

INYANDA ROODEPLAAT WIND FARM, EASTERN CAPE, SOUTH AFRICA: BIRD SURVEYS AUGUST 2015 – JANUARY 2016



Black Harrier © Steve Percival

Report to Newcombe Wind Developments

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TABLE OF CONTENTS

TABLE OF CONTENTS.....	2
INTRODUCTION	3
BIRD SURVEY METHODS.....	3
BREEDING EAGLE SURVEYS	3
YEAR-ROUND VANTAGE POINT SURVEYS	4
GRID CONNECTION ROUTE SURVEYS	5
BIRD SURVEYS AUGUST – OCTOBER 2015: RESULTS.....	5
BREEDING EAGLE SURVEY RESULTS	5
VANTAGE POINT SURVEY RESULTS.....	7
GRID CONNECTION ROUTE TRANSECT SURVEY RESULTS.....	9
ORNITHOLOGICAL ASSESSMENT UPDATE	10
COLLISION RISK MODELLING	10
COLLISION MODELLING RESULTS.....	13
COLLISION MODELLING INTERPRETATION	14
DISTURBANCE EFFECTS	17
EFFECTS OF GRID CONNECTION.....	18
CONCLUSIONS AND RECOMMENDATIONS.....	18
REFERENCES	18

INYANDA ROODEPLAAT WIND FARM: BIRD SURVEYS AUGUST 2015-JANUARY 2016

Introduction

1. This work was commissioned by Newcombe Wind Developments to undertake baseline bird survey work at Inyanda Rooideplaar for the proposed wind farm, updating the previous bird survey work to address concerns with the existing data. Its purpose was not to undertake a full baseline survey but rather to focus on the key issues, data gaps and ornithological sensitivities already identified, specifically:
 - Eagle breeding status and distribution (particularly Verreaux's Eagle and Martial Eagle).
 - Eagle and other large raptor flight activity within and around the proposed wind farm site (particularly Verreaux's Eagle and Martial Eagle).
 - Species vulnerable to collision with overhead wires along the proposed grid connection route (particularly Blue Crane, and Ludwig's and Denham's Bustards)
2. The surveys have been designed to take into account BirdLife South Africa emerging guidance (Jenkins et al. 2015) and other international guidance on bird surveys for wind farms (including Natural England, Drewitt 2010 and Scottish Natural Heritage, SNH 2014). The initial August surveys were undertaken by Mike Hoit and Keith Langdon, during which the local surveyor, Adri Barkhuysen (a local raptor expert) was trained to Ecology Consulting wind farm survey standards. Adri Barkhuysen then undertook the September to January surveys, with all of the data checking and processing undertaken by Ecology Consulting, who are also carrying out all of the data analysis and reporting.
3. The assessment methodology used in this report follows the same as that used in our previous report (Percival et al. 2015). It draws on the methodology developed by SNH and the British Wind Energy Association [BWEA] (Percival et al. 1999) and updated by Percival (2007), and with SNH (2006) guidance on assessing the impacts from onshore wind farms on birds in the wider countryside.

Bird Survey Methods

4. The surveys during the August 2015 – January 2016 period were carried out on the following dates
 - Visit 1: 25-31 August;
 - Visit 2: 22 September – 1 October;
 - Visit 3: 19 – 27 October;
 - Visit 4: 17-24 November;
 - Visit 5: 12-19 December;
 - Visit 6: 21-27 January and 1-2 February.

Breeding eagle surveys

5. Two previous breeding eagle surveys have been undertaken as part of the baseline survey work at this site, in 2013 (by Adri Barkhuysen) and in 2014 (by Avisense Consulting). Further

breeding eagle surveys were carried out in 2015, checking all known and other possible raptor nest sites within a 6km buffer of the wind farm site (plus some additional sites more distant from the site). In addition to the previous surveys, repeat visits are being made to monitor range occupancy and breeding success. The following visit protocol for each range is being implemented through the breeding period: visit 1 to check for occupancy of the range, visit 2 to locate active nests, visit 3 to check for young, and visit 4 to check for fledged young. This includes surveys for all raptors that could use the survey area, but with particular focus on Verreaux's and Martial Eagle.

6. The locations of the surveyed sites in relation to the proposed wind farm is shown in Figure 1.

Vantage point surveys

7. Previous vantage point surveys of the site were incomplete and there were substantial gaps in coverage of the wind farm site. Only minimum survey time was also undertaken, so, given the presence of key species potentially vulnerable to wind farm development (notably Verreaux's Eagle), this has been increased. The 2015-16 surveys are filling these gaps by extending the numbers of vantage points, ensuring that they cover the site to BLSA guidance (minimum 75% of turbines), extending survey time above the minimum (and spreading it over a wider survey period) and using a survey method that increases detectability and viewing distance (using binoculars and telescopes to assist in scanning for target species rather than relying on naked eye).
8. Vantage point surveys are monitoring flight lines of target species to quantify the numbers that could potentially be at risk of collision. The specific aim of the surveys was to collect data on key species flight activity that will enable estimates to be made of:
 - The time each species spends flying over the survey area
 - The relative use each species makes of different parts of the survey area
 - The proportion of flying time each species spends at different elevations above the ground.
9. All flight lines of target species are being mapped, and the flight height of each flock recorded. Six vantage points are being used for the surveys, four overlooking the wind farm site, and an additional two to view the area between the site and the two nearest Verreaux's Eagle nests (Holbak and Perdehoek). In the initial August 2015 surveys nine hours of surveys were undertaken from each VP, then six hours per month thereafter (exceeding the BLSA minimum value and in line with current UK/SNH guidance), from September 2015 through to January 2016 (giving 39 hours total survey time from each of the 6 VPs during this period). As 360° viewing is not required at any VP, a single observer was considered sufficient at each.
10. The location of the vantage points and the computer-generated prediction of viewsheds from those VPs (showing the areas visible at 32.6m above the ground, the lowest point that the rotor sweep of the current proposed turbines would reach, from each VP) are shown in Figure 2, in relation to the proposed 52-turbine layout. The VP locations were chosen on the basis of the best locations irrespective of location within wind farm (VPs would normally be located outside the wind farm but it is not possible to achieve this at this site while maintaining optimal visibility).
11. The following species were recorded as target species:
 - All birds of prey and owls
 - All cranes and bustards
 - Large flocks (>100 birds) of other species
 - Other species/sightings considered of note.

12. All target birds are being recorded, irrespective of their distance from the vantage point. Observations are being carried out throughout daylight hours (planning to cover the full daylight period over the survey visits) but not in periods of severely reduced visibility (<3km).
13. Vantage point surveys were usually carried out for a 3-hour block, with a gap of at least 30 minutes for a rest period between surveys to avoid observer fatigue. When more than one surveyor was active at any one time, VP surveys were not carried out at the same time as any walkover survey of the site.
14. During the observation periods all target species flights were mapped and cross-referenced to a standard recording form using a numbering system, and the flight height of each recorded. To estimate flight height as accurately as possible, available reference features (e.g. met masts, summit/ridgelines) were used. Flight heights were estimated as accurately as possible and recorded on the form, i.e. not summarised to height classes. Below 10m it was possible to estimate to 1m, between 10 and 20m to 2m, between 20m and 50m to 5m, and above 50m to 10m. In any case of uncertainty an estimate of the upper and lower range of height were recorded. When birds were observed over an extended period, estimates of flight height were recorded every 30 seconds. The activity during each flight (e.g. striking prey, displaying, food passing) was also recorded. Particular attention was paid to any observations of birds at rotor height crossing the proposed wind farm site that would be at risk of collision.

Grid connection route surveys

15. Vehicle transects are being driven along the proposed route of the grid connection, recording all target species but particularly focusing on Blue Crane, Ludwig’s Bustard and Denham’s Bustard. Two repeat transects are being driven each month through the year (with 12 completed during August 2015 – January 2016), mapping the location of all target species encountered, and with additional stops at strategic viewpoints along the route overlooking potentially suitable crane/bustard habitat to scan with binoculars/telescope.
16. The grid connection transect survey routes are shown in Figure 3. The 2015-16 grid connection transect surveys cover the main part of each potential route where access for the surveys was possible and where the surveys could be carried out safely. This did not include the full route but did cover a representative range of the habitats through which the route would pass.

Bird Surveys August – October 2015: Results

Breeding Eagle Survey Results

17. The results of the Verreaux’s Eagle breeding surveys are summarised in Table 1. The breeding site locations are shown in Figure 1. Overall it was clear that 2015-16 was a very poor breeding year for this species, with no successful breeding at any of these sites. The previous surveys in 2013 and 2014 found a much higher success rate, so more successful breeding would be expected in the future.

Table 1. Verreaux’s Eagle nest site survey results, August 2015-January 2016.

Eagle range name	Distance from proposed wind farm in km (52T layout)	Comments
Perdehoek	1.4	Pair seen daily flying in vicinity of nest kloof during August visit,

Eagle range name	Distance from proposed wind farm in km (52T layout)	Comments
		showing territory occupied. No sign of breeding success – failure confirmed on September visit. Pair seen over nest site during October VP survey, and in January.
Holbak	2.3	Breeding failure confirmed on September survey. Single seen 3.6km N from site on 22/9/15.
February	3.3	Breeding failure confirmed on September survey.
Tiptree	4.0	Pair seen flying in vicinity of nest site during August VP survey. Nest site located on a cliff facing SW in the Zungarivier valley on October survey. No eagles were seen then and no chick on the nest, but it appeared to have been active (from the white defecation marks and greenery that was laid some time ago).
Tygerberg	5.0	Pair flying around the nest kloof during September visit but no sign of active nest
Guntia	8.5	No chick was seen on either nest during the October survey, and no adults were seen. Some white defecation marks on the smaller nest but no greenery could be seen.
Krompoort	12	No chick on the nest and no adult eagles were seen during the October visit. This nest had active white defecation marks but otherwise it appeared inactive. Single seen near the site on 27/9/15.

18. The records obtained of other breeding raptors during these surveys are summarised below:

- Martial Eagle – there was no sign of any activity in the 2014 nesting area (2.6km SW from proposed wind farm), with the only records of this species being occasional over-flying birds seen during the VP surveys (Figure 4) and a single incidental sighting near Perdehoek in August.
- Booted Eagle - a pale phase bird was seen twice in the Perdehoek kloof during the September surveys, suggesting possible breeding at this location.
- African Harrier-hawk – seen in the February kloof during the September survey.
- Black Harrier – this species was confirmed nesting within the proposed wind farm site, above and very close to the track near the higher of the two meteorological masts. There were a minimum of three adults present, likely to have been a polygamous male with two females (two nests). Breeding was successful, with sightings of fledged juveniles during October and November. Two sightings in the Zunga valley suggested potential nesting there too.

Vantage Point Survey Results

19. The rates of bird flight movement observed across the study area during the vantage point observations are summarised in Table 2. This gives the mean over-flying rate per hour from each VP. Table 2 also gives the percentage of flights of each species that were recorded at rotor height (taking rotor height conservatively as between 30m and 180m above ground level, to allow for errors in flight height estimation, particularly at greater heights). The two most frequently encountered target species were Black Harrier and Jackal Buzzard, with regular sightings also of Verreaux's Eagle, Rock Kestrel and White-necked Raven.

Table 2. Bird flight rates (number of birds per hour) recorded over the VP survey area during August 2015-January 2016 vantage point surveys. N = 39 hours total observation from each of six VPs.

