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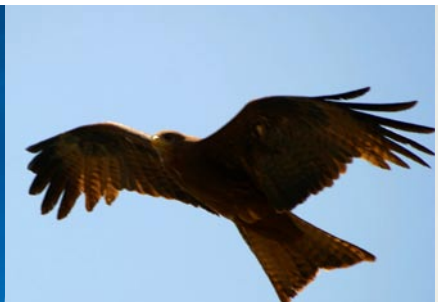
Wind Farms and Birds:
Interim Standards For Risk Assessment

Australian Wind Energy Association Report

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1. INTRODUCTION

The Australian Wind Energy Association (AusWEA) is implementing the Wind Industry Development Project, funded by the Australian Greenhouse Office of the Australian Government. One of the outputs of this project is a framework for investigating the impacts of wind energy projects on birds. This comprises protocols and data set and reporting standards for investigations to estimate and monitor the impacts of wind energy developments on birds in Australia.

In February 2004, a preliminary issues paper was circulated that reviewed approaches to assessing the impacts of wind energy developments on birds in Australia and overseas. This paper formed the basis for a workshop, held in Melbourne in June 2004, which developed an outline for and explored the possible content of the protocol and data set and reporting standards. A draft set of protocols and data set and reporting standards was then prepared and circulated for comment to a range of stakeholders (see Acknowledgments). Additional refinement of a draft was undertaken at a further workshop in Hobart in July 2005 and this set of interim standards is the result.

These interim standards provide information for three key stakeholder groups:

- companies that investigate, construct and operate wind farms;
- government agencies that assess and approve development; and
- community members with an interest in the impacts of wind farms on birds.

1.1. Background and objectives

The Australian wind energy industry is developing rapidly, with some 5,000 MW of capacity either developed, being developed or anticipated by 2010 (AusWEA undated). In Europe and North America, where the wind energy industry has been in existence for longer, wind farms have been found to affect birds. These effects arise from two mechanisms:

- collisions by birds with operating wind turbines, leading to mortality (direct impacts); and
- disturbance to birds and resulting avoidance of habitats in and near wind farms (indirect impacts).

Government agencies in Australia that assess and approve development often require developers to assess the impacts of wind farms on birds. In the initial stages of development of the wind energy industry, bird impacts were not recognised as an issue and these agencies generally did not require assessment of bird impacts. Since 1999, however, bird impacts have

emerged as a significant concern in the development assessment and approval process on the part of these agencies, the broader community and the industry itself.

Bird impact investigations at wind farms in Australia have varied in their level of detail and scientific rigour. This reflects the varying nature and scale of developments, differences in the sites involved and the particular proponent's policies. It has also arisen due to varying requirements among agencies that assess and approve development.

AusWEA has recognised that effective and appropriate impact assessment is an important part of developing wind energy facilities in Australia. In 2002, it issued 'Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia' (AusWEA 2002). These guidelines dealt, among many things, with flora and fauna issues associated with wind farm development and provided guidance on the kind of information most useful in informing the siting, design, planning assessment and management of wind farms.

In light of the level of public and agency interest in the potential impacts of wind farms on birds, the Australia Greenhouse Office has funded AusWEA to prepare this more detailed set of interim standards for the investigation of bird impacts at wind farms.

The objectives of the current project, of which this report forms part, are:

- the assessment of current national and international protocols for Australian appropriateness;
- the development of protocols, and data set and reporting standards, for assessing bird:
  - usage prior to the installation of a wind farm;
  - usage after the installation of a wind farm; and
  - mortality due to collision with wind turbines and towers;
- consultation with key stakeholders in relation to the development of the protocols; and
- the development of data set standards and protocols that meet the varying jurisdictional requirements of bird strike and population viability models.

These interim standards have been developed within the framework of current best practice in environmental risk management in Australia, as documented by Standards Australia (Anon 2000, 2004a, 2004b). The approach used considers both potential environmental consequences and their likelihood, to arrive at a measure of environmental risk.

The protocols, and data set and reporting standards, provide:

- a framework for determining levels of investigation of bird impacts at wind farm sites; and
- a set of systematic and structured protocols for the different levels of investigation that guide the choice and application of bird data collection and analysis methods.

They will provide a systematic, structured and replicable approach to the assessment of bird risk potentially associated with individual wind farms in specific locations[1] as well as provide for consistency between projects in data collection and reporting, enabling comparisons between projects and information sharing within the industry, to the benefit of all interested stakeholders.

1.2. The context of bird impact assessment for wind farms

Birds occasionally collide with operating wind turbines. Investigations to date show that the likelihood of collision depends on a range of factors, including:

- technology, such as:
  - the type of wind turbine;
  - lighting of wind turbines; and
  - the layout of the wind farm;
- site characteristics, including:
  - the ecosystems on the wind farm site;
  - proximity to bird concentrations; and
  - the numbers of birds moving across the wind farm site;
- the risk behaviours of birds (e.g. soaring at rotor swept area (RSA) height); and
- weather conditions.

[1] This document does not discuss the potential impacts of wind farms in general on birds, as this has been done comprehensively elsewhere (see the list of references at the end of this document for some examples). Importantly, it does not set out to determine or advise on levels of acceptable bird impact. That role rests not with industry alone but with government and the wider community through the planning assessment process, which has been developed and is administered to satisfy a range of community values and aspirations. Industry can assist government and the wider community in making decisions about acceptable levels of bird impact in the wind industry by providing data and information of the highest standard, through the adoption and implementation of these standards.

These factors can be used to varying degrees to estimate the potential collision risk at a wind farm. They will influence the objectives and scope of bird risk investigations. Importantly, these interim standards call for the documentation and justification of decisions about the objectives and scope of bird risk investigations. Before considering data gathering protocols and data set and reporting standards, it is worth considering the context within which data gathering occurs.

The impact of wind farms on birds should be assessed both before and after wind farms commence operating. Assessing impacts before a wind farm has been built is a risk assessment exercise, involving quantitative and/or qualitative data to estimate a level of risk of significant bird impact. Monitoring the impacts of an operating wind farm is a compliance and validation process, which can contribute to the adaptive management of the wind farm to minimise ongoing residual risk.

Pre-operational estimation of the risk of significant bird impacts informs the design and development assessment and approval processes, as well as informing proponents of one component of the environmental risk associated with their project.

Operational phase monitoring of impacts tests the pre-operational predictions by providing factual real-time information on wind farm impacts. This enables validation and refinement of prediction methods, allows regulatory compliance monitoring (e.g. whether a project is fulfilling the terms of its approval by planning authorities), and permits proponents to monitor their own environmental performance and to adaptively manage the operation of the wind farm to minimise risk.

1.3. Systematic assessment of bird impact risk

The framework provided in the Australian standard for risk management and related guidelines, AS/NZS 4360 (Anon 2004a, 2004b), and the associated guide for environmental risk management HB203:2000 (Anon 2000), assesses risk using a combination of consequence (or impact) and the likelihood of occurrence of the impact. A staged, and potentially iterative, approach to risk assessment is recommended.

When assessing risk, consequence and likelihood can be estimated in either qualitative or quantitative terms. For example, consequence could be classed as minor or moderate, and likelihood as rare or likely, using a qualitative approach. Quantitative approaches, by contrast, would result in numerical values for consequence and likelihood.

The level of consequence (in this work, mortality of or disturbance to birds of particular species) and its likelihood can then be combined to form a risk matrix, detailing the different levels of risk that arise with particular combinations of consequence and likelihood. It is this level of risk which

drives subsequent proponent action in risk assessment and risk mitigation. If it is low, no further action may be necessary; if it is medium or high, further studies, or mitigation actions, such as modifications to the wind farm layout, may be required. These mitigation actions can reduce the residual risk, or risk remaining after mitigation, to acceptable levels.

