
Eagle, Verreaux's *Aquila verreauxii*	VU	-	LC	1.93	x	-	-	-	x	x	x	x	x
Falcon, Lanner *Falco biarmicus*	VU	-	LC	8.14	x	-	x	Old agric. lands	x	-	x	-	-
Falcon, Red-footed *Falco vespertinus*	NT	-	NT	0.28	Open woodland	-	x	x	-	x	x	-	-
Flamingo, Lesser *Phoenicopterus minor*	NT	NT	NT	0.41	-	x	-	-	-	-	x	-	-
Flamingo, Greater *Phoenicopterus ruber*	NT	Threatened or declining	LC	1.66	-	x	-	-	-	-	x	-	-
Ground Hornbill, Southern *Bucorvus leadbeateri*	EN	Threatened or declining	VU	0.14	x	-	-	-	-	-	x	x	x
Harrier, Pallid *Circus macrourus*	NT	-	NT	0.41	-	x (wetlands)	x	x	-	-	x	x	x
Kingfisher, Half-collared *Alcedo semitorquata*	NT	-	LC	0.14	-	x	-	-	-	-	-	x	-
Korhaan, White-bellied *Eupodotis senegalensis*	VU	-	LC	0.14	Open savanna	-	x	-	-	-	x	x	-
Lark, Short-clawed *Certhilauda chuana*	NT	BOC	LC	6.07	Open savanna	-	-	-	-	-	-	x	-
Painted-snipe, Greater *Rostratula benghalensis*	VU	-	LC	0.28	-	x	-	-	-	-	-	-	-

EN = Endangered, VU = Vulnerable, NT = Near threatened, LC = Least concern, BOC = Bird of concern

Name	Regional status SA (2015)	Regional status Botswana (2000)	Conservation status (IUCN, 2016)	SABAP2 Av. reporting rate (%)	Savanna/ Woodland	Rivers, Wetlands & Dams	Grassland (SA only)	Agricultural Lands	Mountains/ Ridges	Exotic tree stands (*Eucalyptus*)	Collisions	Displacement through disturbance	Displacement through habitat destruction
Pelican, Pink-backed *Pelecanus rufescens*	VU	BOC	LC	0.14	-	x	-	-	-	-	x	-	-
Pratincole, Black-winged *Glareola nordmanni*	NT	-	NT	0.69	-	-	x	x	-	-	-	x	-
Roller, European *Coracias garrulus*	NT	-	NT	7.03	Open woodland	-	x	-	-	-	-	-	-
Sandgrouse, Yellow-throated *Pterocles gutturalis*	NT	-	LC	11.17	-	-	x	x	-	-	x	-	-
Secretarybird *Sagittarius serpentarius*	VU	-	VU	4.69	Open woodland	-	-	Old agric. lands	-	-	x	x	-
Stork, Abdim's *Ciconia abdimii*	NT	-	LC	1.79	Open woodland	x (pans)	x	x	-	-	x	-	-
Stork, Black *Ciconia nigra*	VU	-	LC	1.24	-	x	-	-	x	-	x	x	x
Stork, Marabou *Leptoptilos crumeniferus*	NT	-	LC	4.28	x	x	-	-	-	-	x	x	-
Stork, Yellow-billed *Mycteria ibis*	EN	-	LC	1.10	-	x	-	-	-	-	x	x	-
Vulture, Cape *Gyps coprotheres*	EN	EN	VU	5.52	Open woodland	-	x (foraging)	-	-	-	x	x	-
Vulture, Lappet-faced *Torgos tracheliotus*	EN	BOC	EN	6.48	x	-	x (foraging)	-	-	-	x	x	x
Vulture, White-backed *Gyps africanus*	EN	-	EN	12.14	x	-	x (foraging)	-	-	-	x	x	x
EN = Endangered, VU = Vulnerable, NT = Near threatened, LC = Least concern, BOC = Bird of concern													

5 DESCRIPTION OF EXPECTED IMPACTS

Because of their size and prominence, electrical infrastructure constitutes an important interface between wildlife and man. Negative interactions between wildlife and electricity structures take many forms, but two common problems in southern Africa are electrocution of birds (and other animals) and birds colliding with power lines. (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; Anderson 2001; Shaw 2013).

5.1 Electrocutions

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). Electrocution risk is strongly influenced by the power line voltage of the and design of the pole structure and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energized components.

