

Before the Board of Inquiry  
Hauauru Ma Raki Wind Farm Proposal

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*Under* the Resource Management Act 1991

*In the matter of* Resource consent applications by Contact Wind Limited relating to the Hauauru Ma Raki Wind Farm Proposal

*And*

*In the matter of* Notices of Requirement and a Resource Consent Application by Contact Energy Limited relating to the Hauauru Ma Raki Wind Farm Proposal

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Statement of evidence in chief of ***Dr Steve Percival***

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Dated: 26 March 2009

Date of hearing: Commencing 27 April 2009

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# STATEMENT OF EVIDENCE IN CHIEF OF DR STEVE PERCIVAL

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## **INTRODUCTION**

- 1 My full name is **Dr Stephen Mark Percival**. I have a B.Sc. (Hons) degree in Biological Sciences from the University of Durham (awarded in 1984) and a Ph.D. in Zoology from the University of Glasgow (awarded in 1988). I am a member of the Institute for Ecology and Environmental Management, the British Ecological Society and the British Ornithologists' Union.
- 2 As principal of my own private practice, Ecology Consulting, I have a wide experience of nature conservation and wind energy issues. My clients have included English Nature, the Wildfowl and Wetlands Trust, Scottish Natural Heritage, the Countryside Agency, the DTI's Energy Technology Support Unit, the New Zealand Department of Conservation and numerous wind energy companies. I have been involved in over 300 wind energy projects, including carrying out ecological assessments, preparation of ecological material for environmental statements and giving evidence at public inquiries. I have published papers on the interactions between birds and wind farms and on assessing the potential effects, and given conference papers both within the UK and internationally.
- 3 From 1991 to 2001 I was employed by the University of Sunderland as a Senior Lecturer in Environmental Biology. I took up the post in 1991, moving from the University of Durham where I had been working as a Senior Research Fellow with the late Prof. Evans on waterfowl population ecology. This included the development of ecological models to predict the consequences of habitat change on bird populations. Prior to that I worked two years for the British Trust for Ornithology on the population dynamics of Barn and Tawny Owls, which included the analysis of data from the national bird monitoring schemes to assess the trends in owl numbers and the factors that were affecting them.
- 4 I have been studying the conservation ecology of bird populations since 1983. This has included work on population changes of waders in the Outer Hebrides and detailed ecological studies of barnacle geese, brent geese, wigeon, golden plover and curlew. My work has been published in major international scientific journals including the Journal of Applied Ecology, Biological Conservation, Ecography and Ibis.
- 5 I was commissioned by the Department of Conservation [DoC] to provide them with advice on the potential ornithological impacts of the HMR wind farm in March 2008. In that month I made a visit to the site and met with a representative from the developer and their ecological consultant at the DoC offices in Hamilton. As part of that meeting I made a presentation to give advice on assessing the impacts of wind farms on birds with particular reference to the HMR scheme.
- 6 I am familiar with the proposal which is the subject of the resource consent applications and notices of requirement. I also confirm that I have visited the site, in March 2008.

- 7 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise.
- 8 I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

#### **SCOPE OF EVIDENCE**

- 9 My evidence here focuses on the key ornithological issue at the HMR site, migration of shorebirds through the site. It will deal with the following:
  - **Comment on Contact Witness Evidence**
  - **International Experience of Birds and Wind Farms**
  - **Contact Ornithological Assessment Methodology**
  - **Analysis of Potential Ornithological Impacts**
  - **Recommended Conditions**

#### **SUMMARY OF EVIDENCE**

- 10 In my evidence I have reviewed the relevant information available on the bird populations potentially at risk from the proposed HMR wind farm and found there to be major gaps in our knowledge of how shorebirds in particular migrate across the site. There is no doubt that the site lies on a major migration route but the baseline surveys reported to date have not established robust estimates of the numbers of the birds migrating along that route that would actually be at risk of collision. From the information that is currently available, however, there is a high likelihood of substantial numbers of migrant shorebirds passing through wind farm at rotor height and hence being at risk of collision.
- 11 In order to inform the assessment process, I have used the available data to undertake a preliminary collision risk assessment, using results from a nearby site (Taharoa C; Fuller et al. 2009) and appropriate worst case assumptions to deal with any data gaps. This assessment uses an internationally-recognised standard approach developed in the UK, which was also used for the Taharoa C wind farm proposal. This analysis, together with the population viability analysis undertaken by Dr Dowding, has established that the collision risk has the potential to be significant for a range of shorebird migrants, particularly Southern Pied Oystercatcher [SIPO] and wrybill.
- 12 A key problem at this wind farm is that even a small risk of an impact could be highly significant, through additional mortality to already vulnerable species. Even a rare event can be significant if it

is considered to be high risk. The magnitude of this risk could be reduced and could be better quantified by robust baseline data to inform an appropriate package of mitigation measures (including design mitigation to avoid any zones of higher bird flight activity).