Table 1: Qualitative risk analysis - level of risk

Likelihood	**Consequence**			
	insignificant	minor	moderate	significant
very rare	L	L	M	H
rare	L	L	M	H
possible	L	M	H	H
probable	M	H	H	H

where: L = low risk

M = medium risk

H = high risk

(modified from Anon 2000)

This risk assessment approach is used in these interim standards for assessing the bird impacts of wind farms, and includes, as noted above, both:

- the significance of any predicted or monitored consequences or impacts; and
- the likelihood that those consequences or impacts will occur.

To determine the most appropriate bird impact investigations to undertake at a wind farm site, a hierarchy of studies is recommended. This hierarchy involves increasing levels of detail and specificity in investigations. If investigations at a lower level of detail identify a significant level of risk to birds from a proposed wind farm, then investigations of a higher order should be considered. In this way, the likelihood and consequences of any potential bird impact can be understood with increasing accuracy.

This hierarchical or staged investigative approach accords with the risk assessment process, outlined in the Australia risk management standard AS/NZS 4360 and associated guidelines (Anon, 2004a, 2004b), and detailed in HB 203:2000 (Anon, 2000), the guide to environmental risk management. Further, the approach matches the steps for the investigation and

development of wind energy projects outlined in the "Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia" released by AusWEA in 2002 (AusWEA 2002).

These interim standards recommend investigations at three levels:

- **Level One** investigations provide an initial assessment of the risk of significant bird impacts from the operation of the proposed wind farm; if the level of risk is estimated to be low, or can be reduced to that level through mitigation measures, design reviews or siting alterations,[2] no further investigations are recommended; otherwise, Level Two investigations are recommended;

- **Level Two** investigations refine the risk assessment from the Level One investigation, using more intensive methods; if the level of risk is estimated to be low, or can be reduced to that level through mitigation measures, design reviews or siting alterations, no further investigations are recommended; otherwise, Level Three investigations are recommended;

- **Level Three** investigations are initiated if the results of the Level Two investigation indicate a greater than low level of residual risk of significant bird impacts from the operation of the proposed wind farm.

The results of all three levels of investigation provide:

- estimates of the level of risk of significant bird impacts;

- baseline data for use in operational phase monitoring of impacts; and

- information for use in the design of risk mitigation measures.

Figure 1 shows how these levels of investigation inform the Project Feasibility and Detailed Assessment phases[3], as well as the Planning Assessment process.

As Figure 1 shows, not all projects will require all levels of investigation; it will depend on the outcomes of the risk assessment based on those investigations. A significant process in assessing bird risk at wind farms is consultation between the wind farm developer and key representatives of agencies that assess and approve development. This will greatly assist in ensuring that the most appropriate scope and level of investigation of bird risk occur for a project. In applying these interim standards, it is recommended that consultation with agency representatives occur after the

[2] The level of risk remaining after risk treatment measures have been taken is known as 'residual risk' (Anon 2000).

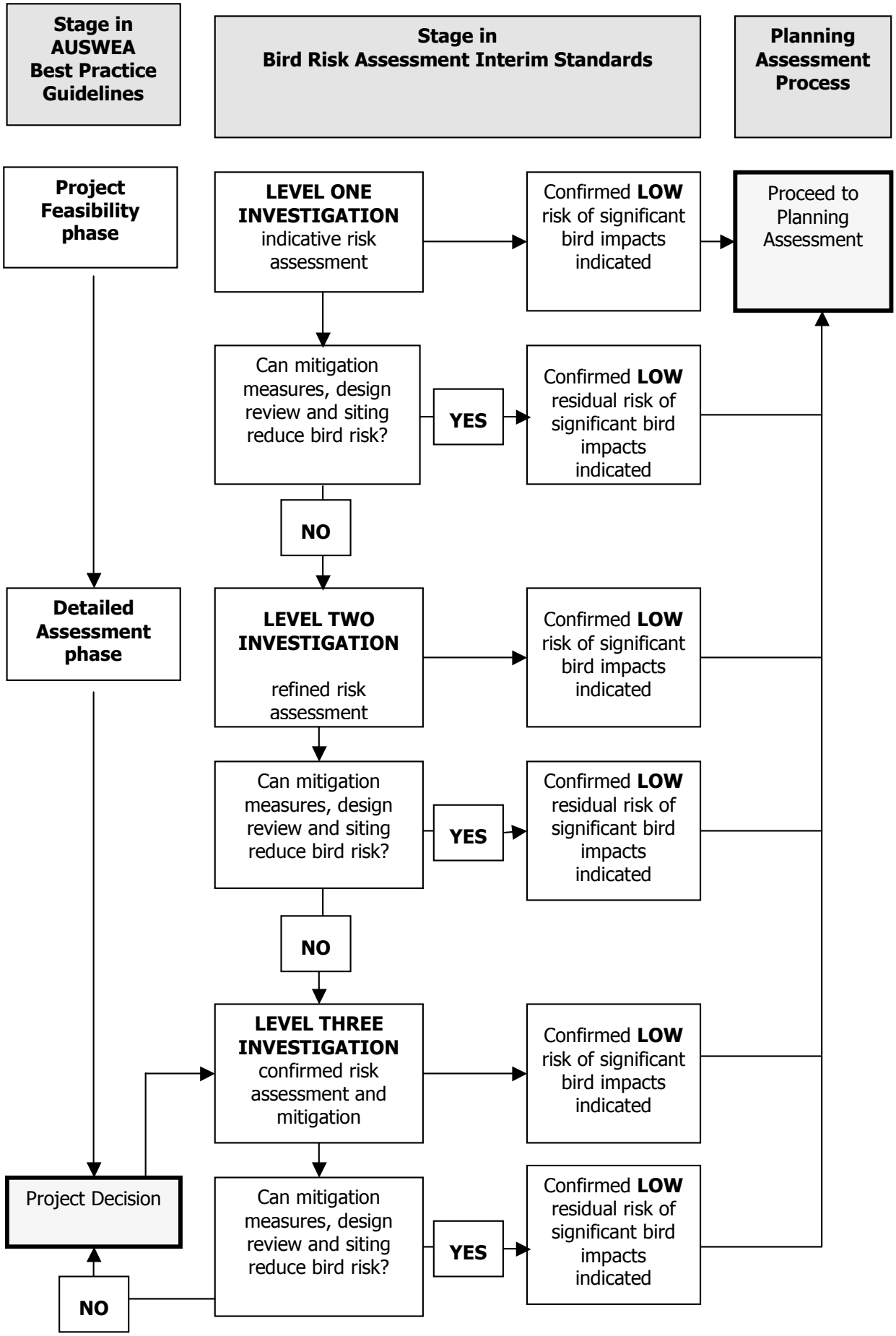
[3] These phases are used here as they are defined in AusWEA (2002).

initial risk assessment (Level One) then again, if required, at the beginning of Level Two and Level Three investigations. These consultations should aim to:

- agree on the issues, questions and objectives of bird impact risk assessment studies;
- agree on the consequence and, where relevant, likelihood criteria that apply to the results of the studies; and
- where required, agree on the nature and effectiveness of mitigation measures.

In this way, all parties know what to expect from the risk assessment process and, importantly, levels of acceptable risk to birds are agreed with the agencies that assess and approve development.

Figure 1: Assessing and documenting bird impact risks at wind farms.



1.4. Estimating consequences and their likelihoods

There are numerous methods available for gathering information to use in estimating the consequences and likelihoods of bird impacts[4] from wind farms. Table 2 shows some methods suitable for use at various stages of the wind farm project cycle. Not all projects will require all types of investigations listed in Table 2 and some may only require only two or three types. The choice of investigations will depend on the risk assessment outcome at each level, as well as discussions with representatives of agencies that assess and approve development.