5.1.1 South Africa

Due to the large size of the clearances on most overhead lines of above 132kV, electrocutions are generally ruled out as even the largest birds cannot physically bridge the gap between dangerous components. It can be concluded that electrocutions on the proposed BOSA 400kV power line will not be possible through conventional mechanisms. Electrocutions within the proposed Watershed B substation are possible, but should not affect the more sensitive Red List bird species as these species are unlikely to use the infrastructure within the substation yards for perching or roosting.

5.1.2 Botswana

The discussion in 5.1.1 above is also applicable to the section of the proposed powerline in Botswana, and the existing Isang substation.

5.2 Collisions

Collisions are probably the biggest single threat posed by power lines to birds in southern Africa (van Rooyen 2004; Shaw 2013). 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; Shaw 2013).

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 low-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, Bevanger 1994)."

As mentioned by Shaw (2013) in the extract above, 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 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 essential 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 and White Storks. 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.

Thus, visual field topographies which have evolved primarily to meet visual challenges associated with foraging may render certain bird species particularly vulnerable to collisions with human artefacts, such as power lines and wind turbines that extend into the otherwise open airspace above their preferred habitats. For these species placing devices upon power lines to render them more visible may have limited success since no matter what the device the birds may not see them. It may be that in certain situations it may be necessary to distract birds away from the obstacles, or encourage them to land nearby (for example by the use of decoy models of conspecifics, or the provision of sites attractive for roosting) since increased marking of the obstacle cannot be guaranteed to render it visible if the visual field configuration prevents it being detected. Perhaps most importantly, the results indicate that collision mitigation may need to vary substantially for different collision prone species, taking account of species specific behaviours, habitat and foraging preferences, since an effective all-purpose marking device is probably not realistic if some birds do not see the obstacle at all (Martin & Shaw 2010).

Despite speculation that line marking might be ineffective for some species due to differences in visual fields and behaviour, or have only a small reduction in mortality in certain situations for certain species, particularly bustards (Martin & Shaw 2010; Barrientos *et al.* 2012; Shaw 2013), it is generally accepted that marking a line with PVC spiral type Bird Flight Diverters (BFDs) can reduce the collision mortality rates (Sporer *et al.* 2013; Barrientos *et al.* 2012, Alonso & Alonso 1999; Koops & De Jong 1982). Regardless of statistical significance, a slight mortality reduction may be very biologically relevant in areas, species or populations of high conservation concern (e.g. Ludwig's Bustard) (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 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) (Barrientos *et al.* 2011). Koops and De Jong (1982) found that the spacing of the BFDs was 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%. 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).

A potential impact of the proposed power lines is collisions with the earth wire present on the proposed power 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: Wildlife & Energy Programme (South African NGO) it is possible to give a measure of what species are likely to be impacted upon (Figure 5 - 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.

