

Boa Vista Wind Farm Ponta do Sol

COLLISION RISK ASSESSMENT REPORT

- Supplementary Environmental Information
- Version 2 Final
- 5 December 2009



Boa Vista Wind Farm Ponta do Sol

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- Version 2 Final
- 8 December 2009

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1. Summary

As part of the Environmental Impact Assessment of the project, various studies have been carried out to identify sensitive ecological receptors and to describe the potential impacts upon those receptors.

One of the studies involves identifying the risk to sensitive bird species of collisions with turbines. Initial survey work and reporting was carried out by Orbicon in November 2008¹, and SKM were commissioned in March 2009 to carry out technical due diligence of the environmental information.

The installation of a wind farm at Ponta do Sol on Boavista in the Cape Verde Islands has the potential to impact upon Alexander's kestrel and Osprey, through disturbance during construction and collisions with turbines during operation. Red-billed tropicbird and Egyptian vulture, although vulnerable to collision with turbines, very rarely pass through the wind farm area and were not found to be at risk from the wind farm.

The due diligence carried out by SKM highlighted that the bird survey work, although sufficient in survey effort, only covered the pre-breeding season for osprey, and therefore recommended that additional work be carried out to provide additional information on use of the site during the breeding season and also to provide quantitative collision risk modelling.

Vantage point surveys were carried out for 49 hours over four months, from March to June 2009, and the data were pooled with 72 hours of vantage point data collected by Orbicon in November 2008.

Using this information, flight maps were produced, which showed that the majority of activity for both species occurs in the western half of the proposed development site. Calculation of theoretical collision risks for both species indicated that the turbine specifications significantly affect the collision risk, so mitigation was proposed in the form of turbine siting to minimise collision risk and disturbance to breeding birds, and choice of turbines. Based on this information, the developer, InfraCo, chose a 5 x 850kW turbine layout sited to minimise the interaction between birds and turbines, which reduced the potential for collisions of ospreys to 15% of the original collision risk estimate and collisions of kestrels to less than 3% of the original risk.

Discussions with the local ornithologist on Boavista, who has monitored the osprey populations for the past ten years and photographic evidence from the monitoring shows that osprey breeding success is currently depressed by factors unrelated to the wind farm, namely predation (predominantly by brown-necked ravens) and human interference. In reality, the osprey

¹ Orbicon, 2009. *Cape Verde Wind Extension Project – Assessment of risk of bird collisions with wind turbines at Ponta do Sol on Boa Vista, Cape Verde*. Report to InfraCo.



population in this area is unlikely to survive even in the absence of the wind farm. As well as choosing a specification and layout to minimise the impacts upon the osprey, conservation action is also proposed to tackle these non-wind farm related issues, in the hope of increasing the breeding success of the ospreys in this region and across the island as a whole.



2. Background

InfraCo is proposing to develop a wind farm on the northern end of BoaVista in the Cape Verde Islands on the Ponta do Sol peninsula. As part of the Environmental Impact Assessment of the project, various studies have been carried out to identify sensitive ecological receptors and to describe the potential impacts upon those receptors.

One of the studies involves identifying the risk to sensitive bird species of collisions with turbines. Initial survey work and reporting was carried out by Orbicon in November 2008², and SKM were commissioned in March 2009 to provide additional fieldwork and quantitative collision risk modelling.

This report details the methodology used and results of the site surveys, and provides collision risk estimates for the key at-risk species, which are considered to be Osprey (*Pandion halietus*), and Alexander's Kestrel (*Falco alexandri*), which is referred to in the Orbicon report as common kestrel.

This report provides quantitative collision risk estimates using the data collected in 2009, as well as the data from the surveys carried out by Orbicon, based on the original 15-turbine layout. It then goes on to provide revised collision risks for osprey and kestrel, based on the revised layout that was implemented in response to the findings from the original collision risk modelling.

Furthermore, the report discusses potential impacts upon the osprey, kestrel and vulture populations on Boavista, and provides suggested mitigation to minimise any potential negative impacts and create opportunities for conservation enhancement.

² Orbicon, 2009. *Cape Verde Wind Extension Project – Assessment of risk of bird collisions with wind turbines at Ponta do Sol on Boa Vista, Cape Verde*. Report to InfraCo.



3. Methodology

In order to obtain information on flight pattern, duration and height within the wind farm area, observers are stationed outside of the development zone (so that their presence would not influence flight behaviour), and the area was surveyed over four months during the osprey and kestrel breeding season.

In March 2009 Karen Blake of SKM, Principal Ecologist and Wind Farm ornithological specialist, visited Ponta do Sol with local ornithologists to establish suitable vantage points and to ensure that data would be collected in a systematic and representative way. The methodology chosen was based on current best-practice UK standards³, which recommend a minimum of 36 hours of survey covering the range of daylight hours. Owing to the size of the site, it was possible to identify a single Vantage Point location which provided clear views across the whole of the wind farm. This point was situated at the northern end of the site, on the high ground.

It was agreed that the target species requiring assessment at the site were osprey and kestrel, with information on any other raptors (such as Egyptian vulture *Neophron percnopterus*) and also red-billed tropicbird (*Phaethon aethereus*) movements also recorded.

Following this visit, Pedro Lopez, a highly experienced local ornithologist and osprey population specialist from Boavista, carried out vantage point surveys for 49 hours over four months, covering a range of daylight hours, to ensure that the results represented an accurate and unbiased collection of the use made of the wind farm by sensitive bird species. The dates, times and duration of the 2009 surveys are given in Table 1 below.