Species	Flight rate (number of birds per hour)						Total number of flights observed	% flights at rotor height
	VP5	VP6	VP7	VP8	VP9	VP10		
Alpine Swift	0	0	0	0	1.03	0	40	100%
African Swift	0	0.38	0.38	0	0.77	0	60	100%
Blue Crane	0	0.05	0	0	0	0.05	4	100%
Black Stork	0	0	0.05	0	0	0	2	100%
White Stork	0	0	0	0	0.08	0.46	21	100%
African Harrier-hawk	0	0	0	0	0	0.03	1	100%
Martial Eagle	0.05	0.03	0.03	0	0	0.03	5	80%
Verreaux's Eagle	0.31	0.41	0.18	0.25	0.21	0.15	59	78%
Booted Eagle	0.03	0.03	0	0	0.08	0.03	6	83%
Black Harrier	1.03	1.46	0.62	0.40	0.10	0.08	144	57%
African Goshawk	0	0	0.03	0	0	0	1	100%
Rufous-breasted Sparrowhawk	0	0	0.03	0	0.03	0.03	3	0%
African Fish-eagle	0	0	0.03	0	0	0	1	100%
Jackal Buzzard	1.05	0.64	0.62	0.69	0.97	0.87	190	73%
Steppe Buzzard	0.33	0.03	0.05	0.07	0.15	0.08	28	75%
Rock Kestrel	1.15	0.33	0.26	0.59	0.54	0.41	129	50%
Lanner Falcon	0.03	0	0.05	0.02	0.03	0	5	20%
White-necked Raven	1.83	1.33	1.13	0.90	1.67	0.93	234	50%

20. The monthly breakdown of the flight rates recorded is summarised in Table 3. Black Harrier flight rates were higher during August-October than later in the survey period, though others, including Verreaux's Eagle, were more similar across the whole survey period.

Table 3. Bird flight rates (number of birds per hour) recorded over the VP survey area during August 2015-January 2016 vantage point surveys. N = 9 hours observation from each of six VPs in August, and 6 hours in September, October, November, December and January.

Species	Flight rate (number of birds per hour)					
	August	September	October	November	December	January
Alpine Swift	0.74	0	0	0	0	0
African Swift	0	0.28	0.28	0	0.56	0
Blue Crane	0.04	0	0.04	0	0	0
Black Stork	0	0.04	0	0	0	0
White Stork	0	0	0	0	0.39	0
African Harrier-hawk	0.02	0	0	0	0	0
Martial Eagle	0.04	0.02	0.04	0	0	0
Verreaux's Eagle	0.37	0.30	0.17	0.02	0.07	0.17
Booted Eagle	0.04	0.02	0.04	0	0.02	0
Black Harrier	1.67	0.39	0.46	0.07	0	0.07
African Goshawk	0	0.02	0	0	0	0
Rufous-breasted Sparrowhawk	0.02	0	0	0.04	0	0
African Fish-eagle	0	0.02	0	0	0	0
Jackal Buzzard	1.48	0.44	0.37	0.50	0.24	0.48
Steppe Buzzard	0.07	0	0	0.09	0.19	0.17
Rock Kestrel	0.91	0.24	0.09	0.24	0.13	0.78
Lanner Falcon	0.04	0	0.02	0.02	0.02	0
White-necked Raven	-	0.72	0.85	0.94	0.57	1.24

Note: white-necked ravens were not recorded as a target species during the August surveys.

21. Maps of the flight activity of the key species recorded during the August 2015-January 2016 VP surveys are shown for Martial Eagle (Figure 4), Verreaux's Eagle (Figure 5), Booted Eagle (Figure 6), Black Harrier (Figure 7), Jackal Buzzard (Figure 8) and Rock Kestrel (Figure 9).

- Martial Eagles (Figure 4) were seen on only five occasions, three of which involved flights through the collision risk zone (and none during November-January). No areas of more concentrated flight activity were apparent.
- Verreaux's Eagles (Figure 5) were recorded widely but at relatively low frequency over most of the survey area. As for the Martial Eagle, no areas of more concentrated flight activity were apparent. The two VPs over-looking the two closest breeding sites did not reveal any specific connectivity with or use of the wind farm site.
- Booted Eagle (Figure 6) was only occasionally recorded, with six flights in total over the August – January survey period. Again, no areas of more concentrated flight activity were apparent.
- Black Harrier (Figure 7) was the most frequently observed target species, with a total of 144 flights logged in total. Activity was greatest around the nesting sites near to the upper met mast, but also further to the east and west along the main ridge running through the wind farm site, and over the ridge south from the nesting area. Activity declined markedly after October (as found in the previous 2013-14 surveys).
- Jackal Buzzard (Figure 8) was frequently recorded, particularly along the main ridge running east-west through the wind farm site (especially at its western end). This species was less frequently seen over the lower ground.
- Rock Kestrel was seen widely over the survey area, with several scattered areas of more concentrated activity, as shown on Figure 9.

Grid Connection Route Transect Survey Results

22. The results of the grid connection route transect surveys are summarised in Table 4. This gives the peak transect count for each target species for each month during August 2015 – January 2016. The Table also gives the total number of incidental ad hoc sightings of each species also recorded.
23. Distribution maps for each key species are shown in Figures 10-13. The records of the key species initially identified as being at particular risk of collision with overhead wires, Blue Crane and Ludwig's Bustards are shown in Figure 10. There were no records of the third key species, Denham's Bustard. Blue Cranes were widely distributed over the more open habitat, particularly at the western end of the main grid connection route (transect 1). That area was also where most of the Ludwig's Bustards were seen, as well as further to the north along the Glen Connor Road (transect 2).
24. The most frequently recorded raptor species was Pale Chanting-goshawk (Figure 11). It was seen mainly along the central part of the preferred grid connection route (transect 1) and along the Glen Connor Road).
25. Less frequently-encountered raptors included African Harrier-hawk, Verreaux's Eagle, Booted Eagle, Black Harrier, Rufous-breasted Sparrowhawk, Jackal Buzzard, Forest Buzzard, Steppe Buzzard, Lesser Kestrel, Rock Kestrel, Lanner Falcon and Peregrine Falcon – their locations are shown in Figure 12.
26. Other species potentially at risk of collision with overhead wires seen during these surveys included Southern Black Korhaan, Kori Bustard, Secretarybird, African Wood-owl, Barn Owl and Spotted Eagle-owl – their locations are shown in Figure 13 (mostly at the western end of the main route (transect 1) and along the Glen Connor Road (transect 2).

Table 4. Transect survey results and other incidental bird records – peak counts per month, August 2015 – January 2016.

Species	Transect 1 (Main route)						Transect 2 (Glen Connor Rd)						Total Ad Hoc sightings
	Aug	Sep	Oct	Nov	Dec	Jan	Aug	Sep	Oct	Nov	Dec	Jan	
South African Shelduck	0	0	0	0	0	0	0	0	0	3	0	0	0
Blue Crane	4	4	11	0	2	0	0	1	0	2	0	0	33
Ludwig's Bustard	2	0	0	0	0	0	15	0	0	2	0	0	13
Kori Bustard	0	0	0	0	0	0	0	0	0	0	2	0	0
Southern Black Korhaan	0	0	0	0	0	0	1	1	0	0	0	0	0
White Stork	0	0	0	0	0	0	0	0	0	0	0	0	18
African Spoonbill	1	0	0	0	0	0	0	0	0	0	0	0	0
Sacred ibis	0	4	0	0	0	0	0	0	0	0	0	0	0
Black-headed heron	0	1	0	3	2	0	0	1	1	0	0	1	0
Hamerkop	0	1	0	0	2	0	0	0	0	0	0	0	0
Barn Owl	0	0	0	0	0	0	0	0	0	0	0	0	1
African Wood-Owl	0	0	0	0	0	0	0	0	0	0	0	0	1
Spotted Eagle-Owl	0	0	0	0	0	0	0	0	0	0	0	0	3
Secretarybird	1	0	0	0	0	0	0	2	0	1	0	1	2

Species	Transect 1 (Main route)						Transect 2 (Glen Connor Rd)						Total Ad Hoc sightings
	Aug	Sep	Oct	Nov	Dec	Jan	Aug	Sep	Oct	Nov	Dec	Jan	
Black-shouldered kite	0	0	0	0	0	0	1	1	2	2	2	1	1
African Harrier-Hawk	0	0	0	0	0	0	0	0	0	0	0	0	6
Verreaux's Eagle	0	2	0	0	0	0	0	0	0	0	0	0	3
Booted Eagle	1	1	0	0	1	0	0	0	0	1	0	0	1
Pale Chanting-Goshawk	5	2	3	2	3	2	2	1	0	1	2	2	3
Black Harrier	0	0	0	0	0	0	0	0	0	0	0	0	5
Rufous-breasted Sparrowhawk	0	0	0	0	0	0	0	0	0	0	0	0	2
Jackal Buzzard	1	1	1	1	1	0	0	0	0	0	0	0	2
Steppe Buzzard	0	0	1	2	0	3	0	0	0	2	1	0	3
Forest Buzzard	0	0	0	0	1	0	0	0	0	0	0	0	0
Lesser Kestrel	0	0	0	0	0	0	0	0	0	0	0	5	0
Rock Kestrel	0	1	2	0	0	0	0	0	0	0	0	0	0
Lanner Falcon	0	0	0	0	0	0	0	0	0	0	0	0	1
Peregrine Falcon	0	0	0	0	0	0	0	0	0	0	0	0	1

Ornithological Assessment Update

Collision Risk Modelling

27. One of the main potential ornithological impacts of concern for the Inyanda Roodeplaat wind farm is collision with the operational turbines. Collision risk modelling (CRM) was undertaken for a previous report (Percival et al. 2015), following the method of Band et al. (2007), as extensively used in the UK. Details of the original SNH guidance on this model (Band 2000) are available from the SNH web site at <www.snh.gov.uk/docs/C205425.pdf>. The model runs as a two-stage process. Firstly, the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.
28. The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action, as has been shown to occur in all studies of birds at existing wind farms (Urquhart 2010¹). Discussion as to the most appropriate avoidance rates to apply is included in the following section.
29. The CRM was carried out on the four key raptor species of concern that were observed flying within the collision risk zone at rotor height; Verreaux's Eagle, Booted Eagle, Martial Eagle and

¹ See SNH web site: www.snh.gov.uk/docs/B721137.pdf

Black Harrier, as in the previous report. The same model structure and basic input data were used as in the previous modelling, but updated to include the August 2015-January 2016 VP survey data.

30. The collision model requires data on bird body size and flight speed. Body sizes and baseline mortality rates were taken from Roberts Birds of South Africa (Hockey et al. 2005). Flight speeds were taken from Alerstam et al. (2007) for ecologically similar species, as none were available for any of the four key species (Golden Eagle for Verreaux's Eagle, the mean of all of the available *Aquila* eagle species for Martial Eagle, the mean of all of the available *Buteo* species for the smaller Booted Eagle and the mean of all *Circus* harrier species for Black Harrier). The data used in the collision risk modelling are shown in Table 5.

