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National Wind Farm Development Guidelines - Draft

July 2010

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These Guidelines have been developed by a Working Group that includes Commonwealth and state representatives of the Environment Protection and Heritage Council (EPHC) and the Local Government and Planning Ministers' Council.

- *The Environment Protection and Heritage Council (EPHC)*

  The Environment Protection and Heritage Council of Australia and New Zealand was established in June 2001 by the Council of Australian Governments (COAG).

  The EPHC addresses broad national policy issues relating to protection of the environment (particularly in regard to air, water, and waste matters) and heritage (natural, Indigenous and historic).

  The members of the EPHC are Ministers from the participating jurisdictions — Australian, state and territory governments; the New Zealand Government; and the Papua New Guinea Government. The Minister representing a jurisdiction may not necessarily be the Minister responsible for the environment in that jurisdiction.

- *The Local Government and Planning Ministers' Council*

  The Local Government and Planning Ministers' Council leads debate in decision making on key strategic policy matters for local government and planning in Australia and New Zealand that can be addressed at the national level.

The Working Group consists of representatives from the following agencies, who were responsible for coordinating inputs from their respective jurisdictions:

- *Australian Government*
  - Department of the Environment, Water, Heritage and the Arts
- *Australian state governments*
  - New South Wales — Department of Planning
  - Queensland — Department of Environment and Resource Management
  - South Australia — Department of Planning and Local Government
  - Tasmania — Environment Protection Authority (EPA Tasmania)
  - Victoria — Department of Sustainability and Environment
  - Western Australia — Department of Environment and Conservation; Department of Planning
- *Planning and Local Government Ministers' Council*

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1 Introduction and common questions

1.1 Why do we need the National Wind Farm Development Guidelines (the Guidelines)?

Through the Council of Australian Governments (COAG), all governments have agreed to support the growth of low emissions technologies, such as wind energy. Wind farms are recognised as an economically, socially and environmentally sustainable technology that can meet a significant proportion of our electricity consumption needs and provide greenhouse gas abatement.

Australian Government modelling predicts that the expanded Renewable Energy Target (RET) will lead to strong demand for the construction of new electricity generation from renewable energy technologies such as wind farms over the next decade. Consequently, planning and environmental authorities will need to assess increasing numbers of applications for wind farm developments.

Australians generally understand the need to reduce our carbon emissions, but also want to ensure that wind farms are developed and operated in a socially and environmentally responsible manner.

In response to growing community concerns about wind farms the Environment Protection and Heritage Council (EPHC) requested its Standing Committee in April 2008 to report on the impediments to responsible wind farm development.

In November 2008, the EPHC released the report *Impediments to Environmentally and Socially Responsible Wind Farm Development*. The report recognised that one of the most significant impediments to responsible wind farm development is the lack of consistency between jurisdictions as to agreed frameworks and methods for assessing issues unique to wind farm developments. The report also recognised that the wind energy industry, communities, relevant authorities and other interested stakeholders would benefit from the adoption of a consistent set of government endorsed current best-practice guidelines.

In July 2010 the EPHC resolved to release these draft Guidelines for a period of twelve months to allow jurisdictions to evaluate their effectiveness and provide the opportunity to assess how the Guidelines could best compliment existing planning and development processes, taking into consideration that these are best practice guidelines, and are not mandatory.

Every jurisdiction has a different process for assessing wind farm proposals and it is not the intention of these Guidelines to change these. Each jurisdiction's process has a stage at which the relevant authority weighs the impacts of the proposed wind farm against the opportunities it presents. These Guidelines aim to give greater transparency and consistency to this process by clearly outlining the key principles and issues for consideration by the relevant authority.

It is vital that interested parties use the Guidelines in conjunction with the relevant state, territory and local government planning and environmental regulations and/or guidelines.

1.2 Why do we need wind farms?

Burning coal and other fossil fuels for electricity generation accounts for more than one third of Australia's current greenhouse gas emissions. The expanded Renewable Energy Target (RET) requires that 20 per cent of Australia's electricity is generated from renewable energy sources by 2020 and is one of a number of strategies to reduce Australia's carbon emissions. The transition to a low carbon economy will require a significant transformation of the electricity sector.

The 20/20 target is challenging; however, it is achievable and energy sources such as wind will have a key role in moving Australia to the clean economy of the future.

The variability of the wind does not prevent wind energy from being an effective means of reducing greenhouse gas emissions. For every megawatt hour (MWh) of wind energy consumed, one less MWh is needed from another source. As around 90 per cent of Australia's electricity comes from fossil fuel-based generation, this means that the energy production that is displaced by wind farms is likely to be from coal- or gas-fired power stations. By displacing coal and gasfired generation, wind farms reduce greenhouse emissions. Wind turbine technology is well established and less expensive than most competing renewable energy technologies and forms a necessary part of our future energy mix with a growing role to play in managing the environmental impact of energy production and use.

1.3 What's covered in the Guidelines?

The purpose of these Guidelines is to provide a nationally consistent set of best-practice methods for assessing the impacts that are unique or significant to wind farm developments and operations.

A number of key topics have been identified and addressed in these Guidelines. Detailed methodologies for six of these topics have been developed and are contained in the Technical Appendices. These six topics are:

- **Community and stakeholder consultation**
- **Wind turbine noise**
- **Visual and landscape impacts**
- **Birds & bats**
- **Shadow flicker**
- **Electromagnetic interference (EMI)**

Some topics do not have detailed methodologies because the solution is relatively simple or is covered well in other planning processes and documents. Guidance is provided in the body of the Guidelines on the following such issues:

- **Aircraft safety and lighting**
- **Blade glint**
- **Risk of fire**
- **Heritage**
- **Indigenous heritage**

1.4 What's NOT covered in the Guidelines?

Each state, territory and local government jurisdiction has a well-developed assessment framework for new developments (not just wind farms), including environmental assessment. These frameworks are generally supported by a range of policies, regulations, guidelines, zoning and other planning controls. Planning legislation also defines the relevant authority (who makes the decisions), the statutory consultation process (including nature and length of public exhibition periods), the review process and rights of appeal. While the generic nature of the processes and documentation is similar between jurisdictions, there are local differences. These Guidelines do not outline the planning processes for each jurisdiction.

Additionally, these Guidelines do not address those areas of wind farm developments and operations that are common to most major developments (not just wind farms). Such issues include;

- **Vegetation clearance**
- **Soil disturbance/erosion**
- **Terrestrial fauna impacts other than birds and bats**
- **Other ecological impacts**
- **Traffic management**
- **Construction and engineering standards.**

Such issues will still need to be addressed in the planning application for a wind farm and subsequent applications for permits; however, they are not addressed in these Guidelines

The social and economic impacts a wind farm development may have on communities or regions, such as job creation and local business opportunities, are also common to most major developments and are not addressed in these Guidelines.

Wind turbines less than 500 kilowatts (kW) rated capacity and offshore wind farms are also not addressed due the different turbine technology involved and the diverse environments in which they occur. The relevant authority should be consulted about any specific requirements in relation to these types of developments.

1.5 Are direct health impacts covered?

These Guidelines recognise that there is anecdotal information that wind farms may cause some health effects. However, the National Health and Medical Research Council (NHMRC) has conducted peer reviewed research indicating that "*There is currently no published scientific evidence to positively link wind turbines with adverse health effects*". Nor are there any known direct health impacts from shadow flicker or electromagnetic interference from correctly designed and sited wind farms. More information on the NHMRC research can be found on their website; http://www.nhmrc.gov.au/.

These Guidelines do discuss issues such as amenity and annoyance which, if not properly addressed, could have health impacts. If evidence of direct health impacts does come to light, these Guidelines would be modified as required.