- 13 Given the inevitable residual risks, a complementary way to mitigate these may be to undertake off-site measures to enhance conservation status of local populations, as proposed in Dr Seaton's evidence. It would need to be ensured that the gain from such programmes clearly exceeded the risk from the wind farm, but may be a part of a solution whereby the collision risk could be more effectively mitigated.
- 14 I conclude that on the information currently available one simply cannot say whether the risk of the HMR wind farm to birds can be avoided, remedied or mitigated. It is possible that it may, but this can only be concluded with any certainty once an adequate baseline data set has been obtained.

### **COMMENT ON CONTACT WITNESS EVIDENCE**

#### **Mr Kessels**

- 15 Mr Kessels describes a wide range of baseline bird surveys that have been undertaken to date, including (i) general surveys of farmland; bush habitats, wetland habitats and resident shorebirds, (ii) specific resident and migratory shorebird surveys, (iii) specific bush surveys, focussing on tui, kereru and morepork; and (iv) wetland bird surveys, focussing on Australasian bittern within Punga Punga Wetland. Whilst the breadth of these surveys is clear, it is also clear that the currently available baseline is lacking in several major areas (particularly regarding migratory bird flight activity through the site). Indeed Mr Kessels himself acknowledges these shortcomings with regard to his migratory shorebird surveys in his evidence. He states in relation to the assessment of migratory bird collision risk that "*quantifying this risk requires a large amount of robust data on a wide range of behavioural and flight patterns of key shorebird species*" but it is clear that this work has not been completed and that the assessment as submitted does not draw on such a robust data set.
- 16 As a consequence of this lack of a robust baseline data set, Mr Kessels' assessment of the potential impact of the wind farm on birds is inevitably very limited and largely qualitative. The analysis of collision risk in particular falls well below usual best practice (Band 2001, Whitfield et al. 2005, Anderson et al. 1999). Though the potential of adopting a collision risk modelling approach is acknowledged, no attempt has been made to carry out such an exercise in the context of the key ornithological issue at the site, migratory shorebirds.
- 17 The results indicated that most shorebirds "*generally hugged the coast*" but also acknowledged possibility of flights overland (through

the wind farm). Mr Kessels concluded that collision risk to these species would be low-moderate but does not give any detail of how he reached this conclusion or any reference to any assessment methodology. The recently published Stage 2 shorebird survey report highlights further the fact that the site does lie on a major shorebird migration route and therefore that shorebird collision risk is a major issue at this site.

- 18 The Stage 2 report provides considerably more information about bird movements through the site and the proposed continuation of that work for another northwards migration and for two southwards migrations should provide the robust baseline that a proper impact assessment requires (provided the survey methodology is robust). However the information currently available, even with that report, is still very limited. For the southwards migration, for example, there are only sparse data from observation surveys. It has been established in studies from the Taharoa C wind farm that shorebird migration through the area at that time of year takes place predominantly at night, so would be largely missed by such surveys (Fuller et al. 2009).
- 19 The Stage 2 report itself also has a range of issues that need to be resolved in relation to data quality and reliability. The lower numbers of radar tracks at the southern end of site, for example, are surprising and not readily accounted for by any immediately obvious ecological explanation. It may indicate methodological issues, such as the detectability of birds from that location may not be as high as from northern site (and hence total numbers under-estimated). It is known from the Taharoa C studies that radar systems such as that used here can substantially underestimate flight activity (in that study by as much as half; Fuller et al 2009).
- 20 Bird monitoring has been proposed as part of the mitigation package. It is important to establish that monitoring is not itself mitigation but rather required to inform what mitigation is needed. There is currently considerable uncertainty as to what mitigation measures are required and which would be most effective, largely as a result of the lack of robust baseline data.

#### **Dr Seaton**

- 21 Though the same shortcomings apply to Dr Seaton's assessment as Mr Kessels' with regard to a lack of robust baseline data and no clear assessment methodology, I would note at the outset of this section that I would largely agree with the conclusions that Dr Seaton has reached and his clear acknowledgement of the limitations of the available data.
- 22 I note in paragraph 5.8 that he identifies 95% as a precautionary avoidance rate to apply to bird collision risk modelling.
- 23 I note that he acknowledges that it is not currently known whether NZ Falcon breeds in the area and proposes further surveys [para. 6.6]. It is my opinion that this work should have been undertaken as

part of the baseline to inform the assessment and any need for mitigation.