Table 2: Methods used for monitoring the potential direct and indirect bird impacts of wind farms

	Investigation level	Direct impacts	Indirect impacts
Pre-operational risk assessment	Level One	• regional overview • indicative bird utilisation survey • roaming surveys	• regional overview • indicative bird utilisation survey • roaming surveys
	Level Two	• continuing bird utilisation studies • gradient studies • roaming surveys • risk modelling	• continuing bird utilisation studies • gradient studies • roaming surveys • risk modelling
	Level Three	• population assessment • population viability analysis	• population assessment • population viability analysis

[4] The bird impacts of wind farms include both the direct impacts due to collision with operating turbines and indirect impacts due to factors such as disturbance of nearby habitats. In this document, the term 'bird impacts' encompasses both types of impacts.

	Investigation level	Direct impacts	Indirect impacts
Operational phase monitoring		• bird utilisation and roaming surveys • population assessment • population viability analysis • dead bird searches	• bird utilisation and roaming surveys • gradient studies • population assessment • population viability analysis • avoidance studies • indirect disturbance impact assessments

These interim standards are structured to provide guidance on the circumstances in which to apply the methods listed in this table, and on how to apply the methods to a particular wind farm site. Their use will produce thorough, robust assessments of the risks to birds from the construction and operation of wind farms of particular types in specific localities.

Where a method is recommended for use at more than one investigative level, it is described in detail at the lowest level and not repeated thereafter. For example, roaming surveys are recommended for use in Level One, Two and Three investigations, and are described only in the Level One text in Section 2.3.

Statistical methods exist for describing data, inferring relationships and testing hypotheses. No detail on these methods is provided in this document, as there are numerous specific texts available which detail the range of statistical methods potentially relevant in work of this type. Statistical methods should be used where the data are adequate and meet the required rules for using them and where their use adds rigour to judgements about risks to birds. For species detected on wind farm sites infrequently, the data gathered are unlikely to be adequate for statistical analysis, particularly if a small number of observations is involved and the species of principal interest are rare. Reliance may need to be placed on behavioural and descriptive information. For the more abundant species, the methods described in this document will permit data to be analysed using a range of statistical techniques. It is important that investigations be designed for particular sites with a clear idea of the statistical analysis to be used. Specialist professional advice may need to be sought in this regard when investigations are being planned. Where required, this has been indicated in these standards.

1.5. The importance of 'BACI'

As indicated in Table 2, a number of data gathering methods can inform more than one stage of the impact assessment.

Significant discussion occurred among involved stakeholders during the preparation of these interim standards and a consensus emerged that, notwithstanding its potential limitations, the best design for bird impact monitoring programs at wind farms was the 'Before – After – Control – Impact' ('BACI') experimental design. It involves measuring an environmental variable (such as bird use) that may be affected by a human-induced change (such as a new wind farm) before and after the impact happens, both where the change will have its effect (impact site) and where it will not have an effect (control site).

Choosing a control site can be very difficult. There are few replicate sites in nature, particularly in terrestrial environments. Therefore, many practitioners prefer to use the term 'reference site' as, in the strict experimental design sense, a control site must be identical to an impact site. Hereafter, control sites are referred to as reference sites, although the term 'BACI' is retained for reasons of familiarity.

In 'BACI', what matters is not the difference between the impact and reference sites, but the change in this difference before and after the impact occurs. This change can be ascribed to the impact. The design thus enables the impact of the human-induced change (in this case a wind farm) to be distinguished from the impact of other, more widespread changes (e.g. drought). Wherever possible, ongoing monitoring of wind farm impact on birds should use a range of methods within a 'BACI' design.

1.6. Structure of this document

The next three sections of the document address the pre-operational risk assessments, conducted during the Project Feasibility and Detailed Assessment phases of project development.

Section 2 describes Level One investigations. After a Level One investigation has been completed, and the potential consequences and their likelihoods have been considered in the risk matrix at Table 1 a decision can be made whether a Level Two investigation is required. This would occur if the level of residual risk identified in the risk matrix was greater than low.

Section 3 describes for Level Two investigations, which serve to provide more accurate information for use in the risk assessment. If the results of a Level Two investigation indicate a greater than low level of residual risk of significant bird impact, a Level Three investigation is recommended.

Section 4 describes Level Three investigations; these further refine the estimates of risk provided in the previous two investigations and, if the

assessed residual risk is still considered greater than low, can provide guidance in the design of suitable additional risk mitigation measures and further Level Three investigations.

Section 5 addresses ongoing monitoring of bird impacts in the operational phase of the project.

Section 6 provides a brief conclusion.

2. LEVEL ONE INVESTIGATIONS – INITIAL RISK ASSESSMENT

This section discusses the first step in the staged risk assessment process for a potential wind farm site. Level One investigations are considered to be a minimum requirement for assessing potential bird impacts at wind farms and are undertaken as part of pre-operational risk assessment conducted in the Project Feasibility phase. They provide a preliminary risk assessment which will inform proponents if the risk of significant bird impacts is low[5] and therefore no further investigation is required, or whether higher level investigations are required to meet the impact assessment expectations of planning authorities.

The **objective** of Level One investigations is to provide an estimate of the risk of significant bird impact. This is done by collecting and analysing information on:

- the consequences of operation of the proposed wind farm, or the potential for collisions by or indirect effects on particular bird species (i.e. which species are expected to use the site); and
- the likelihood of those consequences (as the probability of collision by or indirect effects on individuals of particular bird species).

This information then allows estimation of the risk of significant bird impact, using the matrix detailed in Table 1.

At the commencement of Level One investigations, the specific objectives and scope of the proposed bird risk investigations should be documented and justified.

The Level One **protocols** will enable analysis of the consequences and likelihood of impact on birds at a potential wind farm site. These protocols also set out a process of validating the methods used. Level One investigations include three protocols that should be followed.

Level One investigation protocols

- Protocol for regional overviews, including site inspection
- Protocol for initial bird utilisation surveys
- Protocol for roaming surveys

[5] Or the residual risk can be reduced to a low level, through the incorporation of mitigation measures, design reviews and/or siting alterations.

The Level One protocols outline the information required to address the above aims, inform proponents if further investigations of bird usage and behaviour on the site are required and provide a basis for scoping higher level investigations, including seasonal timing and sampling design issues. Protocols for higher-level investigations are discussed in later sections.

The Level One **data set and reporting standards** provide standards for methodologies that should be followed when carrying out the investigations. These are outlined under each protocol. The data set standards for the regional overview are qualitative and descriptive in nature, whereas the bird utilisation survey provides preliminary quantitative data and some avenues for validating methodology. Level One investigations act as pilot studies for higher level investigations, should these be required, and inform matters such as the location, frequency and intensity (e.g. number of samples) of further investigations, as well as the best statistical analysis methods.

2.1. Protocol for regional overviews

The **regional overview** is the first step in assessing the risks to birds from a proposed project and will:

- provide a qualitative overview of bird usage of the site and the surrounding region; and
- identify the occurrence of:
    - threatened and listed species;
    - large numbers of any bird species;
    - habitats on or near the wind farm for the above species; and
    - species or groups that are prone to collision with turbines or to indirect effects from wind farms.

A key factor that determines bird impacts of wind farms is the extent to which bird species use the site and its surrounding areas. Birds may move large distances in a short time and the occurrence near the site of a significant bird concentration may alter the level of risk to birds from a project. Evaluation of potential risks should therefore cover an area around a wind farm site. As a minimum, it is proposed that such an area should cover a region typically out to a distance of at least five kilometres from the edges of a wind farm site. Local circumstances may require a larger area to be examined, as the location of a particular wind farm in a wider landscape context can exert a strong influence on bird use (e.g. the proximity of the wind farm to areas of high bird concentrations would require extension of the boundaries of the regional overview to encompass those areas).

A regional overview focuses on both the consequences of bird impacts from a project with regard to particular species and their likelihood. It involves two essential components:

- a review of existing, available information on birds within the site and the region; and
- an inspection of the site and the surrounding region by a qualified ecologist to assess the nature of bird habitats and potential patterns of bird usage of the site and its surrounds.

These two steps are described below.

2.1.1. Existing information

A detailed **review of existing data** is conducted, to provide information on the potential occurrence of bird species on and near the site.