1.6 How do these Guidelines interact with existing guidelines

The EPHC acknowledges that other sources of guidance on wind farm development already exist for proponents and other parties. These include the Auswind[1] *Best Practice Guidelines for Implementation of Wind Energy Projects in Australia* (updated 2006), its supporting documents and various State and Commonwealth guidelines. The key differences are that these Guidelines contain more detailed *current* best practice methodologies for addressing the six topics above and they are intended for a wider audience.

1.7 What constitutes a wind farm?

A 'wind farm' development comprises one or more large wind turbine generators. These Guidelines apply to turbines with a rated capacity of over 500 kilowatt and to developments consisting of one or more such turbines (including any existing turbines at the site). Typically, modern wind farms have multiple wind turbines with each turbine having a capacity greater than 1 megawatt (MW) and a height of up to 150 metres.

The definition of wind farm includes the associated infrastructure and works, such as site access (including internal roads), foundations, buildings (construction and operational) and electrical works (see Table 1-1).

The other activities that may occur off the site of the wind farm, or as a consequence of the wind farm development, such as the electrical network connection beyond the site substation, quarrying, vegetation clearance along roadsides and traffic management may require approval under relevant legislation or regulations. Whether or not these matters need to be included or considered as part of the relevant approval for the wind farm will depend on the particular legislative and relevant regimes of the different jurisdictions.

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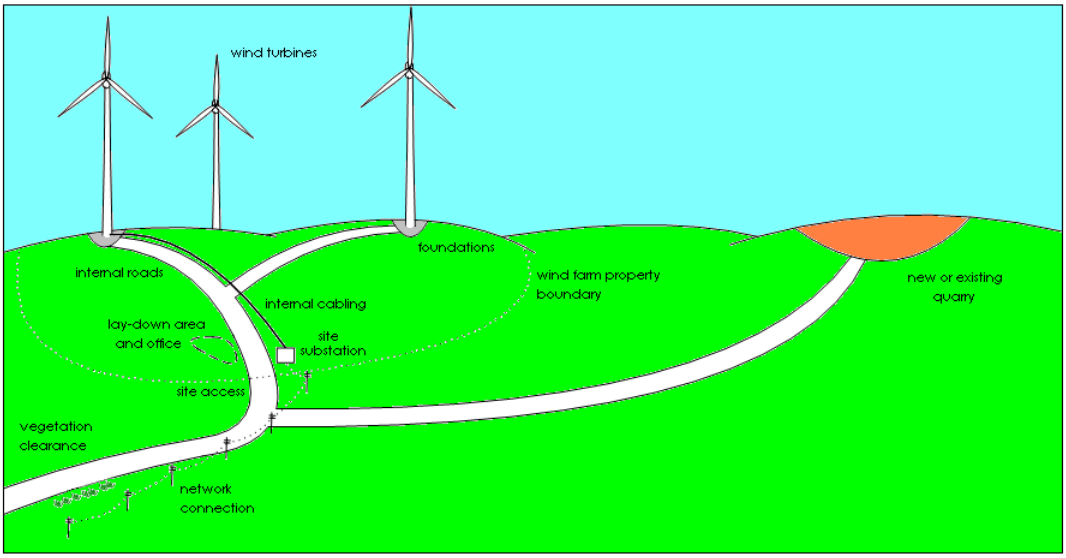
[1] The Clean Energy Council now fills the role previously managed by the Australian Wind Energy Association (Auswind).

Table 1-1
Elements of a 'wind farm' development



1.8 Who is the audience for the Guidelines?

These Guidelines have been written for a wide range of individuals or interest groups involved with wind farms. Some of these stakeholders have been identified below.

- *The proponent*

  A proponent is any entity or individual who seeks to develop or operate a wind farm. This may include wind prospecting companies, renewable energy generators, wind farm construction companies, or private or public businesses seeking to use wind power to supplement their electricity supply.

- *The community*

  The community includes residents, landowners, community and indigenous groups, businesses (and their customers), tourists visiting the region, and the broader community in the region that have an interest in the development of a wind farm at a particular location from an economic, social or environmental perspective.

- *Relevant authority*

  A relevant authority is a government body or person that assesses applications against legal and policy requirements for wind farm developments. They may also have an enforcement role ensuring developments comply with all consent conditions. Relevant authorities may include local councils, state or territory Ministers or government agencies. The Commonwealth Department of the Environment, Water, Heritage and the Arts has specific responsibilities solely in relation to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)].

- *Interested stakeholder*

  An interested stakeholder is a person, business or organisation who has an interest or association with a wind farm. This interest can often be much narrower than the community, generally focussing on individual issues or groups of issues.

  Other interested stakeholders may include a wide range of government agencies related to environment, energy and heritage issues, the Bureau of Meteorology, the Civil Aviation Safety Authority, Department of Defence, fire authorities, bird observers clubs, and telecommunications businesses.

A more comprehensive list of groups who may need to be consulted with during wind farm development, operation or decommissioning can be found in Appendix A.

1.9 How will these Guidelines be used?

These Guidelines are intended to be referred to within the planning process of the relevant state or territory. They are intended to inform the considerations of the relevant authority when assessing a proposal for a wind farm. They are also intended to make those considerations more consistent and transparent to those outside of that planning process.

Once a planning application is submitted, relevant authorities will assess the application based on a balanced consideration of the individual merits of the specific wind farm development. Such an assessment will weigh the benefits provided by the project (particularly in relation to government climate change policies) against the potential impacts on the environment, neighbouring landowners and local communities and what measures can be put in place to mitigate any such impacts.

When conducting their assessment, relevant authorities are expected to have regard to the principles of wind farm development outlined in the next section. They may also have regard to the attached technical methodologies.

Wind farm proponents can use these Guidelines to ensure they structure their application to anticipate the requirements of the relevant authority and facilitate the assessment process.

They are also intended to provide a suitable level of information to the community about the process and scope of wind farm developments.

The guidelines are not intended to be mandatory; every jurisdiction has a different statutory process for assessing wind farm proposals and it is not the intention of the Guidelines to change these. Opting for the release of draft Guidelines allows each jurisdiction to assess how the Guidelines could be best adopted within their processes.

2 Principles for responsible wind farm development

The proponent should be aware of the following principles that underpin these Guidelines. The relevant authority is expected to consider these when assessing the planning application for a wind farm and setting conditions for approval. The community and other stakeholders should also be aware of these principles when engaging with the wind farm development process.

Adequate site assessment is critical to identify suitable sites, based on a range of site selection criteria, prior to making the decision to continue with further more detailed assessments.

The tasks to be undertaken in establishing the impacts of a wind farm can vary depending on the nature of the likely impacts and issues at a particular site.

These Guidelines have been developed to allow the proponent to undertake only those studies necessary to manage the risk from their project, recognising that not all assessment tasks identified in Appendices B-F will need to be followed for all developments.

The level of assessment should be commensurate with the significance of the impact.

If a proponent concludes that no further work is required on an issue they should be able to demonstrate to the relevant authority, the community and other stakeholders that they have satisfactorily addressed the issue. This will also allow appropriate resources to be directed to those matters identified as a priority.

This risk principle should be applied at all stages of the development from the initial high-level risk assessment undertaken during the site selection stage through to adaptive management of risks during the operations stage.

Consultation needs to commence early in the development process, be inclusive and encompass all potential stakeholders.

A primary purpose of these Guidelines is to assist the wind farm development process in maintaining a high level of transparency and responsiveness to community needs. Therefore, thorough stakeholder and community consultation is fundamental to the successful development of an environmentally and socially responsible wind farm. Establishing who should be consulted, when, where and how is critical, as is the process for bringing such information into the design and development of the wind farm.