■ **Table 1: Vantage Point survey dates, times and duration**

| Date | Survey start time | Survey end time | Hours surveyed excluding breaks) |
|------------|-------------------|-----------------|----------------------------------|
| 2009-03-27 | 1130 | 1630 | 5 |
| 2009-03-28 | 1445 | 1645 | 2 |
| 2009-03-29 | 1355 | 1555 | 2 |
| 2009-03-30 | 740 | 1230 | 4 |
| 2009-04-06 | 705 | 1145 | 4 |
| 2009-04-16 | 1015 | 1500 | 4 |
| 2009-04-27 | 1430 | 1915 | 4 |
| 2009-05-02 | 635 | 1115 | 4 |
| 2009-05-22 | 930 | 1415 | 4 |
| 2009-05-26 | 1615 | 1815 | 2 |
| 2009-05-27 | 1400 | 1600 | 2 |

³ Scottish Natural Heritage (2005). Survey methods for use in assessing the impacts of onshore windfarms on bird communities. SNH, Battleby.



| Date | Survey start time | Survey end time | Hours surveyed excluding breaks) |
|--------------------|-------------------|-----------------|----------------------------------|
| 2009-06-02 | 630 | 930 | 3 |
| 2009-06-05 | 930 | 1230 | 3 |
| 2009-06-08 | 1230 | 1530 | 3 |
| 2009-06-09 | 1530 | 1830 | 3 |
| TOTAL HOURS | | | 93 |

Bird flights were recorded and logged at 15 second intervals, including the height band, direction and behaviour. Height bands were divided into 4 categories, as shown below:

- Height Band 1 = 0-10m
- Height Band 2 = 10-20m
- Height Band 3 = 20-100m
- Height Band 4 = >100m

The division into height bands compensates for observer error in estimating height of a moving object, and height band 3 (at between 20m and 100m) covers more than the full range of the rotor-swept height of the proposed turbines, and therefore represents a worst-case collision scenario.

During quantitative collision risk modelling, only flights within height band 3 would be considered at risk of collisions with turbines.



4. Results

4.1. Survey results

The Ponta do Sol wind farm area was surveyed for a total of 49 hours during the period from March to June 2009, and for a total of 72 hours during November 2008. In assessing the collision risk, the data have been combined, although some assumptions have been made regarding the Orbicon data, which does not contain information on flight duration. Correspondence from the author of the report⁴ indicates that the majority of flights were less than 60 seconds, so each flight is assumed to be 60 seconds for the purposes of undertaking a worst-case scenario assessment.

Weather data from each count in 2009 showed that the wind was consistently from the north-east, and the visibility was predominantly more than 10km, and never less than 5km. Cloud cover was typically in excess of 300m high with a minimum of 200m

Of the two sensitive species considered to be ecologically vulnerable to collision risk at this site, namely osprey and kestrel, the table below shows the time spent by each species at each height band within the wind farm area.

■ **Table 2: Osprey flight time (seconds) within different height bands**

| Species | Total flight time (seconds) | Time in height band 1 | Time in height band 2 | Time in height band 3 | Time in height band 4 |
|-----------------------|-----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Osprey (2009) | 3135 | 300 | 690 | 1770 | 375 |
| Osprey (2008) | 1400 | 420 | 120 | 840 | 0 |
| Total observed | 4535 | 720 | 810 | 2610 | 375 |

Flight patterns for osprey use of the wind farm are provided in Figure 1 at the end of this report.

■ **Table 3: Kestrel flight time (seconds) within different height bands**

| Species | Total flight time (seconds) | Time in height band 1 | Time in height band 2 | Time in height band 3 | Time in height band 4 |
|-----------------------|-----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Kestrel (2009) | 2235 | 855 | 555 | 825 | 0 |
| Kestrel (2008) | 2400 | 900 | 600 | 900 | 0 |
| Total observed | 4635 | 1755 | 1155 | 1725 | 0 |

Flight patterns for kestrel use of the wind farm are provided in Figure 2 at the end of this report.

⁴ Email from Flemming Pagh Jensen (Orbicon) dated 6th August 2009 to Ana Monteiro (InfraCo).



Small groups of red-billed tropicbird was seen on several occasions during the study, with only two flights of single birds (November 08) occurring within the wind farm area, both above collision risk height.

On 25th May 2009, a single Egyptian Vulture was seen flying high over the site towards Vigia, spending 45 seconds at collision risk height. This represents less than 0.5 hours predicted activity within the wind farm over a full year. A collision risk assessment for this species is provided in Section 3.2.4.

4.2. Original Layout - Collision risk assessment

Collision risk assessment calculates the number of birds that are predicted to fly through a rotor and the probability of a bird flying through a rotor being hit, to determine the number of birds that may be expected to collide with a turbine blade, if they show no avoidance behaviour.

The collision risk assessment is based on a mathematical model produced by Scottish Natural Heritage (SNH), in consultation with leading UK ornithologists. Details of the methodology, assumptions, and analysis are contained within Band *et al* 2007⁵. As with all mathematical models, some assumptions are inherent, which are described within the methodology report. It is also acknowledged that the methodology is somewhat crude, but provides a consistent approach. Guidance on the use of the model is provided on the SNH website⁶.

There are two forms of the model – one for species that fly through the wind farm, such as geese and migrating species in transit, and those that use the airspace within the wind farm on a regular basis. The species of concern in this area would use the wind farm airspace regularly, and that is the model used in this case.