Table 5. Key species body size and flight speed data used in the collision risk modelling

Species	Body length (m)	Wing span (m)	Flight speed (m/s)
Verreaux's Eagle	0.88	2.4	11.9
Booted Eagle	0.50	1.23	11.5
Martial Eagle	0.81	2.15	10.4
Black Harrier	0.51	1.0	9.7

31. The collision modelling requires a range of input data on the wind turbine specifications, which were provided by the client and the turbine manufacturers (Table 6). This modelling has taken a reasonable worst-case approach, running the model for the turbine likely to give the highest collision risk of the options being considered. The model was run for this report on the current proposed 52-turbine layout being assessed for the EIA. It is likely that the number of turbines will be reduced further, but this has been assessed as a worst case at this stage.

Table 6. Wind turbine data used in the collision risk modelling.

Specification	52-turbine input data
Number of turbines	52
Hub height	85m
Rotor diameter	130m
Height to blade tip	150m
Minimum height of blade above ground	20m
Rotational speed (variable – mean of range used)	9.5 rpm
Blade maximum chord	4.2m
Blade pitch (variable – mean value used)	6°
Turbine operation time (when not constrained by	90%

Specification	52-turbine input data
high/low wind speed or maintenance activity)	

32. Data from the VP surveys were used to determine the proportion of flights at rotor height, with all flights between 30m and 180m treated (conservatively to take into account the difficulty of accurately estimating flight heights) as being at rotor height.
33. The collision risk zone was defined, as per Band et al (2007) and SNH guidance (Whitfield et al. 2010) as a 500m zone around the proposed wind turbine locations.
34. The improved VP survey protocol enabled viewing to 2km and, in combination with more VPs, enabled a high coverage of this zone (including viewing of the full risk volume of 46 of the 52 turbine locations, in comparison with only 27 turbines within the effective viewing zone in the previous analysis).
35. As more recent data are only currently available for the six months of August-January (though a full year's surveys are in progress to be completed in July 2016), some assumptions are needed to convert the modelling output to a full year and compare with the previous results. For the three species resident in the area year-round, Verreaux's Eagle, Martial Eagle and Booted Eagle, it was assumed, that the same level of flight activity in the collision risk zone will occur through the remainder of the year, so the August-January flight activity was doubled to give an initial annual estimate. Black Harrier, however, was only present in the survey area during the breeding period in the previous 2013-14 surveys, so it has been assumed that there would not be any further flight activity of this species in the February-July period.
36. The results of any collision risk modelling using the Band et al. (2007) approach is highly sensitive to the avoidance rate used (Chamberlain et al. 2006). Application of an appropriate rate is therefore of fundamental importance in undertaking such modelling. However, there are very few studies at existing wind farms where avoidance rates have been fully determined, comparing pre-construction flight activity with the actual numbers of collisions post-construction (Urquhart 2010). The approach generally used to address this is to apply a precautionary rate based on the available data, such that any collision prediction is unlikely to be exceeded (i.e. represents a reasonable worst case). Where data on actual avoidance rates of particular species/groups have been established, then this has usually enabled a higher rate to be safely applied. For example, SNH has recently recommended a move from a 99% rate to 99.8% for geese based on recent research (Douse 2013). SNH now recommends using a value of 99.8% as an avoidance rate for geese (Douse 2013), 99% for several birds of prey (including Golden Eagle and Hen Harrier), and 98% for most other species (Urquhart 2010).
37. There is a lack of specific avoidance rate data from South Africa and on the species of concern at Inyanda Roodeplaat. As collision avoidance rates are not yet known for the species of concern, suitable overseas species have been used as proxies, following the same assumptions as made for the previous CRM. The selection of appropriate rates followed SNH guidance and with reference to the bird-wind farm literature. As recommended in SNH guidance, a precautionary 98% was adopted as the default value (Urquhart 2010) but the work has also explored whether particular species exhibit similar behaviour to more vulnerable species such as White-tailed Sea Eagle and Kestrel, or such behaviour that would reduce risk (and hence allow higher rates to be used as is recommended by SNH for Golden Eagle and Hen Harrier for example). The collision risk modelling results have been presented for each layout for a range of avoidance rates to inform the assessment but the most appropriate rate to apply in each specific case is also indicated. Most weight has been given to the precautionary SNH position of applying a 98%, though Verreaux's Eagle in particular shares an ecological similarity with Golden Eagle (albeit at a generally higher breeding density), for which SNH recommends a 99% avoidance rate, so applying that rate could be justified (particularly in relation to adult birds). The Golden Eagle is recognised as the Verreaux's Eagle's closest relative (Wink and Sauer-Gürth 2000). However, a more precautionary approach has been adopted in this assessment,

as previously. Given that the Inyanda Rooideplaar eagles occur at a much lower density (approximately 2.4/100km²) than the white-tailed eagles at Smøla where a density of 73/100km² has been recorded with 13 pairs of white-tailed eagle nesting in the wind farm which extends over 17.3km², Bevanger et al. 2009) and that the eagle core ranges have been buffered, it is not considered appropriate to apply as low a rate as 95% to the Verreaux's Eagle or for any other modelled species at Inyanda Rooideplaar.

Collision Modelling Results

38. The results of the collision risk modelling for the proposed 52-turbine layout for each of the four key species are summarised in Table 7. The results from the previous CRM (based on baseline data from 2013-14, but updated for the current turbine specification as set out in Table 6) are given in Table 8 for comparison. These Tables record the number of collisions predicted per year based on a range of avoidance rates (95% - 99%). Verreaux's and Martial Eagle are both large non-colonial eagles, and the area in proximity to their nest sites has been avoided in the design process (so 'riskier' display flights and early juvenile flights would be less likely to occur in the wind farm). As a result, 99% should be a suitable precautionary avoidance rate to apply (as is used in the UK for Golden Eagle, an ecologically similar species), though as discussed above a more precautionary 98% has been adopted for the purpose of this assessment. Booted Eagle is more ecologically similar to buzzard species, so on the basis of the information currently available, the possibility of lower avoidance cannot be excluded so the SNH default 98% value has been applied. SNH has recommended the use of 99% avoidance rate for harriers, so that value is the primary one used for Black Harriers.

Table 7. Collision risk modelling predictions based on Aug 2015-Jan 2016 data (adjusted for a full year as set out above) for the Inyanda Rooideplaar wind farm 52-turbine layout, applying a range of avoidance rates. Predictions in bold represent the precautionary result used in the further assessment.

Species	Precautionary predicted number of collisions per year			
	Avoidance Rate	95%	98%	99%
Verreaux's Eagle	6.59	2.64	1.32	0.66
Martial Eagle	0.72	0.29	0.14	0.07
Booted Eagle	0.52	0.21	0.10	0.05
Black Harrier	7.36	2.94	1.47	0.74

Table 8. Collision risk modelling predictions for the Inyanda Rooideplaas wind farm 52-turbine layout based on 2013-14 data, applying a range of avoidance rates. Predictions in bold represent the precautionary result used in the further assessment.

Species	Precautionary predicted number of collisions per year			
	Avoidance Rate	95%	98%	99%
Verreaux's Eagle	4.30	1.72	0.86	0.43
Martial Eagle	0.53	0.21	0.11	0.05
Booted Eagle	0.20	0.08	0.04	0.02
Black Harrier	0.83	0.33	0.17	0.08

39. The predicted risks for all three eagle species using the recent data were broadly similar to those produced previously, with no major differences from the previous assessment apparent at this stage. The collision risk for black harrier, though was considerably higher than the previous prediction, as a result of much-increased flight activity of this species in 2015-16 (when two nests were active within the wind farm site – see above).

Collision Modelling Interpretation

40. Whilst the Band collision model produces a quantitative estimate of the numbers of birds that might collide with the wind turbines, those numbers need to be put into the context of the existing mortality to enable their significance to be assessed. The same level of additional mortality on a population that has a low level of background mortality could potentially have a much more important effect than on a population with a higher level of existing mortality. The collision mortality needs to be assessed in the context of each species population dynamics. In the UK a 1% increase over the baseline mortality is now frequently being used as an initial filter threshold above which there may be a concern with the predicted collision mortality (and hence requiring further investigation). Collision risks below this level are usually considered not to be significant.

41. In the context of the Inyanda Rooideplaas site, the predicted collision mortality has been set against the regional background mortality for each of the four key species at risk of collision. The population data used in this analysis are summarised in Table 9. The region has been taken as the Karoo biome (Mucina and Rutherford 2006, and with reference to the WWF Karoo ecoregion).

Table 9. Background population data for Verreaux's Eagle, Booted Eagle and Martial Eagle. Source: Roberts VII (Hockey et al. 2005) and Gargett (1990).

Species	Regional population	Adult mortality rate	Immature mortality rate	Annual productivity (chicks/pair/year)	Age at first breeding	Baseline mortality

Species	Regional population	Adult mortality rate	Immature mortality rate	Annual productivity (chicks/pair /year)	Age at first breeding	Baseline mortality
Verreaux's Eagle	940 pairs	5%	20%	0.5	5	94 (adult)
Martial Eagle	300 pairs	7%	20%	0.6	5	150
Booted Eagle	700 pairs	10%	20%	1.0	3	500
Black Harrier	150 pairs	20%	50%	1.9	2	330 (all) 60 (adult)

42. The Verreaux's Eagle baseline population has been estimated in the same way as the previous report. This gave a conservative estimate of 600 pairs of Verreaux's Eagle for the Karoo escarpment (Roggeveld, Nuweveld, Sneeuberge and Winterberge) plus a further 100 pairs for the smaller inselbergs outside of the main mountain ranges was produced by Rob Simmons for the Witberg wind farm project (Percival 2013). These numbers were derived primarily from information collected by Rob Davies for his PhD work (together with other published population density estimates; Simmons in Hockey et al. 2005) and since then the population is thought to have declined by about 15% on the basis of recent field surveys carried out by Rob Davies. This would therefore give a current populations estimate for the escarpment plus the inselbergs of about 600 pairs. The area on which this estimate is based does not include approximately 24,000km² of other Karoo mountain ranges that would provide suitable habitat Verreaux's Eagle habitat. Using a very conservative nesting density of 1 pair per 60km² (the lowest recorded according to Davies 1994, densities at the Karoo National Park and around the Inyanda Rooideplaar site are considerably higher than this) over this entire area, this gives a further 400 pairs over this area. That too should be scaled down from the 1994 density by 15%, giving an estimated 340 additional pairs, and hence a more realistic total of about 940 pairs for the Karoo.
43. Table 10 shows the predicted collision risk and associated impact significance for each of the four species in the context of their background mortality and the % increase over the baseline that each risk represents. For Verreaux's Eagle, the assessment summarised in this Table assesses the collision risk against the adult population, as the large majority of records from the site related to adult birds.

Table 10a. Collision risk for Verreaux’s Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on Aug 2015-Jan 2016 data (adjusted for full year prediction).

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect	Likely significant effect?
Verreaux’s Eagle	98%	2.64	2.8%	Low	Possible, but could be mitigated
Martial Eagle	98%	0.29	0.19%	Negligible	No
Booted Eagle	98%	0.21	0.04%	Negligible	No
Black Harrier	99%	1.47	0.45% (all) 2.5% (adult only)	Negligible/Low	Possible, but could be mitigated

Table 10b. Collision risk for Verreaux’s Eagle, Martial Eagle, Booted Eagle and Black Harrier and the increases that these represent over baseline mortality, for the 52-turbine layout based on 2013-14 data.