Data set standards

- Potential bird usage of a zone at least five kilometres from the edge of a wind farm site should be assessed, with this distance being increased in response to local conditions or the likely movement patterns of particular species or the potential occurrence of bird concentrations.
- Existing information on birds in a region can be obtained from a range of sources and consideration should be given to using multiple sources, where these are relevant or available. Potential sources include:
    - public databases on the occurrence of fauna held by government agencies (e.g. Atlases of NSW or Victorian Wildlife);
    - the Web-based Protected Matters Search Tool of the Australian Government Department of the Environment and Heritage on matters of national environmental significance (http://www.deh.gov.au/erin/ert/epbc/index.html);
    - databases held by a range of non-government organisations (e.g. Birds Australia's The New Atlas of Australian Birds (Barrett *et al*. 2003));
    - published and unpublished reports on the biodiversity of the region concerned (e.g. Biodiversity Action Plans in Victoria, or the Regional Biodiversity Plans in South Australia);
    - personnel from state parks and/or wildlife agencies, particularly regional fauna and/or biodiversity officers with local knowledge of wildlife in a region; and

- personnel or local members of national or regional non-government bird, wildlife or field naturalists' organisations.

Based on the review of existing information, a **profile of potential bird usage** of the region can be developed. It should address the following potential bird habitats and occurrences in the region:

- the presence of Ramsar wetlands and protected areas within the site or region;
- the occurrence of wetlands and coastal habitats within the site or region that could support listed migratory species that could fly across the site;
- evaluation of the presence and suitability of habitat for bird species threatened at a state or national level within the site or region, and the possibility of movements of these species across the site;
- evaluation of the presence of bird species not listed that may be prone to an impact due to their behaviour or regional status;
- the presence of any other large bird concentrations within the site or the region (e.g. wetlands, communal roosts);
- the occurrence of geographical features that might concentrate bird movements on or near a wind farm site, such as promontories, isthmuses, waterways, ridgelines with soaring birds of prey, etc.; and
- potential corridors or zones of bird movement.

2.1.2 Site inspection

A **site inspection** should be undertaken once existing information has been reviewed, to ascertain in detail the nature and location of habitats or geographical features of significance with regard to bird populations and the probability that species or groups of birds use them regularly and in significant numbers.

Data set standards

- Visit the site and the nearby region to characterise bird habitats and determine the likelihood that state or nationally threatened bird species might occur on or near the site.
- Inspect all waterways and wetlands on and near the site, and determine if movements between wetlands/waterways across the site are possible.
- Characterise and locate vegetation and other habitat features likely to support significant numbers of birds and ascertain the potential for bird movements between these habitats within and near the site.

- Determine the likelihood that birds of prey or owls regularly use some or all of the site.
- Determine the possible occurrence of communal bird roosts on or near the site and the potential for movements of dispersing birds across or close to the site.
- Determine the location and extent of any geographic features on or near the site that may have high rates of bird usage.

Reporting standards

In reporting the results of a regional overview, the following information should be documented.

- The sources of information on birds on the site and the surrounding region (both published and unpublished).
- A list of the relevant people consulted for information on local and regional bird populations and habitats.
- A tabulated list of rare, threatened and listed migratory species recorded in the region, together with a summary of their status in the region and the potential for their occurrence (including any confirmed records) on the proposed wind farm site.
- Detailed consideration of the likely location, habitat and behaviour of any listed or threatened bird species with potential to occur on the wind farm site.
- If required, document the questions to be addressed by Level Two investigations, including the outcomes of consultations with agencies that assess and approve development.

2.2. Protocol for initial bird utilisation surveys

The **bird utilisation survey** is the most commonly used method for generating quantitative data on bird use of a potential wind farm site. This can be used to estimate potential collision rates and provide a ranked abundance of species use of the site at varying heights. The questions that such surveys can potentially answer include:

- what bird species use the site?
- with what frequency does each species occur at the site?
- at what height do birds of each species fly?
- what is the distribution of bird species across the site?

Bird utilisation surveys are therefore a significant component of any bird risk assessment at a wind farm. They inform both the regulatory assessment of a wind farm and wind farm design decisions. The indicative bird utilisation survey should be a minimum requirement for all wind farm sites and should inform the design of higher-level investigations, if required. The data set standards are outlined below.

Data set standards

- Fixed point counts should be used.
- The search area radius of fixed point counts should be standardised. Where site conditions permit, the search radius from the point should be at least 100m for small birds and up to 800m for large birds (e.g. birds of prey, waterbirds). Range finders could be used to determine distances.
- Visibility of the small bird search area should be complete, while visibility of the bird of prey and large waterbird search area should be at least 75% of the fixed point circumference.
- The duration of a fixed point count should be between 15 and 45 minutes and should be consistent across the site. Species detection tables for appropriate time intervals within the survey period should be generated, to assess the adequacy of the survey period for a particular site and to inform selection of appropriate survey periods for higher-level investigations.
- The height at which each bird flies when passing through the survey area should be estimated to the nearest 20m (e.g. by using nearby fence-posts or other known distance features to estimate height, or range finders) and related back to the height of the RSA for the particular turbines proposed to be used.
- The direction that each bird sighted is flying should be recorded to the nearest 45 degrees of the compass.
- Where significant habitat features occur (such as remnant vegetation, wetlands/ waterways/ ridgelines/ coasts or bird movement paths), survey points should be selected at varying distances from these features to ascertain how bird usage varies on the site in response to them.
- To obtain a representative picture of birds on a site, each fixed point survey site should be counted during at different times of day (e.g. early morning, late morning, early afternoon and late afternoon) to account for diurnal differences in bird activity.
- The number of points surveyed on a site and their locations should be selected to be representative of site conditions and the basis for site choice reported.

- Results of the indicative bird utilisation survey should be analysed to assess the adequacy of methods and to inform selection of appropriate survey design (i.e. survey period, numbers and locations of sites and number of surveys at each site) for higher level investigations. A cumulative species curve by number of surveys is considered to be a minimum requirement in this regard. To inform the design of Level Two investigations, a statistical power analysis may be appropriate.

A suitable number of reference sites[6] should be counted with the same survey effort, to provide a comparison with on-site bird usage. Reference sites are also an important component of any further pre-operational and operational phase impact monitoring. They should be between 500m and 1500m from the nearest wind turbine site, and located in similar habitats and landscape settings to the wind farm (impact) sites.

Reporting standards

There is no recommended manner to report bird utilisation rates. As long as the methodology and a detailed breakdown of survey effort (survey duration per point, number of points and surveys, and total duration of surveys) are described, and the base data collected are presented, then comparisons between studies are possible.

As a minimum, the following should be reported.

- A map of the survey sites and the dates, duration and number of times they were surveyed.
- Justification for the specific methods adopted.
- A ranked listing of species from the wind farm site and the reference sites (with numbers) should be tabulated, separating birds at RSA height and those at other heights.
- A cumulative species curve should be presented, showing the total number of species found, including additional species in subsequent counts, with the x-axis showing each point count in chronological order. Additional counts should be undertaken if this analysis shows that the rate at which new species are found has not yet shown strong signs of levelling off (e.g. final 20% of counts increased numbers of species found by less than 10%).
- If required, document the questions to be addressed by Level Two investigations, including the outcomes of consultations with agencies that assess and approve development.

6 See Section 1.5 for more information about reference sites.

- Document the desired scope of operational phase impact monitoring.

- Where required, subsequent bird utilisation surveys should be designed and documented, having regard to the analysis of the initial bird utilisation survey results and identification of adequate survey parameters, such as fixed point survey duration, numbers of points, number of surveys and times of day (based on cumulative species curves for the initial survey and, if required, a power analysis of the resulting data).

2.3. Protocol for roaming surveys

Roaming surveys are comparatively unstructured surveys involving an experienced bird surveyor walking over the wind farm site recording species, location, numbers, habitat choice and movements of birds. The objectives and site- and/or species-specific approach to roaming surveys should be decided on, documented and justified.