Timing is also important. Communities should be consulted with as early as possible, with particular attention at the early stages in talking to people about the development and consultation processes. It is also important to start talking early to relevant authorities and local government to understand their expectations of the project, what issues are known to exist in the area, and for advice on consulting with other stakeholders.

The consultation should be a two-way process — the proponent needs to be open about informing stakeholders about various aspects of their project, and they also need to actively encourage feedback and questions from stakeholders and to bring this into their development process. This sort of consultation facilitates better outcomes for all parties.

Impact assessments should be made using the best scientific knowledge available.

The methodologies within these Guidelines have been produced using the best available scientific knowledge at the time of publication; however, science is constantly evolving and new information will need to be drawn upon in assessing a project.

Revising the Guidelines as new scientific knowledge becomes available will ensure they continue to be responsive to stakeholder expectations for responsible development.

If developers can demonstrate that the best scientific methods have been used to assess a potential or actual impact (e.g. noise or shadow flicker), then relevant authorities and stakeholders can make the best possible judgement about the validity of the assessment.

The non-direct impacts of the wind farm development should be identified and addressed.

In addition to the direct impacts that a wind farm may have on the environment and community in which it is located, there may also be a number of non-direct impacts. The term 'cumulative impacts' is often used to cover any incremental and indirect impacts resulting from the project and/or its interaction with third-party developments.

Specifically, there are three distinct types of non-direct impacts that should be considered, namely:

- *Indirect impacts*

  These are impacts that are not the direct result of the project, but which are caused solely by the project (even though they may be the result of complex processes and distant from the site). For example where road widening or realignment required for the wind farm construction vehicles occurs some distances from the wind farm site.

- *Cumulative impacts*

  These result from the incremental impacts of multiple projects over time. These projects may exist, be under development or about to be developed. For example bird mortality due to turbine collisions at a single wind farm may be small but, when considered over multiple sites, it may impact the viability of a particular species.

- *Impact interactions*

  These result from two or more impacts of the project (or multiple projects) interacting in a manner that produces a new impact. The loss of habitat and bird mortality due to turbine collisions may combine to have a greater impact on the viability of a particular species than when considered separately.

A range of technical studies may be required to assess these potential impacts. Attention is drawn to the European Commission's *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (May 1999) and Entec (2008).[2]

In order to address such impacts, the proponent will need to identify those third-party developments necessary to be included in the assessment of indirect and cumulative impacts. Given the available tools and the nature of the impacts, this will change depending on the discipline being considered. However, in order to allow for accurate assessment, non-direct impacts should only be considered in relation to existing developments and those developments under construction.

Not all developments for which a planning approval has been granted will necessarily be constructed. The proponent should, however, identify such approved developments and discuss with the relevant authority which of these developments may also need to be considered in the analysis of non-direct impacts. This discussion may involve consideration of when the planning permits for each development lapse.

Renewal of lapsed permits should require re-consideration of non-direct impacts as part of the assessment of whether to grant new permits and the determination of conditions attached to such permits.

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2 Entec (2008) *Review of Guidance on the Assessment of Cumulative Impacts of Onshore Windfarms: Phase 1 Report*. Report to the UK Department for Business Enterprise and Regulatory Reform (BERR).

3 Wind Farm Specific Issues

The specific issues associated with wind farms are related to the size of the wind turbines and the rotation of their large blades. Factors that can magnify these issues are the number of turbines and their geographical spread. It makes sense that two wind turbines will generally have a greater impact than one, but the relationship may not be directly proportional (i.e. double the impact) as the impact will depend on how wind turbines are arranged.

The specific issues associated with wind farms are outlined below. Detailed guidance and methodologies for the first six issues have been included in this document as Appendices A-F. The other five issues do not have detailed methodologies because the solution is relatively simple or is covered well in other planning processes and documents.

3.1 Community and stakeholder consultation

Early community consultation and establishing an ongoing commitment to provide information and ensuring opportunities for input is a critical process in the successful development of wind farms.

The issue

To produce the maximum possible electricity, and therefore greenhouse gas abatement, wind farms need to be located in areas that have a regular, strong and consistent wind resource. The location, assessment and development of potential wind farm sites is a long and highly technical process which is detailed in the following section.

During the early stages of investigating a site, developers are unable to confirm with any certainty whether or not a wind farm could be built at or near that location or the number of turbines and layout. In many instances the final layout and number of turbines may not be resolved until after the final approval has been granted by the relevant authority.

Guidance notes

Best-practice development requires the proponent to understand community concerns, and to ensure that such concerns are considered in the design and development of the wind farm project as far as possible. However, there are also limitations to the extent to which all community expectations can be satisfied and ultimately it may be a matter for the relevant authority to determine where the balance of public interest lies.

Appendix A provides the proponent with best-practice guidance on:

- preparing communication and consultation plans and making an early commitment to community participation.
- a methodology for planning and delivering community participation activities associated with the various stages of a wind farm's development. This involves a risk management approach i.e. the amount of community participation activities is commensurate with the level of community concern.
- managing community input into the assessment and management of key technical study areas — noise, landscape and visual impacts, birds and bats, shadow flicker and electromagnetic interference.

Detailed guidance on consultation and stakeholder communications for specific issues is provided in the individual technical appendices.

Section 4 provides an overview of the development process, which includes a summary of consultation requirements for each stage.

3.2 Wind Turbine Noise

The issue

Excessive noise may cause annoyance, disturbance of activities such as watching TV, or sleep disturbance when received at a noise-sensitive location such as a dwelling. At higher levels, environmental noise has been linked to long term health issues such as raised blood pressure and cardiovascular disease.

The noise produced by wind turbines comes from their internal operation and as the turbine blades pass through the air. The noise level diminishes with distance from the wind farm; noise levels at a particular receiving location will be determined by factors such as the number of turbines operating and the wind speed and direction.

Noise emissions from a wind farm development therefore need to be assessed and managed to ensure that sleep is not disturbed, and to avoid unreasonable impacts on wellbeing and unreasonable interference with normal domestic activities.

A unique characteristic of wind turbines is that their noise emission increases with increasing wind speed; therefore the increase in noise from turbines is often, but not always, accompanied by an increase in the background noise environment. A large component of this additional background noise is generated from wind blowing past or through objects, such as trees or buildings. As a result, the background noise near a dwelling may be high enough to 'mask' the sound of the turbines.

This feature of wind farm developments has been accounted for in the assessment methodology within these Guidelines.

Some industrial noise emissions contain characteristics that may make the noise more annoying: tonality (humming, whining), modulation (regular variation in noise level or pitch) and impulsiveness (hammering, banging). For wind farm noise, these characteristics may generally be eliminated by design or operational management. However, the Guidelines address their assessment and management.

There have also been concerns raised about possible health impacts associated with low frequency noise (rumbling, thumping) and infrasound (noise below the normal frequency range of human hearing) from wind farms. Low frequency noise and infrasound levels generated by wind farms are normally at levels that are well below the uppermost levels required to cause any health effects. As a result, these Guidelines do not require specific assessment of low frequency noise and infrasound, but do present guidance on their assessment in response to complaints.

The Guidelines also recognise the potential for cumulative noise impacts should a new wind farm or an extension to an existing wind farm be proposed in close proximity to the existing wind farm.

Guidance notes

These Guidelines are intended to provide an effective way to assess and manage noise impacts from proposed wind farm developments, consistent with current environmental legislation. This will be achieved by addressing noise issues in three key ways within Appendix B, namely:

- By recognising the methods of Australian Standard 4959-2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators*.
- By providing supplementary guidance on, and technical methodologies for assessing issues that are not contained within the Australian Standard but which are still relevant to wind farm noise emissions.
- By including guidance on community consultation.

