Gamma – Kappa 2nd 765kV

BIRD IMPACT ASSESSMENT REPORT

APRIL 2013

Revised August 2017

Chris van Rooyen
Albert Froneman

EXECUTIVE SUMMARY

INFRASTRUCTURE

ESKOM has appointed Nzumbululo HS (Pty) Ltd Consulting to undertake an Environmental Impact Assessment (EIA) for the proposed Gamma Kappa 2nd 765kV power line in the Northern and Western Cape. Nzumbululo Consulting has appointed Chris van Rooyen Consulting as specialist to investigate the potential bird related impacts associated with the proposed new transmission line. A report was produced in April 2013, and subsequently updated in August 2017.

The infrastructure which forms the subject of this bird impact assessment report is listed below:

- ±400km 765kV line from Gamma substation to Kappa Substation

HABITAT

The study area extends primarily over three biomes, namely Nama Karoo, Succulent Karoo and Fynbos. The following bird habitat classes have been identified in the study area:

- Karoo
- Renosterveld
- Rivers and dams
- Transmission lines
- Slopes
- Low impact areas (degraded areas, mines, urban/industrial areas, a few agricultural areas and major roads).

AVIFAUNA AND POTENTIAL IMPACTS

A total of 18 Red Data species have been recorded by SABAP1 and SABAP2 in the QDGCs that are bisected by the various corridor alternatives.

Power line sensitive Red Data species that are associated with Karoo habitat in the study area are Ludwig's Bustard, Kori Bustard, Martial Eagle, Karoo Korhaan, Secretarybird, Blue Crane, Black Harrier and Lanner Falcon. The major expected impact in this habitat is collisions with the earthwire of the proposed power line, particularly for Ludwig's Bustard, Blue Crane, Kori Bustard, Karoo Korhaan and Secretarybird.

Power line sensitive Red Data species that may occur in the fynbos biome in the study area are Black Harrier, Martial Eagle, Secretarybird while Ludwig's Bustard and Karoo Korhaan may occur sporadically, especially in ecotonal areas between renosterveld and succulent Karoo. Envisaged impacts are collisions with the earthwire (mainly large terrestrial species) and displacement due to disturbance may also occur, e.g. breeding Black Harrier.

Transmission lines are an important roosting and breeding substrate for large raptors in the study area. Should any new lines be constructed next to existing lines, the construction activities could lead to temporary displacement of breeding eagles, resulting in breeding failure in a particular season, or even permanent abandonment of a breeding territory.

The study area contains a variety of man-made water bodies (e.g. Gamka Dam, Leeugamka Dam, Floriskraal Dam, Beaufort – West Water Works and many smaller ones) and ephemeral rivers which are of specific importance to some Red Data power line sensitive species in the semi-arid study area. The major envisaged impact is collisions with the earthwire (waterbirds, cranes, flamingos and to a lesser extent raptors), and displacement due to habitat destruction.

Cliffs are potentially important roosting and breeding habitat for a variety of Red Data power line sensitive species, e.g. Black Stork, Lanner Falcon, Verreaux's Eagle and the non-Red Data Peregrine Falco *Falco peregrinus,* Jackal Buzzard *Buteo rufofuscus* and Booted Eagle *Aquila pennatus*. The major envisaged impact on these species is collisions with the proposed power line, and displacement of breeding birds due to disturbance. Steep slopes are also important in that they are generally avoided by the Red Data collision-prone Ludwig's Bustard and Kori Bustard, which prefer the topographically flat plains and plateaus.

CONCLUSIONS

It is envisaged that the proposed 2d Gamma – Kappa 765kV line will have two major potential impacts on Red Data avifauna, namely displacement due to disturbance of breeding birds, especially breeding Martial Eagles on existing transmission lines, and mortality of large terrestrial species due to collisions with the earthwire of the proposed line. The latter impact is especially concerning as far as the Endangered Ludwig's Bustard is concerned, as the species is known to be highly susceptible to this impact, and conventional mitigation methods, i.e. the marking of the earthwire with Bird Flight Diverters, seems to have limited success in reducing mortality for this species (Hoogstad pers. comm 2017). It must therefore be accepted that even with current state of the art mitigation, Ludwig's Bustard collisions are likely to still take place, irrespective of which corridor is ultimately selected.

The cumulative impact of transmission lines in the Karoo as far as collision mortality of large terrestrial species is concerned is alarming, and potentially catastrophic as far as Ludwig's Bustard is concerned, with an estimated 41% of the population being killed annually, with Kori Bustards also dying in large numbers (at least 14% of the South African population killed in the Karoo alone) (Shaw 2013). The addition of another transmission line will potentially aggravate the situation further. Ludwig's Bustard migratory movements are along a broad east-west axis (Shaw 2013), which is a mitigating factor to some extent as the line also follows a broad east-west axis, and does not cut diagonally across the general flight path of this species when doing long distance migratory flights. However, research has shown that the highest collision risk occurs when birds are resident in an area between migratory movements, presumably because they fly higher during migratory flights (Shaw 2013).

No electrocution risk is envisaged as the clearances (phase – phase and phase – earth) on the proposed 765kV line are too large for any bird to physically bridge, thereby eliminating any potential for a bird causing a short circuit.

The three alternative corridors emerged with very similar risk ratings, indicating that the expected impacts are very similar for all three. However, Alternative 2 is the preferred alternative, the reason being that this alternative is situated next to the existing Droërivier – Hydra 2 400kV line (between Gamma and Droërivier substations), and the Droërivier- Muldersvlei 400kV line (between Droërivier and Kappa substations), which potentially reduces the risk of collisions. Placing the new line next to an existing transmission line is believed to reduce the risk of potential collisions in the long term, because it creates a more visible obstacle to birds and the resident birds, particularly breeding adults, are familiar with an obstacle in that geographic location and may have learnt to avoid it (Shaw 2013; APLIC 2012; Sundar & Choudhury 2005). Whereas it is acknowledged that this alternative, unless mitigated, could potentially result in significant short term temporary displacement impacts on breeding eagles on the adjoining existing transmission line during the construction phase, this should be weighed up against the reduction of the risk of long term collision impacts on large terrestrial species, particularly Ludwig's Bustard.

The proposed mitigation measures should reduce the impact of the proposed line to low in all instances for all impacts, except for Ludwig's Bustard, where the collision impact will remain high, even with mitigation.

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 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). 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 he is currently jointly coordinating pre-construction monitoring programmes at 11 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.

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 proposed project, other than fair remuneration for work performed in connection with the Environmental Impact Assessment for the proposed 2d Gamma-Kappa 765kV transmission line.

Full Name: Chris van Rooyen
Title / Position: Director

1. INTRODUCTION

Nzumbululo Heritage Solutions (Nzumbululo) was appointed by Eskom Holdings SOC Limited (Transmission) to conduct an Environmental Impact Assessment (EIA) study for the proposed construction of a +/-370km 765kV transmission powerline, infrastructures and associated auxiliary and substation infrastructure. The powerline is planned to run from the Gamma Substation located near Victoria West in the Northern Cape Province to Kappa Substation close to Touwsrivier in the Western Cape Province. The proponent identified three, 2km wide alternative corridors for assessment.

Chris van Rooyen Consulting was appointed by Nzumbulilo to compile a bird impact assessment report, assessing the potential impacts of the proposed line on birds, which was duly finalised in April 2014. In August 2017, Chris van Rooyen Consulting was requested to update the report in accordance with potentially changed baseline conditions.

A full project description of the proposed infrastructure is provided in the Draft Environmental Impact Assessment Report.

2. BACKGROUND AND BRIEF

The terms of reference for this bird impact assessment study are as follows:

- Describe the affected environment.
- Indicate how birdlife will be affected.
- Discuss gaps in baseline data.
- List and describe the potential impacts.
- Assess and evaluate the potential impacts.
- Recommend mitigation measures for the potential impacts.

3. STUDY APPROACH

3.1 Sources of information

The study made use of the following data sources:

- Bird distribution data of the Southern African Bird Atlas Project 1 (SABAP1) and 2 (SABAP 2)[1] were obtained in order to ascertain which species occur in the study area. A separate data set was obtained for each quarter degree grid cell (QDGC) which overlapped with the proposed corridors. QDGCs are grid cells that cover 15 minutes of latitude by 15 minutes of longitude (15. × 15.), which correspond to the area shown on a 1:50 000 map. SABAP1 covers the late 1980s to early 1990s. The SABAP2 data covers the period 2007 to 2013.
- The Important Bird Areas project data was consulted to get an overview of important bird areas and species diversity in the study area (Marnewick *et al*. 2015).
- 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).

[1] http://sabap2.adu.org.za

- Land cover data for the study area was obtained from the National Land Cover Project (NLCP) (version 2009), obtained from the South African National Biodiversity Institute.
- Data on biomes and vegetation types in the study area was obtained from the Vegetation Map of South Africa (Mucina & Rutherford 2006).
- Data on the alignment of existing high voltage lines were obtained from Eskom.
- The conservation status of all species considered likely to occur in the area was determined as per the most recent iteration of the South African Red Data list for birds (Taylor *et al*. 2016), the 2017.1 IUCN Red List[2] of Threatened Species and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- Personal observations have also been used to supplement the data that is available from SABAP, and has been used extensively in forming a professional opinion of likely bird/habitat associations.
- Data was obtained from the Eskom Electric Eagle Project indicating the historical location of large eagle nests on the existing 400kV Droërivier – Hydra 1 & 2, Droërivier – Muldersvlei 1, Bacchus - Droërivier transmission lines in the study area (Jenkins *et al.* 2006).
- The study area was inspected by vehicle in March 2013, and the major bird habitats were recorded photographically. Because it is not possible to travel along each corridor all the way, spot checks were made where access to the corridor was possible, and representative habitat was recorded in the greater study area to form a general impression of bird habitat.

3.2 Limitations & assumptions

It should be noted that the following factors may potentially detract from the accuracy of the predicted results:

- As the NLCP data dates from 2009, the land cover situation on the ground may have changed in places since then. However, given the arid nature of the study area and the low human population, it can safely be assumed that no major changes have taken place in the study area, which would have affected bird distribution significantly. The vast majority of the habitat in the study area is still untransformed natural habitat where extensive livestock farming has been practised for many decades.
- The Eskom Electric Eagle Project was completed in 2006. The data on the location of large eagle nests on existing transmission lines in the study area is therefore now rather dated. However, indications are that the number of occupied territories tend to remain relatively stable (De Goede & Jenkins 2009; De Goede & Jenkins 2011).
- Different levels of survey effort for QDGCs in both the SABAP1 and SABAP2 coverage means that the reporting rates of species may not be an accurate reflection of relative densities in QDGCs that were sparsely covered to date. The reporting rates were therefore not treated as a realistic reflection of the actual densities, but merely as a guideline for the potential presence or absence of a specific species. Strong reliance was placed on professional judgment (see 3.1 above).
- Predictions 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 hold true under all circumstances; therefore professional judgment 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.
- The assessment is made on the basis of baseline conditions as it currently stands. Future potential changes in land use were not take on into account (e.g. renewable energy developments and fracking) as it is not known to which extent these developments will materialise.
- Emphasis was placed on the potential impact on Red Data species.