In assessing the worst-case scenario, the longest body length, longest wing span and slowest flight speed is used in the model, along with a 100% operation capacity for the turbine as this presents the highest likelihood (worst-case scenario) of a collision.

⁵ Band, W., Madders, M., & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*, pp. 259-275. Quercus, Madrid.

⁶ SNH 2000. *Windfarms and birds: Calculating a theoretical collision risk, assuming no avoiding action*. <http://www.snh.org.uk/pdfs/strategy/renewable/COLLIS.pdf>.



4.2.1. Turbine Characteristics

Three turbine configurations under consideration for the wind farm, each of which produces different collision risk models. The details of the three options are provided in Table 4 below and the models have been run for each option.

■ **Table 4: Turbine Characteristics - Cape Verde Wind Farm Project**

| | Proposal 1 | Proposal 2 | Proposal 3 |
|---|---------------------|---------------------|--------------------|
| Nominal Capacity | 850 kW | 750 kW | 275 kW |
| Height of Towers | 55 m | 45 m | 55 m |
| Number of Blades | 3 | 3 | 2 |
| Rotor Speed Range | 14 - 31 rpm | 15 - 25 rpm | 31 - 46 rpm |
| Rated Rotor Speed | 26 rpm | 25.5 rpm | 26 rpm |
| Rotor Swept Plane | 2124 m ² | 1735 m ² | 802 m ² |
| Blade Length | 25.3 m | 21.0 m | 16.0 m |
| Rotor Diameter | 52 m | 47 m | 32 m |
| Maximum Blade Height | 80.3 m | 66 m | 71 m |
| Minimum Blade Height | 29.7 m | 24 m | 39 m |
| Thickness of Blade (blade root/blade tip) | 2.3 m / 0.33 m | 1.7 m / 0.80 m | 1.3 m / 0.30 |
| Pitch of Blade | 16° | 0 to -4° | 0 to 30° |
| Maximum Noise Level (at 8 m/s at 10mAGL) | 104 dB(A) | 100 dB(A) | 105 dB(A) |
| Total Number of Turbines for Boa Vista | 5 | 5 | 15 |

4.2.2. Collision risk for osprey

Biometric data on length and wingspan for osprey is taken from the Birds of the Western Palearctic⁷ and the flight speed from the Cambridge Encyclopaedia of Ornithology⁸.

⁷ Cramp, S. (1980). "Handbook of the Birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic. Volume II (Hawks to Bustards)" Oxford University Press, Oxford.

⁸ Brooke M and Birkhead T (Eds.) (1991) "The Cambridge Encyclopaedia of Ornithology" Cambridge University Press, Cambridge.



■ **Table 5. Biometric data for osprey used in the collision risk model.**

| Average flight speed (m/s) | Body length (m) | Wing span (m) |
|----------------------------|-----------------|---------------|
| 13 | 0.55-0.58 | 1.45-1.70 |

Results from the collision risk model produce the following results

■ **Table 6. Osprey collision risk model* results for each turbine option.**

| Step | Parameter | Unit and calculation | Option 1 | Option 2 | Option 3 | Revised |
|------|---|--|-------------|-------------|-------------|-------------|
| [1] | Wind farm area | ha | 23 | 23 | 23 | 23 |
| [2] | Observation time | min | 7260 | 7260 | 7260 | 7260 |
| [3] | Time spent in flight | min | 75.58 | 75.58 | 75.58 | 75.58 |
| [4] | Proportion of flight at rotor height | | 0.5755491 | 0.5755491 | 0.5755491 | 0.120977 |
| [5] | Proportion of observation time at rotor height | $[(3)/[2]]*[4]$ | 0.01 | 0.01 | 0.01 | 0.00 |
| [6] | Proportion of rotor-height flights per ha | $[5]/[1]$ | 0.0003 | 0.0003 | 0.0003 | 0.0001 |
| [7] | Flight risk area | ha | 3.93 | 4.93 | 5.93 | 3.93 |
| [8] | Proportion of time birds flew at rotor height within flight risk area | $[7]*[6]$ | 0.0010 | 0.0013 | 0.0015 | 0.0002 |
| [9] | Potential bird occupancy in days per annum | d | 365.00 | 365.00 | 365.00 | 365.00 |
| [10] | Potential flight hours per day | hr | 12.00 | 12.00 | 12.00 | 12.00 |
| [11] | Potential total occupancy | hr/yr $[9]*[10]$ | 4380.00 | 4380.00 | 4380.00 | 4380.00 |
| [12] | Bird occupancy at rotor swept height within risk area per annum | sec $[(11)*[6]]*3600$ | 4107.73 | 4107.73 | 4107.73 | 863.42 |
| [13] | Flight risk volume | $m^3 = ([7]*10000)*[15]$ | 2042035.32 | 2315685.77 | 1896637.12 | 2042035.22 |
| [14] | Number of turbines | | 5 | 5 | 15 | 5 |
| [15] | Rotor diameter | m | 52 | 47 | 32 | 52 |
| [16] | Rotor depth | m | 2.3 | 1.7 | 1.3 | 2.3 |
| [17] | Bird length | m | 0.58 | 0.58 | 0.58 | 0.58 |
| [18] | Volume swept by rotor blades | $sec \frac{([16]+[17])*pi}{([15]/2)^2*[14]}$ | 30581.52 | 19778.37 | 22679.79 | 30581.52 |
| [19] | Bird occupancy of rotor swept volume | $[12]*([18]/[13])$ | 61.52 | 35.08 | 49.12 | 12.93 |
| [20] | Flight speed | m/sec | 13.00 | 13.00 | 13.00 | 14.00 |
| [21] | Time taken for transit through rotors | $sec = ([16]+[17])/[20]$ | 0.22 | 0.18 | 0.14 | 0.21 |
| [22] | Number of transits through rotors | $[19]/[21]$ | 277.68 | 200.04 | 339.66 | 62.86 |
| [23] | Band collision probability | % | 0.12 | 0.13 | 0.15 | 0.12 |
| [24] | Collisions per annum (no avoidance) | $[22]*[23]$ | 31.93 | 26.01 | 50.95 | 7.54 |
| [25] | Collisions per annum (95% avoidance) | $[24]*0.05$ | 1.60 | 1.30 | 2.55 | 0.38 |

* This approach to the collision risk modelling follows that given in the Natural Research paper by Whitfield⁹.