Species	Precautionary avoidance rate	Predicted collision risk	% increase over baseline mortality	Magnitude of effect	Likely significant effect?
Verreaux’s Eagle	98%	1.72	1.8%	Low	Possible, but could be mitigated
Martial Eagle	98%	0.21	0.14%	Negligible	No
Booted Eagle	98%	0.08	0.02%	Negligible	No
Black Harrier	99%	0.17	0.05%	Negligible	No

44. For Martial Eagle and Booted Eagle, the predicted collision risks from the 2015-16 data continued as previously to be very small both numerically and in a population context. Those increases were considerably less than 1% when assessing the collision risk against the regional population. With such a negligible magnitude risk there would not be likely to be any regionally significant population impact for either of these species for any of the layouts.
45. For Verreaux’s Eagle, the predicted collision risk of 2.6 collisions per year was, as previously, assessed as a low magnitude effect, which would be considered to be of low significance on a high sensitivity species, and hence strictly not a significant impact (see Avifaunal Impact Assessment Report for more details of the assessment methodology). However, it is above the 1% increase in the baseline mortality, and therefore requires careful consideration as to whether on the information currently available a significant effect on Verreaux’s Eagle can be ruled out.

46. It was recommended previously that mitigation measures should be implemented to reduce the collision risk to Verreaux's Eagle, and this remains the case from the new 2015-16 data collected so far. As previously, it should be noted that the collision risk results presented here are from a precautionary assessment, not the most likely outcome. The analysis has adopted a precautionary approach, including:
- Use of a precautionary 98% avoidance rate rather than the more evidence-based 99% for the closely related Golden Eagle;
 - Use of a conservative regional population estimate against which to assess the predicted wind farm mortality;
 - Assessment of mortality has been made against only the existing adult mortality rather than the usual assessment against all of the predicted mortality ;
 - Assuming that flight activity through the wind farm will continue at the same rate after construction. Given that mitigation measures have been recommended to improve the food resource within nest buffers away from the wind farm (see next section) and the observed behavior of Golden Eagles at existing wind farms (e.g. Walker et al. 2005), some reduction in risky flight activity is more likely.
47. The predicted collision risk for Black Harriers (1.5 collisions per year) is higher than that predicted from the 2013-14 data (0.2 per year), reflecting this species' higher use of the wind farm site in August 2015-January 2016 than had been recorded previously (including two nests). Set against the overall regional mortality this would be an increase of only about 0.5% over the existing baseline mortality, which would be a negligible magnitude effect (and not significant). However, focusing on adult mortality (most of the flights within the risk zone were of adult birds) this increases to a 2.5% increase over the baseline, a low magnitude effect. This species is globally 'vulnerable' (on the 2015 IUCN red list) and is listed as 'endangered' on the BirdLife South Africa red list and is a near-endemic to South Africa (SA holds >70% world population), so that has the potential to be a significant impact. Potential mitigation measures for this species should be developed with Black Harrier as a specific target species to benefit from a conservation management plan, as they are likely to be required to ensure that this species is not adversely affected by the development.

Disturbance Effects

48. The loss of key species' foraging range that could result from wind farm disturbance was assessed previously (Percival et al. 2015) in an analysis based on theoretical range modelling, so that is unaffected by the new field data. The new VP data do, however, confirm the previous finding that the wind farm site itself is not a particularly important foraging area for either Verreaux's or Martial Eagle.
49. The 2015-16 data have shown that the wind farm site can be important for Black Harrier, with breeding birds nesting there and a high level of use of the site for foraging as well. This was in contrast to previous surveys, which had shown that this species made only occasional use of the site. Population fluctuations in this species are well-documented (Simmons et al. in Hockey et al. 2005), so the breeding as in 2015-16 is not an event that is certain to be repeated in future years. As noted above in the discussion of collision risk, Black Harrier is a species of particular conservation importance, being an IUCN globally vulnerable and a South African endangered red list species. With two nests within the wind farm site, disturbance to breeding birds does have the potential to be significant, so mitigation measures should be developed to ensure that any net adverse effect on this species is avoided.

Effects of Grid Connection

50. The potential collision risk posed by the overhead lines required to connect the wind farm into the grid was identified by Jon Smallie as an impact that would require mitigation. He advised that all overhead power line should be on 'bird friendly' pole design as per Eskom Standard, and that high risk sections to be marked with 'bird flappers'. There was though no field survey as part of that work to enable those higher risk sections to be defined.
51. The 2015-16 surveys have shown that several species prone to collision with overhead wires (including Blue Crane and Ludwig's Bustard) are present in the area through which the overhead lines would pass. It will be important therefore to ensure that suitable mitigation is put in place. The 2015-16 surveys are also informing where those species occur and hence the higher collision risk areas where those measures would need to be applied. It was not possible to obtain access to survey the full routes of all three possible grid connection routes (and the results available to date only cover the August-January period), so a further survey should be undertaken once the final route is confirmed to identify the locations where these measures will be needed (in combination with the 2015-16 data).

Conclusions and Recommendations

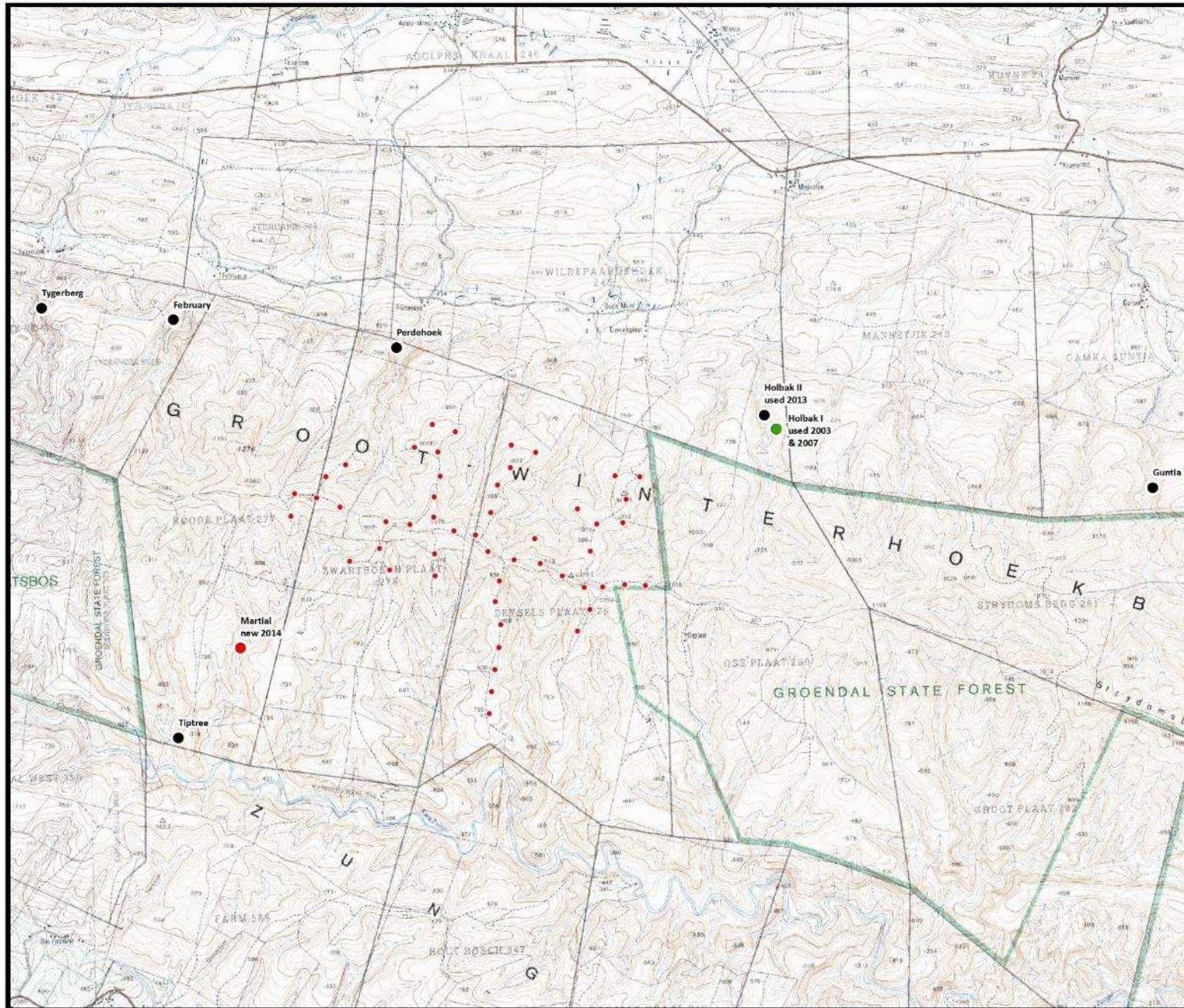
52. Six additional months' baseline survey have been successfully completed during August 2015-January 2016. A local surveyor, Adri Barkhuysen, has been trained to undertake vantage point surveys to international standards, and a high quality field dataset has been collected.
53. Breeding Verreaux's Eagle were active in most of the known ranges around the wind farm site, but all of these birds failed to breed successfully in 2015 (though they had bred successfully at many of these sites in 2013 and 2014, and are likely to do so again in the future). There was no evidence of any breeding Martial Eagles within the survey area in 2015. Use of the wind farm site by these species during August 2015-January 2016 was at a similar level to that recorded previously, and as a result the predicted collision risks were similar too.
54. Breeding black harriers had not been previously noted in the survey area in the 2013-14 surveys, but at least two females were nesting within the wind farm site in 2015-16. They made extensive use of the wind farm site, being the most frequently recorded raptor species during the VP surveys.
55. Mitigation measures for Verreaux's Eagle were suggested previously (Percival et al. 2015), that had two specific aims (a) to ensure that the relative attractiveness of the wind farm site for this species was not increased following construction of the wind farm, and (b) to improve nesting/foraging habitat further away from wind farm (to encourage birds to move away from the wind farm). Additionally, a programme of post-construction studies were recommended to understand interaction with wind farm and provide more information on their basic ecology. Given the increased use of the site by Black Harriers in 2015, and the conservation status of this species (globally 'Vulnerable' and nationally 'Endangered'), it is strongly recommended that similar measures should be developed for this species as well.