- 24 I note that Dr Seaton records the presence of two breeding pairs of NZ Dotterel in the area but that neither of them is in proximity to any wind turbines. He considers that it would not be likely that there would be many local movements through the wind farm given the lack of habitat inland for these birds to move to/from. I note however in Dr Dowding's evidence that he considers that this species may be at some risk of collision, though it is not possible from the information currently available to quantify this risk. Given Dr Dowding's position, the presence of this species in the area and its threatened status, I would consider it appropriate to include it in the proposed measures for avoidance and mitigation.
- 25 In para. 10.4 of his evidence Dr Seaton states that, in relation to migratory shorebird collision risk "*modelling a range of potential scenarios of collision risk will also provide some insight into the potential effects on the populations of these species*". It is this approach that I have adopted and present later in my evidence.
- 26 I concur also with Dr Seaton's statement in para. 10.8 that "*in my opinion it is important that the proportions of migratory birds passing over and through the areas where the turbines are proposed are established with greater certainty, in order that the numbers at risk can be defined, and the overall effect on populations of each species at risk can be modelled*" This is a clear acknowledgement that the current baseline data are insufficient to properly assess the impact of the proposed development.
- 27 Two years' post-construction collision monitoring is proposed, during the main migration periods. From my experience I would consider this to be too short a time, especially given the importance of this issue at this site. I would instead propose a post-construction monitoring programme in line with recent recommendations published in the UK (SNH 2009), in years 1,2,3,5,10 and 15 after commissioning of the wind farm. Additional robust baseline data are also required to define those main migration periods during which collision monitoring would be undertaken more precisely. Carcass search visit frequency needs to ensure that it is linked to the results of the scavenger removal trials: if scavenger removal rates are high then more frequent search visits will be necessary.
- 28 In paras 11.7 and 11.8 Dr Seaton identifies the primary ornithological issue at this site as being, in my opinion correctly, migratory shorebirds, and with the lack of baseline information, reaches the conclusion that "*it is important in my opinion that further monitoring of migratory shorebirds is completed before the wind farm commences operation to allow any potential effects to be avoided.*" The critical question then follows as to how further monitoring can allow effects to be avoided. A range of proposed mitigation measures are offered in Dr Seaton's evidence, though he acknowledges the need for further baseline information before the most effective of these can be determined. They include the following on-site measures:

- (a) Do not build turbines in areas where high densities of migratory birds are passing through;
- (b) Ensure wide "corridors" with no turbines are available for migrating birds to pass through the wind farm;
- (c) Switch off high risk turbines at times of high bird migration;
- (d) Switch off high risk turbines at times when high bird migration and inclement weather conditions coincide.

29 Dr Seaton also proposes the following off-site conservation management:

- (a) The implementation of predator control programs at key breeding and wintering sites for migratory birds,
- (b) Intensive, sustained and targeted predator control and habitat enhancement for bush and wetland birds (at Punga Punga Wetland),
- (c) Predator control in and habitat enhancement of local areas of bush (particularly for kereru).
- (d) Providing funds and facilitating long-term formal legal protection of affected key natural features on private land within the Waikato Wind Farm study area
- (e) Long-term funding of a shorebird study group whose objectives are to describe the major pathways of migratory birds around New Zealand (similar to the Department of Conservation "Project River Recovery" funded by Meridian Energy Ltd).

30 These all appear to be sensible ideas but all need clarification as to how they would be triggered and how they would work. Avoidance of significant impacts on threatened populations could be dependent on their effective deployment and they need, in my opinion, to be more precisely defined in the Proposed Conditions. Currently (in Daysh section 6) all that is stated is that the developer would "put in place additional measures to ensure that any significant adverse effects of the exercise of the consents on migratory shorebird species are appropriately avoided, remedied or mitigated." Without details of implementation of these proposals it could not, in my opinion, be concluded that such measures would definitely be effective in avoiding/remediating/mitigating the collision risk. It is likely to require a package of measures that will likely include design mitigation (avoiding areas of higher flight activity when those are properly defined/reducing turbine numbers), turbine shut-down and off-site management for shorebirds and better baseline information to inform these measures before risk reduction to an acceptable level could be a reasonable possibility.

31 In para. 10.11 Dr Seaton notes that bright white lights at night are not proposed and that navigational lights would be shielded if practical. Given that the site is on a major bird migration route it is very important that this is confirmed by condition to avoid any possibility of birds being attracted into the wind farm at night and colliding more frequently with the turbines as a result.