The original 15 turbine layout produced a collision risk (2.55 strikes per annum) of almost twice that of the 5 turbine 750kW layout (1.3 strikes per annum).

⁹ Whitfield, D.P. 2009. *Collision Avoidance of Golden Eagles at Wind Farms under the ‘Band’ Collision Risk Model. Report to Scottish Natural Heritage.* Natural Research Ltd, Banchory.



4.2.3. Collision risk for kestrel

Biometric data on length and wingspan for Alexander’s Kestrel is taken from the Birds of the Atlantic Islands¹⁰ and the flight speed from the Cambridge Encyclopaedia of Ornithology, assuming the same parameters as for Common Kestrel (*Falco tinnunculus*).

■ **Table 7. Biometric data for kestrel used in the collision risk model.**

| Average flight speed (m/s) | Body length (m) | Wing span (m) |
|----------------------------|-----------------|---------------|
| 9 | 0.30 – 0.34 | 0.60 – 0.75 |

Results from the collision risk model produce the following results

■ **Table 8. Kestrel collision risk model results for each turbine option.**

| Step | Parameter | Unit and calculation | Option 1 | Option 2 | Option 3 | Revised |
|------|---|--|-------------|-------------|-------------|-------------|
| [1] | Wind farm area | ha | 23 | 23 | 23 | 23 |
| [2] | Observation time | min | 7260 | 7260 | 7260 | 7260 |
| [3] | Time spent in flight | min | 77.25 | 77.25 | 77.25 | 77.25 |
| [4] | Proportion of flight at rotor height | percentage | 0.3721683 | 0.3721683 | 0.3721683 | 0.0151025 |
| [5] | Proportion of observation time at rotor height | $[(3)/(2)]*[4]$ | 0.004 | 0.004 | 0.004 | 0.000 |
| [6] | Probability of rotor-height flights per ha | $[5]/[1]$ | 0.0002 | 0.0002 | 0.0002 | 0.0000 |
| [7] | Flight risk area | ha | 3.93 | 4.93 | 5.93 | 3.93 |
| [8] | Proportion of time birds flew at rotor height within flight risk area | $[7]/[6]$ | 0.000676 | 0.000848 | 0.001020 | 0.000027 |
| [9] | Potential bird occupancy in days per annum | d | 365.00 | 365.00 | 365.00 | 365.00 |
| [10] | Potential flight hours per day | hr | 12.00 | 12.00 | 12.00 | 12.00 |
| [11] | Potential total occupancy | hr/yr $[9]*[10]$ | 4380.00 | 4380.00 | 4380.00 | 4380.00 |
| [12] | Bird occupancy at rotor swept height within risk area per annum | sec $[(11)*[6]]*3600$ m3 = $[(7)*10000]*[15]$ | 2714.88 | 2714.88 | 2714.88 | 110.17 |
| [13] | Flight risk volume | | 2042035.32 | 2315685.77 | 1896637.12 | 2042035.32 |
| [14] | Number of turbines | | 5 | 5 | 15 | 5 |
| [15] | Rotor diameter | m | 52 | 47 | 32 | 52 |
| [16] | Rotor depth | m | 2.3 | 1.7 | 1.3 | 2.3 |
| [17] | Bird length | m | 0.34 | 0.34 | 0.34 | 0.34 |
| [18] | Volume swept by rotor blades | $[(16)+[17]]*pi$ $[(15)/2]^2*[14]$ | 28033.06 | 17696.43 | 19784.49 | 28033.06 |
| [19] | Bird occupancy of rotor swept volume | sec $[12]*[(18)/[13]]$ | 37.27 | 20.75 | 28.32 | 1.51 |
| [20] | Flight speed | m/sec | 9.00 | 9.00 | 9.00 | 9.00 |
| [21] | Time taken for transit through rotors | sec = $[(16)+[17])/[20]$ | 0.29 | 0.23 | 0.18 | 0.29 |
| [22] | Number of transits through rotors | $[19]/[21]$ | 127.06 | 91.53 | 155.41 | 5.16 |
| [23] | Band collision probability | % | 0.11 | 0.13 | 0.14 | 0.11 |
| [24] | Collisions per annum (no avoidance) | $[22]*[23]$ | 13.98 | 11.90 | 20.98 | 0.57 |
| [25] | Collisions per annum (95% avoidance) | $[24]*0.05$ | 0.70 | 0.59 | 1.05 | 0.03 |

¹⁰ Clarke, T. Field Guide to the Birds of the Atlantic Islands. Helm, London, pg 215.



Again, the original 15 turbine layout produced a collision risk 50% higher than the best 5 turbine layout.

4.2.4. Collision risk for Egyptian vulture

Biometric data on length and wingspan for Egyptian vulture is taken from the Birds of the Western Palearctic and the flight speed from the Cambridge Encyclopaedia of Ornithology.