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**Inyanda Roodeplaat
Wind Farm**

FIGURE 1
Breeding Eagle Survey
2015-16 - locations of
sites checked

- KEY:**
- 52-turbine layout
 - Eagle nest sites**
 - Martial Eagle (estimated)
 - Verreaux's Eagle
 - Verreaux's old site



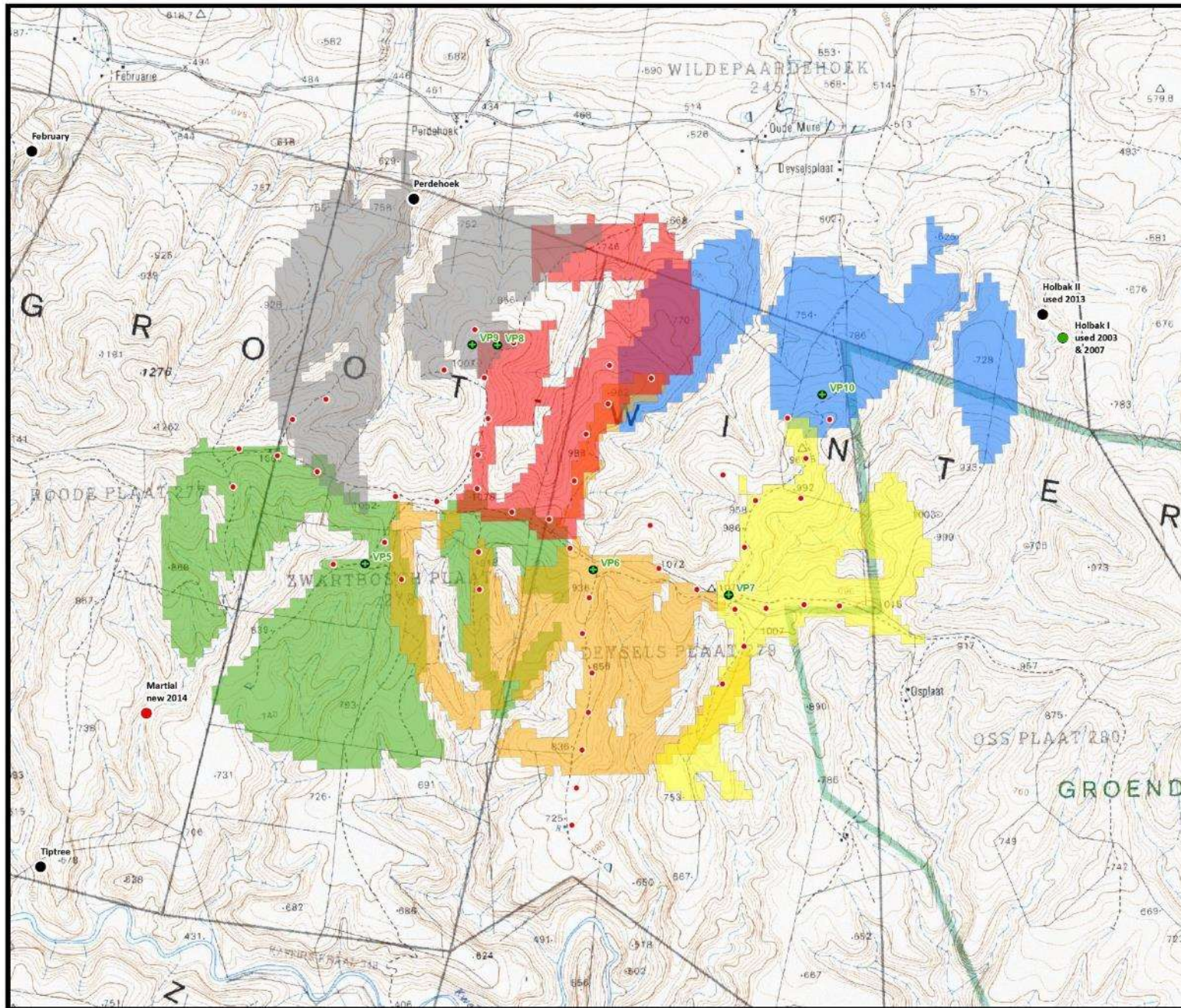
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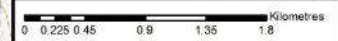
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**Inyanda Roodeplaat
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FIGURE 2
**Vantage Point Survey
Locations and Viewsheds
(20m above ground), 2015-16**

- KEY:**
- 52-turbine layout
 - VP Locations
 - VP9 Viewshed
 - VP8 Viewshed
 - VP7 Viewshed
 - VP6 Viewshed
 - VP5 Viewshed
 - VP10 Viewshed
- Eagle nest sites**
- Martial Eagle (estimated)
 - Verreaux's Eagle
 - Verreaux's old site

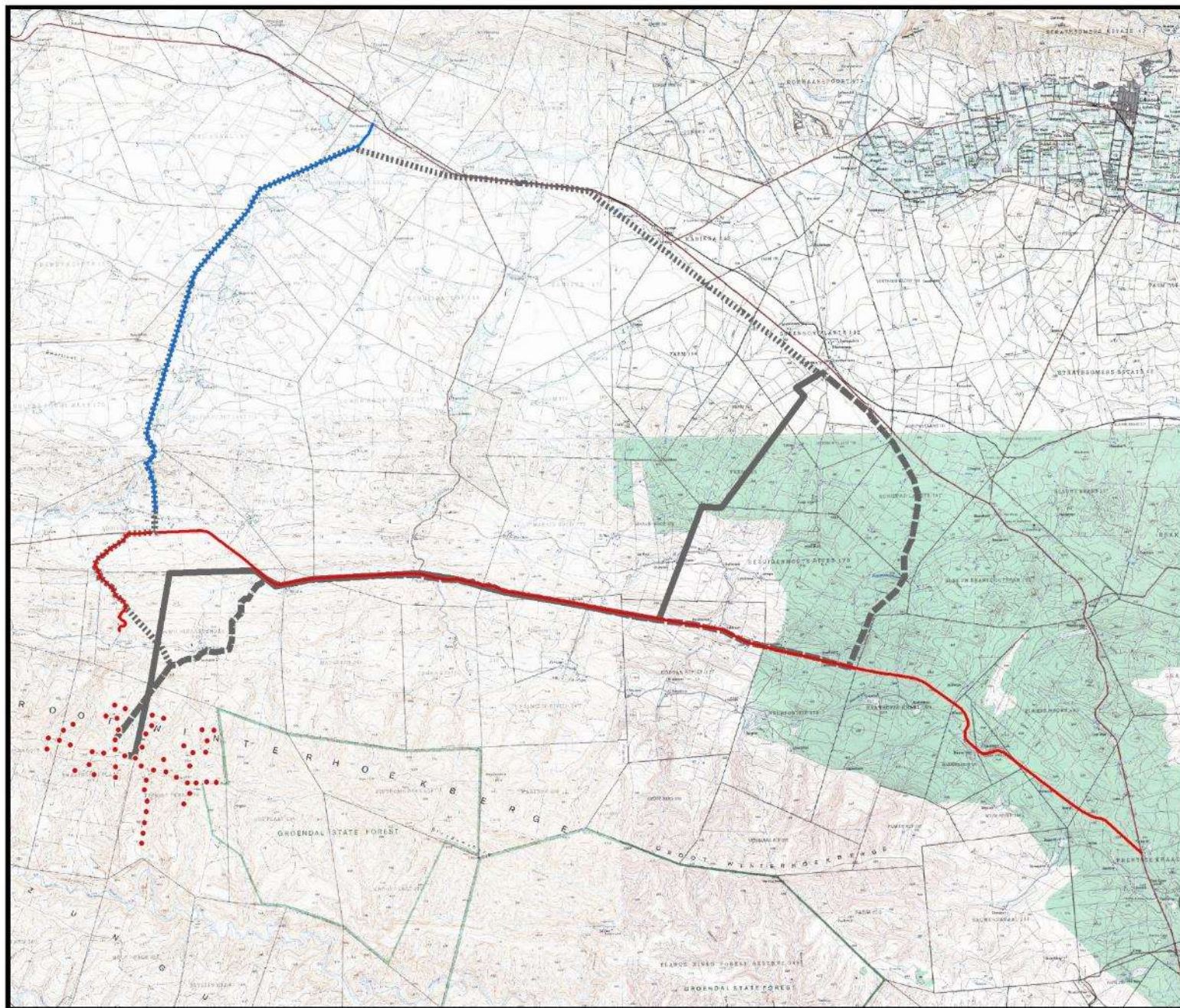


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FIGURE 3
**Grid Connection Route
Survey Transects
2015-16**

- KEY:**
- 52-turbine layout
 - Powerline Alternative Route 2
 - Powerline Alternative Route 1
 - Powerline Preferred Route
- Transects**
- 1 (Main Route)
 - 2 (Glen Connor Rd)



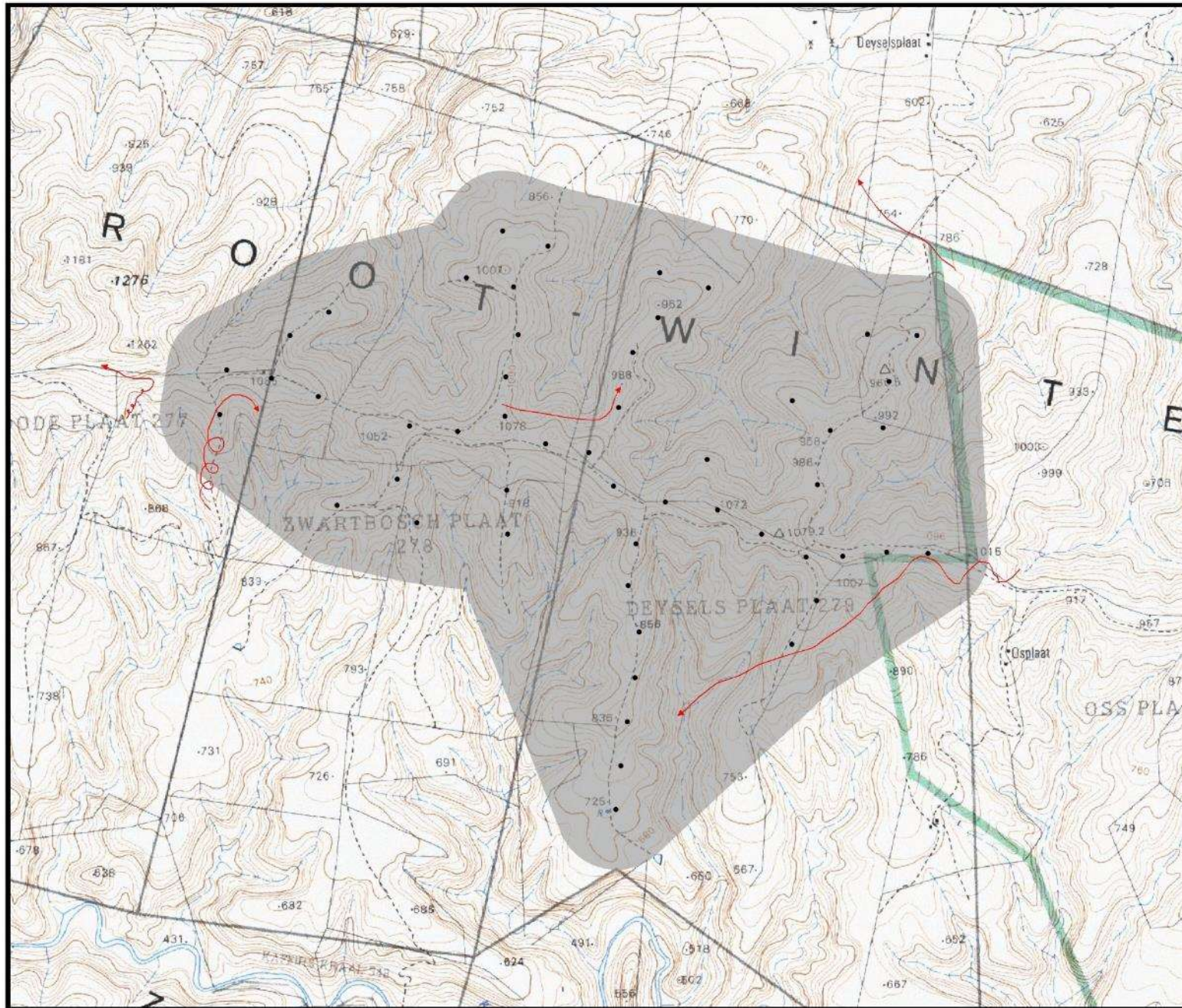
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**Inyanda Rooideplaai
Wind Farm**