[2] http://www.iucnredlist.org/

4. STUDY AREA

The study area extends for approximately 380km from the vicinity of Victoria West in the Northern Cape Province to the vicinity of Touws River in the Western Cape Province (see Figure 1 below). The study area overlaps substantially with the following Important Bird Areas (IBAs) (Barnes 1998):

- Karoo National Park (SA 102)
- Anysberg Nature Reserve (SA 108)

The dry, semi-arid Karoo National Park is situated in the central Great Karoo, just north of Beaufort West and is contained in the study area. The IBA incorporates the Karoo National Park, the town of Beaufort West and its sewage works. The cliffs near the Gamka Dam hold breeding Verreauxs' Eagle, Booted Eagle and Black Stork. The other extensive patch of open water in the district, the Beaufort West sewage works, is particularly important for waterfowl in times of drought and when the surrounding farm dams and ephemeral waterbodies dry up. Greater Flamingo and Lesser Flamingo, both Red Data species, have been recorded at the sewage works. Powerline sensitive Red Data IBA trigger species for this IBA are the following:

- Blue Crane
- Martial Eagle
- Black Harrier
- Secretarybird
- Kori Bustard
- Ludwig's Bustard
- Verreaux's' Eagle
- Lanner Falcon
- Black Stork
- Karoo Korhaan

Corridor 3 bisects the southern part of the IBA.

The study area also overlaps partially with the Anysberg Nature Reserve, the closest potential corridor (alternative 3), is situated approximately 13km away. Located 20km south of Matjiesfontein and 20km southwest of Laingsburg, the Anysberg Nature Reserve is situated on the poorly known western fringe of the Little Karoo in a broad fynbos-Karoo transition zone. The proposed powerline is not expected to impact directly on the avifauna in the IBA.

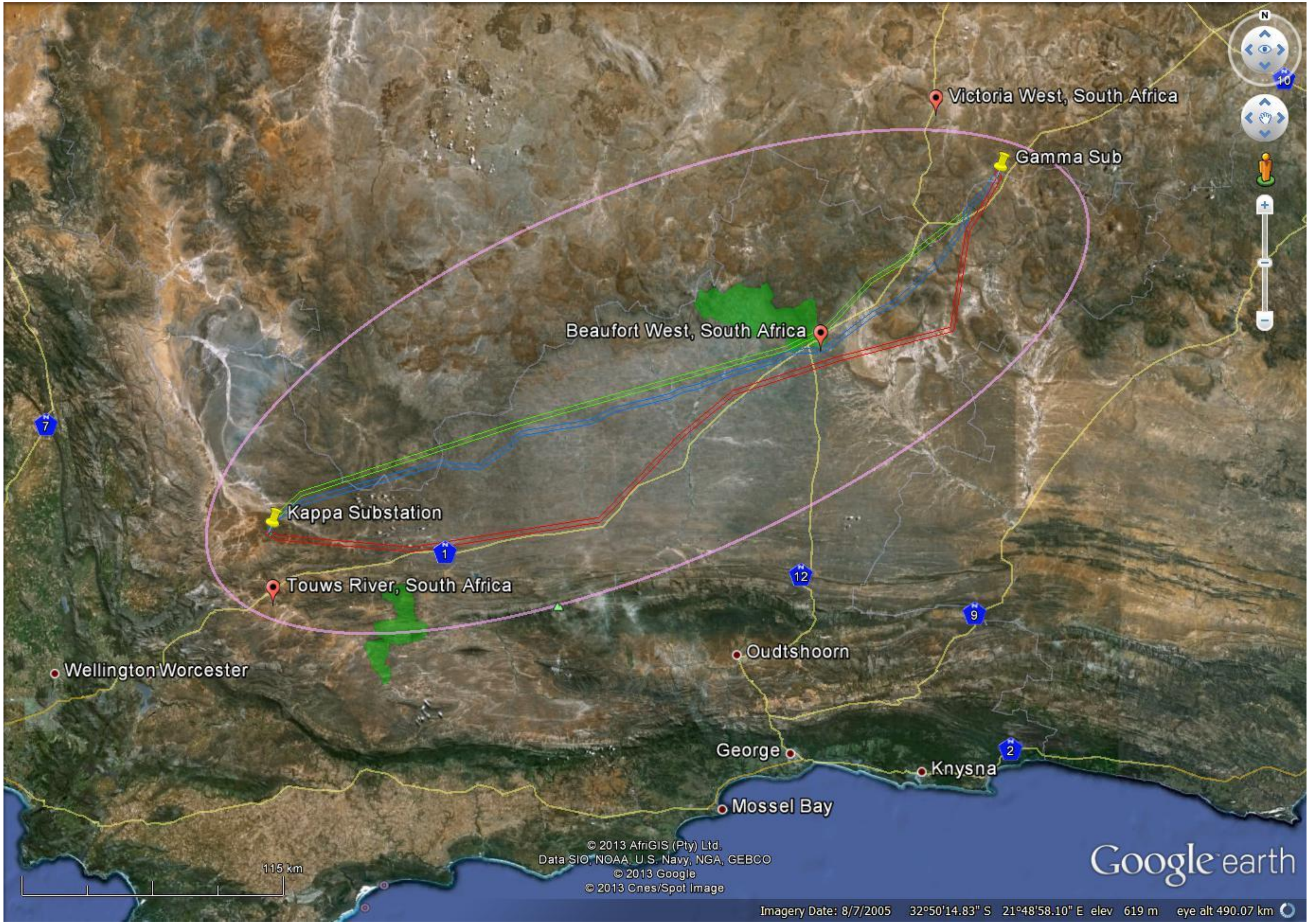

Figure 1: Map of 2km wide corridors (red = alternative 1, blue = alternative 2, green = alternative 3) and location of IBAs (green areas) within the greater study area (oval shaped area).

4.1 Description of vegetation types

The study area extends primarily over three biomes, namely Nama Karoo, Succulent Karoo and Fynbos, with small sections of Grassland Biome and Albany Thicket (Mucina & Rutherford 2006) (Figure 2). 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, SABAP1 recognises six primary vegetation divisions 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 criteria used by the SABAP1 authors 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. Appendix 1 provides a photographic record of the different bird habitats in the study area.

4.2 Description of bird habitat classes

Whilst much of the distribution and abundance of the bird species in the study area can be explained by the composition of the natural vegetation, it is as important to also examine the modifications which have changed the natural landscape, and which may have an effect on the distribution of power line sensitive species. These are sometimes evident at a much smaller spatial scale than the biome types, and are determined by a host of factors such as vegetation type, topography, land use and man-made infrastructure. For purposes of the analysis in this report, the following bird habitat classes were defined from an avifaunal perspective (vegetation descriptions based largely on Harrison *et al* 1997):

4.2.1 Karoo

Nama Karoo as dominated by low shrubs and grasses; peak rainfall occurs in summer. Trees, e.g. *Acacia karroo* and alien species such as Mesquite *Proposis glandulosa* are mainly restricted to watercourses, where fairly luxurious stands can develop. The Succulent Karoo falls within the winter rain-fall region in the far west, and is characterised by succulent shrubs, and a particular paucity of grass cover and trees. In comparison with the Succulent Karoo, the Nama Karoo has higher proportions of grass and tree cover. The two Karoo vegetation types support a particularly high diversity of bird species endemic to Southern Africa, particularly in the family *Alaudidae* (Larks). Its avifauna typically comprises ground-dwelling species of open habitats. Rainfall in the Nama Karoo falls mainly in summer, while peak rainfall in the Succulent Karoo occurs mainly in winter. This provides opportunities for birds to migrate between the Succulent and Nama Karoo, to exploit the enhanced conditions associated with rainfall. Many typical karroid species are nomads, able to use resources that are patchy in time and space (Barnes 1998). Power line sensitive Red Data species that are associated with Karoo habitat in the study area are Ludwig's Bustard, Kori Bustard, Karoo Korhaan, Martial Eagle, Secretarybird, Blue Crane, Black Harrier and Lanner Falcon. The major expected impact in this habitat is collisions with the earthwire of the proposed power line, particularly for Ludwig's Bustard, Blue Crane, Kori Bustard, Karoo Korhaan and Secretarybird.

4.2.2 Renosterveld

Fynbos is dominated by low shrubs and has two major vegetation divisions: fynbos proper characterised by restioid, erioid and proteoid components; and renosterveld, dominated by Asteraceae, specifically Renosterbos *Elytropappus rhinocerotis*, with geophytes and some grasses. The fynbos biome is primarily present in the western part of the study area and it is represented by shale renosterveld. Renosterveld, unlike fynbos, extend into the karoo shales, where rainfall patterns allow a high grass cover and abundance of non-succulent shrubs. Shale renosterveld shows strong affinities with neighbouring succulent Karoo vegetation (Mucina & Rutherford 2006). This biome is characterised by a high level of diversity and endemism in its botanical composition, which is not paralleled in its terrestrial avifauna, which is depauperate relative to other southern African biomes (Harrison *et al*. 1997). Power line sensitive Red Data species that may occur in the fynbos biome in the study area are Black Harrier, Martial Eagle, Secretarybird while Ludwig's Bustard and Karoo Korhaan may occur sporadically, especially in ecotonal areas between renosterveld and succulent Karoo. Envisaged impacts are collisions with the earthwire (mainly large terrestrial species) and displacement due to disturbance may also occur, e.g. breeding Black Harrier.

4.2.3 Waterbodies and rivers

The study area contains a variety of man-made water bodies (e.g. Gamka Dam, Leeugamka Dam, Floriskraal Dam, Beaufort-West Water Works and many smaller ones) and a myriad of ephemeral rivers which are of specific importance to some Red Data power line sensitive species in the semi-arid study area (see Figures 3 and 4). Ephemeral drainage lines are also corridors for woodland, which Kori Bustard often associate with, and occasionally, after good rains when pools form in the channels, they act as a draw card for waterbirds, including Black Stork. During such times, small birds are attracted to the water, which in turn may attract Lanner Falcons and other raptors. Man-made dams attract a multitude of water birds, including both Lesser and Greater Flamingo, and may sometimes be used as roosts by Blue Cranes in the eastern part of the study area. Dams with shallow sloping sides are also important for large raptors for bathing and drinking. Secretarybirds may be attracted to small *Vachellia karroo* trees in the water courses for breeding purposes. The major envisaged impact is collisions with the earthwire (waterbirds, cranes, flamingos and to a lesser extent raptors), and displacement due to habitat destruction.

4.2.4 Transmission lines

Transmission lines are an important roosting and breeding substrate for large raptors in the study area. Existing transmission lines are used extensively by large raptors - an aerial survey conducted under the auspices of Eskom and the Endangered Wildife Trust (Eskom Electric Eagle Project) in 2006 recorded a total of 38 large eagle nests on transmission line towers in the study area (Jenkins *et al* 2006) (Figure 5). Transmission lines therefore hold a special importance for large raptors. Should any new lines be constructed next to existing lines, the construction activities could lead to temporary displacement of breeding eagles, resulting in breeding failure in a particular season, or even permanent abandonment of a breeding territory (De Goede & Jenkins 2011).