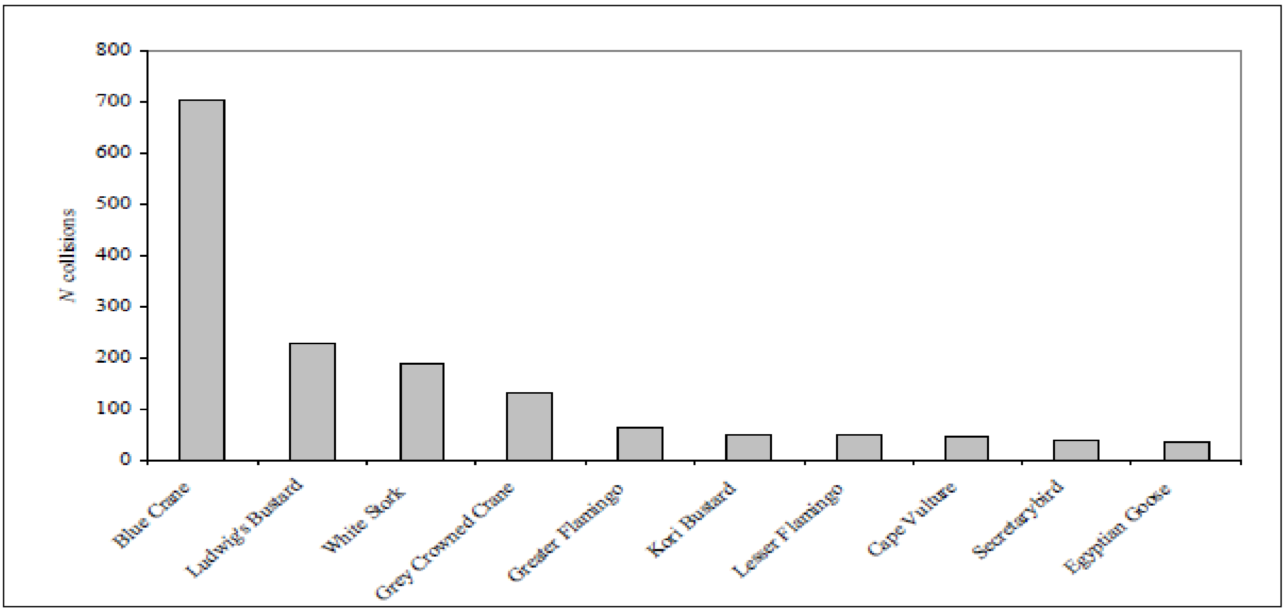

Figure 5: The top ten collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins *et al.* 2010)

5.2.1 South Africa

Relevant to this development, collisions are likely to be linked to specific habitat types and/or specific sets of circumstances. The following potential collision scenarios, involving Red List species, present themselves in the study area (see also Table 4-1):

- Lines crossing rivers. These are important habitat for a variety of Red List species, and the constant movement of birds up and down the river in search of food creates a collision risk.
- Proximity of breeding Red List raptors and vultures to the proposed power lines. In this scenario, the young, recently fledged birds would be most at risk of collisions in the woodland biome.
- Lines crossing or skirting areas of natural grassland or old and fallow lands in commercial farming areas.
- Lines crossing agricultural fields surrounded by natural woodland are important for other large terrestrial species, which are highly susceptible to the collision impact.
- Vultures feeding on a carcass in close proximity to the proposed lines. Vultures descending to a carcass are at risk of collisions with a nearby power line. Birds will also be at risk when rapidly taking off at the carcass if disturbed by people or mammalian predators.
- Vultures have taken to roosting and perching (sometimes overnight) on existing 400kV transmission infrastructure (Figure 4 - Phipps *et al.* 2013). Camera trap footage of two 400kV power lines located at the Rhino & Lion Park in the Cradle of Humankind, revealed that the vultures roost on the earth peaks and are flying extremely close to the earth wires when landing and taking off from the earth peaks (Smallie & Strugnell, 2011). It is highly likely that the vultures in the study area are behaving in a similar manner, resulting in them being vulnerable to collisions with the proposed BOSA 400kV overhead earth wires.

5.2.2 Botswana

Relevant to this development, collisions are likely to be linked to specific habitat types and/or specific sets of circumstances. The following potential collision scenarios, involving Red List species, present themselves in the study area (see also Table 4.1):

- Lines crossing rivers. These are important habitat for a variety of Red List species, and the constant movement of birds up and down the river in search of food creates a collision risk.
- Proximity of breeding Red List raptors and vultures to the proposed power lines. In this scenario, the young, recently fledged birds would be most at risk of collisions in the woodland biome.
- Lines crossing agricultural fields surrounded by natural woodland are important for other large terrestrial species, which are highly susceptible to the collision impact.
- Vultures feeding on a carcass in close proximity to the proposed lines. Vultures descending to a carcass are at risk of collisions with a nearby power line. Birds will also be at risk when rapidly taking off at the carcass if disturbed by people or mammalian predators.
- Vultures have taken to roosting and perching (sometimes overnight) on existing 400kV transmission infrastructure (pers. obs). Camera trap footage of two 400kV power lines located at the Rhino & Lion Park in the Cradle of Humankind in South Africa, revealed that the vultures roost on the earth peaks and are flying extremely close to the earth wires when landing and taking off from the earth peaks (Smallie & Strugnell, 2011). It is highly likely that the vultures in the study area are behaving in a similar manner, resulting in them being vulnerable to collisions with the proposed BOSA 400kV overhead earth wires.