Specific noise limits are not provided in the Guidelines because they are the responsibility of state and territory authorities. These limits should be set to protect the general noise amenity of noise-sensitive sites, and to prevent unreasonable annoyance or disturbance.

These Guidelines provide the current best practice methodologies to model and measure noise to ensure that the wind farm can be designed and managed to comply with the relevant noise limits.

The Guidelines recognise that compliance with reasonable noise limits should provide for sufficient buffers between the wind farm and noise-sensitive sites, to ensure that the noise emissions are reasonable and that they are free of annoying noise characteristics (tonality, modulation and impulsiveness.)

Given that certain noise characteristics are not addressed within AS 4959–2010, the Guidelines seek to either eliminate these at the design stage or to provide suggested methods for assessing whether these characteristics are present within the noise emission when received at a noise-sensitive site.

An approach to cumulative impact assessment is contained within Appendix B.

3.3 Landscape

The issue

Given the size and layout of wind turbine towers, the construction of a wind farm will impact upon the landscape and its significance. Therefore, the significance of the landscape values, and the extent of the impact, needs to be determined.

A landscape is the appearance of an area of land, referring to the combination of elements such as landform, vegetation, waterbodies, and all types of human land use. Landscape values are the perception of these elements held by people and communities.

Landscapes change over time, both naturally and through human intervention. Landscape values, being subjective, change not only with time, but also from person to person. This results in a wide variety of opinions of what is valued and what is not. The perceptions by which we value landscapes are influenced by a range of factors such as visual, cultural, spiritual, environmental, and based on memories or different aesthetics.

Many highly-valued landscapes are protected under statutory controls (such as national parks, nature reserves, marine parks and planning schemes) to ensure they protect the values important to the community. However, there may be other significant landscapes that do not have statutory protection and special care needs to be taken to identify and appropriately manage these landscapes.

The construction of a new wind farm in an area where one or more wind farms already exists will result in cumulative impacts that will need to be addressed; this includes new stages of existing or approved wind farms. Such impacts can be due to multiple farms being visible from a fixed location or being progressively visible as a viewer moves through the landscape (e.g. driving along a tourist road). Cumulative impact assessment is addressed in Appendix C, Landscape.

Guidance notes

The proponent should undertake a preliminary investigation of the landscape values of a site and its surrounds early in the development process. Early engagement with community members and specific interest groups will help to identify landscape values to be considered.

Appendix C provides a staged approach to landscape assessment, outlining what level of detail is recommended for each stage in the process. There are some examples of how particular components might be undertaken, such as viewshed mapping and production of photomontages in the Practice Notes; however the scope of the work required will be determined by the landscape significance of the proposed site and the scale and location of the wind farm.

Cumulative impact assessment is also addressed in Appendix C.

Two principal sources have been used in the development of the assessment methods — the *Wind Farms and Landscape Values: National Assessment Framework* (Auswind and ACNT, 2007) and the *Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design* (WAPC, 2007). Both documents provide a useful companion to the Guidelines.

3.4 Birds and bats

The issue

The construction of a wind farm may impact on birds and bats indirectly through the loss of habitat cleared at the turbine locations, along access tracks within the site or along roadsides leading to the site. Once operating, a wind farm may impact birds and bats directly due to interaction with wind turbine infrastructure. The most apparent cause of death or injury is collision with turning blades, but other causes include collision with stationary infrastructure and barotrauma (traumatic respiratory tract injury in bats caused by the sudden changes in air pressure adjacent to the rotating blades). In addition, birds may modify their behaviour in response to the presence of the wind farm. They may be reluctant to fly through or over the wind farm (barrier effect) or they may avoid areas adjacent to the turbines (alienation). Either or both of these can be significant if, for example, they restrict access to important habitat. The degree of impact will depend on the species affected.

Wind farms (proposed or actual) may be located within the migratory corridors of bird and bats, thereby increasing the risk of impacts.

Historically the numbers of collisions of birds and bats with wind turbines is low. However it becomes a concern where vulnerable or endangered species are impacted.

Locating additional wind turbines along a migratory corridor may have a cumulative impact on birds and bats. This is particularly an issue if there are species that utilise the wider area of the combined wind farms. Migratory birds may fall into this category as, while they may only be present at a site for short periods of time, they may be exposed to more wind farms.

Guidance notes

Appendix D provides detailed guidance on bird and bat issues.

Given the high level of variability of habitats and species across the country, the approach has been to develop a robust scientific framework for undertaking an assessment of impacts on birds and bats. The focus is on the questions that would need to be answered to demonstrate that a wind farm will not compromise the viability of key species, particularly those species considered threatened at Commonwealth and state/territory levels.

Best practice is achieved by focussing on the ecological questions to be addressed rather than the specific techniques being deployed. This also ensures that these Guidelines retain their currency as new technologies and techniques for ecological assessment are developed and evolve. It is the responsibility of the proponent to demonstrate that the assessment techniques used and the data collected are appropriate and sufficiently demonstrate the conclusions reached.

These Guidelines suggest that a risk-tiered approach is used to allow the proponent to undertake only those studies necessary to manage the risk from their project. This risk principle should be applied at all stages of the development from the high-level risk assessment undertaken during the site selection stage through to adaptive management of risks during the operations stage.

Note that general impacts through vegetation clearance and habitat loss are similar to other developments and are adequately dealt with by existing statutory processes.

3.5 Shadow flicker

The issue

Shadow flicker is produced by wind turbine blades blocking the sun for short periods of time (less than 1 second) as the blades rotate, causing a strobing effect. The likelihood of shadow flicker affecting people is dependant on the alignment of the wind turbine and the sun, and their distance from the wind turbine.

The main risk associated with shadow flicker is the potential to disturb residents in the immediate vicinity. Investigations undertaken when developing these Guidelines determined that the potential risk for epileptic seizures and distraction of drivers is negligible to people living, visiting or driving near a wind farm.

Guidance notes

Shadow flicker can be modelled prior to the finalisation of a wind turbine layout using specialist modelling software. Best practice would suggest engaging appropriately qualified people to use such software packages.

Appendix E provides a best-practice approach to addressing the risk of shadow flicker by providing a set of modelling assumptions for assessment of any layout and an exposure limit that should not be exceeded.

3.6 Electromagnetic interference (EMI)

The issue

Wind turbines can interfere with electromagnetic (or radio communication) signals either by blocking, reflecting or refracting electromagnetic waves emitted from a source. They can also on-transmit or scatter radio communication signals.

Microwave, television, radar and radio transmissions are all examples of radio communication signals which may be impacted by the development of a wind farm.

Guidance notes

Appendix F provides best practice guidance about the issues associated with EMI impacts, and details methods for assessing the potential of such impacts. They also advise on which stakeholders should be consulted and what sort of information they may require.

Mitigation strategies and post-construction monitoring methodologies are also presented.

3.7 Aircraft safety

The issue

Wind farms inherently involve the construction of tall structures (towers plus blades) that have potential to impact on the safety of low flying commercial, private and defence aircraft. In this respect, wind farms are similar to tall buildings, communications towers and other tall engineered structures. They differ by virtue that they are generally located in areas remote from other tall structures, and are generally deployed along ridgelines (further exacerbating the potential impacts) and they involve components moving through shared airspace. Thus, the primary impact of a wind farm is the potential safety risk it may pose to aircraft operating at low levels (below 350 metres above ground level) in vicinity of the wind farm.

The movement of the turbine blades and the materials and size of the turbines may also interfere with radio communications and aircraft and meteorological radar. These potential impacts would need to be considered when selecting a site and in designing a layout for the site.