4.2.5 Slopes

The majority of the proposed corridors are located in the topographically flat plains below the Nuweveld escarpment. However, in places the proposed corridors do cross steep terrain. In some instances, e.g. along the Nuweveld escarpment in the east between Beaufort West and Gamma Substation, in the mountains in the west nearer to Kappa Substation (e.g. Koedoesberge, Oliviersberg, Klein Roggeveldberge), along or close to inselbergs (e.g. Blinkfontein se berg, Rooiberg, Three Sister and Perdeberg) and along some of the drainage lines (e.g. Buffelsrivier) these slopes contain cliffs. These cliffs are potentially important roosting and breeding habitat for a variety of Red Data power line sensitive species, e.g. Black Stork, Lanner Falcon, Verreaux's Eagle and the non-Red Data Peregrine Falcon *Falco peregrinus,* Jackal Buzzard *Buteo rufofuscus* and Booted Eagle *Aquila pennatus*. The major envisaged impact on these species is collisions with the proposed power line, and displacement of breeding birds due to disturbance. Steep slopes are also important in that they are generally avoided by the Red Data collision-prone Ludwig's Bustard, Karoo Korhaan and Kori Bustard, which prefer the topographically flat plains and plateaus.

4.2.6 Low impact areas

The proposed corridors run through several types of habitat which would generally not attract power line sensitive Red Data species. For purposes of the analysis, these have all been grouped together under low impact areas. These are degraded areas, mines, urban/industrial areas, a few agricultural areas and major roads. No significant impacts on power line sensitive Red Data species are expected in these areas.

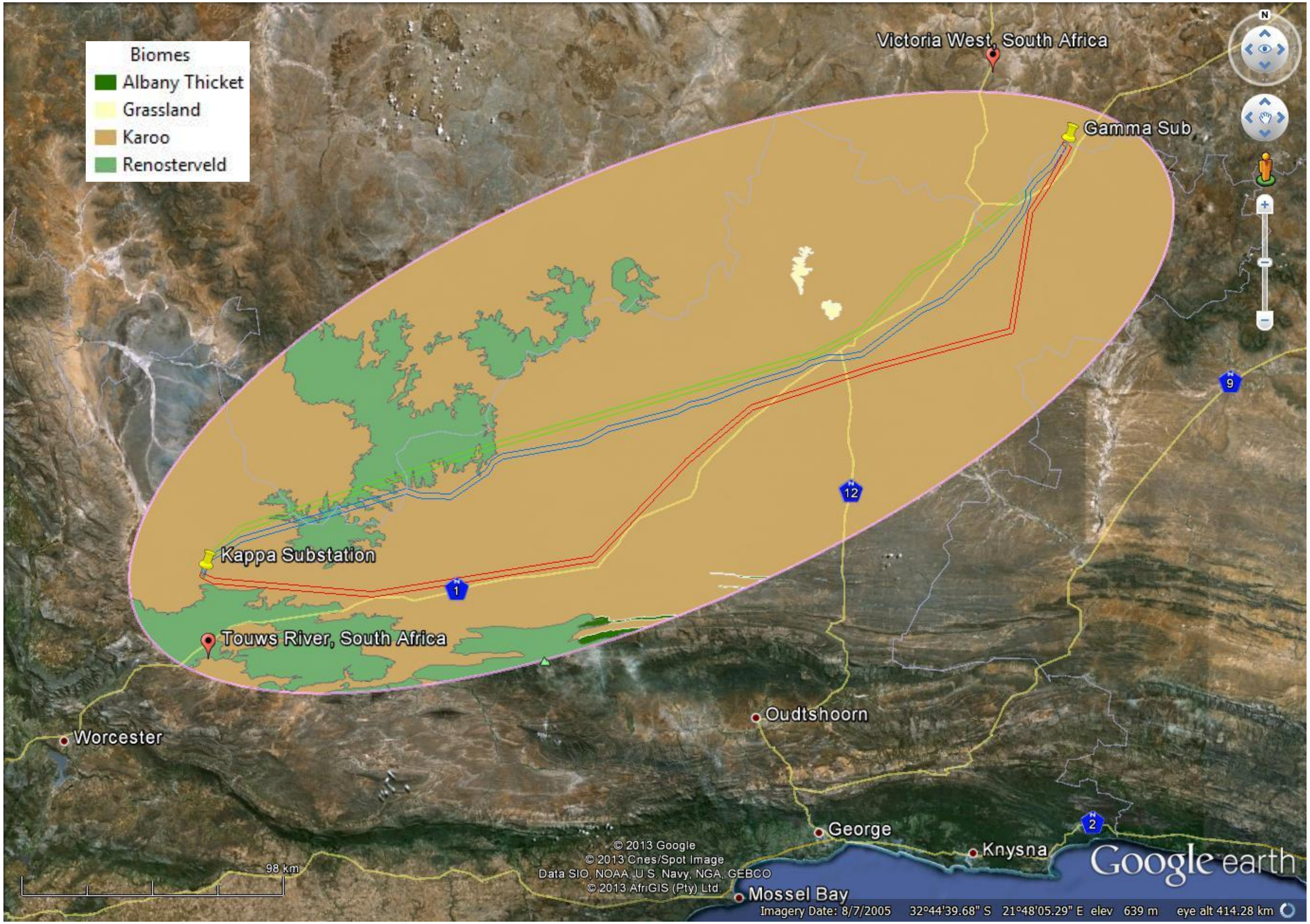

Figure 2: Biomes in the study area (Mucina & Rutherford 2006)

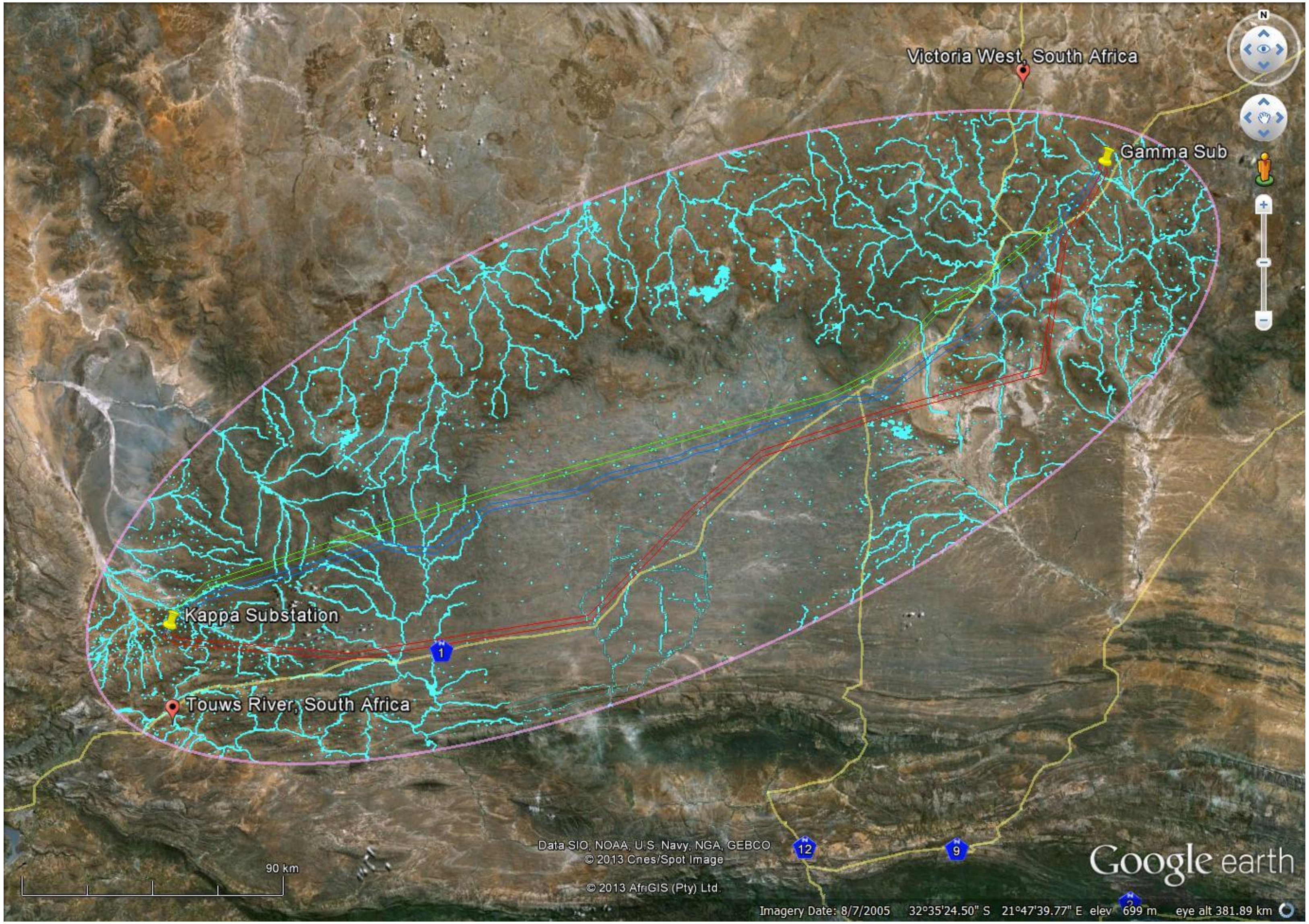

Figure 3: Ephemeral rivers and water bodies in the study area (Mucina & Rutherford 2006; NLCP 2009)