## **INTERNATIONAL EXPERIENCE OF BIRDS AND WIND FARMS IN RELATION TO THE HMR PROPOSAL**

### ***International guidance on wind farms and avifauna***

- 32 There are generally considered to be three main issues with birds at wind farms; the direct mortality through collision with the wind turbines, disturbance from a zone around the wind turbines and habitat loss through construction of the wind farm (Langston and Pullan 2003, Percival 2005, Powlesland 2009).
- 33 The key bird issue at HMR is collision risk to migrating shorebirds, so that is the focus of my evidence.
- 34 As a precautionary approach, general guidance regarding birds and wind farms is to try to avoid locating wind farms in areas with large/vulnerable bird populations and major migration routes (Langston and Pullan 2003).
- 35 When wind farms are proposed in areas with high bird populations the importance of a robust baseline dataset becomes even more important in assessing the potential impacts of a scheme. This needs very careful consideration, particularly with regard to the case here where such high proportions of several populations of major conservation importance are involved.
- 36 Where wind farms have been constructed within areas of high bird flight activity, such as migratory routes, there have usually been at least some bird collisions resulting. In most cases, particularly with shorebirds, the levels of mortality have been low, but have involved species that are much more abundant than the key ones at HMR (and less vulnerable to any additional mortality) (Erickson et al 2001, Hotker et al. 2004, Percival 2005). The situation at HMR is rather different in that several of the species present are so scarce that even a small number of collisions could be significant. Shorebirds in general are not a group that have a high vulnerability to collision with wind turbines (Langston and Pullan 2003; Percival 2005) but there will always be likely to be at least a low level of residual risk. A key question is then whether this residual risk is acceptable. The only way that this can be judged is with a comprehensive knowledge of how the key bird species use the site that can form the baseline for a detailed impact assessment.
- 37 There have been several wind farm schemes of which I am aware (and some that I have been directly involved with) that have used baseline bird survey data to locate wind turbines away from areas of higher bird activity and hence reduce the collision risk, but this has always been very much a risk reduction management process rather than removing the risk altogether. It requires clearly identifiable areas of higher and lower bird activity, ideally with clear ecological reasons behind the observed patterns, such as habitat preferences and topography. Such an approach may be possible at HMR but with the baseline information currently available there remains considerable uncertainty about this.

- 38 The HMR site presents a combination of bird risk factors that have not been studied elsewhere at existing constructed wind farms: it is located on a major migration route with a high proportion of several populations using that route (giving high population exposure to risk) and with species involved that are likely to be sensitive to even low levels of additional mortality. The usual approach to deal with such a novel issue would be to firstly establish a comprehensive baseline data set to understand the magnitude of the issues and carry out a proper impact assessment to inform the decision-making process, i.e. before consent is given. That should include a robust quantification of the birds at risk of collision and collision risk modelling to determine the likely magnitude of that risk. This has not yet been achieved at HMR.
- 39 In the absence of such a baseline it is appropriate to take an initial precautionary approach to determine what might conceivably happen as a result of the development, and use this to inform the assessment process. Contact's consultants have identified this as a potential way forward but have not undertaken such an assessment themselves.

#### **International information on bird strike**

- 40 It is well established that birds of a range of species can collide with wind turbines, but that those collision rates are generally low. There are however a number of specific examples where levels of mortality have been sufficiently high to result in impacts at the population level, notably golden eagles in California (Hunt et al 2002, Smallwood and Thelander 2005), griffon vultures in Spain (Barrios and Roduigez 2004) and white-tailed eagles in Norway (Statkraft 2008). Shorebird collisions too have been recorded, albeit at relatively low levels (Hotker et al. 2004). There are, however, some circumstances in which shorebird collisions can occur.
- 41 Many developers have adopted a precautionary approach, avoiding such areas for development, and as a result few studies have been undertaken of wind farms on major shorebird migration routes. In addition at the HMR site there is potentially a very high proportion of several endemic populations at risk, populations which themselves are not large and hence potentially more vulnerable to any additional mortality that may result from the wind farm. The potential risk at HMR is enhanced further by the high likelihood that southwards migration through the site, from the results of the Taharoa C studies (Fuller et al. 2009), will take place mainly at night (when visibility will obviously be much lower and the birds therefore potentially more vulnerable to collision).
- 42 The HMR site therefore raises several potentially important issues that have not been studied at existing wind farms, a combination of (i) location on a major shorebird migration route, (ii) species present that have small populations vulnerable to additional mortality, and (iii) the likelihood of major movements at night when birds' ability to avoid turbines is likely to be reduced.

## **CONTACT MONITORING METHODOLOGY AND RESULTS**

- 43 There are two basic requirements for baseline data from a proposed wind farm site necessary to make an assessment of the potential impacts of that wind farm. These are:
- Data on bird flight activity and behaviour that can be used to quantify the risk of collision; and
  - Data on the local bird populations in and around the potential impact zone that enables the bird populations at risk of disturbance and loss of habitat to be identified and quantified.
- 44 It is against this basic requirement that I have made my assessment of the adequacy of the proposal, drawing on relevant experience from my own work on wind farm proposals and from other relevant case studies and guidance worldwide (including from the UK, Whitfield et al. 2005, and USA, Anderson et al. 1999).
- 45 It is clear and indeed inferred in Contact's own evidence that the initial baseline data currently available from the HMR site is inadequate for the purposes of a full ornithological impact assessment. Prior to the production of the Stage 2 report their work had identified potential issues but provided no real quantification of those issues, particularly shorebird migration.
- 46 It is only with the production of the Stage 2 shorebird report that the baseline bird survey work is starting to be carried out in a way that is likely (by the end of the study period in mid-2010) to provide an adequate baseline. The key problem with the Contact monitoring is that it is not yet complete and hence presents only a partial picture of the baseline conditions and no analysis has been presented on the key collision risk issue at the site, shorebird migration. The Stage 2 report was only made available on 16 March 2009 so it has not been possible by the time of writing this evidence to include a full analysis/validation of that report.