Roaming surveys compliment the bird utilisation survey and usually add to the species found on a site. Particularly localised concentrations of birds, or birds in specific habitats or using certain geographic features of the wind farm site, can be detected during roaming surveys. These surveys are often done between the bird utilisation survey periods, while moving from one site to the next, or as a separate exercise. They do not generate quantitative data comparable with the data from bird utilisation surveys or gradient studies, but may nonetheless produce data of value. Thorough and systematic recording of observations of species of concern will allow informative *post-hoc* quantitative analyses.

The way in which roaming surveys are planned and executed will vary depending on the target bird species or groups of bird species and their usual use of the habitat and landscape on and near the proposed wind farm site. Sound expertise in bird ecology should be sought in planning such searches and the observer should be field-experienced in bird identification.

Roaming surveys are usefully employed to assess the possible occurrence on a wind farm site of a rare or threatened species that has a restricted habitat preference:

- where there is a known population of (or high potential for the occurrence of) a threatened bird species that could potentially be affected by the wind farm (i.e. site usage pre-disposes it to collision with wind farm infrastructure or it is sensitive to disturbance) on or within say 5 km of a wind farm site;

- where there are known concentrations of birds, such as communal roosts or significant numbers of waterbirds on wetlands, including listed migratory species; and/or

- where Level One investigations show there to be unusual numbers of species considered to have a higher collision risk (e.g. birds of prey), or the behaviour of which puts them at risk.

Roaming surveys involve survey methods specific to particular, targeted bird species, bird groups or habitats.

Data set standards

- Surveys should cover the wind farm site and any nearby suitable habitats for the species of concern.
- Surveys should be undertaken at times of year when there is maximum likelihood of the target species being present.
- The specific habitats of target species (determined based on a review of existing information, such as the regional overview) need to be thoroughly searched if they are on or near a wind farm site.
- If large numbers of communally roosting species occur in an area, then dawn and dusk roost watches should be undertaken to determine the locations of flight paths, directions and numbers of birds arriving at and departing from roosts, and their likely daytime foraging areas.
- Where counts are undertaken (e.g. of wetland birds), these should be done in a repeatable manner from the same observation points each time, by an observer familiar with bird census techniques.

Reporting standards

- The reporting of roaming survey results should include the following minimum information: survey dates; survey effort (person-days and area covered); location and area of potential habitat searched; numbers and locations of target species found; and information on the behaviour of target species in relation to the proposed wind farm).

Documentation from roaming surveys should :

- describe the usage of a wind farm site by the species of concern, supplementing any information generated by bird utilisation surveys;
- describe usage of habitats in the region assessed around the wind farm site by the species;
- present information on likely regional population levels of the species of concern, where known;
- place usage of the wind farm site by the species in an accurate and up-to-date context of regional habitat use patterns;

- if required, document the questions to be addressed by Level Two investigations, including the outcomes of consultations with agencies that assess and approve development; and

- Document the desired scope of operational phase impact monitoring.

2.4. Outcomes of Level One investigations

The results of Level One investigations are evaluated to decide whether higher-level investigations are required. The estimates of both consequence and likelihood are used to produce an estimate of the level of risk of significant bird impact, using the risk matrix at Table 1.

The concept of 'species of concern' is critical to implementing these standards. Species of concern include:

- state or nationally threatened species;

- species that exhibit behaviour that puts them at risk of regular collision with operating wind turbines (e.g. soaring birds of prey);

- species regularly using nearby Ramsar wetlands or protected areas; or

- listed migratory species belonging to an important population on the site or on nearby habitats (as defined in the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) Administrative Guidelines on Significance (Environment Australia 2000)).

If any species of concern occurs or is likely to occur on the wind farm site (regularly in the case of non-threatened species), the consequence of the potential wind farm is automatically classed at a minimum of 'moderate', thus resulting in a level of assessed risk of medium or greater (see Table 1), prior to the consideration of methods to reduce the risk level. Risk levels of medium or greater require a Level Two investigation. If the risk level is low, or can be reduced to that level through the incorporation of mitigation measures, design reviews and/or siting alterations, then further investigation of bird impact risk at the site is not warranted. If otherwise, a Level Two investigation is recommended.

3. LEVEL TWO INVESTIGATIONS – REFINED RISK ASSESSMENT

This section discusses Level Two investigations, the second step in the staged risk assessment process. These should be carried out when Level One investigations have identified potential for a greater than low residual risk of significant bird impacts. They provide further and more detailed information on the bird use of a site. Level Two investigations, where required, would be undertaken as part of the Project Feasibility and/or Detailed Assessment phases outlined in the AusWEA Best Practice Guidelines (AusWEA 2002).

The **objective** of Level Two investigations is to provide a more refined estimate of the level of significant bird impact risk. This is done by:

- obtaining detailed information on the occurrence of threatened species or species of concern;
- assessing the magnitude of the potential or actual direct and indirect impacts on birds (i.e. potential numbers of birds affected); and
- assessing the likelihood of significant direct and indirect bird impacts.

The Level Two **protocols** will enable more detailed analysis of the consequences of the operation of the proposed wind farm with regard to particular species and the likelihood of those consequences. Level Two investigations will allow estimation of the risk of significant impact on birds at a wind farm site to a greater level of accuracy than is possible through Level One investigations. These protocols also set out a process of validating the methods used.

At the commencement of Level Two investigations, the specific objectives and scope of the proposed bird risk investigations should be documented and justified.

Level Two investigations include some or all of the four protocols described below. A combination of protocols should be considered if the bird species or groups potentially at risk, and their conservation status, warrant it. This decision should be informed by the results of the Level One investigations, as well as by consultations with the agencies that assess and approve development (see Section 1.3).

In reporting Level Two investigations, the justification for choosing particular investigations should be documented.

Level Two investigation protocols

- Protocol for continuing bird utilisation surveys
- Protocol for gradient studies
- Protocol for roaming studies
- Protocol for risk modelling

The Level Two protocols outline the information required to meet the objectives and provide guidance for scoping investigations, including seasonal timing limitations.

The Level Two **data set and reporting standards** provide standard methodologies that should be followed when carrying out the investigations and when documenting them. These are outlined under each protocol.

3.1. Protocol for continuing bird utilisation surveys

This protocol and its associated reporting standard are identical to the protocol and reporting standard for indicative bird utilisation surveys conducted in Level One investigations, and thus they are not repeated here. The only difference is the data set standard below.

Data set standards

- Bird utilisation surveys should cover seasonal variation in bird occurrence and be informed by Level One investigation results.

Reporting standards

The same information should be presented as for the indicative bird utilisation survey, with the addition of the following.

- Each season of data should be presented separately, with the final ranked listing of species abundance applied to the sum of observations for all seasons surveyed (below and at RSA height).
- The cumulative percentage relative abundance of each species should be calculated for the total numbers of birds observed in sequential seasons to determine how additional species found by the last seasonal survey alter the percentage relative abundance (e.g. further survey work may be needed if the cumulative percentage relative abundance of the additional species was greater than say 5% of the total in the last survey).

- If required, document the questions to be addressed by Level Three investigations, including the outcomes of consultations with agencies that assess and approve development.

- Document the desired scope of operational phase impact monitoring.

3.2 Protocol for gradient studies

Gradient studies are a refinement of or addition to the bird utilisation survey. They aim to determine changes in bird utilisation rates across an environmental gradient. Examples of such gradients include but are not limited to:

- distance from the coast, waterways or wetlands supporting significant bird concentrations;

- distance from ridges where soaring birds of prey might occur; or

- distance from wind turbine sites or clusters.

A gradient study would be required if wind turbines were proposed to be located near a large concentration of birds, or near a habitat feature in the assessed region that attracts or concentrates bird usage.

Gradient studies are particularly important as they inform bird impact mitigation strategies at wind farm sites (e.g. set-back distances, areas to be avoided, etc.).