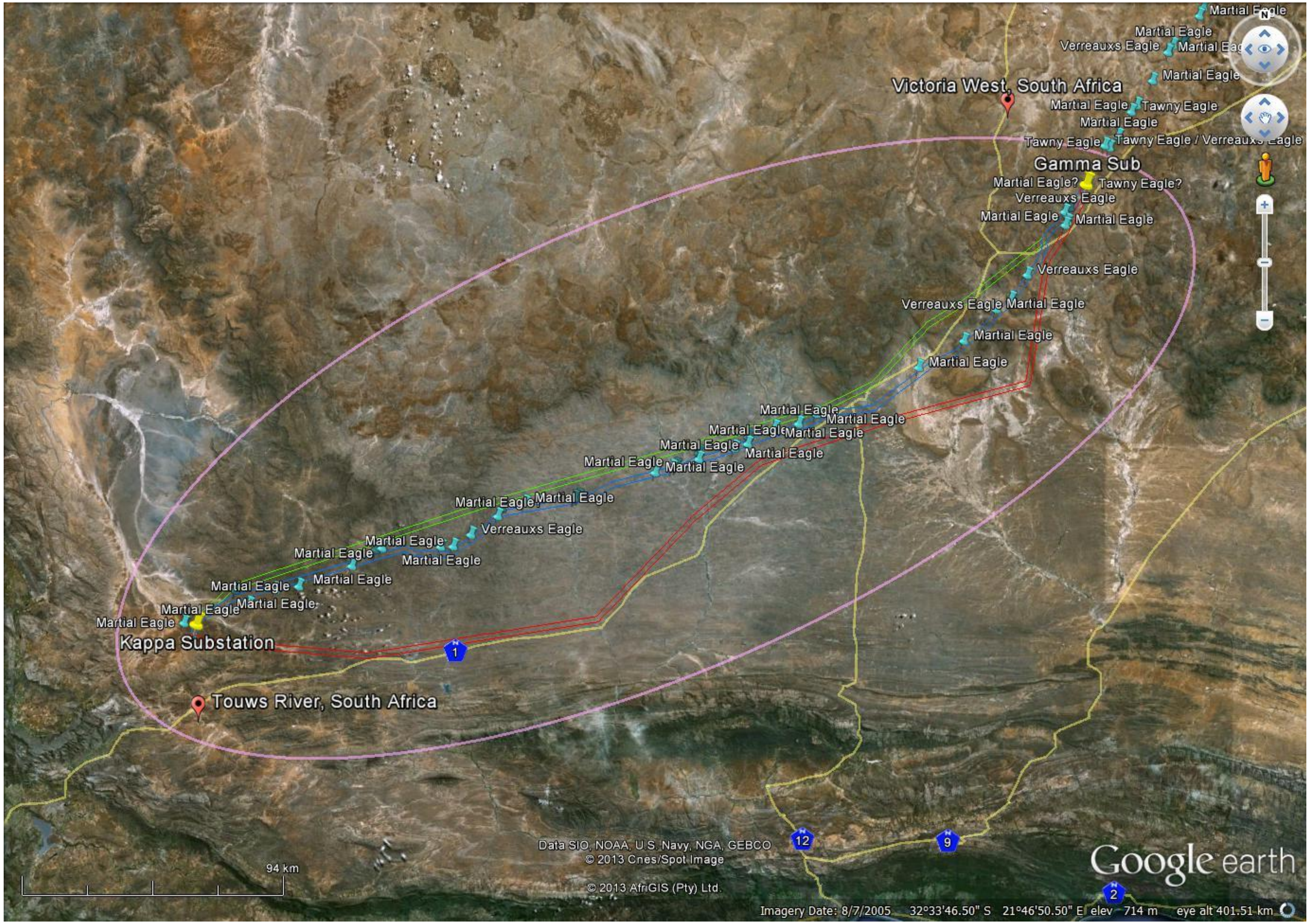

Figure 4: Historical large raptor nests on existing transmission lines in the study area (Jenkins *et al* 2006)

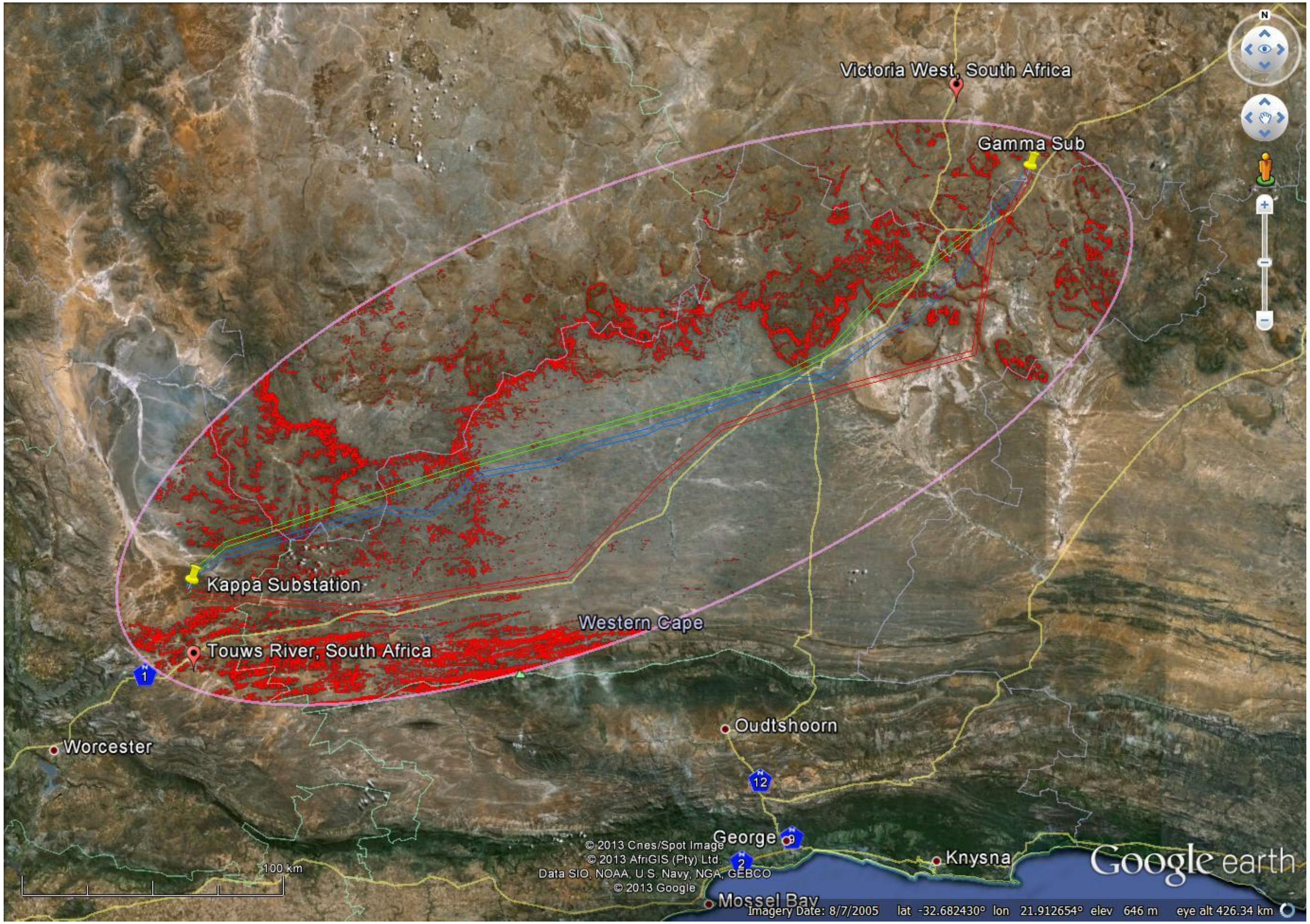

Figure 5: Slopes in the study area (areas with a gradient of >12°) calculated with a 90m digital elevation model (Jarvis *et al* 2008)

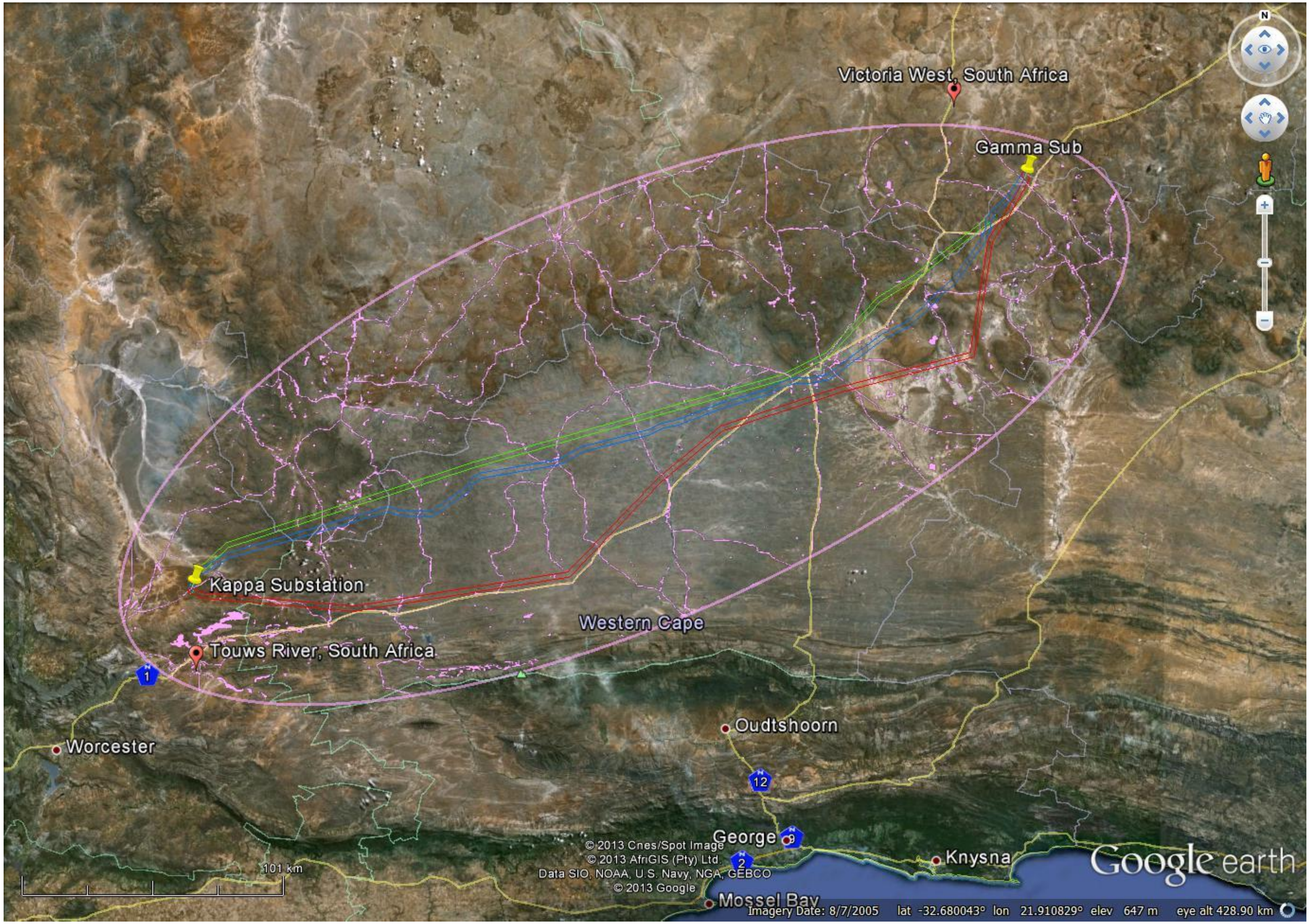

Figure 6: Low impact areas (degraded areas, mines, urban/industrial areas, a few agricultural areas and major roads) in the study area.

4.3 Power line sensitive species occurring in the study area

A total of 18 Red Data species have been recorded by SABAP1 and SABAP2 in the QDGCs that are bisected by the various corridors (see Table 3). Vagrants are indicated with an asterisk. For each species, the potential for occurring in a specific habitat class was indicated, as well as the potential impact most likely associated with this specific species.