## **POTENTIAL ORNITHOLOGICAL IMPACTS: COLLISION RISK TO SHOREBIRD MIGRANTS**

### **Analysis of data**

- 47 No quantitative assessment of collision risk for shorebird migrants has been presented in the Contact submissions. I have therefore undertaken collision modelling myself to further inform the assessment process. The key question that I have addressed is what numbers of shorebird collisions might occur. John Dowding, in his evidence, then uses these results to address the likely impact of such additional mortality at the population level and whether there might be a possibility of the HMR wind farm resulting in a significant collision risk. I have read Dr Dowding's evidence and fully support the conclusions that he has reached using these results.

- 48 The principle that I have used in my analysis has been to work from the best available data (from the HMR site where available), but make reasonable worst-case assumptions (i.e. assumptions that could potentially occur) where there are data gaps. Monte Carlo modelling has been used to explicitly address uncertainties in the baseline data.
- 49 As well as data from the Contact studies, there is also relevant information available from other sources, particularly the baseline surveys that have been undertaken at the Taharoa C proposed wind farm about 50km to the south of the HMR site. Taharoa C is a much smaller site and proposed wind farm but has similar issues. An expert group was established to discuss the issues at that site and has produced a report that provides a useful background on bird detectability, flight heights and migratory behaviour through the year (particularly the predominantly night migration when moving south) (Fuller et al. 2009).

### **Background to Collision Modelling**

- 50 The collision risk modelling carried out for the HMR wind farm presented here in my evidence follows the standard approach developed by Scottish Natural Heritage [SNH] (Band 2001; Band et al. 2007) and recently reviewed by the British Trust for Ornithology [BTO] (Chamberlain et al. 2005). All of the models constructed for the HMR assessment have been validated and cross-checked against the standard examples given in Band et al. (2007).
- 51 The collision risk assessment process proceeds in two stages; (1) 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, then (2) allowance is made for the likelihood that some birds may take avoiding action.
- 52 The calculation of no-avoidance risk (stage 1) is a mechanistic calculation. The collision risk is the product of two factors; (a) the probability of a bird flying through the rotor swept area, and (b) the probability of a bird colliding if it does so.
- 53 In establishing the first probability, one of two approaches is normally appropriate. For some species (including the key species at HMR, shorebird migrants), flight behaviour may be along generally consistent flight directions or within defined flight corridors. In such cases, flight rates are estimated within a vertical box of the maximum likely flight height and of the overall width of the flight corridor. The probability of flying through the rotor swept area is then the proportion of the area of that vertical box occupied by the wind turbines. For other species, such as raptors, flight behaviour is one of ranging within a reasonably defined ground area, but with no regular flight direction. Here the model works by establishing the overall volume - ranging area multiplied by maximum flying height - which the species uses, then calculates the proportion of that space within which the bird is at risk of collision through overlapping with the volume swept out by the rotors.

54 The second probability (b) involves calculation of the chance that a rotor blade will hit any part of a bird making passage through the rotor swept area. That probability depends on the size of the bird, its flight speed, the number of blades and their dimensions, and how fast they rotate. The probability also depends on the distance of the flight path out from the rotor hub, because of the tapering blade size and because of the increasing space between blades towards their tips. There is a lower risk of collision when a bird is flying downwind than when flying upwind, because of the orientation of the blade. Band's (2001) standard spreadsheet has been used to assess this risk for the key bird species at HMR and specifically for the turbine geometries proposed at HMR (taken from the Contact submissions and relevant wind turbine product brochures).

### **Input Data**

- 55 There are five key shorebird species that are likely to be at risk of collision at the HMR wind farm, SIPO, wrybill, banded dotterel, pied stilt and bar-tailed godwit. The only species for which a reasonable dataset is likely to be obtained is SIPO (a large, noisy and hence more detectable species). Other less detectable species are very difficult to reliably pick up over such a wide area. The same problem occurred at Taharoa C. At that site the expert group agreed that the best option for the assessment was to treat SIPO as a surrogate for the other species, i.e. to assume that their behaviour was the same as SIPO. I have therefore adopted this same approach for HMR here.
- 56 The collision model requires a range of input data on both the birds and on the specifications of the proposed wind turbines. The bird parameters include size (length and wing span) and flight speed (usually derived from standard publications such as the Handbook of Australian, New Zealand and Antarctic Birds (1991-2007) and Campbell and Lack (1985)).
- 57 Whilst the overall size of the migrant shorebird populations along the west coast of North Island are reasonably well known (Dowding and Moore 2006, Fuller et al. 2009; I also note this is dealt with in Dr Dowding's and Dr Battley's evidence), the proportion of these flying through the HMR site is not. The Stage 2 shorebird report does give an indication of the approximate numbers that could potentially be involved flying through the HMR site. Overall during the 2009 radar and observational surveys 27% of SIPO flights were observed to go inland (and hence over the land on which the wind turbines would be located). Of those 54% were noted as being at the same height as the wind turbine rotors (a similar value to that found at Taharoa C, where 52% were at rotor height). Therefore for my collision risk modelling I have assumed that 27% of the birds flying up the west coast for each respective population could potentially fly through the HMR wind farm and of those 54% would be at the same height as the rotors. The Contact Stage 2 report does not appear to have been corrected for the fact that a proportion of birds moving through the area are inevitably missed (by both observers and radar) but it does still give an indication of