Guidance notes

The physical intrusion of towers and blades into the airspace used by aircraft is addressed by the Civil Aviation Safety Authority (CASA) guidelines, which are currently under review. The CASA guidelines, once finalised, may indicate that night lighting should be installed on some or all turbines within the wind farm. This, in turn, may pose a visual impact that will need to be considered in the landscape assessment and in the birds and bats assessment. The proponent should also ensure that key aviation bodies are consulted with during the planning and development of the project, particularly CASA, Air Services Australia and the Department of Defence.

Aircraft safety related assessments are particularly important where major airports, aerodromes or landing strips are nearby, or if farmers in the area utilise aircraft for crop-dusting, mustering or other purposes. There is also a need to ensure that structures are reported so that they may be depicted on aeronautical charts. CASA Advisory Circular *AC 139-08(0) - Reporting of Tall Structures* provides details of when and how this is to be done.

The above mentioned authorities should be contacted in the project feasibility stage.

The potential to affect radio communications and radar services is addressed as part of the assessment of electromagnetic interference (see Section 3.6). Section 4 and Appendices C and G show at what stage during the planning process aircraft safety (including night lighting) should be addressed.

3.8 Blade glint

The issue

Blade glint can be produced when the sun's light is reflected from the surface of wind turbine blades. Blade glint has potential to annoy people.

Guidance notes

All major wind turbine blade manufacturers currently finish their blades with a low reflectivity treatment. This prevents a potentially annoying reflective glint from the surface of the blades and the possibility of a strobing reflection when the turbine blades are spinning. Therefore the risk of blade glint from a new development is considered to be very low.

Proponents should ensure that blades from their supplier are of low reflectivity.

3.9 Fire risk

Similar to other facilities where there is electrical equipment (e.g. generators and transformers) and flammable materials (e.g. lubricant oils, vehicle fuels, etc), there is a risk of fire associated with wind farms. Although the risk is considered to be low, proponents should consult with local and regional fire authorities to ensure an appropriate fire management plan is in place to respond to a potential fire prior to the development of a site.

3.10 Heritage

The issue

Places of cultural significance to communities and individuals occur in many places throughout Australia. The terms heritage or cultural heritage are often used when discussing the historic connection that people have with particular places.

Wind farms may be proposed at or near places of cultural significance and have the potential to impact on the significance of those places by altering the landscape, or by disturbing the ground and interfering with culturally significant artefacts.

Guidance notes

Heritage issues are not specific to wind farms; however, due to the extent and nature of the disturbance footprint (excavation for foundations, cabling and access roads), it is important that the proponent consult with the relevant authority responsible for heritage conservation. This should facilitate a process towards community engagement.

Impacts on heritage values due to landscape, vegetation and ground disturbance activities are similar in nature to other development projects, and the proponent should follow the process required by the jurisdiction within which a project is being considered.

The heritage specialist should also be encouraged to consult with local communities to identify particular fauna, flora or ecological communities that may have cultural significance and advise the specialist undertaking the ecological assessment to ensure that impacts to cultural values are assessed.

Section 4 identifies when cultural values should be addressed in the design and planning of a wind farm development.

3.11 Indigenous Heritage

The issue

Both developers and local indigenous communities have sometimes had difficulty identifying and addressing Indigenous heritage issues at wind farms sites. In addition to the heritage values discussed above, in considering Indigenous heritage issues, it is necessary to look not only at physical landscapes (tangible values) but also at cultural landscapes (intangible values). These cultural landscapes include stories and song lines, places where hunting and gathering occurs, and effects on the bush and animals (totemic animals can be affected).

Guidance notes

Indigenous heritage assessment needs to consider both tangible and intangible values. Best practice assessment in relation to Indigenous heritage values should integrate consultation and landscape assessment with the examination of physical remains of past Indigenous activity. It is important that the proponent consult with the appropriate authority responsible for indigenous heritage. This should facilitate a process towards indigenous community engagement.

The proponents are encouraged to consult with local indigenous communities to identify particular fauna, flora or ecological communities that may have cultural significance and include these in the ecological assessment.

4 Wind Farm Development Process

4.1 Overview of the development process

In the early stages of the development process, there is a high degree of uncertainty as to whether a proponent will proceed with the development of a particular site. As information becomes available about the local wind resource, environmental impact assessments and community acceptance of the project, this uncertainty begins to diminish. Typically, a proponent will have multiple sites under consideration at once, and will only proceed through to construction and operation of projects once they are confident about making an investment in the particular site and community.

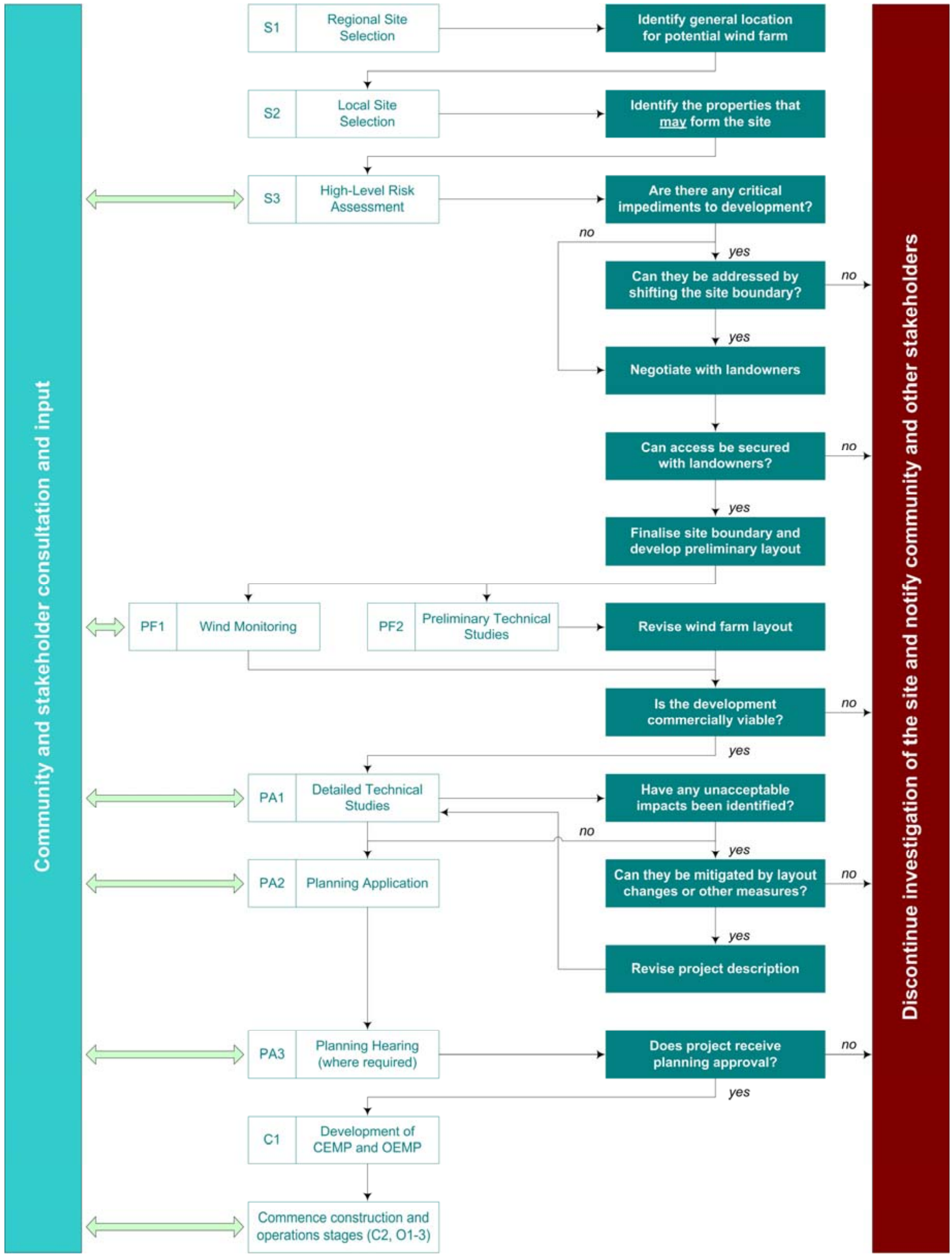
A detailed wind farm development process is contained in Appendix G.