Data set standards

- Gradient studies should follow the data set standard for bird utilisation surveys, taking account of the additional requirements below.

- Fixed survey points should be located very close to the start of the environmental gradient or habitat feature of concern to document bird usage in the area of concern.

- Survey points should be spaced evenly along the environmental gradient so that the survey areas do not overlap. Wider spacing may be appropriate if the distance between wind turbines and the area of high bird usage is great (e.g. a kilometre or more).

- The survey point furthest from the area of concern should be located in an area where bird use is judged by an ecologist familiar with the site (from Level One Investigations) likely to be at 'background' levels.

Reporting standards

- Bird numbers and utilisation rates (minimum requirement in the protocol for indicative bird utilisation surveys) should be tabulated by point and corresponding distance along the environmental gradient concerned.

- A combination of the furthest point and other appropriate bird utilisation survey points should be used to calculate a 'background' level of bird utilisation to determine the maximum distance over which such rates may be affected by the environmental gradient or habitat feature.

- If required, document the questions to be addressed by Level Three investigations, including the outcomes of consultations with agencies that assess and approve development.

- Document the desired scope of operational phase impact monitoring.

3.3 Protocol for collision risk modelling

Collision risk modelling involves using point count data to estimate the bird mortality that might arise from a new wind farm. Collision risk modelling relies on quantitative estimates of bird movements on a wind farm site. Quantitative estimates can be derived by using:

- point count results from bird utilisation surveys on a site; or

- informed assumptions about bird movements on a wind farm site.

A collision risk model aims to estimate the number of bird movements that may result in a collision with operating wind turbines. The most widely used model in Australia for impact assessment is that of Meredith and Baird (2000).

Despite the paucity of site-specific data on site usage by rare species, collision risk modelling has proved to be most informative where rare or threatened species are involved. It has been used in Victoria on the Orange-bellied Parrot and the White-bellied Sea-eagle, and in Tasmania on the Orange-bellied Parrot and Wedge-tailed Eagle. In most of these cases, bird utilisation data were available. In the case of the Orange-bellied Parrot in Victoria, no individuals had been observed on the sites in question but the opinions of experts on the species were used to model the impacts of wind farms for a range of site usage scenarios.

Collision risk modelling is most useful in these circumstances and for assessing the impacts on the most abundant birds in the area. Results from monitoring at wind farms indicates that collision risk models may over-estimate collision rates, although more monitoring work is required to determine if this difference is widespread and for validating modelling. Notwithstanding this, it is appropriate to adopt a precautionary approach in

this matter and in this respect the current modelling is considered informative.

Data set standards

Where bird utilisation surveys, gradient studies and/or roaming surveys can provide information on the rate of bird movements across a wind farm site (for a given area), then collision risk modelling can be done. The collision risk model of Meredith and Baird (2000) integrates a number of variables, including but not limited to:

- layout of wind farm;
- number of turbines;
- specifications of turbines;
- wind direction data, as this affects the orientation of turbine blades;
- point count data (standardised at least to area and time);
- size and flight speed of birds;
- number of hours per day bird moves across site; and
- times of year that site is used by species of concern.

It also makes a number of assumptions, including:

- bird flight behaviour relative to the wind farm (i.e. it assumes that bird movement can be either unidirectional or multidirectional);
- flight frequency and behaviour of species of concern; and
- bird avoidance behaviour (this is commonly varied between 95% and 99.9% avoidance rate to provide a range of estimated collision (mortality) rates, although any scenario can be adopted).

Reporting standards

The following documentation is considered appropriate for describing collision risk.

- A ranked listing of species and their total abundance at RSA height during the bird utilisation surveys (as a minimum and where there is a low likelihood of the regular occurrence on the site of threatened species or species of concern).

- The predicted annual number of movements at risk where species of concern are involved (expressed as the total numbers of birds of a species affected per year for the whole wind farm).

- Where possible, some indication of the precision of this estimate should be provided, usually by presenting a range of scenarios (e.g. for different assumed avoidance rates).

- If required, document the questions to be addressed by Level Three investigations, including the outcomes of consultations with agencies that assess and approve development.

- Document the desired scope of operational phase impact monitoring.

Collision risk modelling cannot be relied upon in isolation. Estimates of collision rates generated by modelling to assess the likelihood of wind farm impacts need to be considered in the context of other information about the behaviour and abundance of the species concerned and its likely use of an area.

3.4 Outcomes of Level Two investigations

The results of Level Two investigations are evaluated to decide whether higher level investigations are required. As was done at the conclusion of the Level One investigations, the estimates of both consequence and likelihood of bird impact are used in the risk matrix at Table 1 to produce an estimate of the level of risk of significant bird impacts. If any species of concern[7] occur on the site, the consequences of the potential wind farm are automatically classed at a minimum of 'moderate', thus resulting in a risk level of medium or high. Appropriate mitigation measures, design reviews and/or siting alterations can be considered at this stage.

If the level of residual risk of significant bird impact is then estimated to be low, further investigation of bird impact risk at the site is not warranted and it is appropriate for the results of the Level Two investigations to be discussed with the planning authorities to determine if bird risk levels are acceptable.

[7] As defined in Section 2.4.

4 LEVEL THREE INVESTIGATIONS – CONFIRMED RISK ASSESSMENT AND MITIGATION

If the results of a Level Two investigation lead to an estimated residual risk of significant bird impacts greater than low, a Level Three investigation is recommended. Level Three investigations enable more accurate estimation of the level of risk posed to bird populations by proposed wind farms.

The **objectives** of Level Three investigations are:

- to further refine the risk assessment in the context of the regional or wider population of birds; and
- to inform wind farm feasibility, design and operational measures sufficient to achieve acceptable levels of bird mortality risk.

Two approaches which have been used for determining the risk of significant bird impacts at and near wind farm sites are discussed below. Level Three **protocols** are provided as follows.

Level Three investigation protocols

- Protocol for population assessments
- Protocol for population viability analyses

The relevant **data set and reporting standards** are provided. At the commencement of Level Three investigations, the specific objectives and scope of the proposed bird risk investigations should be documented and justified.

4.1 Protocol for population assessments

For each threatened species or species of concern, the consequences of both the modelled annual number of collisions and of the indirect disturbance, and their likelihood, need to be determined. For common species, this is fairly straightforward, as the abundance of birds is usually so high that the loss of individuals is unlikely to affect regional or wider populations. Qualitative judgements about the significance of population impacts are frequently made for common species (e.g. Strickland *et al*. 2000).

For less abundant species that are of interest, such as raptors or threatened species, judgements about population impacts are made based on the foregoing considerations, but also on factors such as the proportion of regional habitat occupied by the proposed wind farm (Schmidt *et al*. 2003).

Meredith and Baird (2000) compared the modelled collision risk at a wind farm with the likely regional and wider population, as a basis for judging the consequences of the impacts of the proposed West Coast Wind Farm in Tasmania on a range of bird species. The factual basis for deriving regional population estimates was limited and so reasonable professional judgements were used, as well as consultations with relevant experts.

There is a lack of information on population size of many birds in Australia, making judgements about impacts difficult. However, for threatened birds, a range of professional judgements about population size have been collated and published (Garnett and Crowley 2000) and can be used to evaluate the relative significance of wind farm impacts on a national threatened species population.

The recently released New Atlas of Australian Birds (Barrett *et al*. 2003) provides useful distributional information, together with information on reporting rate at a 1-degree latitude – longitude scale. Regional scale data on the occurrence of threatened species or species of concern can be obtained from the New Atlas of Australian Birds database, and the relevant state fauna atlas or database projects. Experts exist for some species (in government or academic institutions) who can provide excellent, informed judgements about the size and distribution of the regional populations of those species. If there is a greater than low risk of significant bird impacts, then targeted surveys in the wider region may be required to improve the data on which regional population assessments are made.