■ **Table 9. Biometric data for vulture used in the collision risk model.**

| Average flight speed (m/s) | Body length (m) | Wing span (m) |
|----------------------------|-----------------|---------------|
| 12.5 | 0.6 – 0.7 | 1.55 – 1.80 |

Results from the collision risk model produce the following results.

■ **Table 10. Vulture collision risk model results for each turbine option.**

| Step | Parameter | Unit and calculation | Option 1 | Option 2 | Option 3 |
|------|---|--|----------|-------------|-------------|
| [1] | Wind farm area | ha | | 23 | 23 |
| [2] | Observation time | min | | 7260 | 7260 |
| [3] | Time spent in flight | min | | 0.01667 | 0.01667 |
| [4] | Proportion of flight at rotor height | percentage | | 0.75 | 0.75 |
| [5] | Proportion of observation time at rotor height | $[(3)/(2)]*[4]$ | | 0.000002 | 0.000002 |
| [6] | Probability of rotor-height flights per ha | $[5]/[1]$ | | 0.0000001 | 0.0000001 |
| [7] | Flight risk area | ha | | 3.93 | 4.93 |
| [8] | Proportion of time birds flew at rotor height within flight risk area | $[7]/[6]$ | | 52447827.01 | 65803555.86 |
| [9] | Potential bird occupancy in days per annum | d | | 365.00 | 365.00 |
| [10] | Potential flight hours per day | hr | | 12.00 | 12.00 |
| [11] | Potential total occupancy | hr/yr $[9]*[10]$ | | 4380.00 | 4380.00 |
| [12] | Bird occupancy at rotor swept height within risk area per annum | sec $[(11)*[6]]*3600$ m ³ = | | 1.18 | 1.18 |
| [13] | Flight risk volume | $[(7)*10000]*[15]$ | | 2042035.32 | 2315685.77 |
| [14] | Number of turbines | | | 5 | 5 |
| [15] | Rotor diameter | m | | 52 | 47 |
| [16] | Rotor depth | m | | 2.3 | 1.7 |
| [17] | Bird length | m | | 0.7 | 0.7 |
| [18] | Volume swept by rotor blades | $[(16)+[17]]*pi$ $[(15)/2]^2*[14]$ | | 31855.75 | 20819.33 |
| [19] | Bird occupancy of rotor swept volume | sec $[12]*[(18)/[13]]$ | | 0.02 | 0.01 |
| [20] | Flight speed | m/sec | | 13.00 | 13.00 |
| [21] | Time taken for transit through rotors | sec = $[(16)+[17])/[20]$ | | 0.23 | 0.18 |
| [22] | Number of transits through rotors | $[19]/[21]$ | | 0.08 | 0.06 |
| [23] | Band collision probability | % | | 0.14 | 0.16 |
| [24] | Collisions per annum (no avoidance) | $[22]*[23]$ | | 0.01 | 0.01 |
| [25] | Collisions per annum (95% avoidance) | $[24]*0.05$ | | 0.00 | 0.00 |



As there was only one flight of Egyptian Vulture recorded during 121 hours of survey, it is unsurprising that the collision risk model returns a zero collision risk for all three turbine options.



5. Discussion

Both osprey and kestrel make use of the wind farm area, but as seen in both Figures 1 and 2, the majority of flight activity is in the western portion of the wind farm area, with a bias towards the northern side of the site.

5.1. Impact assessment

Only kestrel and osprey were found to be using the wind farm in a way that would put them at risk of collisions with turbines, and therefore the impact assessment and mitigation strategy was restricted to those two species.

5.1.1. Osprey

There is an historic osprey nesting site also located to the north-western edge of the wind farm site, although Pedro Lopez, who monitors the nesting success every year, has said that their breeding success has been very poor for the past several years, with only one successful year in the past seven at this site. On Cape Verde, each osprey has several nest site locations, which it chooses between each year, although this has not resulted in better breeding success. This lack of breeding success contrasts sharply with the annual chick production of two-three chicks that is seen in the UK most years. The lack of success on Boavista appears to be primarily a result of predation at the nest, or disturbance by people, as the nests are generally more accessible on Boavista, as a result of the easy-access terrain and historic cultural behaviour.

The potential for human disturbance and predation by brown-necked ravens has previously been discussed in the paper on the current status of ospreys in the Cape Verde Islands¹¹. It is also possible that the pair of ospreys at Ponta do Sol has reached old age, and is no longer capable of producing chicks. However, photographs taken by Pedro Lopez of the nest site in 2008, clearly showed eggs in the nest one month that were gone on the following visit.

As the osprey population of the Cape Verde Islands is non-migratory, unlike that further north in the world, the birds are at risk from the wind farm all year round, and the potential for recruitment is low, given the current poor breeding success.

The majority of flight activity takes place in the western half of the wind farm site, with a bias towards the northern side, which is where the nest sites are.

Disturbance during the construction period is likely to affect the ospreys, although it will have no impact upon their foraging behaviour, as they forage at sea, only sometimes bringing their catch into the wind farm area to feed. There is a large area available for them to use for feeding, so this

¹¹ Palma, L; Ferreira, J; Cangarato, R; and Pinto, P. 2004. Current status of the Osprey in Cape Verde Islands. *Journal of Raptor Research* 38: 141-147.



is not expected to cause a significant impact on feeding birds. Disturbance at the nest has the potential to be a bigger issue for osprey, particularly during periods of heavy machinery use, and foundation construction. However, given the current issues facing the osprey at this location, this is unlikely to result in any decrease in the breeding success of this pair. Bizarrely, the level of activity during construction may provide a measure of protection from human interference and possibly predation and could potentially provide the osprey with its best chance of a successful breeding season in many years.