Table 1: Red Data species recorded by SABAP1 and SABAP2 in the study area

NT=Near threatened VU=Vulnerable EN = Endangered LC = Least Concerned

Name	Taxonomic name	Regional Status (Taylor *et al.* 2015)	Global Status IUCN 2017	Habitat class						Potential impact		
				Karoo	Renosterveld	Waterbodies and rivers	Transmission lines	Low impact areas	Slopes	Collisions	Displacement through disturbance	Displacement through habitat destruction
Black Harrier	*Circus maurus*	EN	VU	x	x					x	x	
Black Stork	*Ciconia nigra*	VU	LC			x			x	x		
Blue Crane	*Anthropoides paradiseus*	NT	VU	x		x				x		
Cape Vulture*	*Gyps coprotheres*	EN	EN	x						x		
Kori Bustard	*Ardeatis kori*	NT	NT	x		x				x		
Lanner Falcon	*Falco biarmicus*	VU	LC	x	x		x	x	x		x	
Ludwig's Bustard	*Neotis ludwigii*	EN	EN	x						x		
Martial Eagle	*Polemaetus bellicosus*	EN	VU	x	x		x			x	x	
Verreaux's Eagle	*Aquila verreauxii*	VU	LC						x	x		

Name	Taxonomic name	Regional Status (Taylor *et al.* 2015)	Global Status IUCN 2017	Habitat class						Potential impact		
				Karoo	Renosterveld	Waterbodies and rivers	Transmission lines	Low impact areas	Slopes	Collisions	Displacement through disturbance	Displacement through habitat destruction
Sclater's Lark	*Spizocorys sclateri*	NT	NT	x								
Secretarybird	*Sagittarius serpentarius*	VU	VU	x	x	x				x	x	x
Tawny Eagle*	*Aquila rapax*	EN	LC	x			x			x	x	x
Marabou Stork*	*Leptoptilos crumeniferus*	NT	LC			x				x		
Yellow-billed Stork*	*Mycteria ibis*	EN	LC			x				x		
Great White Pelican*	*Pelecanus onocrotalus*	VU	LC			x				x		
Lesser Flamingo	*Phoenicopterus minor*	NT	NT			x				x		
Greater Flamingo	*Phoenicopterus roseus*	NT	LC			x				x		
Karoo Korhaan	*Eupodotis vigorsii*	NT	LC	x						x		

* Vagrant

5. DESCRIPTION OF EXPECTED IMPACTS

Because of their size and prominence, electrical infrastructures constitute 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; van Rooyen 2004, Jenkins & Smallie 2009; Jenkins *et al*. 2010; 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). The electrocution risk is largely determined by the pole/tower design. Potential tower types that could be utilised are self-supporting towers, cross-rope suspension towers and guyed-V towers. The topography will largely dictate the type of tower that will be used. **Due to the large size of the clearances on overhead lines of 765kV, electrocutions are ruled out as even the largest birds cannot physically bridge the gap between energised and/or energised and earthed components.** The risk of electrocution posed to Red Data species by the new power line infrastructure is therefore likely to be negligible, irrespective of which design is used, and need not be investigated further.

5.2 Collisions

Collisions are probably the biggest single 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 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 2012). 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 2012, 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 2012).

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)."

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 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 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.

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. 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 from 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).

A significant impact that is foreseen is collisions with the earth wire of the proposed 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 7 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.

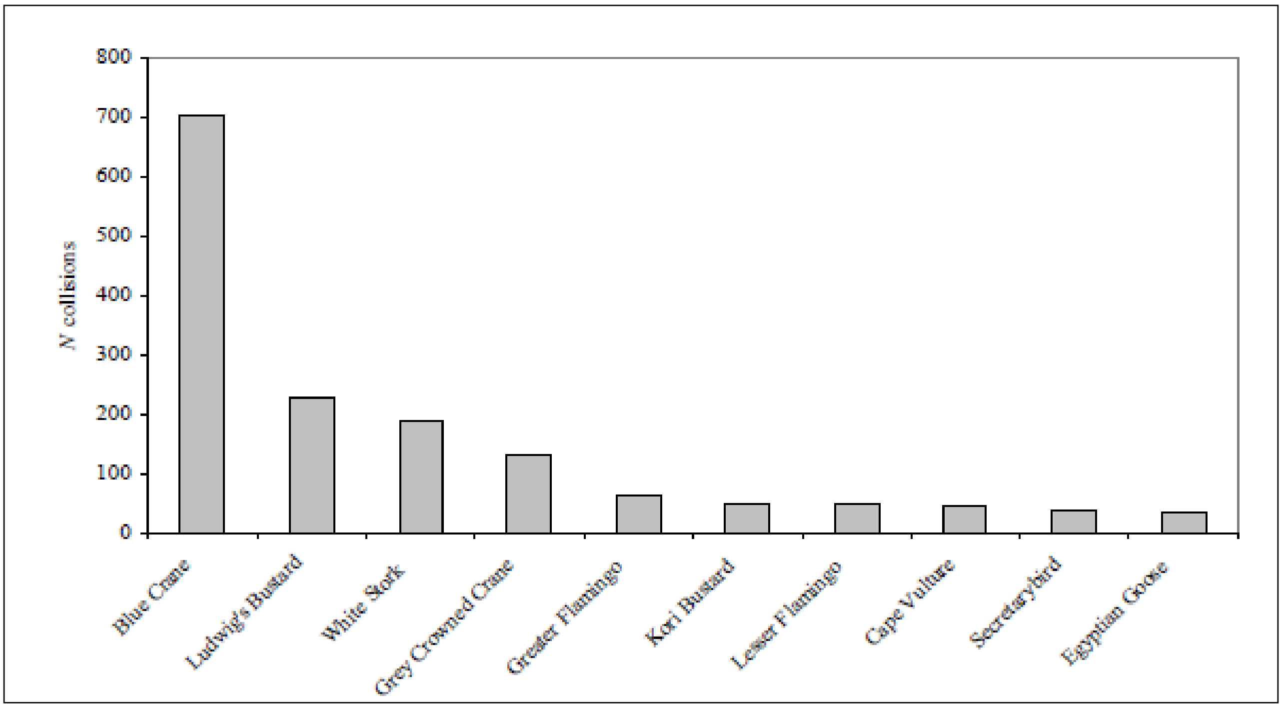

Figure 7: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins *et al* 2010)

The most likely candidates for collision mortality on the proposed power lines are Ludwig's Bustard, Kori Bustard, Karoo Korhaan, Greater Flamingo, Lesser Flamingo, Blue Crane and Secretarybird.

For Ludwig's Bustard, this risk is particularly relevant in the Karoo in the flat areas, as that is the preferred habitat for the species. Ludwig's Bustard is highly vulnerable to power line collisions (Jenkins & Smallie 2009; Jenkins et *al* 2010; Shaw 2013). Ludwig's Bustard will be at risk, 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; Shaw 2013), 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 corridors cross suitable habitat and the species is likely to be present in varying numbers, depending on foraging conditions. Ludwig's Bustard migratory movements are along a broad east-west axis (Shaw 2013), which is a mitigating factor to some extent as the line also follows a broad east-west axis, and does not cut diagonally across the general flight path of this species when doing long distance migratory flights. However, research has proven that the highest risk occurs when birds are resident in an area between migratory movements, presumably because they fly higher during migratory flights (Shaw 2013).

The highest risk for Black Stork will be where the corridors cross ephemeral rivers, where there are pools of standing water, and on slopes containing cliffs. Flamingos might be at risk near water bodies, particularly large dams e.g. the Gamka Dam and the smaller Beaufort-West Water Works. The biggest risk for Blue

Cranes will be near water bodies that are used as roost sites. Kori Bustards might be at risk anywhere in the Karoo habitat in flat areas, particularly when flying to roost sites in the late afternoon and early evening. It is not possible to link the risk to Secretarybirds to any specific habitat of behaviour, they could be at risk anywhere in flat areas in their foraging range. Lanner Falcon and Verreaux's Eagle will be most at risk on slopes containing cliffs, as would Peregrine Falcon, Booted Eagle and Jackal Buzzard.

5.3 Displacement due to habitat destruction 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. In the present instance, the risk of displacement of Red Data species due to **habitat destruction** is likely to be fairly limited, given the nature of the habitat. The biggest risk is likely to be where the line crosses ephemeral rivers, which could potentially result in the removal of trees, which are important breeding substrate for a number of species.

Apart from direct habitat destruction, the above mentioned construction and maintenance activities also impact on birds through **disturbance**, particularly during breeding activities. This could lead to breeding failure if the disturbance happens during a critical part of the breeding cycle. As far as disturbance is concerned, a specific situation may arise if the line is constructed near an existing transmission line. As mentioned earlier in this report, transmission lines are highly sought after by large raptors, particularly Martial Eagles, for roosting and breeding purposes. Construction activities in close proximity could be a source of disturbance and could lead to temporary breeding failure or even permanent abandonment of nests. Disturbance nay also occur where the line traverses steep cliff faces where Verreaux's Eagle, Booted Eagle, Jackal Buzzard, Lanner Falcon, Peregrine Falcon or Black Stork could be breeding or roosting.

6. ASSESSMENT OF IMPACTS AND SELECTION OF A PREFERRED ALTERNATIVE

One of the main objectives of this study is to arrive at a preferred corridor for the proposed transmission power lines, from an avifaunal interaction perspective. The Draft Environmental Impact Report provides a description of the various 2km wide corridor alternatives that were considered for this study (see also Figure 1 above). The methods that were followed to select a preferred corridor alternative are outlined below.

6.1 Methods

The potential for interaction with the proposed power line was assessed for each of the Red Data species listed in Table 1. This was done by assessing the probability of each potential impact (collisions, displacement through disturbance and displacement through habitat destruction) occurring, for each species, within each of the described habitat classes. The following probability scale was used: 1 = low, 2 = medium, 3 = high (see Appendix 2). Each habitat class therefore received a risk score for each species. The total risk score for a habitat class was calculated as the sum of the various individual species scores for that habitat class. Table 2 below gives the risk scores for each of the habitat classes:

Table 2: Risk scores for each habitat class

Habitat class	Risk score
Karoo	31
Renosterveld	11
Waterbodies & rivers	40
Transmission lines	10
Low impact	0
Slopes	19

The risk scores in Table 2 were incorporated into a formula to arrive at a risk rating for each 2km wide corridor alternative. The surface area of a corridor that intersected with a habitat class was calculated. Buffers were designed as follows for the following habitat classes:

- Waterbodies and rivers: A buffer of 250m was drawn around waterbodies, which were identified from the National Land Cover Project (2009). Rivers were identified from the Vegetation Map of South Africa (Mucina & Rutherford 2006), and also buffered by 250m.
- Existing transmission lines: A buffer of 200m was drawn around existing transmission lines.
- Low impact areas: Degraded areas, mines, urban/industrial areas, a few agricultural areas and major roads were identified from the National Land Cover Project (2009). A buffer of 100m was drawn around degraded areas.
- The **risk rating** for a power line **corridor alternative** was calculated by multiplying the percentage that each habitat class constitute of the total surface area of the 2km wide corridor with the risk score for that habitat class, and then adding up the totals. The risk ratings of the respective corridors are listed in Table 3 below.