Information on population size, at a regional or wider scale, can be used to determine whether a wind farm site is in an important centre of a species' range or not. Matters of interest are whether the wind farm site occupies a significant proportion of a species' regional range or habitat, and whether the number of birds likely to be affected represents a significant proportion of the regional or wider population. It does not, however, completely avoid the need for qualitative judgements about population impacts, where population assessment data are lacking or incomplete.

Assessment of the consequences and likelihood for a bird population of mortality or disturbance arising from a wind farm should be undertaken as part of impact assessment. The matters below should be considered in assessing the consequences and likelihoods for a bird population which may be affected by a proposed or operating wind farm.

Data set standards

- Qualitative judgements about population impacts for common species should be sufficient, as the regional and wider populations are usually large.

- For species of concern, population impacts can be determined based on the predicted numbers of birds affected versus the estimated regional or

wider population. Some fieldwork (e.g. nest surveys or regional counts) may be necessary to put the predicted level of impact in context and evaluate its significance. The methods for such regional population assessments are likely to vary depending on the species concerned and appropriate expertise should be employed, where available.

- For such species, the consequences for the total population (of concern at a state or national scale, for example, under the EPBC Act) can be determined based not just on general knowledge of abundance, but on good distributional information. Sources of such information that should be accessed include, but are not limited to:

  - the New Atlas of Australian Birds (Barrett *et al.* 2003) (all species – regional and wider scale);

  - in the case of threatened bird species, population estimates in Garnett and Crowley (2000);

  - information held by experts in particular species or regions, including good amateur birders, if relevant (usually contactable through national birders' groups); and

  - additional, regional-scale roaming survey work to determine the distribution and abundance of threatened species and species of concern.

Reporting standards

In documenting regional population assessments, the following information should be presented.

- The extent of the region of concern.

- Information on the regional or wider distribution of the threatened species or species of concern.

- The best available data on the regional or, in the case of a threatened species, the total state or national population size, synthesised from the sources listed above.

- Where additional roaming surveys of a region have been undertaken, the reporting standard for roaming surveys should be followed.

- Document the desired scope of operational phase impact monitoring.

In documenting the possible consequences of a likely impact on birds, the following information should be presented, if available.

- The proportion of the regional or wider range of the bird occupied by the wind farm and its estimated zone of indirect disturbance (noting if the wind farm might lie in a particularly important part of the species' range).

- The proportion and relative quality and significance of any habitat occupied by the wind farm and its estimated zone of indirect disturbance.

- The extent to which particular stages in the life history of a species might be affected (e.g. breeding, migration, moult-migration, etc.).

- The proportion of the regional or total state or national population of a species that might be affected by direct and indirect impacts from the wind farm.

4.2 Population viability analyses

Population viability analysis (PVA) was developed as a modelling tool for determining the viability (extinction probability) of populations of threatened species, where good information was available on a range of population variables (Boyce 1992). It is a disciplined and consistent way of organising and analysing information about the population of a threatened species. However, like all models, it is only as good as the data that underpins its assumptions and functions. Usually, this is incomplete and partly relies on professional judgements from a range of specialists.

A thorough review of population modelling is provided by Anderson *et al*. (1998) and it is not proposed to repeat this here. It has also been explored theoretically by Wilson (1995) and Morrison and Pollock (1998). Despite extensive theoretical exploration of population modelling in the wind energy – bird impact literature, only one example of its use overseas exists: for the Golden Eagle at Altamont Pass in central California (Hunt 1998).

A recent example of the use of PVA in an impact assessment in Australia has been for the Orange-bellied Parrot at proposed Victorian coastal wind farm sites. This is based on an approach originally developed for the Tasmanian West Coast Wind Farm (Dreschler and Meredith 1999), and subsequently applied to the Portland Wind Energy Project (Meredith and Baird 2002). The PVA for the Orange-bellied Parrot enabled an extinction risk curve to be generated and the determination of changes in extinction risk due to additional mortality (based on a collision risk model) from a proposed wind farm.

PVA is a useful modelling approach to explore a range of future scenarios arising from the impacts of a wind farm on the population of a bird. PVA is a well researched, formalised approach, and its information requirements are well documented. Notwithstanding this, for most threatened species in Australia, a previous PVA is unlikely to exist. In the light of this, the standards below should apply.

- Where an existing PVA is available for a threatened species, it should be used to explore future scenarios for the species concerned due to the potential likely impacts of a wind farm.

- Where a PVA does not exist, and adequate knowledge of the relevant population parameters exists, a PVA should be developed, ideally in cooperation with the relevant state wildlife agency, to explore impact scenarios.

- Where a PVA does not exist, and inadequate quantitative information on population parameters exists, consideration should be given to developing one through an expert panel approach, if adequate expertise and qualitative knowledge of the species exists and a useful PVA can be developed from it.

When reporting the results of a PVA, the information described below should be documented.

- The origin of the PVA and the input information it uses should be documented.

- The consequences for a bird population from a wind farm should be expressed in terms of the increased probability of extinction that arises.

Discussions with agencies that assess and approve development are advisable at this stage to define:

- an appropriate range of values to be used in relevant parts of the PVA as part of exploring scenarios; and

- an appropriate range of plausible impact scenarios (i.e. numbers of bird deaths) to be used to explore scenarios.

4.3 Outcomes of Level Three investigations

The results of Level Three investigations provide a further refined assessment of the level of risk of significant bird impact from the proposed wind farm. They inform the development and operation of risk mitigation measures and operational phase monitoring of impacts and adaptive management of the wind farm.

After the completion of Level Three investigations, a "statement of residual risk" for the species of concern should be possible.

If the level of residual risk is assessed as low, no further investigation of bird impact risk is recommended; if otherwise, additional Level Three investigations are recommended. Alternatively, a decision on the future of the project may be considered.

Operational phase monitoring is discussed in the following section.

5 OPERATIONAL PHASE IMPACT MONITORING

Once pre-operational impact assessment has been completed, it will be possible to short-list the most significant potential bird impacts of a wind farm project. These predicted significant impacts should form the focus of an operational phase monitoring program, in which the impacts of operation of the wind farm are monitored Potential monitoring methods are noted in Table 2. The results of this monitoring can be used as necessary in the adaptive management of the wind farm, to further reduce the level of risk of significant bird impact.

Three additional[8] **protocols** for operational phase impact monitoring methods are detailed in this section. The relevant da**ta set and reporting standards** are provided for each protocol.

Operational phase impact monitoring

- Protocol for dead bird searches
- Protocol for indirect disturbance impact assessments
- Protocol for avoidance studies.

5.1 Protocol for dead bird searches

The most widespread method of monitoring bird collisions is the **dead bird search**. This usually involves regular searches under operating wind turbines for bird carcasses and remains (e.g. Strickland *et al*. 2000). Feather spots include a number of feathers clustered together under a wind turbine. They may indicate a collision by a bird with an operating turbine, but they can also arise for other reasons, such as predation. The concept of feather spot for a project should be defined in consultation with the agencies that assess and approve development.

Searches for carcasses and remains usually include both wind farm sites and reference sites, so that wind farm-related mortality can be distinguished from background mortality (see notes on the 'BACI' design in Section 1.5). However, in Australia, some wind farm developers have been happy to dispense with the BACI design and assume that any dead birds under turbines are the result of a collision. In low risk sites this is probably a low risk strategy but where assessed risk of significant bird impacts is considered to be higher, then a full BACI design should be implemented.

[8] That is, not detailed in earlier sections of this document.

All dead bird search programs should include searcher efficiency trials and scavenging trials. These are particularly important features of a dead bird search monitoring program, as scavengers may take bird carcasses before they are found by an observer, and observers may not find all birds (Morrison 2002). Morrison (2002) reviewed scavenging and observer efficiency findings and found scavenging rate estimates ranging from 50 to 75% between one and four weeks after a carcass was placed in an area. He also found observer efficiency varied significantly, from as low as 35% up to 85%, with habitat, ground cover and size of carcass contributing to detectability.

Data set standards

Dead bird search programs should involve the tasks described below.