From the three turbine specifications under consideration, the collision risk model estimated collisions of between 1.3 and 2.5 birds per annum (at 95% avoidance). Assuming that the birds at Ponta do Sol were productive, this would pose a significant risk to this pair. In terms of the overall osprey population on Boavista, this is also significant as the population is very low, numbering less than 20 pairs on the island. Therefore, the impact of the wind farm, without mitigation is considered to be significant at a moderate scale.

The impact assessment for ospreys is complicated by the poor breeding success resulting from other factors and in the status quo situation, the pair is likely to die out without producing sufficient recruits to replace the adults as they die. Therefore it is considered that the impact on the population without the wind farm is likely to be the same in the long-term as it potentially would be from the wind farm i.e. disappearance of the breeding pair from Ponta do Sol.

Following the calculation of the potential collision risk for the original layout, the turbine specification and layout was revised, to use five 850kW turbines, located in the south-eastern portion of the site as far as possible (as shown on Figure 1). This reduced the number of osprey flights that would potentially interact with turbines from 2.55 collisions per year to 0.38 collisions per year (or just 15%) of the original risk.

5.1.2. Kestrel

Kestrels nested successfully in the locality, and the young were observed flying around the northern end of the site during the initial set-up visits. Kestrels were observed hunting within the wind farm area, which may put them at increased risk of collisions with turbines. Observations in March suggested that a single pair, with two offspring were resident just to the north of the wind farm site, and made frequent flights around the area.

The main impacts predicted for kestrels at Ponta do Sol from the construction and operation of a wind farm, are disturbance during construction, and collisions with turbines.

Increased levels of human and machinery activity during the construction period may influence the prey availability for kestrels within the wind farm area, and the noise may also cause the birds to leave the area, at least temporarily. However, the wind farm area is relatively small in comparison to the area of habitat available for hunting, and so the impact on the kestrel's ability to forage and to find a suitable nest site during construction is considered to be temporary, short-term and therefore not significant on the overall conservation status of the species.



The collision risk estimate (assuming a precautionary 95% level of avoidance and an average combined collision probability for upwind and downwind flight), ranges from 0.6-1.1 birds per annum, depending on the choice of turbines. The figures quoted should not be taken as an absolute number of birds that will be killed each year, as there are many, as yet poorly understood factors that may contribute to the potential for collisions with turbines and figures are strongly influenced by flight pattern and wind direction. It should also be remembered that these figures represent the worst-case scenario, with turbines operational 100% of the time, and the whole of any flight within the site and surrounding 500m buffer considered to be at risk of collision (rather than just the portion through the wind turbines themselves).

Recent post-construction monitoring of golden eagles within wind farms in Scotland⁹, has shown that avoidance rates of 99% can be adopted for that species, whereas 95% has been used since the inception of collision risk modelling, clearly overestimating potential collision risk. Using a 99% avoidance rate on kestrel flights would have a significant impact on the predicted collision risk, bringing it down to 0.12-0.21 birds per annum, or one bird every 5 to 9 years.

Other factors will also influence the potential for collision, such as the proportion of flights that approach the turbines upwind or downwind, the size of the individual birds and habituation to the operating turbines.

In terms of impacts, without mitigation, the impact on the kestrels on Ponta so Sol was considered likely to be high, as it is likely that the adults will collide with turbines at some time, resulting in mortality of one or both adults, and therefore potentially also of dependent young. In terms of the conservation status of Alexander's Kestrel on Cape Verde, the significance of the impact will be low, as the rest of the population will be unaffected by the presence of the wind farm.

In light of the potential impacts upon kestrels, the layout and turbine choice was revised, to place the turbines as far south and east on the site as possible, to minimise the number of turbine encounters that the kestrels would face. The new layout only had three kestrel flights in close proximity to turbines, and of those only one passed through the turbine array (see Figure 2).

Calculating a revised collision risk for kestrel with the new layout resulted in a collision risk (assuming 100% turbine operation i.e. worst-case scenario) of 0.03 collisions per year, which is just 3% of the collision risk of the original layout.

As a result of the turbine layout change, the impact upon Alexander's Kestrel has been significantly reduced and is considered to be not significant to the conservation status of this species within Boavista.

5.2. Mitigation

The main impacts identified as being potentially significant to both kestrel and osprey are disturbance during construction, and collisions with turbines.



Beyond the design mitigation and siting that has been carried out already to reduce the impacts upon these bird species, additional mitigation principles are recommended as follows.

Construction during the main breeding period should normally be avoided, to minimise the risk of nest failure. Where this is not an option, the maximum possible distance should be maintained from the nest area, and all construction staff should be prevented from working, or taking breaks in the area of the construction site closest to the nesting area.

If these basic mitigation strategies are implemented, then the predicted impacts upon kestrels will become not significant, and for ospreys will drop the potential collision risk to around one in four years, instead of two per year, which will be a minor significant impact.

5.3. Biodiversity enhancement

It is clear from the studies of the ospreys carried out at Ponta do Sol over the past nine years, that these birds face enormous pressure from outside influences, including predation by brown-necked raven, and human interference.

There is a valuable opportunity, as part of this wind farm project, to contribute to the conservation of the species, through targeted measures specifically designed to tackle these two issues. These need not be elaborate or expensive, but well thought-out and precisely applied techniques to address specific issues.