5.3 Displacement due to habitat transformation and disturbance

During the construction phase and maintenance of power lines and substations, some habitat destruction and transformation inevitably takes place. This happens with the construction of access roads, the clearing of servitudes and the levelling of substation yards. Servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, to prevent vegetation from intruding into the legally prescribed clearance gap between the ground and the conductors and to minimize the risk of fire under the line, which can result in electrical flashovers. These activities have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through transformation of habitat, which could result in temporary or permanent displacement.

5.3.1 South Africa

In the present instance, the risk of displacement of Red List species due to habitat transformation is likely to be fairly limited given the low reporting rate for Red List species in the broader area. The biggest potential impact would be the removal of large trees that could potentially serve as nesting substrate for large Red List raptors such as those listed in Table 4.1 (and many other non-threatened avifauna), although again it is noted that reporting rates for these species are very low.

Historically (i.e. before the establishment of the current settlements and industries) the area surrounding the proposed power lines comprised entirely of undisturbed woodland. As a result, it almost certainly supported a number of power line sensitive species, particularly Red List raptor species such as Martial Eagle, Tawny Eagle, Bateleur, Lappet-faced Vulture and also non-raptors such as Southern Ground Hornbill and Kori Bustard. However, the area has been transformed to accommodate a change in land use (i.e. urban settlement and agriculture) which reduced the number and variety of species originally inhabiting the area, on account of the loss of habitat and decline in food availability. However intact (if disturbed) areas of woodland habitat still remain in the study area, it is therefore likely that the remaining Red List species will still utilize the area, albeit only irregularly for some species. Vultures are regularly present (Figure 4), not so much because of the remaining woodland, but because of the high numbers of livestock and existing high voltage structures which provide convenient perches and roosts. The clearing of woodland (mostly small trees and woody shrub) under the new line should have a limited impact on the avifauna, provided that large trees are not removed. The biggest impact is likely to be where riparian vegetation needs to be cleared, particularly large trees, as these trees are important breeding and roosting substrate, especially for raptors.

The habitat at the three proposed Watershed B substation alternatives, namely disturbed open woodland on old agricultural clearings, does not contain unique features that will make it critically important for avifauna, particularly the Red List species mentioned in the previous paragraphs. This habitat is common in the area and due to the mobility of the large raptor species; they could conceivably forage in similar habitat adjacent to the substation. The species that are most likely to be affected by the loss of habitat are the smaller, non-threatened passerines that are currently potentially resident in the area to be taken up by the proposed substation. It is not envisaged that any Red List species will be displaced from the broader area by the habitat transformation that will take place as a result of the construction of the proposed Watershed B substation.

Apart from direct habitat destruction, the abovementioned construction and maintenance activities also impact on birds through disturbance; this could lead to breeding failure if the disturbance happens during a critical part of the breeding cycle. Construction activities in close proximity could be a source of disturbance and could lead to temporary breeding failure or even permanent abandonment of nests. The relatively low reporting rates for Red List species in the study area are an indication that they are not regularly utilising the area for breeding. However, if the alignment is authorised, a detailed inspection would be required to establish if there are any breeding Red List species that could be disturbed. In such an event, appropriate mitigation measures would need to be implemented (such as postponing the construction of the line to avoid peak breeding season).

Relevant to this study, the type of impact that could potentially affect each of the Red List species, recorded in the study area, as a result of the construction and operation of the BOSA 400kV power line and its associated substations are indicated in Table 4.1.

5.3.2 Botswana

The discussion in 5.3.1 above is also applicable to the section of the proposed powerline in Botswana.

6 CONCLUSION

6.1.1 South Africa

In general, the habitat in which the proposed Watershed B substation and the BOSA 400kV power line corridor (Option C) are located is moderately sensitive from a potential bird impact perspective. The natural habitats are likely to support a diversity of Red List power line sensitive species. However, there is evidence of anthropogenic impacts in the broader area, particularly in the form of urbanisation, cultivation and pastoral activities which is visible in the disturbed state of the natural habitat. The levels of disturbance associated with these land use practices are significant and have therefore had a negative impact on avifaunal diversity and abundance reflected in the low reporting rates for the majority of the power line sensitive Red List species.

Potential impacts that were identified related to the construction and operation of the proposed power line include: collision of large terrestrial birds, vultures and raptors with overhead power line and displacement as a result of habitat transformation and disturbance.