4.1.1 A typical development decision process

No two projects are the same, partly due to their locations; however a typical decision process in the flow chart below is generic to most wind farm developments. The flowchart shows the sub-stages and the decisions and actions associated with each sub-stage. It indicates (in a simplified way) when decisions to progress or discontinue the project are normally made and when community consultation should occur.

It should be noted that progressing a wind farm planning application through these processes is not a guarantee that the wind farm application will be approved by the relevant authority.

Table 4-1
Typical decision process



4.1.2 Typical stages of wind farm development

Table 4-2 below outlines the typical stages of wind farm development, together with a description of the project proponent's objective at each stage.

Table 4-2
Typical stages of development

Project Stage	Project Sub-stages		Purpose
Site Selection	S1	Regional Site Selection	To identify the general locality in which to site a potential wind farm.
	S2	Local Site Identification	To identify the properties that may form the site and identify the possible boundary of the wind farm site.
	S3	High-Level Risk Assessment	To ascertain whether there are any critical impacts that may prevent development at the site, to select a site boundary and negotiate with landowners, and to develop a preliminary wind farm layout.
Project Feasibility	PF1	Wind Monitoring	To confirm the wind resource at the site in order to decide whether the site is worth pursuing commercially.
	PF2	Preliminary Technical Studies	To provide initial site-specific data that will enable refinement of the wind farm layout.
Planning Approval	PA1	Detailed Technical Studies	To provide detailed site-specific data to enable optimisation of the project layout and assess the impacts of the project.
	PA2	Planning Application	To present the proposed project and its impacts in a form suitable for assessment by the relevant authority and for community information.
	PA3	Planning Assessment (if applicable)	To present the planning application to the appropriate relevant forum, to respond to queries from the relevant authorities and inform the community.
Construction	C1	Development of Construction & Operation Environmental Management Plans	To ensure health, safety and environmental management plans (and associated documentation) address the conditions of project approval prior to commencement of construction.
	C2	Construction	To undertake construction of the wind farm in accordance with the planning permit, management plans and associated documentation.
Operation	O1	Operation	To undertake the operation of the wind farm in accordance with any operational conditions of the planning permit.
	O2	Monitoring (Compliance)	To undertake studies to confirm that the operation of the wind farm complies with any planning permit conditions.
	O3	Monitoring (Confirmation)	To undertake studies to confirm that assumptions in the planning application are tested and, if necessary, to modify the operation of the wind farm where actual conditions differ from those assumed in the planning application.
Decommissioning	D1	Decommissioning Decision	To assess the feasibility of decommissioning or redeveloping the site.
	D2	Decommissioning	To undertake studies to confirm that the wind farm can be decommissioned in accordance with any planning permit conditions, and to decommission the wind farm.
	D3	Redevelopment(if relevant)	To undertake the necessary studies required to submit a new project for a new planning application (feeding back into the process at sub-stage PA1)

Key: Uncertainty as to whether project will proceed at the site or that the site will be redeveloped

High uncertainty	Moderate uncertainty	Low uncertainty

The studies and community consultation undertaken at each stage should focus on addressing specific issues that may arise before proceeding to the next stage.

The stages in the table have been colour-coded to reflect the level of commitment and investment the proponent is willing to make at that stage of the project.

- purple - being a high level of uncertainty that the project will proceed
- amber - being a moderate level of uncertainty
- green - being a low level of uncertainty.

Whilst these are presented as distinct stages, there is also likely to be some overlap between stages depending on the processes adopted by the proponent, and issues surrounding the specific project, local planning provisions and processes, and the proponent's timeframe for progressing its development portfolio.

4.1.3 Site selection

Regional site selection

Regional site selection normally involves a desktop study focussing on the wind resource, generally by checking national or state wind atlases and proximity to an adequate electricity network.

Major incompatible land use activities, such as urban areas, national parks, culturally significant sites, sensitive ecosystems and habitats (among others), should be avoided at this stage.

Some states/regions have policy initiatives to assist wind farm developments and may have produced wind atlases and guides to help identify potential areas for wind development. Refer to the relevant state or territory agency to source these tools.

Local site identification

Assessment of property-specific locations within identified wind resource areas includes factors such as the geography and topography of the site, the size of the properties and the proximity to electrical and road networks. The local site assessment provides an indication of how many wind turbines and of what size may be possible. This also forms the basis for a broad economic analysis.

As a number of wind farm sites may have been developed, be under construction or approved in the area it is important to consider the greater potential for cumulative impacts to increase community interest and add competition for network access.

Local site identification can mostly be done via a desktop study. A visit to the area to better understand site characteristics, road quality, power lines, and the general location of houses should be done as a final check to decide whether to proceed to the next stage.

The final step is identifying properties that should be considered further in the high-level risk assessment to ascertain possible boundaries and a preliminary layout for detailed investigation and discussion with the landowners and community.

Preparation of a preliminary communication and consultation Plan, to support the activities for the high level risk assessment process should commence at this time. The Plan may include discussion with the local planning authority in order to obtain further background information on the site/s investigated. This can assist in determining the appropriateness of the site/s for wind farm development.

High-level risk assessment

At this stage the assessment is designed to provide a high-level, preliminary overview of any possible critical impacts that may prevent the development from proceeding.

An overview of the major issues of the site the relevant approvals context should be mapped out identifying what consents/permits are likely to be required at:

- Commonwealth level - through the operation of the *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)*.
- State/Territory level - legislation (some states have an assessment threshold in terms of energy generation capacity).
- Local level - through the local planning/development processes (often containing triggers related to matters differing from the state assessment process).

This stage should map the stakeholders, processes and timeframes for the planning requirements and assessment processes identified in discussions with the relevant authorities.

The outcome of this process is to identify an initial group of landowners who may be approached regarding land access, wind monitoring and options for longer term land use. Negotiations with landowners should commence in accordance with the preliminary Communication and Consultation Plan. Drafting the detailed Project Communication and Consultation Plan, outlining the objectives of the consultation program for the development stages should commence at this stage.

Initial communications with the broader community should follow the risk assessment process, site investigations and landholder negotiations. This should occur through a formal announcement in numerous publicly accessible forums of intentions to progress detailed wind farm development investigations.

A Community and Stakeholder Consultation

A.1 Introduction

This appendix addresses stakeholder participation in the wind farm development process.

The coordination and delivery of stakeholder participation activities is the responsibility of the wind farm developer. This technical appendix provides a methodology to wind farm developers which outlines the recommended standards and requirements for stakeholder participation in each stage of development. It is important that stakeholder participation activities are tailored to the specific circumstances of a proposed wind farm development, including the nature and interests of relevant stakeholders, as well as the scale and location of the development. In this context, the methodology presented in this document should not be viewed as prescriptive, and instead used as a starting point to guide the development of a stakeholder participation approach tailored to individual circumstances.