the proportion of the population moving past the site that may fly through the wind farm at rotor height. It also notes that 37% of the inland flights were within valley systems (below the wind farm), with the remaining 63% over the ridgelines on which the wind turbines would be located. However it is likely that flocks will move between valley and ridgeline routes as they pass through the wind farm corridor, so even the flocks classed as 'valley' birds are still likely to be at some risk of collision as they move through the landscape.

- 58 Turbine parameters include rotor diameter, maximum chord width of each blade, blade pitch, rotational speed, the number of turbines and the dimensions of the wind farm site (taken as 6km width across the site, as given in Mr Kessels' evidence), so that the particular specifications of the machines planned for the site and site layout can be used in the model to make the collision risk prediction as accurate as possible.
- 59 I have used Monte Carlo modelling to provide further information on the possible consequences of the uncertainty in the bird input data for the collision risk modelling, primarily as a result of the fact that baseline data do not yet provide a robust baseline on which to base the assessment. This is a particularly important issue as large numbers of birds were recorded passing in close proximity to and indeed through the HMR wind farm site during 2009 on the northwards migration. A slight shift in their flight route in further years could bring substantially higher numbers through the collision risk zone in future years. Also, whilst the field data have provided a substantial amount of information for SIPO, data collected on other scarcer species were much more scant. It has been assumed for the purposes of this assessment that these other species behave in the same way as the SIPO, but there remains a high degree of uncertainty as to their actual behaviour whilst migrating through this area. The Monte Carlo modelling enables this uncertainty to be explicitly considered. Given the lack of baseline data generally and the specific paucity of data on scarce species such as wrybill, I would, in my professional opinion, consider it essential that consideration is given to the range of possible outcomes that the analysis produces, particularly the upper end of the predicted collision risk. Without further baseline data and without specific information on the key scarcer species, it is my opinion that such a possible outcome cannot be precluded.
- 60 The first stage of the model was adapted to run as a Monte Carlo simulation by defining bird size and flight speeds as normally distributed variables, and the wind turbine blade pitch and rotation period as uniform distributions. The turbine data are all taken from manufacturer specifications and assume uniform distributions where values are not fixed. The principle used throughout is to select the simplest distribution to describe the data where that distribution is unknown and uncertainty is involved. The Monte Carlo simulation was run 5,000 times, selecting individual values from each of these distributions for each run.

### **Avoidance Rate**

- 61 The avoidance rate is the parameter to which the collision risk prediction is most sensitive, simply as a result that in most cases it is a very high value. This has been recognised from the initial publications on the model and its use in the assessment process (Percival et al. 1999, Band 2001), and highlighted in the recent British Trust for Ornithology review (Chamberlain et al. 2005). In most collision risk models it is uncertainty over avoidance rate that represents the largest uncertainty in the risk assessment.
- 62 Much of the problem in measuring avoidance rate in the field relates to the very low frequency of collisions (and as a result avoidance rates measured for many species are 100%, i.e. no collisions have been detected). At the same time there are other difficulties that can lead to avoidance rates being under-estimated, such as a lack of calibration of collision monitoring to determine observer efficiency and carcass removal. SNH (Band et al. 2007) have proposed the use of 95% as a precautionary rate to use in the absence of any other specific data, though have modified this up to 98% for some species such as golden eagle (W. Band and A. Douse, pers. comm.).
- 63 Recent reviews have suggested rather higher values are appropriate for a range of species including harriers (99%; Whitfield and Madders 2006a), red kite (99%; Whitfield and Madders 2006b) and geese (99.93%; Fernley et al. 2006). There have been no studies published of avoidance rates for shorebirds migrating through wind farms in large numbers, in particular at night.
- 64 A precautionary approach has therefore been adopted, using a 95% avoidance rate for the northwards migration (when most of the movements are likely to be during the day) and 90% for the southwards migration (the majority of which is likely to take place in the region at night from the results of the Taharoa C studies). The use of this more precautionary 90% avoidance rate was agreed by the expert group for that site. It is my opinion that a similar precautionary approach should be adopted for the HMR site, both from the point of view of consistency with the approach at that site and also given the potentially large numbers flying through the HMR site at night and the high proportions of several of the populations involved (as detailed in Dr Dowding's evidence). For the longer-distance arctic-breeding migrant being considered here, bar-tailed godwit, a 95% avoidance rate has been adopted for all flights as its flights through the HMR area are less likely to be so concentrated at night on the southwards migration.