6.1.2 Botswana

In general, the habitat in which the proposed BOSA 400kV power line corridor (Option C) are located is moderately sensitive from a potential bird impact perspective. The natural habitats are likely to support a diversity of Red List power line sensitive species. However, there is evidence of anthropogenic impacts in the broader area, particularly in the form of urbanisation, cultivation and pastoral activities which is visible in the disturbed state of the natural habitat. The levels of disturbance associated with these land use practices are significant and have therefore had a negative impact on avifaunal diversity and abundance reflected in the low reporting rates for the majority of the power line sensitive Red List species.

Potential impacts that were identified related to the construction and operation of the proposed power line include collision of large terrestrial birds, vultures and raptors with overhead power line and displacement as a result of habitat transformation and disturbance.

7 GOING FORWARD

At this early stage of the assessment process, the confidence with which the potential impacts have been predicted is moderate given the absence of primary data which still has to be gathered by means of a field visit. The following impacts needs further investigation:

- Collisions of Red List species with the earthwire of the proposed powerline;
- Displacement of Red List species due to disturbance and habitat transformation associated with the construction of the powerline

The investigations will take the form of a site visit to record data at selected areas identified beforehand through the study of aerial imagery of the entire 2km corridor, which is currently being collected by means of an aerial survey.

8 REFERENCES

- Alonso, J.A. & Alonso, C.A. 1999. Mitigation of bird collisions with transmission lines through groundwire marking. In: Birds and Power Lines Eds: M. Ferrer & G. F. E. Janss, Quercus, Madrid.

- Anderson, M.D. 2001. The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa. Draft report to Eskom Resources and Strategy Division. Johannesburg. South Africa.

- Aurecon South Africa (Pty) Ltd. 2016. Final Inception Report – BOSA Transaction Advisory Services. 10 August, 2016.

- Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute. Washington D.C.

- Avian Power Line Interaction Committee (APLIC). 2012. Mitigating Bird Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute. Washington D.C.

- Barrientos, R., Alonso, J.C., Ponce, C., Palacín, C. 2011. Meta-Analysis of the effectiveness of marked wire in reducing avian collisions with power lines. Conservation Biology 25: 893-903.

- Barrientos, R., Ponce, C., Palacín, C., Martín, C.A., Martín, B. and Alonso, J.C. 2012. Wire marking results in a small but significant reduction in avian mortality at power lines: a BACI designed study. PLos One 7: 1-10.

- Beaulaurier, D.L. 1981. Mitigation of bird collisions with transmission lines. Bonneville Power Administration. U.S. Dept. of Energy

- BirdLife International. 2017. Important Bird Areas factsheet: Mannyelanong Hill. Downloaded from http://www.birdlife.org on 27/01/2017.

- BirdLife International. 2017. Important Bird Areas factsheet: South-east Bostwana. Downloaded from http://www.birdlife.org on 27/01/2017.

- Botswana Government, 2009, Fourth National Report to the Convention on Biological Diversity, Ministry of Environment Wildlife and Tourism, Gaborone.

- Botswana Government, 2012, Selected Botswana Biodiversity Indicators 2011, Department of Environmental Affairs, Ministry of Environment Wildlife and Tourism, Gaborone, Botswana.

- Hancock, P., 2008, The status of globally and nationally threatened birds in Botswana, BirdLife Botswana.

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

- Herremans, M. and Herremans-Tonnoeyr, D., 2000, Land use and the conservation status of raptors in Botswana, *Biological Conservation 94: 31–41.*

- Herremans, M., 1998, Conservation status of birds in Botswana in relation to land use, *Biological Conservation 86: 139–160*.

- Hobbs, J.C.A. and Ledger J.A. 1986a. The Environmental Impact of Linear Developments; Power lines and Avifauna. (Third International Conference on Environmental Quality and Ecosystem Stability. Israel, June 1986).

- Hobbs, J.C.A. and Ledger J.A. 1986b. “Power lines, Birdlife and the Golden Mean.” Fauna and Flora, 44, pp 23-27.

- Jenkins, A.R., Smallie, J.J. & 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.

- Koops, F.B.J. & De Jong, J. 1982. Vermindering van draadslachtoffers door markering van hoogspanningsleidingen in de omgeving van Heerenveen. Electrotechniek 60 (12): 641 – 646.

- Kootsositse V. M., Hancock, P. & L. Rutina. (2008) 2008 Status Report for Protected Important Bird Areas in Botswana. Prepared with Funding from the European Commission EuropeAid/ENV/2007/132-278 (Unpublished).