The corridors emerged with very similar risk scores, indicating that the expected impacts are very similar for all three alternatives. However, Alternative 2 is the preferred alternative, the reason being that this alternative is situated next to the existing Droërivier – Hydra 2 400kV line (between Gamma and Droërivier substations), and the Droërivier- Muldersvlei 400kV line (between Droërivier and Kappa substations), which potentially reduces the risk of collisions. Placing the new line next to an existing transmission line should reduce the risk of collisions in the long term, because it creates a more visible obstacle to birds and the resident birds, particularly breeding adults, are used to an obstacle in that geographic location and have learnt to avoid it (Shaw 2013; APLIC 2012; Sundar & Choudhury 2005). Whereas it is acknowledged that this alternative could potentially result in significant short term temporary displacement impacts on breeding eagles on the adjoining existing transmission line during the construction phase, this should be weighed up against the reduction of the risk of long term collision impacts on large terrestrial species.

Table 3: Risk ratings of the alternative corridors

Alternative corridor	Habitat class	Habitat risk score	Percentage of surface area in corridor	Risk rating/100
Alt1	Transmission lines	10	3.92%	0.39
	Karoo	31	83.31%	25.83
	Low impact	0	2.23%	0.00
	Renosterveld	11	0.02%	0.00
	Slope	19	2.34%	0.45
	Waterbodies & rivers	40	8.17%	3.27
			Total	**29.94**
Alt2	HV Lines	10	19.20%	1.92
	Karoo	31	63.63%	19.72
	Low impact	0	1.61%	0.00
	Renosterveld	11	3.24%	0.36
	Slope	19	4.33%	0.82
	Waterbodies & rivers	40	7.99%	3.19
			Total	**26.02**
Alt3	HV Lines	10	1.50%	0.15
	Karoo	31	67.99%	21.08
	Low impact	0	1.82%	0.00
	Renosterveld	11	10.31%	1.13
	Slope	19	9.47%	1.80
	Waterbodies & rivers	40	8.92%	3.57
			Total	**27.72**

Figure 7: A map indicating alternative 2 (solid green line) which has emerged as the preferred alternative from a bird impact assessment perspective.

7. ASSESSMENT OF IMPACTS

The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Spatial extent
- Magnitude
- Duration
- Significance
- Probability of occurrence
- Confidence

Table 4: Assessment criteria for the evaluation of impacts.

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	Regional Local Site specific	Beyond a 10 km of the site boundary Within a 10 km of the site boundary On site or within 10 m of linear infrastructure corridors
Magnitude of impact (at the indicated spatial scale)	High Medium Low Very Low Zero	Natural and/ or social functions and/ or processes are severely altered. Natural and/ or social functions and/ or processes are notably altered. Natural and/ or social functions and/ or processes are slightly altered. Natural and/ or social functions and/ or processes are negligibly altered. Natural and/ or social functions and/ or processes remain unaltered.
Duration of impact	Construction period Medium Term Long Term	Up to 5 years 0-10 years after construction More than 10 years after construction

Table 5: Definition of significance ratings.

SIGNIFICANCE	DESCRIPTIVE RATINGS
High	• High magnitude with a regional extent and long-term duration • High magnitude with either a regional extent and medium term duration or a local extent and long term duration • Medium magnitude with a regional extent and long term duration
Medium	• High magnitude with a local extent and medium-term duration • High magnitude with a regional extent and construction period or a site specific extent and long term duration • High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration • Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Low magnitude with a regional extent and long term duration
Low	• High magnitude with a site-specific extent and construction period duration • Medium magnitude with a site specific extent and construction period duration • Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Very low magnitude with a regional extent and long term duration
Very low	• Low magnitude with a site-specific extent and construction period duration

	Very low magnitude with any combination of extent and duration except regional and long term
Neutral	Zero magnitude with any combination of extent and duration

Table 6: Probability rating estimations

PROBABILITY	DESCRIPTIVE RATING
Definite	Estimated greater than 99 % chance of the impact occurring.
Highly probable	Estimated 80 to 99 % chance of the impact occurring.
Probable	Estimated 20 to 80 % chance of the impact occurring
Possible	Estimated 1 to 20 % chance of the impact occurring.
Unlikely	Estimated less than 1 % chance of the impact occurring.

Table 7: Confidence ratings

LEVEL OF CONFIDENCE	DESCRIPTIVE RATING
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing impact
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Tables 8-10 below provides a summary of the expected impacts applying the criteria as listed in tables 4-7 above.

Table 8: Assessment of impacts: Alternative 1

Without mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	High	Long term	High	Definite	Sure
Displacement due to disturbance and habitat destruction	Local	Medium	Construction period	Medium	Probable	Unsure
With mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	Medium	Long term	Medium (except Ludwig's Bustard which remains high)	Definite	Sure
Mitigation:	• Once the final alignments and tower positions have been selected, the sections of the line that would need the application of Bird Flight Diverters to mitigate for potential collisions should be indicated by the avifaunal specialist. This walk-through exercise should be informed by an analysis of satellite imagery supplemented by on site ground-truthing. • In the case of nocturnal collisions, e.g. flamingos and/or Blue Cranes coming in to roost at a dam, the recently developed Viper LED bird flight diverter should be employed. • See Appendix 3 for the recommended Bird Flight Diverter and spacing.					
Displacement due to disturbance and habitat destruction	Local	Medium	Construction period	Low	Probable	Unsure
Mitigation:	• Restrict the construction activities to the construction footprint area. • Do not allow any access to the remainder of the property during the construction period. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • The recommendations of the specialist ecological study must be strictly adhered to, especially as far as rehabilitation of vegetation is concerned.					

Table 9: Assessment of impacts: Alternative 2

Without mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	Medium	Long term	High	Definite	Sure
Displacement due to disturbance and habitat destruction	Local	High	Construction period	Medium	Definite	Sure
With mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	Medium	Long term	Medium (except Ludwig's Bustard which remains high)	Probable	Sure
Mitigation:	• For the reasons stated earlier, Alternative 2 emerged as the alternative with the lowest collision risk to birds. It is therefore recommended that this corridor is selected. • Once the final alignments and tower positions have been selected, the sections of the line that would need the application of Bird Flight Diverters to mitigate for potential collisions should be indicated by the avifaunal specialist. This walk-through exercise should be informed by an analysis of satellite imagery supplemented by on site ground-truthing. • In the case of nocturnal collisions, e.g. flamingos and/or Blue Cranes coming in to roost at a dam, the recently developed Viper LED bird flight diverter should be employed. • See Appendix 3 for the recommended Bird Flight Diverter and spacing.					
Displacement due to disturbance and habitat destruction	Local	Medium	Construction period	Low	Probable	Sure
Mitigation:	• Restrict the construction activities to the construction footprint area. • Do not allow any access to the remainder of the property during the construction period. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • The recommendations of the specialist ecological study must be strictly adhered to, especially as far as rehabilitation of vegetation is concerned. • Prior to construction commencing a helicopter inspection should be conducted in order for the avifaunal specialist to record any large raptor nests on existing transmission lines that could be impacted by the construction of the proposed line. • Should any nests be recorded, it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist, and the Environmental Control Officer. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable them to ascertain when, and where breeding Red Data eagles could be impacted by the construction					

	activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle, once it has been established that a particular nest is active.

Table 10: Assessment of impacts: Alternative 3

Without mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	High	Long term	High	Definite	Sure
Displacement due to disturbance and habitat destruction	Local	Medium	Construction period	Medium	Probable	Unsure
Mitigation:	• Once the final alignments and tower positions have been selected, the sections of the line that would need the application of Bird Flight Diverters to mitigate for potential collisions should be indicated by the avifaunal specialist. This walk-through exercise should be informed by an analysis of satellite imagery supplemented by on site ground-truthing. • In the case of nocturnal collisions, e.g. flamingos and/or Blue Cranes coming in to roost at a dam, the recently developed Viper LED bird flight diverter should be employed. • See Appendix 3 for the recommended Bird Flight Diverter and spacing.					
With mitigation						
Nature	**Extent**	**Magnitude**	**Duration**	**Significance**	**Probability**	**Confidence**
Collisions with the earthwire	Local	Medium	Long term	Medium (except Ludwig's Bustard which remains high)	Definite	Sure
Displacement due to disturbance and habitat destruction	Local	Medium	Construction period	Low	Probable	Unsure
Mitigation:	• Restrict the construction activities to the construction footprint area. • Do not allow any access to the remainder of the property during the construction period. • Measures to control noise and dust should be applied according to current best practice in the industry. • Maximum used should be made of existing access roads and the construction of new roads should be kept to a minimum. • The recommendations of the specialist ecological study must be strictly adhered to, especially as far as rehabilitation of vegetation is concerned. • The 25km section of this alternative which runs next to the existing Hydra – Droërivier 2 400kV line and Gamma – Omega 765kV line must be inspected for raptor nests. • Should any nests be recorded, it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the					

		involvement of the avifaunal specialist, and the Environmental Control Officer. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable them to ascertain when, and where breeding Red Data eagles could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle, once it has been established that a particular nest is active.

8. MITIGATION

Any attempt at quantifying the potential bird impacts for the proposed development would entail the collection of significant amounts of quantitative data, for example one would have to establish how many pairs of a given species are using a particular area of habitat and document the potential breeding failure through disturbance that could occur if a transmission line is constructed through that area of habitat. Then the influence of this impact on the ability of the local, regional or even national population to persist would have to be documented and quantified. Clearly such detailed studies fall outside the scope of this report. The fact that impacts such as habitat destruction and disturbance could be significant but difficult to quantify, requires that all possible mitigation measures should be implemented on the basis of the pre-cautionary principle. The World Charter for Nature, which was adopted by the UN General Assembly in 1982, was the first international endorsement of the precautionary principle. The principle was implemented in an international treaty as early as the 1987 Montreal Protocol and among other international treaties and declarations is reflected in the 1992 Rio Declaration on Environment and Development. Principle 15 of the Rio Declaration 1992 states that: “in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, **lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation.”**.

There are many methods that can be used to mitigate avian power line interactions (see for example, APLIC 2012) and several investigations dealing with the collision problem have focused on finding suitable mitigation measures (see APLIC 2012 for an overview). The most proactive measures are power line route planning (and the subsequent avoidance of areas with a high potential for bird strikes) and the modification of power line designs (this option includes line relocations, underground burial of lines, removal of over-head ground wires, and the marking of ground wires to make them more visible to birds in flight). In many instances, decisions on power line placement and possible mitigation measures are however eventually based on economic factors.

The relocation of an existing line is the last option that is usually considered when trying to mitigate avian collisions. The huge expense of creating a new line and servitude usually cannot be justified unless there are biologically significant mortalities. Underground burial of power lines is another option available to utility companies in areas of high collision risk. This will obviously eliminate collisions, but the method has many drawbacks. The costs of burying lines can be from 20 – 30 times (or more) higher than constructing overhead lines, and such costs are related to the line voltage, type and length of cable, cable insulation, soil conditions, local regulations, reliability requirements, and requirement of termination areas. Limitations of cable burial include: no economically feasible methods of burying extra high voltage lines have been developed, there is a potential to contaminate underground water supplies if leakage of oil used in insulating the lines occurs, and extended outage risks due to the difficulty in locating cable failures (APLIC 2012).