The recommended methodology in this guideline describes:

- Principles which should be employed by wind farm developers when planning and delivering participation activities.
- Considerations for planning stakeholder participation programs, including preparing and delivering Communication and Consultation Plans and making an early commitment to stakeholder participation in the development process.
- A recommended methodology for planning and delivering stakeholder participation activities associated with the various stages of a wind farm's development.
- Recommendations for stakeholder input into the assessment and management of key technical study areas (i.e. noise, landscape, birds and bats, shadow flicker and electromagnetic interference).

A.1.1 What is a "Stakeholder"?

This methodology uses the term Stakeholder to describe any individual, business or group who may live or work in proximity to a wind farm, or who may have an interest or association with a wind farm development or its potential impacts. Stakeholders may include community members (including the Aboriginal community), statutory and non-statutory agencies, businesses and organisations.

A.1.2 How can stakeholders use this appendix?

Whilst this methodology has been prepared to provide guidance to wind farm developers on planning and delivering stakeholder participation opportunities, it can also act as a tool for stakeholders to understand:

- When participation in a wind farm development may commence and occur
- How participation may occur
- What developers should consider in supporting stakeholder participation in the wind farm development process

For a quick overview of what planning and consultation activities may occur during various stages of development refer to Figure A-2.

A.2 Background

Stakeholder consultation has become a critical process in the development of wind farms in Australia and throughout the world. The visible nature of wind farms has resulted in a high degree of scrutiny from local communities and interest groups. As such, stakeholders have become increasingly involved during the design and approval process phases of wind farm projects in Australia.

Stakeholder participation in the wind farm development process can facilitate:

- Responsible wind farm design,
- The incorporation of stakeholder feedback in to project design and development,
- Identification and management of potential impacts,
- Identification and enhancement of potential benefits and opportunities,
- Education and awareness, particularly in relation to expected impacts.

In Australia, the coordination and delivery of stakeholder participation activities are largely the responsibility of the wind farm developer.

Establishing a dialogue with stakeholders and ensuring their input into the planning and development process, can assist developers in delivering a socially responsible wind farm which contributes positively to the community in which it is located.

A.3 Principles of stakeholder participation for wind farm developments

The following principles are taken from the Australian Wind Energy Association's (now Clean Energy Council) *Best Practice Guidelines for Implementation of Wind Energy Projects in Australia* (2006). The five principles outlined below provide a framework for wind energy developers on how to prepare and conduct good practice stakeholder participation activities.

Wind farm developers should be able to demonstrate that the stakeholder participation activities they have conducted were done in a manner which reflects the intent of these five principles.

- **Focus**
  - The type of consultation methods chosen should be appropriate for the task.
  - There is a clear statement about what the consultation aims to achieve.
  - There is a clear statement about the role of the proponent and the role of participants in the consultation.
  - The proponent should focus consultation activities to ensure robust and effective input into its decision-making process.
  - There is appropriate internal coordination and resources to achieve consultation objectives.
- **Inclusive**
  - The proponent should actively seek out people/groups for consultation.
  - The way that consultation is set up and implemented encourages the participation of people who are affected by or interested in a decision.
  - Groups and individuals that are affected by or interested in the decision should be given opportunity to participate in the consultation.
  - The type of consultation or engagement should be sensitive to the needs of individuals and groups to maximise their ability to contribute.

- **Responsive**
  - There is a commitment to consider views and respond to participants.
  - Consultation should be transparent. All people involved should have a clear understanding of how their feedback and comments are to be used.
  - The proponent should maintain openness during the consultation process and be willing to consider new ideas.
  - There is respect for the diverse range of interests that may be represented during a consultation.
  - All reasonable attempts should be made to resolve conflicts.
- **Open and transparent provision of information**
  - Information relating to the consultation program should be readily available to allow participants to make informed and timely contributions.
  - Information relating to the consultation process can be accessed easily by those involved before key decisions are made.
  - Relevant information should be presented in an easily understood/appropriate level format.
  - Confidential or commercial details about an issue may not be disclosed to the public.
  - Clear expectations and responsibilities should be set for the provision and management of information, including issues around commercial-sensitivity of some information.
- **Timely feedback and evaluation**
  - Participants should receive timely feedback about the outcomes of the consultation, and how the final decisions regarding design were reached.
  - If a difference occurs between the inputs into the consultation and the final decision, the reasons for this should be clearly documented. The consultation process should be documented to provide:
    - Clear evidence of the activities that were undertaken
    - The input that was received
    - The decisions that were made.

In addition to these five principles, wind farm developers should also be prepared to acknowledge uncertainties in the development process where they exist. Furthermore, it may benefit some developers to obtain professional advice and assistance from an experienced community consultation practitioner when preparing and delivering activities to ensure the sensitive management of community and stakeholder issues, and to maximise the effectiveness of participation activities.

A.4 Planning for stakeholder participation

A.4.1 Commitment to level of stakeholder participation

Developers are encouraged to make a commitment to the level of stakeholder participation that should occur in the development process, prior to the commencement of engagement activities.

This commitment should be clearly communicated to stakeholders, so that they may have a clear understanding of their ability to contribute to the planning, design and delivery of the wind farm project.

The International Association of Public Participation (IAP2) Spectrum of Public Participation provides an overview of the various levels of community engagement that can be employed on a project or development. This spectrum is provided in Figure A-1 with additional information on how it may be applied to wind farm developments.

Wind farm developers are encouraged to use this spectrum as a guide when planning and preparing community participation activities.

At a minimum wind farm developers should CONSULT with stakeholders and the local community at some stage throughout the development process. However, it is acknowledged that the level of community participation may vary, depending on the unique characteristics of a project (e.g. size, location, relevant stakeholders).

A recommended level of overall community participation associated with each stage of the wind farm development process has been outlined below (See Public Participation Goals in Figure A-1 for definitions):

- Site Selection **INFORM**
- Project Feasibility **CONSULT**
- Planning Application **INVOLVE**
- Construction **CONSULT**
- Operation **CONSULT**
- Decommissioning **INVOLVE**

Figure A-1
IAP2 Public Participation Spectrum[3] and Application to Wind Farm Developments

Levels of Participation: :	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Participation Goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions	To obtain public feedback on analysis, alternatives and/or decisions	To work directly with the public through-out the process to ensure that public concerns and aspirations are consistently understood and considered	To partner with the public in each aspect of the decision including the development of alternatives and identification of the preferred solution	To place final decision-making in the hands of the public
Promise from wind farm developer to the community	We will keep you informed	We will keep you informed, listen to and acknowledge your concerns and provide feedback on how public input influenced the decision	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible	We will implement what you decide
Example techniques	▪ Fact Sheets ▪ Web Sites ▪ Newsletters	▪ Community Information Session ▪ Surveys ▪ Public Comment	▪ Workshops ▪ Community Reference Group ▪ Deliberative polling	▪ Participatory decision making processes	
Spectrum level recommended for stages of wind farm development	▪ Site Selection	▪Project Feasibility ▪ Construction ▪ Operation	▪Planning Application ▪Decommissioning		

These recommended participation levels are indicative only, and may differ with each stakeholder participation activity. Similarly, certain projects may require a higher or lower level of participation than that outlined, during a particular stage.

A.4.2 Familiarisation with locality and identification of stakeholders

The Community and Consultation Plan/s should be prepared in a manner which is tailored to the needs and desires of the stakeholders which it aims to engage.

Conducting desktop social research on the demographics of the local community should enhance the effectiveness of the plan. In particular, consideration of the size of the local community, industries and land use types, population trends (resident/transient) and the history of development in the area should be taken into account. This research can also assist in identifying groups or individuals who may have an interest/association with the development.