### **Prediction of Numbers of Collisions**

- 65 The second part of the modelling takes the individual collision risk and scales it up for the bird numbers and numbers of turbines at the site being assessed, to produce a collision risk estimate for the specific site and species. At this stage there are several important

variables that have only been measured for one migration period and hence have a considerable degree of uncertainty attached to them. The Band individual collision risk was input from the results of the first stage of the Monte Carlo modelling (as a normal distribution, truncated to the maximum and minimum values from the Monte Carlo modelling). The main variables with a high degree of uncertainty that have greatest effect on the collision risk prediction relate to the number of birds flying through the collision risk zone. These comprise:

- The percentage of birds flying at rotor height (recorded as 54% in the 2009 baseline surveys during conditions when it was possible to observe the birds);
- The percentage of the flights that were through the proposed wind farm site (taken as the percentage of birds flying inland in the 2009 surveys, 27%).
- Lastly turbine downtime has also been considered. No information was available for HMR so the value from Taharoa C has been used (16%) (Fuller et al. 2009).

66 The principle in dealing with all of these parameters has been to run the Monte Carlo simulation with a range of input values. The Monte Carlo model runs many times (5,000) choosing from specified data distributions for each run. The principle used in defining these distributions has been to make them as simple as possible where that distribution is unknown (mainly uniform distributions) but to include a range appropriate to each scenario. Details of the input data values and distributions are given in Appendix SP.1.

67 The resulting collision risk predictions for the annual numbers of collisions are summarised in Table 1. This gives the mean, range (minimum and maximum values) and upper and lower 95% values for each of the key species, SIPO, Wrybill, Bar-tailed Godwit, Banded Dotterel and Pied Stilt.

*Table 1. Monte Carlo collision risk predictions for key migratory shorebird species.*

<b>Species</b>	<b>Mean</b>	<b>Lower 95%</b>	<b>Upper 95%</b>	<b>Range</b>
SIPO	203	55	389	4-645
Wrybill	10.9	3.1	22.6	0.1-37
Bar-tailed godwit	13.8	1.2	31.4	0-47
Banded dotterel	15.4	4.1	30.0	0.1-44
Pied stilt	8.8	2.5	17.0	0.3-26

- 68 The mean values in Table 1 give the most likely outcome given the input data. However, as the uncertainty within those data is high (given the lack of robust baseline from the site) consideration should also be given to the variation around those mean values, and that the higher values within that range cannot be ruled out given the current information available. Hence it would not be unreasonable to conclude that upper 95% of the range of predicted outcomes could be a possible outcome. The key question for each species is where the range of predicted values lies in relation to the threshold at which a significant population impact might be expected. Dr Dowding has carried out a population viability analysis [PVA] to assist in the determination of that threshold value for each species – this is presented in his evidence.
- 69 In conclusion this analysis has demonstrated that it is possible, on the basis of the data currently available and making precautionary worst case assumptions to take into account data gaps, that about 200 SIPO collisions and about 10-15 wrybill, bar-tailed godwit, banded dotterel and pied stilt collisions could potentially occur annually. When the uncertainty inherent in the current baseline is taken into account using Monte Carlo modelling that annual collision risk could increase to about 400 for SIPO and about 20-30 birds per year for each of the other species (taking the upper 95% confidence limit for the predicted collision risk).

### **Risk analysis**

- 70 It is clear from the previous section that there is a potentially important collision risk to shorebird migrants. The next question is therefore whether the risks at this site can be adequately addressed while allowing consent to be granted. The collision risk is (from Dr Dowding's evidence) of such a magnitude that it could result in significantly reduced populations. To manage this risk therefore would need avoidance, remediation, or mitigation measures that reduced that collision risk to an acceptable level.
- 71 As noted above, Dr Seaton, in his evidence, proposes several possible mitigation measures with the specific aim of reducing collision risk. These include:
- (a) *Do not build turbines in areas where high densities of migratory birds are passing through;*
  - (b) *Ensure wide "corridors" with no turbines are available for migrating birds to pass through the wind farm;*
  - (c) *Switch off high risk turbines at times of high bird migration;*
  - (d) *Switch off high risk turbines at times when high bird migration and inclement weather conditions coincide.*
- 72 Mr Kessels in AEE under the heading Strike Avoidance Strategies, page 86 states that "*It may, for example, be feasible and effective to detect migratory bird flocks with radar and have a system whereby particular turbines are slowed or stopped until such time as it is calculated the migrating flock has passed.*" This potential measure has also been raised in Mr Tonks evidence (in section 5.2 Options to avoid, remedy or mitigate – strike avoidance strategies).