- In the first instance, searches should cover an area out to a distance equivalent to the height of the wind turbine for dead birds, remains and feather spots. This distance can be altered if carcass locations indicate this.
- Information on each carcass found should be recorded as follows:
  - date;
  - species;
  - signs of injury and likelihood of death due to collision;
  - signs of scavenging;
  - distance and bearing from turbine tower base; and
  - ground conditions (e.g. height and density of vegetation, presence of stock, etc.).
- Each search should involve thoroughly searching by transects within the search area. All searchers should be appropriately inducted to ensure that they understand and implement the search protocol consistently.
- Searches should occur on randomly chosen dates a number of times within each season, with the same number of searches within each season. Randomisation aims to ensure representativeness across seasons, allowing annual collision rates (see below) to be computed that take account of seasonal changes in bird use at a site. However, some species of concern may require searching at particular times of year.
- Searches should be undertaken of the total number of turbines in a wind farm (randomly selected, where necessary – see below)) on average at least every month and more frequently if the predicted level of risk of significant bird impact warrants this.

- For larger wind farms, a random selection of turbines per day should be chosen for a survey, with surveys lasting up to several days to ensure that at least the total number of turbines visited is equivalent to the total on the wind farm (note that because turbines will be selected randomly, not all turbines will be searched each survey).

- Different intensities of searching may be required for particular turbines, depending on assessed bird collision risk.

- For larger wind farms, dead bird searches should be undertaken for a minimum of two years. If a significant level of bird mortality (of concern to a regional or species population) is measured, then the monitoring should continue for longer.

- A scavenging trial should be undertaken at least twice over the initial (two year) monitoring period, during conditions of differing ground vegetation cover, to determine the rate of removal by scavenging animals.

- An observer efficiency trial should be run in the same season as the scavenger trial, and up to twice per year, to determine the proportion of dead birds that the observer undertaking the searches actually finds. If the same observers are engaged at different sites or projects then observer efficiency trials may not need to be duplicated.

- Correction factors for scavenging and observer efficiency should be developed from these trials and applied to the monitored number of dead birds in order to derive an estimate of collision rate.

- An appropriate number of reference sites should be searched in addition to the turbine sites if a BACI experimental design is adopted.

- Searches should be undertaken before and after the operation of the wind farm to help distinguish wind farm related bird mortality from background bird mortality. (Note that some proponents at low risk sites have assumed that all dead birds found under turbines are the result of a collision).

Reporting standards

Reports of dead bird search programs should provide the following.

- A detailed account of the methods of the dead bird search program, including the total number of sites counted (turbine sites and reference sites, their locations, including AMG coordinates, whether they represent all or randomly selected turbine sites, and whether any fixed search sites were included).

- Mortality estimates should be provided for birds (in total and by species) as the number of dead birds per turbine per year, including application of correction factors for scavenging and observer efficiency.

- The estimate of mortality rates by species should be compared with any pre-operational bird utilisation survey results (at RSA height) to determine which species are at greatest risk from the wind farm.

- The estimated mortality rates should be compared with the results of the regional population assessments and population viability analyses undertaken as part of Level Three investigations, where relevant.

- The requirement for continued monitoring should be reviewed, together with the monitoring methodology.

5.2 Protocol for indirect disturbance impact assessments

Wind farms can lead to indirect disturbance of birds. The effect may vary between species of concern but it may include but not be limited to:

- avoidance either partly or completely by individuals or all birds of areas within a critical distance of operating turbines or wind farms; or

- suppression of foraging, roosting or breeding in critical habitats on or near a wind farm, leading to declines in local and regional populations of species of concern.

Indirect disturbance after operations commence can be assessed using the same methods that were used for pre-operational impact assessment, within a 'BACI' design (see Section 1.5).

Data set standards

- Operational phase monitoring must be preceded by equivalent pre-operational studies using the applicable protocols.

- Operational phase studies can include bird utilisation surveys (using the same survey points and duration and number of surveys as used in pre-operational risk assessment), gradient studies and roaming surveys (likewise using the same level of effort).

- Targeted bird surveys, using survey methods specific to particular species of concern (e.g. roost watches) or habitats (e.g. wetland bird counts) may also be appropriate as part of operational phase monitoring. It will be important that the same survey effort and methods are used before operations commence to enable interpretation of post-operational results within a BACI design.

Reporting standards

Reporting the results of operational phase indirect impact monitoring should include the following as a minimum.

- Presentation of the raw numbers at impact and reference sites, with an indication of the percentage change in numbers before and after operations commence.

- Comparison of bird numbers at points along any gradient studied.

- Information about patterns of habitat use (numbers and locations) by species of concern collected during roaming or targeted surveys.

- Information on changes in foraging, roosting and breeding numbers and success, where relevant.

- Statistical analysis of differences (i.e. those that occur regularly at most or a reliable sub-set of survey points) may add to the certainty of judgements about impacts.

- The requirement for continued monitoring should be reviewed, together with the monitoring methodology.

5.3 Studying avoidance behaviour

Avoidance behaviour includes a number of behaviours, defined below.

Avoidance involves birds remaining on a wind farm site but flying around, over or under operating wind turbines and it is a commonly observed behaviour at wind farms.

Diversion involves birds remaining within the area around a wind farm but avoiding the wind farm site entirely.

Displacement involved birds being displaced through disturbance from the area around the wind farm.

Studies of avoidance behaviour have aimed to elucidate the extent to which birds avoid collisions with wind turbines. Avoidance studies have the following objectives:

- to provide a specific avoidance rate figure for use in collision risk modelling at future wind farms where the same species are involved (cognisant of the limitations of such extrapolation); and

- to ascertain how wind farms might alter the usual flight behaviour of birds (e.g. when moving between roosting and feeding grounds).

In the literature, the term 'avoidance rates' is used to refer to two different responses by birds to wind farms. The first use of the term (as it is generally used in Australia) refers to how a bird responds when it encounters an individual turbine, that is, at what rate does the bird attempt to avoid the structure as opposed to colliding with it?

The second use of the term refers to avoidance of a wind farm, whereby a bird or birds encounter the wind farm and divert around the whole array of turbines. This term is often used in the literature from Europe and in particular that discussed in Langston and Pullan (2002). In order to reduce the confusion over these terms in this report, 'avoidance rates' is used to refer to the probability of a bird avoiding collision with a turbine, and 'diversion rates' refers to avoidance of the wind farm or array of turbines.

Pre-operational risk assessments may be necessary to inform specific mitigation measures in the event of a moderate to high likelihood of a significant risk to birds at a particular site, once operations have commenced. Specific data set and reporting standards would be required for the particular set of circumstances and no further discussion is provided here.

6 CONCLUSION

The interim standards detailed in this guide provide potential wind farm developers with a structured, systematic and repeatable approach to the assessment of the risk to bird populations potentially posed by the construction and operation of wind farms in specific locations. This will assist wind farm developers to assess the feasibility of their projects and to obtain approval for their projects from the relevant local, state and Commonwealth agencies that assess and approve development.

The interim standards, based on a hierarchical, staged approach to risk assessment, accord with the principles contained in the Australian standard for risk management (AS/NZS 4360) and with the more specific guidance for the assessment of environmental risk provided by HB203:2000. They reflect and build from the staged investigation process detailed in the 'Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia' (AusWEA 2002).

The interim standards enable estimation of the consequences and likelihoods of direct and indirect impacts on individual bird species from proposed or operating wind farms. Thus the risk of significant bird impact can be estimated. They therefore provide essential information to inform wind farm location, design, risk mitigation and adaptive operational management.

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LIST OF ABBREVIATIONS

AMG	Australian Map Grid
AS/NZS	Australian Standard/ New Zealand Standard
AusWEA	Australian Wind Energy Association
BACI	Before - After - Control - Impact (experimental design)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
PVA	Population Viability Analysis
RSA	Rotor Swept Area, referring to the height range within which the blades of operating wind turbines move