- Kruger, R. and Van Rooyen, C.S. 1998. Evaluating the risk that existing power lines pose to large raptors by using risk assessment methodology: the Molopo Case Study. (5th World Conference on Birds of Prey and Owls: 4 - 8 August 1998. Midrand, South Africa.)

- Kruger, R. 1999. Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa. M. Phil. Mini-thesis. University of the Orange Free State. Bloemfontein. South Africa.

- Ledger, J. 1983. Guidelines for Dealing with Bird Problems of Transmission Lines and Towers. Escom Test and Research Division Technical Note TRR/N83/005.

- Ledger, J.A. and Annegarn H.J. 1981. "Electrocution Hazards to the Cape Vulture (Gyps coprotheres) in South Africa". Biological Conservation, 20, pp15-24.

- Ledger, J.A. 1984. "Engineering Solutions to the problem of Vulture Electrocutions on Electricity Towers." The Certificated Engineer, 57, pp 92-95.

- Marnewick, M.D., Retief E.F., Theron N.T., Wright D.R., Anderson T.A. 2015. Important Bird and Biodiversity Areas of South Africa. Johannesburg: BirdLife South Africa.

- Martin, G.R., Shaw, J.M. 2010. Bird collisions with power lines: Failing to see the way ahead?. Biol. Conserv. (2010), doi:10.1016/j.biocon.2010.07.014.

- Phipps WL, Wolter K, Michael MD, MacTavish LM, Yarnell RW (2013) Do Power Lines and Protected Areas Present a Catch-22 Situation for Cape Vultures (*Gyps coprotheres*)? PLoS ONE 8(10): e76794. doi:10.1371/journal.pone.0076794

- Shaw, J.M. 2013. Power line collisions in the Karoo: Conserving Ludwig's Bustard. Unpublished PhD thesis. Percy FitzPatrick Institute of African Ornithology, Department of Biological Sciences, Faculty of Science University of Cape Town May 2013.

- Smallie, J. & Strugnell, L. 2011. Use of camera traps to investigate Cape Vulture roosting behaviour. Unpublished Eskom Research Report. Johannesburg

- Sporer, M.K., Dwyer, J.F., Gerber, B.D, Harness, R.E, Pandey, A.K, Marking Power Lines to Reduce Avian Collisions Near the Audubon National Wildlife Refuge, North Dakota. Wildlife Society Bulletin 37(4):796–804; 2013; DOI: 10.1002/wsb.329.

- Taylor, M.R., Peacock, F. and Wanless, R.M. (eds) 2015. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg.

- Tyler, S & Borello, W. 2000. The Red Data list of birds in Botswana. A proposal by the Botswana Bird Club. Babbler 37. 2000.

- Van Rooyen, C.S. and Ledger, J.A. 1999. "Birds and utility structures: Developments in southern Africa" in Ferrer, M. & G..F.M. Janns. (eds.) Birds and Power lines. Quercus: Madrid, Spain, pp 205-230

- Van Rooyen, C.S. 1998. Raptor mortality on power lines in South Africa. (5th World Conference on Birds of Prey and Owls: 4 - 8 August 1998. Midrand, South Africa.)

- Van Rooyen, C.S. 1999. An overview of the Eskom - EWT Strategic Partnership in South Africa. (EPRI Workshop on Avian Interactions with Utility Structures 2-3 December 1999, Charleston, South Carolina.)

- Van Rooyen, C.S. 2000. "An overview of Vulture Electrocutions in South Africa." Vulture News, 43, pp 5-22. Vulture Study Group: Johannesburg, South Africa.

- Van Rooyen, C.S. 2004. The Management of Wildlife Interactions with overhead lines. In The fundamentals and practice of Overhead Line Maintenance (132kV and above), pp217-245. Eskom Technology, Services International, Johannesburg.

- Verdoorn, G.H. 1996. Mortality of Cape Griffons Gyps coprotheres and African Whitebacked Vultures *Pseudogyps africanus* on 88kV and 132kV power lines in Western Transvaal, South Africa, and mitigation measures to prevent future problems. (2nd International Conference on Raptors: 2-5 October 1996. Urbino, Italy.)

- Weare, P.R., and Yalala, A. 2009. Provisional Vegetation Map of Botswana. Botswana Notes Rec. 3: 131-152