In terms of predation, there is a wealth of experience in the UK of controlling corvid (crow family) numbers to protect vulnerable breeding species, and this may be an option on Boavista. Regularly removing the key predators in the locality could have an immediate positive impact upon the breeding success of the pair of ospreys, which will in turn help the overall osprey population, as young move out and colonise other empty territories on the island (and on other islands in the archipelago). This does not mean exterminating all brown-necked ravens across the island, but helping to achieve a balance of populations, so that one species is not decimating another. This may have spin-off benefits for other species at risk from predation by this species. It could also be applied over more than one site, thereby assisting a larger number of birds, including the vultures.

The issue of human interference is a trickier proposition, as there are cultural and socio-economic drivers behind the behaviour. It is clear from work done in this field around other parts of Africa that generating a cultural change can be a slow and frustrating task, but as Cape Verde seeks to increase its appeal as a tourist destination, then the potential for eco-tourism is consequently much higher on the political agenda. The most likely way to tackle this would be through an education programme, aimed initially at school-age children and then expanding to the wider community. Other techniques that have been successfully used in the past have included incentive payments for people handing in the target quarry (e.g. 10 pence for a grey squirrel tail in the UK in the past). This would need to be managed carefully to avoid a gold-rush mentality, but can have a place in an overall strategy.



In addition, it is a recommendation of the ornithologist on Boavista that artificial osprey platforms be constructed that can be made vandal-proof and provide safe nesting opportunities for ospreys. Again this can be done at strategic locations all over the island, not just at Ponta do Sol.

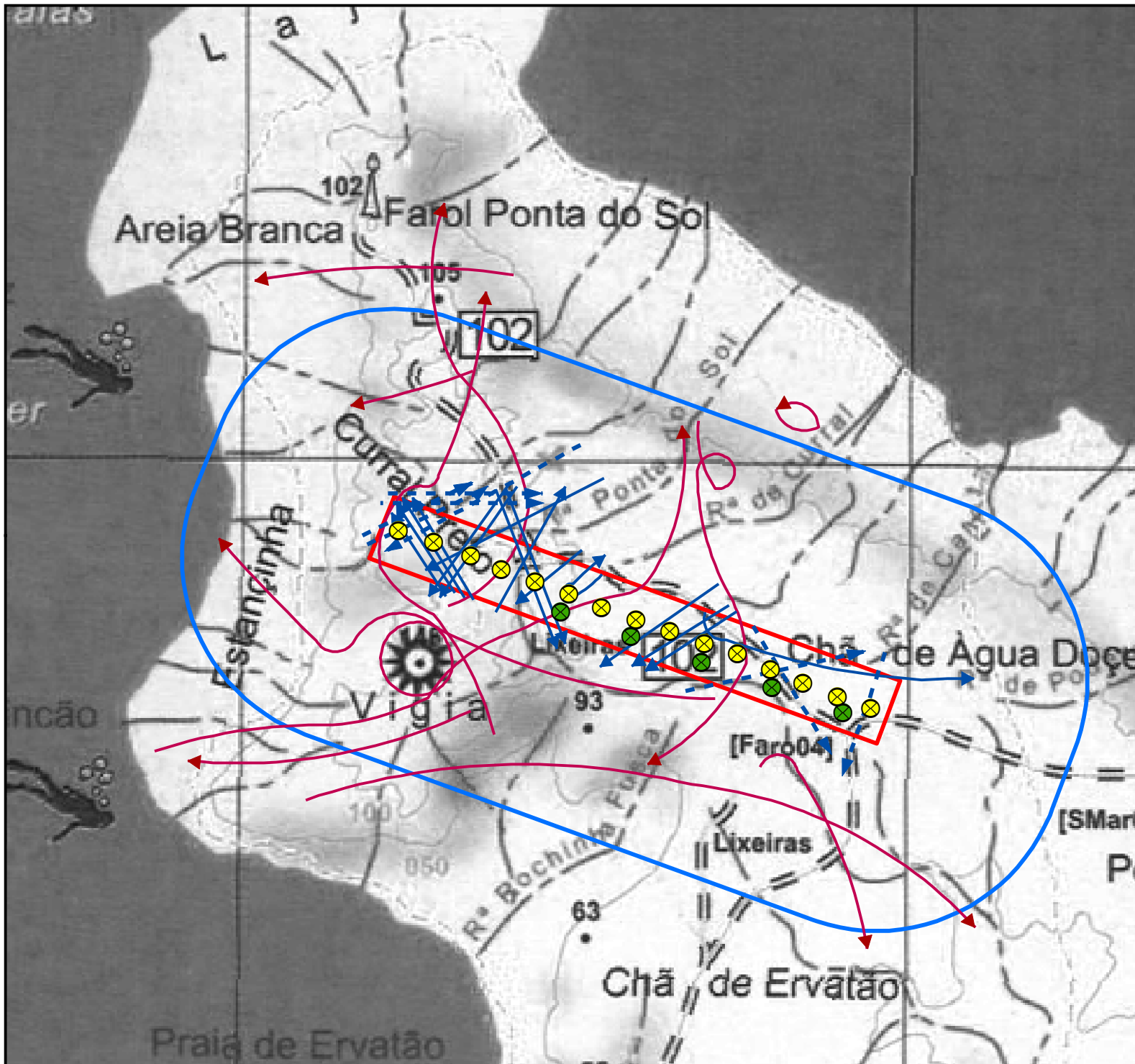
Both of these conservation opportunities will require detailed consultation with the relevant officials and government agencies and input from the local ornithological and cultural experts to ensure that any action has the highest likelihood of success.