Since most strikes involve earth-wires (more than 80% of observed bird collisions), the removal of these wires would decrease the number of collisions. It is assumed that the large number of earth-wire collisions is because birds react to the more visible conductors by flaring and climbing and then collide with the thinner earth-wires (Anderson 2001). Earth-wire removal is, however, not a simple matter. Due to the need for lightning protection and other types of electricity overload, it is only possible on lower-voltage power lines (where polymer lightning arresters can be used). The marking of overhead earth-wires to increase their visibility is usually considered to be the most economical mitigation option for reducing collision mortality (APLIC 2012). This is particular so for the thousands of kilometres of established power lines through areas of high potential for avian interaction which cannot be rerouted.

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 many studies which prove that marking a line with PVC spiral type Bird Flight Diverters (BFDs) generally reduce mortality rates significantly (e.g. Sporer *et al*. 2013; Barrientos *et al* 2011; Jenkins *et al* 2010; Alonso & Alonso 1999; Koops & De Jong 1982), but less so 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 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. Hoogstad (pers. comm 2017) confirmed that experiments in line marking with Bird Flappers, an alternative to BFDs, conducted by the Endangered Wildlife Trust in the Karoo, are also effective in significantly reducing Blue Crane mortality.

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). In the case of nocturnal collisions, e.g. flamingos and/or Blue Cranes coming in to roost at a dam, the option of using the recently developed Viper LED bird flight diverter should be explored.

It is not the objective of this report to attempt to demarcate all sections of power line for all the alternative corridors that would need to be mitigated for potential collisions or disturbance of Red Data breeding species. This can only be done through a walk-through exercise once the final alignment has been selected and tower positions have been finalized.

See section 7 above and Appendix 3 for proposed mitigation measures recommended for each alternative.

9. CONCLUSIONS

It is envisaged that the proposed 2d Gamma – Kappa 765kV line will have two major potential impacts on Red Data avifauna, namely displacement due to disturbance of breeding birds, especially breeding Martial

Eagles on existing transmission lines, and mortality of large terrestrial species due to collisions with the earthwire of the proposed line. The latter impact is especially concerning as far as the Endangered Ludwig's Bustard is concerned, as the species is known to be highly susceptible to this impact, and conventional mitigation methods, i.e. the marking of the earthwire with Bird Flight Diverters, seems to have limited success in reducing mortality for this species (Hoogstad pers. comm 2017). It must therefore be accepted that even with current state of the art mitigation, Ludwig's Bustard collisions are likely to still take place, irrespective of which corridor is ultimately selected.

The cumulative impact of transmission lines in the Karoo as far as collision mortality of large terrestrial species is concerned is alarming, and potentially catastrophic as far as Ludwig's Bustard is concerned, with an estimated 41% of the population being killed annually, with Kori Bustards also dying in large numbers (at least 14% of the South African population killed in the Karoo alone) (Shaw 2013). The addition of another transmission line will potentially aggravate the situation further. Ludwig's Bustard migratory movements are along a broad east-west axis (Shaw 2013), which is a mitigating factor to some extent as the line also follows a broad east-west axis, and does not cut diagonally across the general flight path of this species when doing long distance migratory flights. However, research has shown that the highest collision risk occurs when birds are resident in an area between migratory movements, presumably because they fly higher during migratory flights (Shaw 2013).

No electrocution risk is envisaged as the clearances (phase – phase and phase – earth) on the proposed 765kV line are too large for any bird tp physically bridge, thereby eliminating any potential for a bird causing a short circuit.

The three alternative corridors emerged with very similar risk ratings, indicating that the expected impacts are very similar for all three. However, Alternative 2 is the preferred alternative, the reason being that this alternative is situated next to the existing Droërivier – Hydra 2 400kV line (between Gamma and Droërivier substations), and the Droërivier- Muldersvlei 400kV line (between Droërivier and Kappa substations), which potentially reduces the risk of collisions. Placing the new line next to an existing transmission line could reduce the risk of potential collisions in the long term, because it creates a more visible obstacle to birds and the resident birds, particularly breeding adults, are familiar with an obstacle in that geographic location and may have learnt to avoid it (Shaw 2013; APLIC 2012; Sundar & Choudhury 2005). Whereas it is acknowledged that this alternative, unless mitigated, could potentially result in significant short term temporary displacement impacts on breeding eagles on the adjoining existing transmission line during the construction phase, this should be weighed up against the reduction of the risk of long term collision impacts on large terrestrial species, particularly Ludwig's Bustard.

The proposed mitigation measures should reduce the impact of the proposed line to low in all instances for all impacts, except for Ludwig's Bustard, where the collision impact will remain high, even with mitigation.

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APPENDIX 1 BIRD HABITATS

Figure 1: Typical Karoo grassland and scrub on the plains south of the Nuweveld escarpment

Figure 2: The Gamka River, a typical ephemeral drainage line in the Karoo

Figure 3: Existing transmission lines near Droërivier Substation

Figure 4: Steep slopes and cliffs along the Nuweveld escarpment

Figure 5: Typical inselberg with steep slopes and low cliffs

Figure 6: Black Storks *Ciconia nigra* at a pool in the Soutrivier near Nelspoort


Figure 7: Beaufort West Dam

Figure 7: Acacia woodland along a dry ephemeral river (Vanderbylskraalrivier) near Merweville


Figure 8: Cliffs along the steep sides of the Buffelsrivier near Kappa Substation


Figure 9: Renosterveld in the western part of the study area

APPENDIX 2 HABITAT RISK RATINGS FOR INDIVIDUAL RED DATA SPECIES

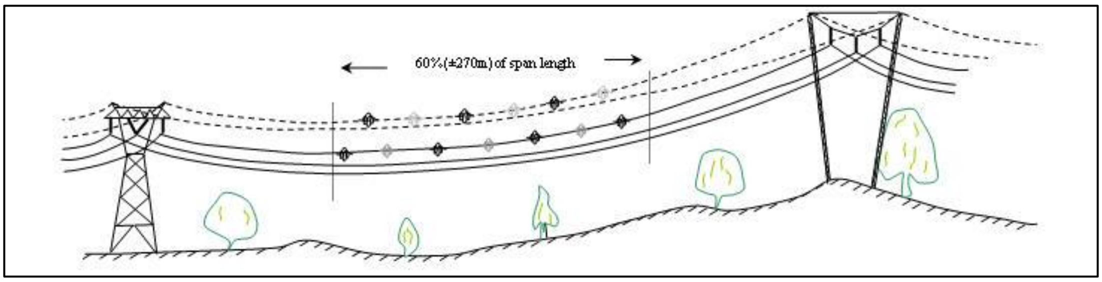
Black Harrier	Collisions	Disturbance	Habitat destruction	Total
Karoo	1	2	1	4
Renosterveld	1	3	1	5
Waterbodies & rivers	0	0	0	0
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	1	3	1	5
Black Stork	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	3	2	2	7
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	3	2	1	6
Blue Crane	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	3	2	1	6
Renosterveld	0	0	0	0
Waterbodies & rivers	3	3	2	8
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Cape Vulture	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	0	0	0	0
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0

Kori Bustard	Collisions	Disturbance	Habitat destruction	Total
Karoo	3	2	1	6
Renosterveld	0	0	0	0
Waterbodies & rivers	1	2	2	5
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Lanner Falcon	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	2	2	1	5
Transmission lines	2	2	0	4
Low impact	0	0	0	0
Slopes	2	2	1	5
Ludwig's Bustard	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	3	2	0	5
Renosterveld	2	1	0	3
Waterbodies & rivers	0	0	0	0
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Martial Eagle	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	1	0	0	1
Renosterveld	0	0	0	0
Waterbodies & rivers	1	0	0	1
Transmission lines	2	3	0	5
Low impact	0	0	0	0
Slopes	0	0	0	0
Verreaux's Eagle	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	1	2	0	3
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	2	1	0	3

Sclater's Lark	Collisions	Disturbance	Habitat destruction	Total
Karoo	0	1	0	1
Renosterveld	0	0	0	0
Waterbodies & rivers	0	0	0	0
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Secretarybird	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	3	1	0	4
Renosterveld	1	0	0	1
Waterbodies & rivers	0	2	0	2
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Tawny Eagle	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	0	0	0	0
Transmission lines	0	1	0	1
Low impact	0	0	0	0
Slopes	0	0	0	0
Marabou Stork	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	1	0	0	1
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Yellow-billed Stork	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	1	0	0	1
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0

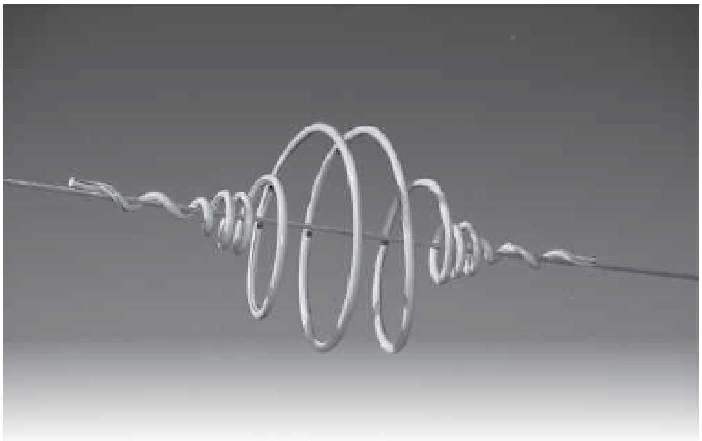
Great White Pelican	Collisions	Disturbance	Habitat destruction	Total
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	1	0	0	1
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Lesser Flamingo	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	3	0	0	3
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Greater Flamingo	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	0	0	0	0
Renosterveld	0	0	0	0
Waterbodies & rivers	3	0	0	3
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0
Karoo Korhaan	**Collisions**	**Disturbance**	**Habitat destruction**	**Total**
Karoo	2	2	0	4
Renosterveld	1	1	0	2
Waterbodies & rivers	0	0	0	0
Transmission lines	0	0	0	0
Low impact	0	0	0	0
Slopes	0	0	0	0

APPENDIX 3: RECOMMENDED BIRD FLIGHT DIVERTERS AND SPACING



PLP – The connection you can count on

Double Loop Bird Flight Diverter



General Recommendation

The Bird Flight Diverter is designed to make overhead lines visible to birds and provides and economic means of reducing the hazard to both lines and birds. For low and medium voltage construction (up to 40kV) it is applied to the phase conductors (bare or jacketed). For high voltage it is used on the earth wire.

The fitting is light in weight, offers little wind resistance and is easily and quickly applied. The positive grip of the fitting on the conductor ensures that it remains in the applied position and cannot move along the span under vibration.