- 73 Each of these measures could potentially contribute to reducing collision risk, but the lack of baseline data means that it is currently not possible to determine the potential effectiveness of each. Option (a), avoiding constructing turbines in areas of high flight activity, could be an effective measure if those areas of high flight activity can be defined and understood (such that the same areas would be likely to be used in future years). Option (b) may be effective for birds moving through the area during the day but less so at night (when the bulk of the southwards migration is likely to occur). It would however still be a sensible precautionary measure. Options (c) and (d) would reduce the collision risk but could (especially option (c)) result in a considerable loss of power generation. With both these options more baseline data would be needed firstly to identify 'high risk turbines' and second likely 'times of high bird migration'. Temporary turbine shutdown has been proposed at several wind farm developments in the UK, temporarily halting the rotation of the wind turbine rotors at times when the collision risk is considered to be particularly high. This measure is also now being implemented at Altamont in California.
- 74 My experience is that it can be difficult to implement such a scheme that is both economically acceptable and that will deliver a guaranteed acceptable level of risk. If movements of key species are at well-defined times of day and season then it may be possible to implement this as a possible solution. Examples where it has been implemented in schemes that I have been involved include where a wind farm site lies on the flight route between a roost and a regular feeding site (e.g. for geese and swans, where the large majority of risk flights take place in relatively short dawn and dusk periods), on a bird migration route where the peak activity of key species occurs over a short defined period (defined particularly by weather conditions) and conditional shutdown where scarce raptor species may breed in proximity to turbines after construction (for example to deal with the possibility that birds may move into an area following habitat change such as forest felling). It is a measure that can reduce collision risk in some circumstance, if a suitable implementation framework can be agreed, but cannot eliminate it. There are no specific examples of which I am aware relating to shorebirds where any such operational risk reduction schemes have been implemented.
- 75 Other measures have also been proposed and in some cases trialled at other wind farm sites to reduce collision risk. Making turbines more visible through painting them with a range of colours and patterns has been tried in several countries and may reduce the collision risk in some circumstances, but this measure is not guaranteed to be effective and is likely to be least effective at the time when birds are at most risk of collision (when visibility is low). Lighting turbines can potentially increase risk (attracting migrating birds to the lights) as much as reduce it. Such measures would not be able to ensure that the collision risk could be managed to an acceptable level.
- 76 Given the inevitable residual risks, an alternative or complementary way to manage/mitigate these might be to undertake off-site

measures to enhance conservation status of local populations. Such measures have been proposed by Dr Seaton in his evidence and have the potential to deliver a net conservation gain from the scheme as a whole, provided they are implemented at an appropriate level. They would need to ensure that the gain from the off-site measures clearly exceeded the risk from the wind farm, but may be a way in which such risk might be more effectively mitigated. As noted in Dr Dowding's evidence, the magnitude of such measures required to mitigate the predicted collision risk on the basis of the currently available information would be very considerable indeed and probably not achievable if this were the only mitigation option. Hence it is clear that this will require a complementary package of on-site measures to reduce collision risk (through design mitigation and/or turbine shutdown) and off-site measures to mitigate the residual risk. There remains though a possibility that the level of mitigation required, even with the complementary on- and off-site approach might not be achievable.

#### **OVERALL CONCLUSIONS AND RECOMMENDATIONS.**

- 77 From the information currently available there is a high likelihood of substantial numbers of migrant shorebirds passing through wind farm at rotor height and hence being at risk of collision.
- 78 This risk is likely to be heightened given that the southwards migration is likely to be largely at night (from the results of the surveys carried out for the Taharoa C wind farm and on the working assumption that other species behave in the same way as SIPO).
- 79 The collision risk modelling has shown that the risk for shorebirds migrants (particularly SIPO and wrybill) has the potential to be substantial, sufficient for it to result in a significant population impact (as discussed in Dr Dowding's evidence following his population viability analyses).
- 80 A key problem at this wind farm is that even a small risk of an impact could be highly significant, through additional mortality to already vulnerable species. Even a rare event can be significant if it is considered to be high risk. As stated above I think that there will always be a collision risk at this site, but the magnitude of this risk might be reduced and certainly could be better quantified by robust baseline data to inform an appropriate package of avoidance and mitigation measures (including design changes to avoid any zones of higher bird flight activity and temporary turbine shutdown during times of high bird flight activity) If there were areas of higher bird flight activity and these could be avoided then this could be an effective risk-reduction measure.
- 81 Given the inevitable residual risks, a complementary way to mitigate these may be to undertake off-site measures to enhance conservation status of local populations, as proposed in Dr Seaton's evidence. It would need to be ensured that the gain from such programmes clearly exceeded the risk from the wind farm, but may

be a part of a solution whereby the collision risk could be more effectively mitigated.

- 82 I conclude that on the information currently available one simply cannot say whether the risk of the HMR wind farm to birds can be avoided, remedied or mitigated. It is possible that it may, but this can only be concluded with any certainty once an adequate baseline data set has been obtained.

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**26 March 2009**