FIGURE 4
VP Survey Flight
Lines Aug 2015 - Jan 2016:
Martial Eagle

- KEY:**
- 52-turbine layout
 - Collision Risk Zone (52T)
 - Flight Lines

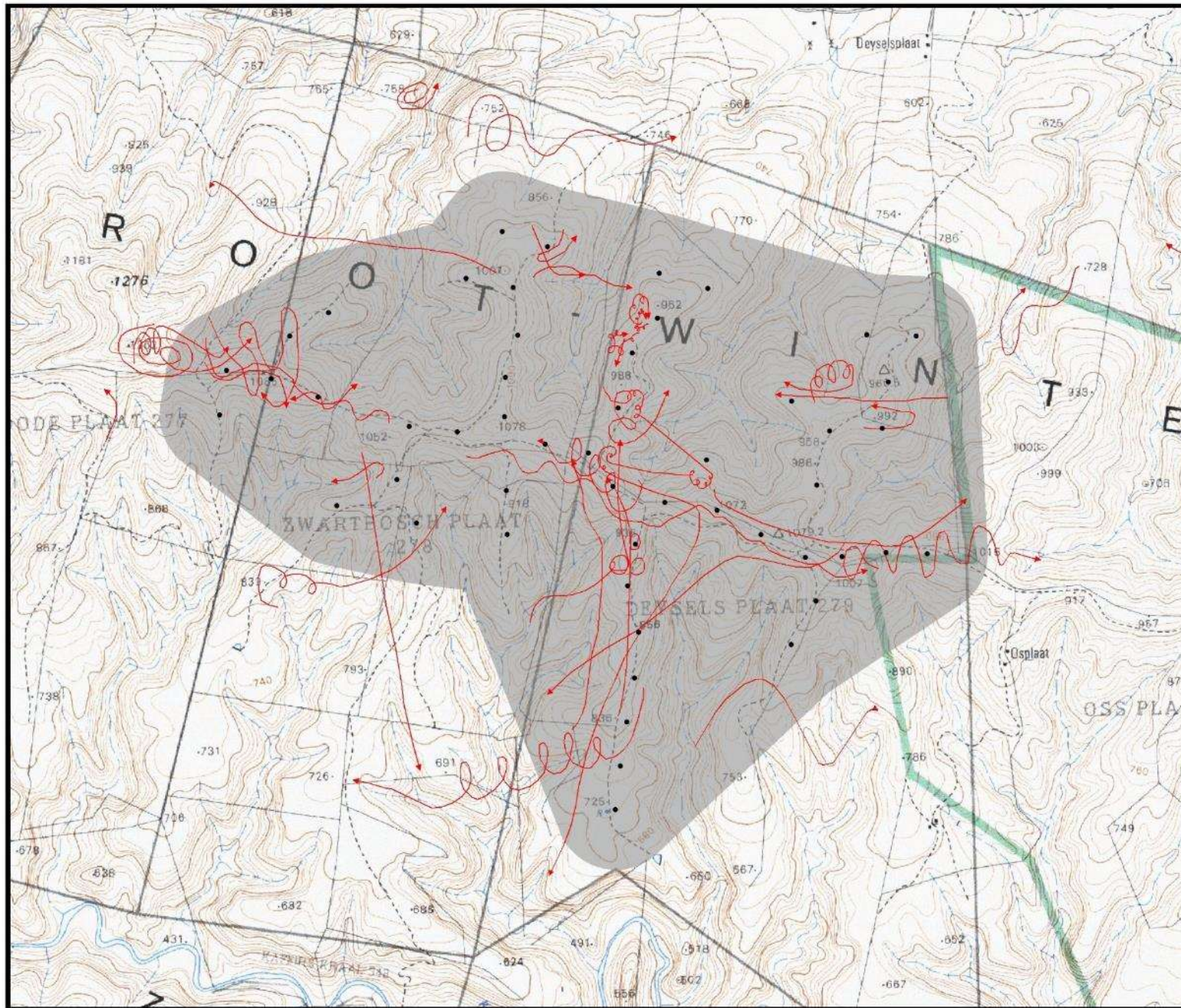


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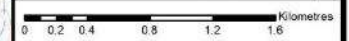
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**Inyanda Roodeplaat
Wind Farm**

FIGURE 5
VP Survey Flight
Lines Aug 2015 - Jan 2016:
Verreux's Eagle

- KEY:**
- 52-turbine layout
 - Collision Risk Zone (52T)
 - Flight Lines

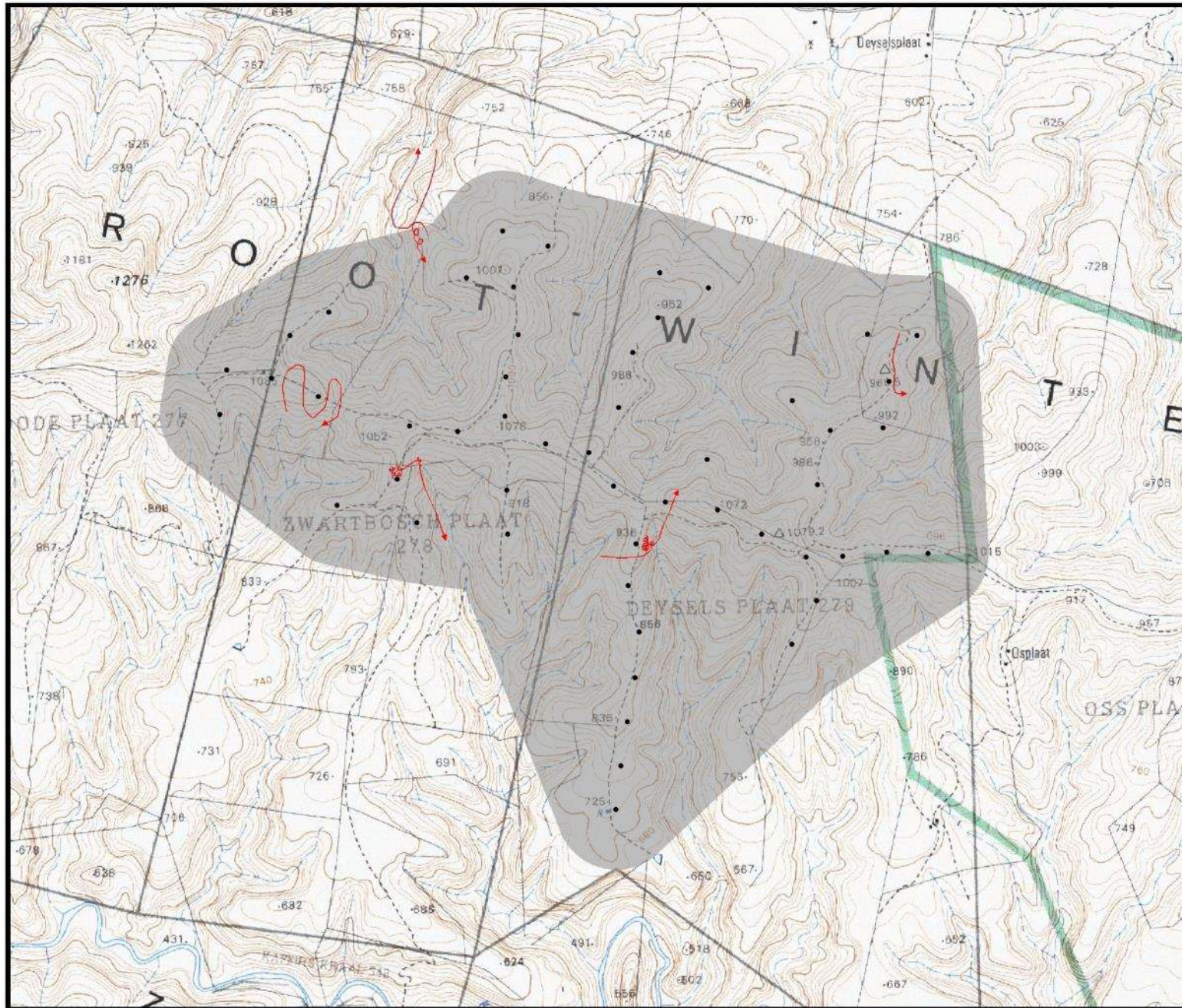


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**Inyanda Roodeplaat
Wind Farm**

FIGURE 6
**VP Survey Flight
Lines Aug 2015 - Jan 2016:
Booted Eagle**

- KEY:**
- 52-turbine layout
 - Collision Risk Zone (52T)
 - Flight Lines

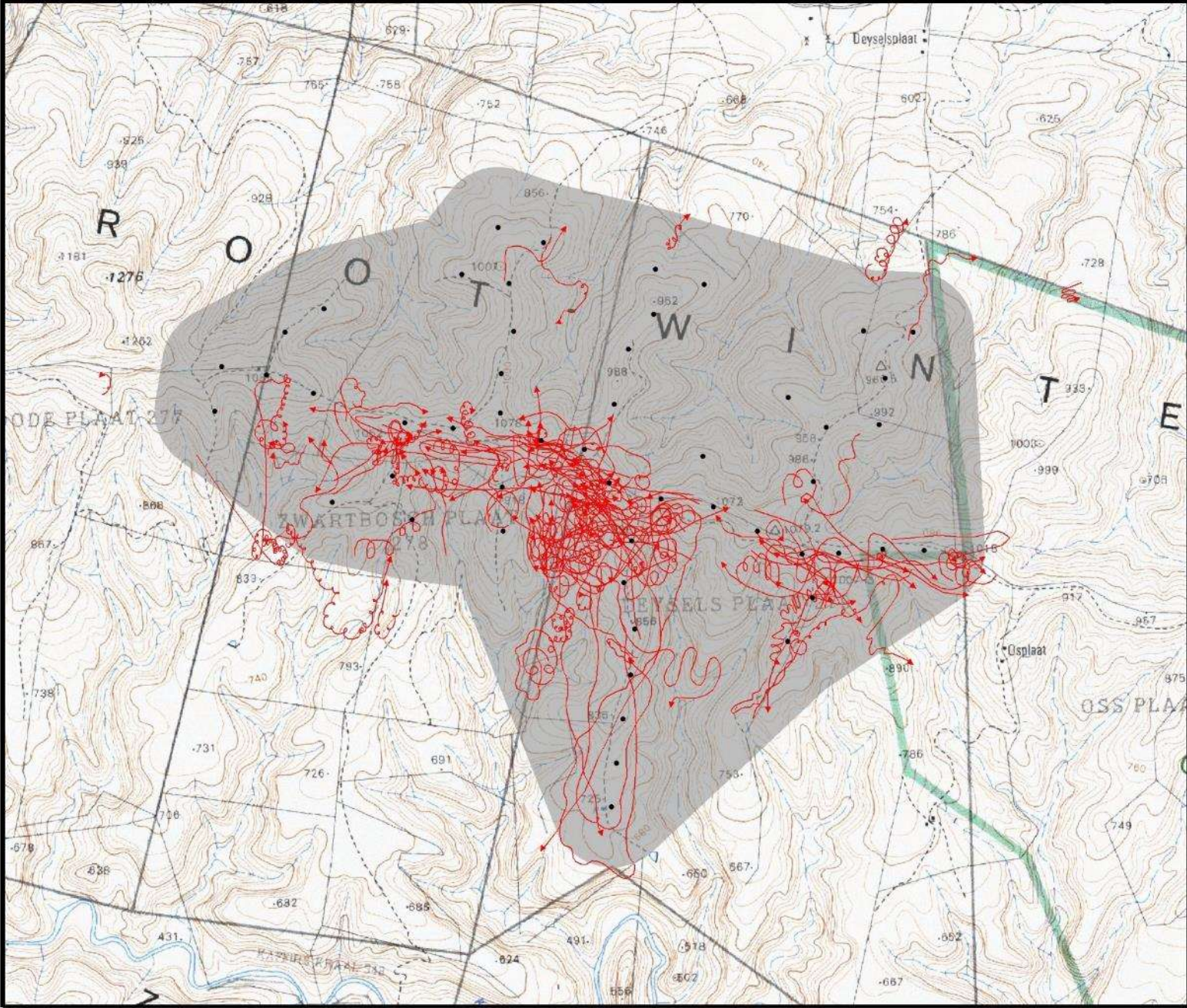


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**Inyanda Roodeplaai
Wind Farm**