These are simply a couple of ideas for nature conservation enhancements. There will be other opportunities for contributing to enhancement for the local communities that should also be considered.

5.4. Post-construction bird monitoring

It is important, in light of the paucity of information on collision risks for at-risk species, to carry out post-construction monitoring of the site, to ground-truth the predicted collision risk and identify displacement (or attraction) associated with the wind farm. It also provides the evidence on the success, or not, of the mitigation measures that were implemented in the design and layout of the wind farm. The improvement in understanding the actual use of the wind farm by bird species and the actual collisions is important in ensuring that the precautionary approach does not overstate the risks.

This monitoring should take the form of repeated vantage point surveys, to obtain flight data for birds, for a period of at least five years from the start of operation. This should be coupled with regular (monthly) searches for corpses around every turbine, to identify any fatalities.



Osprey Flight Path Map

November 2008 - June 2009

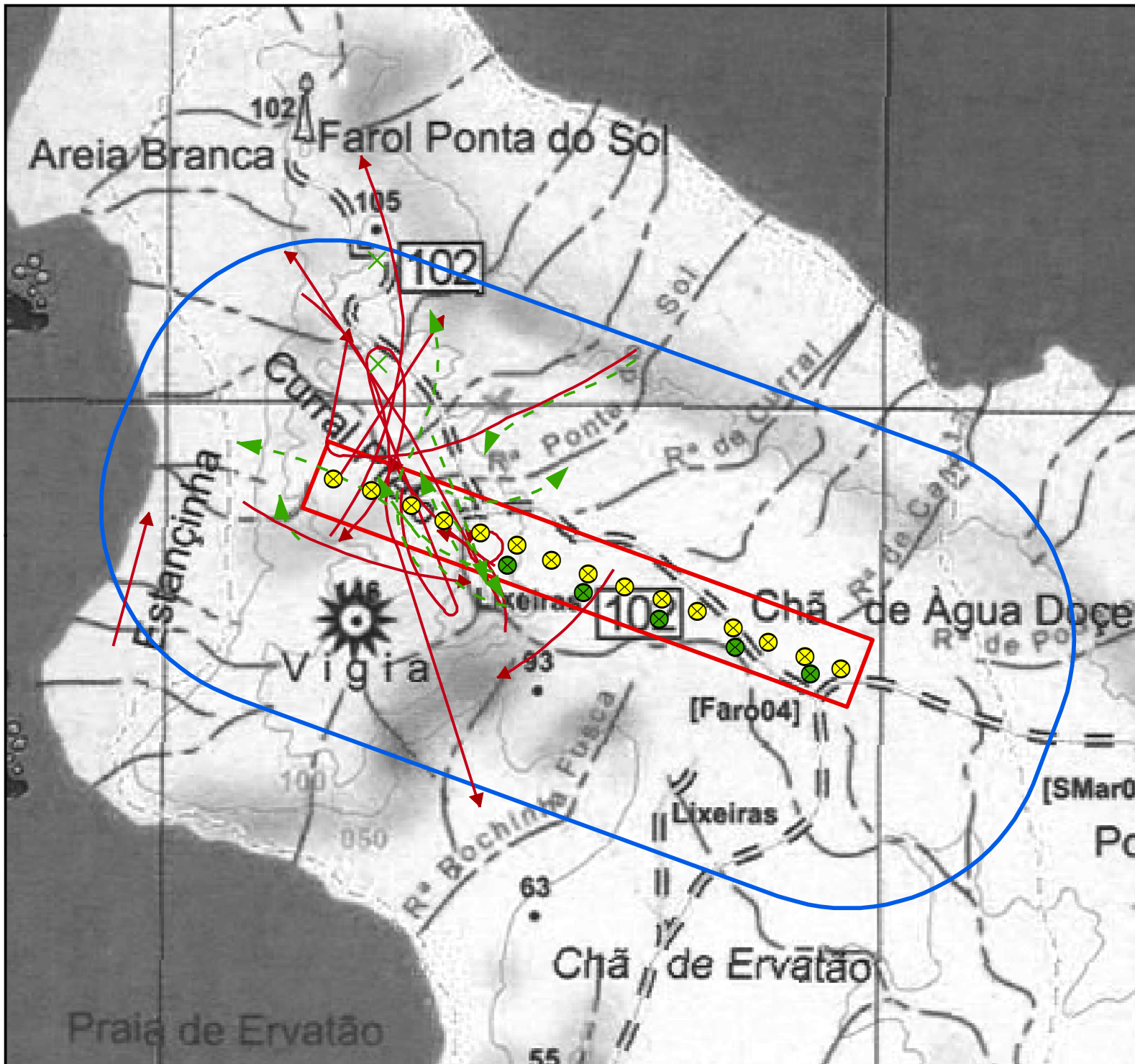
Figure 1

Legend

- Site Boundary
- 500m Buffer
- Original Turbine Layout
- Revised Turbine Layout
- Obericon: Flights Outwith Collision Risk Height
- Obericon: Flights Within Collision Risk Height
- Flights Within Collision Risk Height

0 250 500 Metres





Kestrel Flight Path Map

March 2009 - June 2009

Figure 2

Legend

- Site Boundary
- 500m Buffer
- X Original Turbine Layout
- X Revised Turbine Layout
- Flights Within Collision Risk Height
- ▶ Flights Outwith Collision Risk Height
- X Kestrel Nest

No Obericon flight paths are included in this map