Visibility: The diverter section increases the visibility profile of the cable or conductor to a degree necessary to ensure safety, but avoids undesirably bulky outline.

Spacing: Spacing distances are not critical and will depend upon local conditions. Since wind resistance is very limited, sufficient fittings can be used to ensure adequate visibility without creating stresses on the line. When marking adjacent spans, overall visibility is improved by staggering the application.

We recommend generally a spacing of 10 or 15 metres.

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Telephone: 033 387 1520 • Facsimile: 033 387 7094
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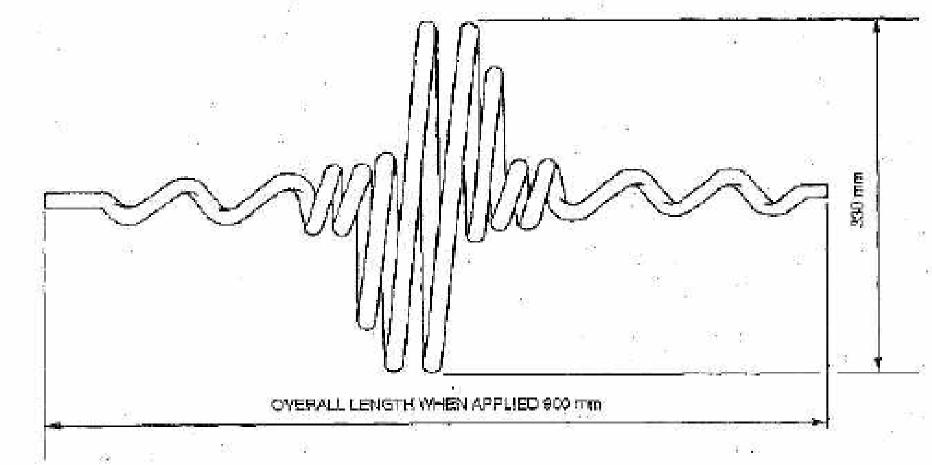
Double Loop Bird Flight Diverter



Material Used: Manufactured from rigid solid high impact polyvinyl chloride, possessing excellent chemical and strength properties and which will retain good physical characteristics within the range of extreme temperatures. Outdoor aging tests indicate that the material does not deteriorate in function or appearance from the effects of severe weather conditions. Industrial fumes and salt water cannot seriously degrade the properties of rigid PVC.

Colour: White or Black

Lay Direction: Bird Flight Diverters are supplied right hand lay for both right hand and left hand lay bare conductors and insulated cables.

CATALOGUE NO.	CONDUCTOR/ E/WIRE DIA. RANGE
BFD 0914/LD2*	9 mm – 14 mm

*Add B or W to denote colour

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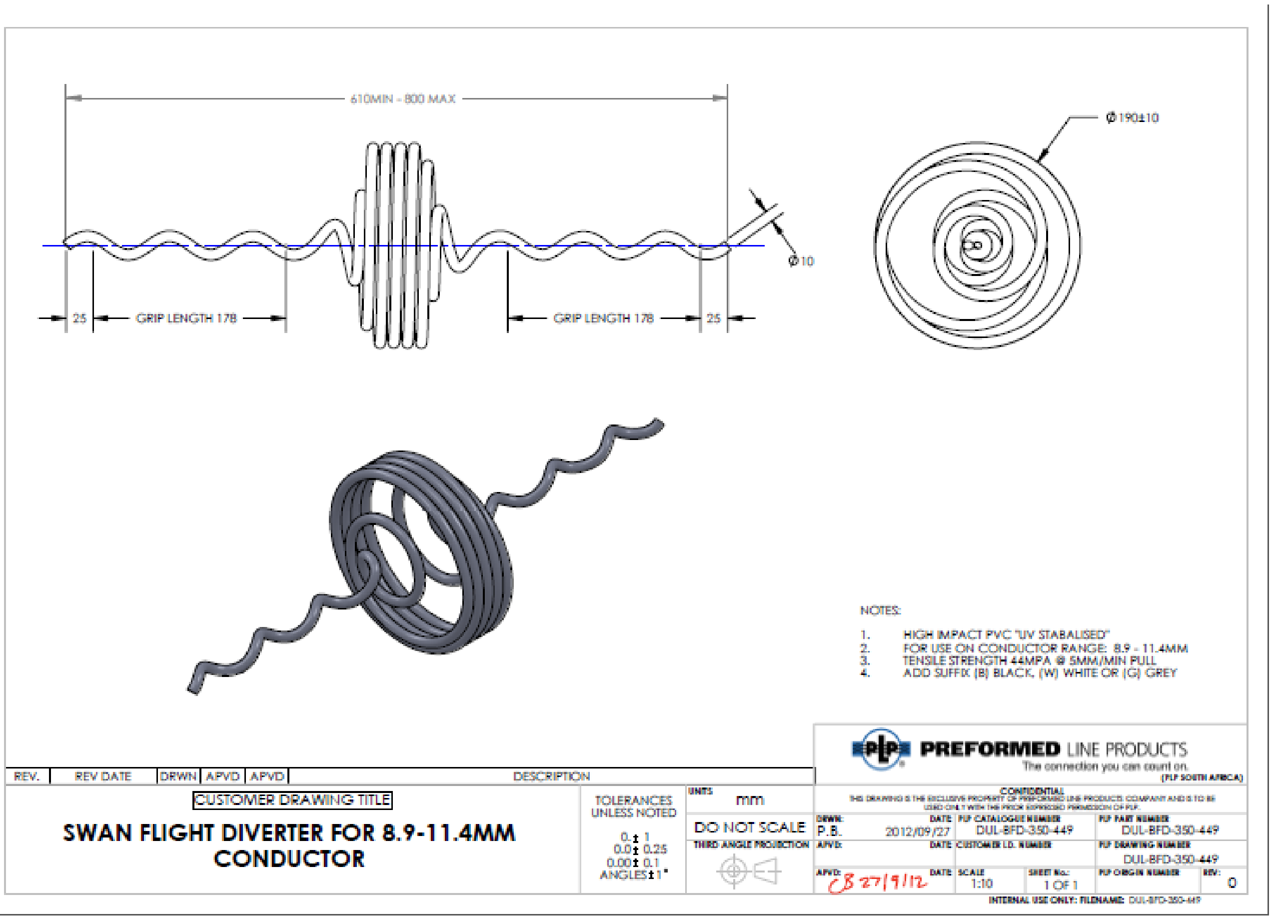
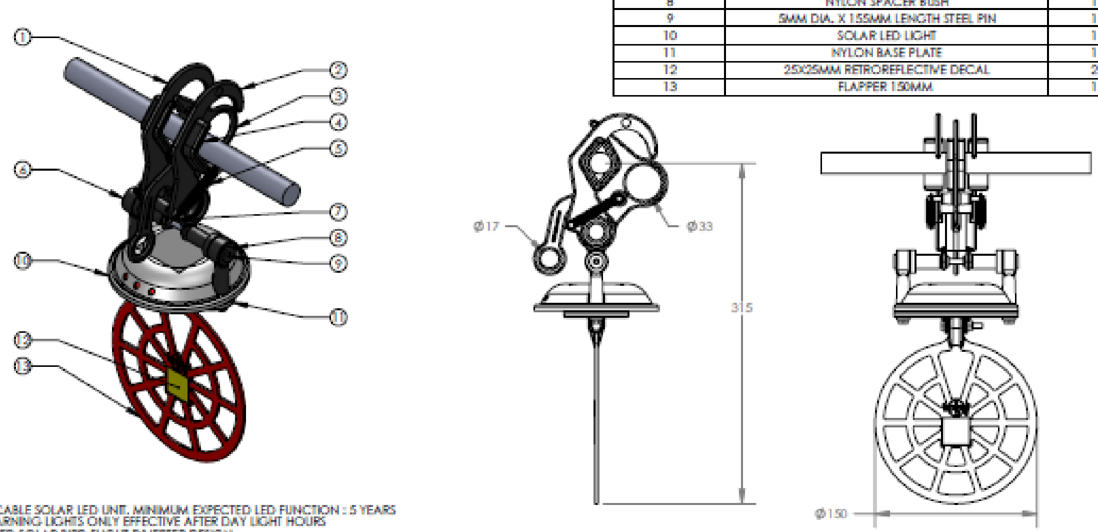


CAT. NO.	FLAPPER COLOURS	LED COLOURS
BFFL-LED	B : BLACK	R : RED
	W : WHITE	B : BLUE
	G : GREY	W : WHITE
	R : RED	G : GREEN
	Y : YELLOW	O : ORANGE
E.G. FOR CAT NUMBER : BFFL-LED R RW BIRD FLIGHT DIVERTER FOR CONDUCTOR RANGE 5 - 40MM WITH RED FLAPPER, RED LED LIGHTS ONE SIDE AND WHITE LED LIGHTS ON THE OTHER.		

ITEM NO.	DESCRIPTION	QTY.
1	VIPER BFD OUTER ARM 1	1
2	VIPER BFD OUTER ARM 1	1
3	VIPER BFD CENTRE ARM	1
4	RUBBER GRIP STRIP	3
5	STAINLESS STEEL SPRING 41.9-61.3MM	2
6	NYLON ARM	2
7	SPRING PIN	2
8	NYLON SPACER BUSH	1
9	5MM DIA. X 155MM LENGTH STEEL PIN	1
10	SOLAR LED LIGHT	1
11	NYLON BASE PLATE	1
12	25X25MM RETROREFLECTIVE DECAL	2
13	FLAPPER 150MM	1



NOTES:

1. REPLACABLE SOLAR LED UNIT. MINIMUM EXPECTED LED FUNCTION : 5 YEARS
2. LED WARNING LIGHTS ONLY EFFECTIVE AFTER DAY LIGHT HOURS
3. PATENTED SOLAR BIRD FLIGHT DIVERTER DESIGN
4. WEIGHT : 500 GRAMS
5. ALL PLASTIC COMPONENTS UV STABALISED
6. CONDUCTOR DIAMETER 5-40MM

PREFORMED LINE PRODUCTS
The connection you can count on.
(PLP SOUTH AFRICA)

REV.	REV DATE	DRWN	APVD	DESCRIPTION

CUSTOMER DRAWING TITLE

VIPER LIVE LINE BIRD FLIGHT DIVERTER WITH SOLAR LED LIGHT

TOLERANCES UNLESS NOTED: 0. ± 1; 0.0 ± 0.25; 0.00 ± 0.1; ANGLES ± 1°

UNITS: mm — DO NOT SCALE — THIRD ANGLE PROJECTION

CONFIDENTIAL

DRWN: P.B. DATE 2015/01/27 — PLP CATALOGUE NUMBER — PLP PART NUMBER: SEE TABLE

APVD: CB 27/1/15 DATE — CUSTOMER I.D. NUMBER — PLP DRAWING NUMBER: BFFL-LED (SALES)

APVD: DATE — SCALE 1:10 — SHEET No.: 1 OF 1 — PLP ORIGIN NUMBER — REV:

INTERNAL USE ONLY: FILENAME: BFFL-LED (SALES)