FIGURE 7

**VP Survey Flight
Lines Aug 2015 - Jan 2016:
Black Harrier**

KEY:

- 52-turbine layout
- █ Collision Risk Zone (52T)
- Flight Lines



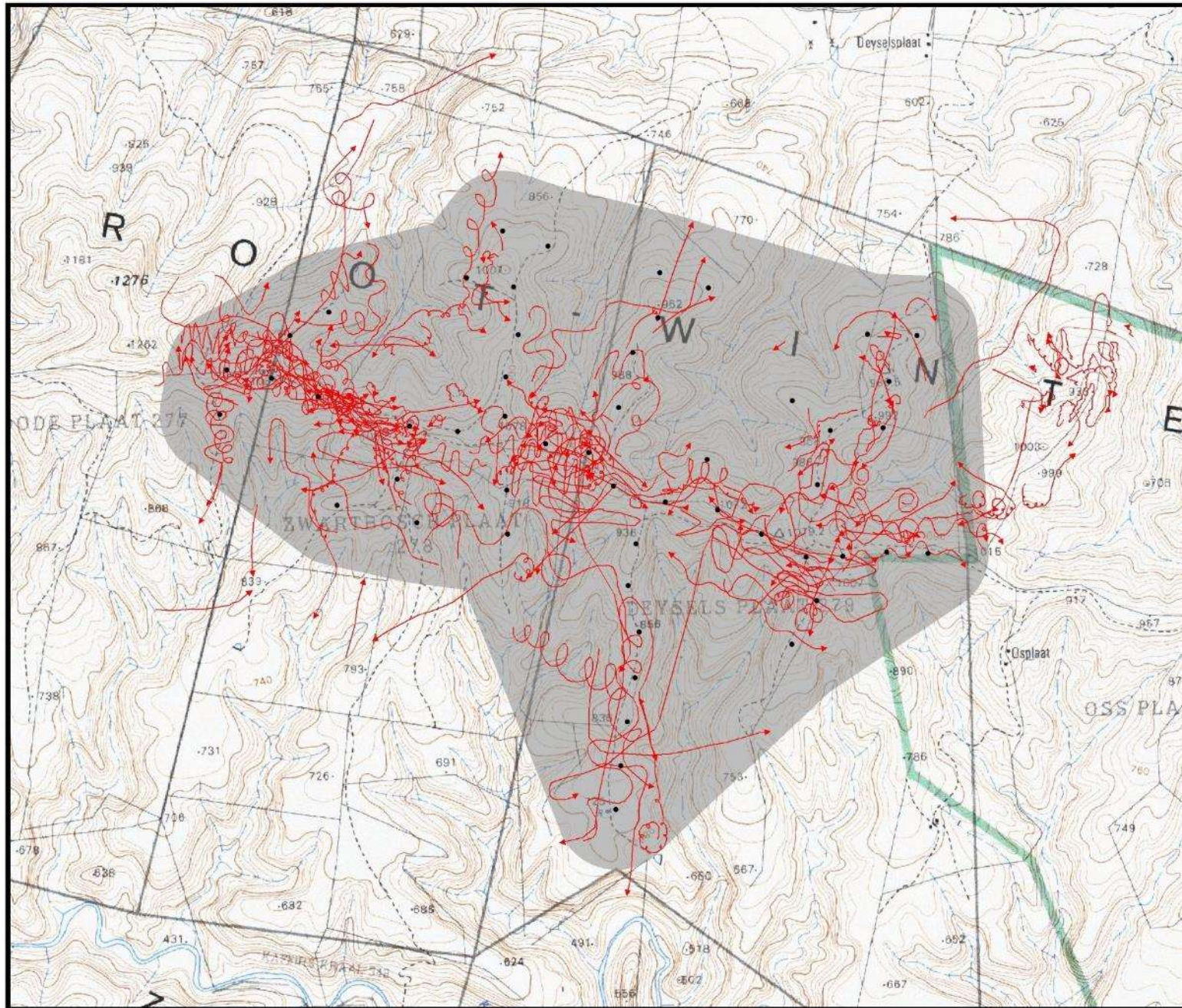
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**Inyanda Rooideplaas
Wind Farm**

FIGURE 8
**VP Survey Flight
Lines Aug 2015 - Jan 2016:
Jackal Buzzard**

- KEY:**
- 52-turbine layout
 - Collision Risk Zone (52T)
 - Flight Lines

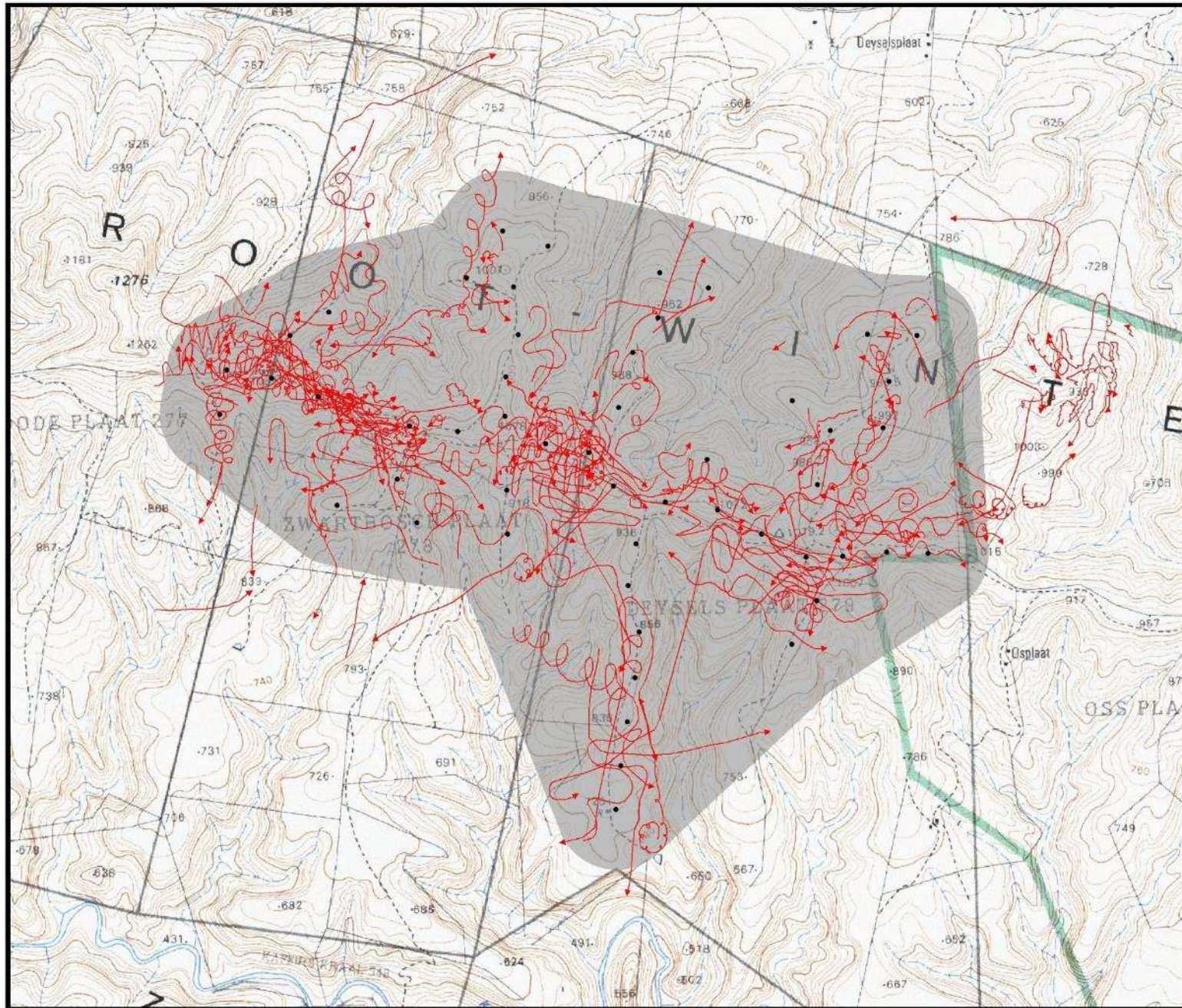


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**Inyanda Roodeplaat
Wind Farm**

FIGURE 9
VP Survey Flight
Lines Aug 2015 - Jan 2016:
Rock Kestrel

- KEY:**
- 52-turbine layout
 - Collision Risk Zone (52T)
 - Flight Lines



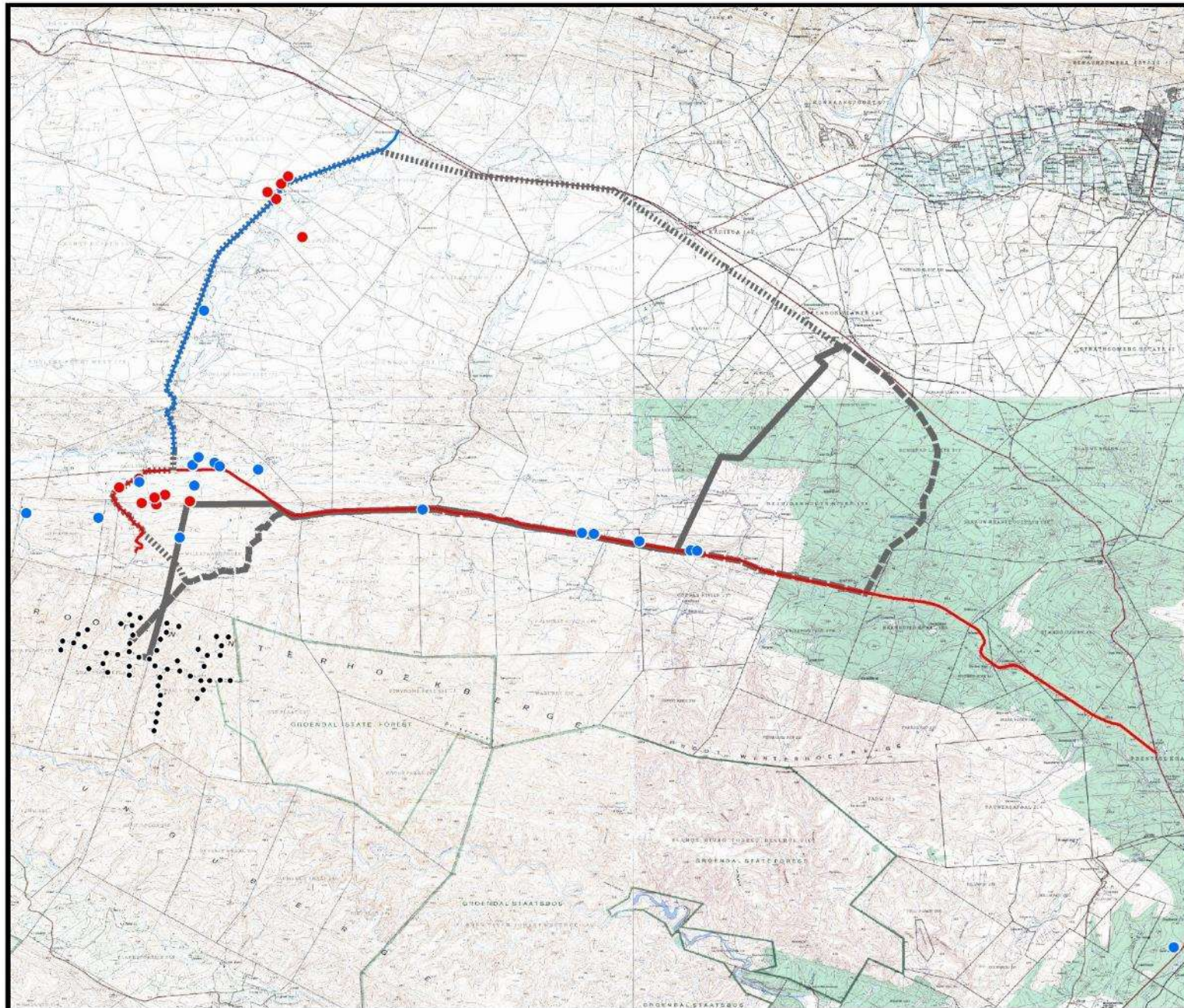
DATE	N/A	REVISION	N/A
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PROJECT NUMBER: EC-2016-1

SCALE - 1:30,000 @ A3

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Wind Farm**

FIGURE 10

**Grid Connection Survey
Records Aug 2015-Jan 2016:
Blue Crane & Ludwig's Bustard**

KEY:

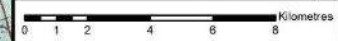
- 52-turbine layout

Species

- Blue Crane
- Ludwig's Bustard

Transects

- 1 (Main Route)
- 2 (Glen Connor Rd)
- Powerline Alternative Route 2
- ==== Powerline Alternative Route 1
- Powerline Preferred Route



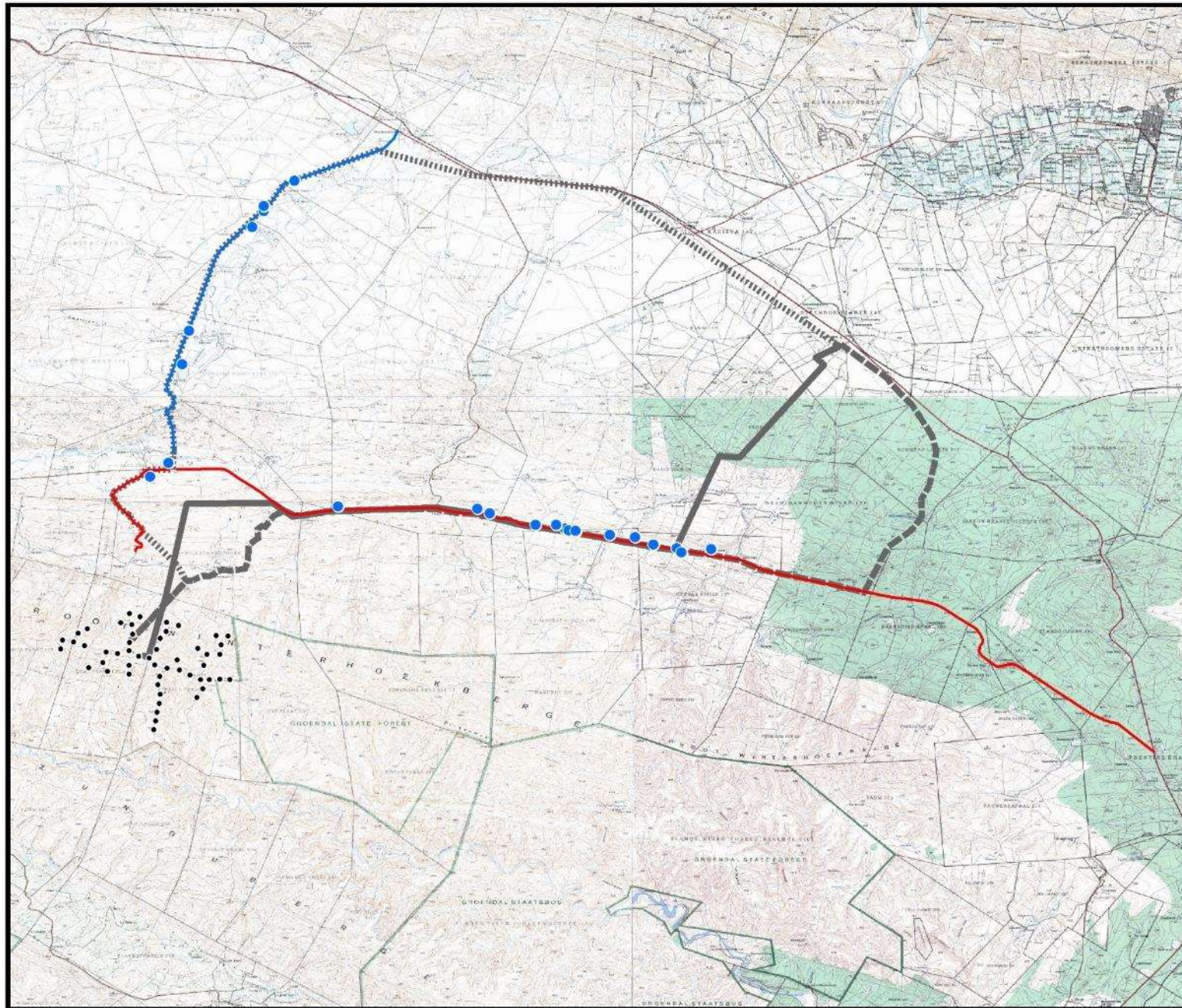
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PROJECT NUMBER: EC-2016-1

SCALE - 1:150,000 @ A3

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FIGURE 11

**Grid Connection Survey
Records Aug 2015-Jan 2016:
Pale Chanting-goshawk**

- KEY:**
- 52-turbine layout
 - Pale Chanting-goshawk
- Transects**
- 1 (Main Route)
 - 2 (Glen Connor Rd)
 - Powerline Alternative Route 2
 - ==== Powerline Alternative Route 1
 - Powerline Preferred Route

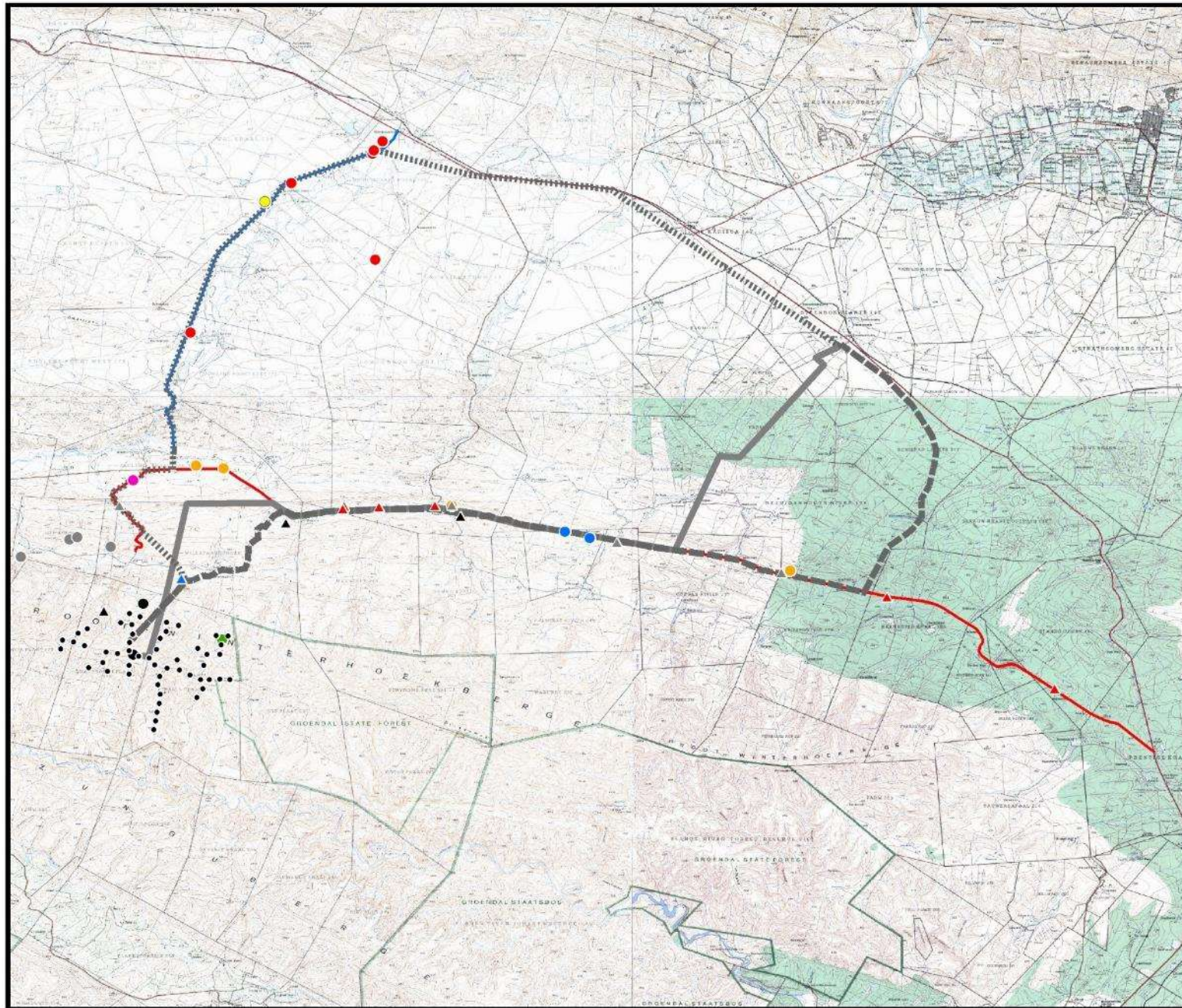


DATE	N/A	REVISION	N/A
PROJECT NUMBER	EC-2016-1		

SCALE - 1:150,000 @ A3

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FIGURE 12

**Grid Connection Survey
Records Aug 2015-Jan 2016:
other raptor species**

KEY:

• 52-turbine layout

Species

- African Harrier-Hawk
- Black Harrier
- Black-shouldered kite
- Booted Eagle
- Forest Buzzard
- Jackal Buzzard
- Lanner Falcon
- Lesser Kestrel
- Peregrine Falcon
- ▲ Rock Kestrel
- ▲ Rufous-breasted Sparrowhawk
- ▲ Steppe Buzzard
- ▲ Verreaux's Eagle

Transects

- 1 (Main Route)
- 2 (Glen Connor)



DATE	N/A	REVISION	N/A
PROJECT NUMBER	EC-2016-1		

SCALE - 1:150,000 @ A3

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