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[3] International Association of Public Participation (2007) *IAP2 Foundations of Public Participation*, International Association of Public Particioaruib www.iap2.org

This Stakeholder identification process is critical to the development of a Communication and Consultation Plan.

The practice note in Section A.8.1 provides a list of common stakeholder types associated with wind farm developments, and stages in the development process where consultation with each stakeholder type may be required. The list is not exhaustive, and care should be taken to ensure that stakeholders relevant to the development are identified.

Stakeholders will differ considerably between wind farm projects, and depending on the size and location of the wind farm, or interest of individuals/groups to be involved, and consultation should be tailored accordingly.

It is also likely that during the implementation of the Communication and Consultation Plan/s new stakeholders may become known. Similarly, stakeholders identified at the commencement of the development process may change or no longer exist. The Communication and Consultation Plan/s should be updated to reflect these changes at the identified review points or as required.

Consultation with local planning authorities

Whether an approving body or not, engaging with the local planning authority is essential at all stages of the wind farm development process.

The local planning authority can:

- Provide developers with background information on the local area and community.
- Provide planning advice for management of matters relating to a wind farm development, including necessary permits and approvals
- Facilitate the dissemination of project information to the local community (i.e. notification of community participation events)
- Identify potential opportunities to maximise community benefits from the development.

The extent to which the local planning authority is involved in the development process will be strengthened by ensuring that open, honest and timely dialogue between the developer and the local authority occurs wherever possible.

However, where the local planning authority is also the approving body, a developer should ensure that all statutory regulations and protocols with respect to communication between the development proponent and the approving authority are followed.

Seeking input from the local authority when preparing the Communication and Consultation Plan/s can be a useful way to define the ongoing role, objectives and frequency of local authority participation in the development process.

A.4.3 The Communications and Consultation Plan

Developing the Plan

Once a commitment to the level of stakeholder engagement has been made and stakeholders have been identified, the plan can be written.

It is important to note that, at times, the lengthy nature of various wind farm development stages may require the preparation of multiple Communication and Consultation Plans to ensure that the plan remains current and up to date. This may particularly be the case for large scale wind developments (generally over 30 MW), which usually require a greater level of investigation and can be subject to both State and Commonwealth approval processes.

The plan/s should clearly outline the community participation requirements/activities for each stage of the wind farm development process. A breakdown of the planning and consultation tasks likely to be associated with each stage is outlined in Section A.6.

Specific components which should be included in the Communication and Consultation Plan are:

- The objectives of the stakeholder participation program
- A list of identified stakeholders
- Tools/methods which should be used to engage specific stakeholders
- Tools/methods used to provide information to stakeholders
- Responsibilities for delivery
- Frequency or timeframes for delivery of tools/methods
- Avenues for responding to queries (including email, 1800 number, etc)
- Main contact persons
- How activities, feedback and outcomes should be recorded, used and disseminated.

Developers may wish to consider conducting a brief survey, or consult with key stakeholders, to determine preferred consultation methods and frequency.

Revising and amending the Plan

At a minimum, the Communication and Consultation Plan/s should be revised, amended and updated prior to progressing to each new stage of development. However, developers are encouraged to build in a more frequent review cycle to ensure the stakeholder participation program remains relevant and responsive to the needs of the local community and other stakeholders.

Incorporating stakeholder feedback mechanisms (such as comment forms, satisfaction surveys, etc) can be a useful tool to assess the qualitative aspects of the consultation process, or for determining preferred consultation methods.

Similarly, monitoring the number and nature of stakeholder enquiries about the project, via web site hits, media articles and the likes, can be useful in assessing stakeholder interest in the proposal.

Implementing the Plan

The project delivery team, which may, depending on circumstances, include a dedicated community engagement manager or coordinator, is responsible for coordinating the delivery of the activities in the consultation plan/s.

When implementing the actions outlined in the Communication and Consultation Plan, it is important that all team members behave in a manner which is in line with the principles outlined in Section A.3.

A.5 Stakeholder participation methodology (by project stage)

Figure A-2 provides an overview of the processes associated with stakeholder participation activities for each stage of a wind farm's development[4].

These activities have been broken up into three categories:

- **Planning:** Preparatory actions for stakeholder participation activities
- **Consultation:** Actions and activities conducted at various stages (including key consultation milestones associated with each stage)

[4] Figure B-2 was prepared using the typical processes employed for a large-scale wind farm development within Australia as a model. The process may vary slightly for wind farm developments of varying scale or purpose.

- **Technical Area Stakeholder Inputs:** Identifies where stakeholder input is required to complete/inform key technical study area assessments.

Further information on stakeholder inputs associated with individual technical study areas (e.g. noise, landscape, birds and bats, shadow flicker and electromagnetic interference) is provided in the Technical Appendices of these Guidelines. Direct references to these appendices are provided in this Section.

It is important to note that regular updates to stakeholders on the wind farm development and its progress should be provided at all stages of development. Information on the various technical investigations that are conducted, and their outcomes, should be included in these updates.

A.6 Development stages and tasks

A.6.1 Site Selection

Planning & Consultation

Developers are encouraged to conduct background research on the region or local area investigated. Specifically, data on relevant stakeholders and any existing stakeholder forums, recent development proposals in the area and issues raised with those developments and the success or otherwise of other community consultation activities in the area, should be considered. This information can assist in tailoring a consultation approach that is both relevant to potential stakeholders and reflective of issues that are important to them.

Once a specific location has been identified, further research on the landowners (both potential host landowners and neighbours) and the existing usage of the land should be conducted.

When a proposed site has been identified, it is recommended that a preliminary Communication & Consultation Plan is prepared. The purpose of this plan is to:

- Identify stakeholders with whom dialogue should be initiated (for example, the local planning authority, potential wind farm site landowners and immediate neighbours).
- Detail how these discussion should be undertaken (how, when, by whom).
- Detail how project team members should respond if they receive community or media enquiries on investigations being conducted.

For smaller developments, this plan may be used for the duration of the project's development (with revision and updates at the end of each stage). For larger projects it is recommended that this plan outline the requirements for the project feasibility, or project feasibility and planning application phase (depending on duration) only. This plan should be prepared using Section A.4.3 as a guide.

It is recommended that dialogue with a representative of the local planning authority commences (through a meeting with a planner or similar) as soon as possible in the site selection phase. The local planning authority can be a useful source of background information on the local area and community. This information can be used in the development and refinement of the Communication & Consultation Plan and later to inform the decision to progress with the next phase of development (Project Feasibility). Please note that this task is suggested regardless of whether the local planning authority would be the approval body for the wind farm.

Figure A-2
Example of Good Practice Stakeholder Participation Methodology by Project Stage

Stage	Step	PLANNING	CONSULTATION	TECHNICAL AREA STAKEHOLDER INPUTS
Site Selection	S1 – Site Selection (Regional)	Conduct background information on local area, including wind development history (if any)		
	S2 – Site Selection (Local)	Prepare a preliminary Communication & Consultation (C&C) Plan (to accompany site selection investigations only)	Discussion with local council may commence to obtain background information on site	
	S3 – High Level Risk Assessment	Prepare Project Communication & Consultation Plan (to be implemented at next stage, if decision to progress investigations occurs)	Implement Project C&C Plan **Key milestones:** *- Commence discussions with potential project landowners* *- Announce investigations to wider community (if decision to progress investigations occurs)*	**Birds & Bats:** Information sought from relevant government agencies (federal/state/local) **Landscape:** Information and advice sought from local planning authority on community landscape values
Project Feasibility	PF1 – Wind Monitoring		Implement Project C&C Plan **Key milestones:** *- Establishing dialogue with identified stakeholders* *- Inform stakeholders of project details and progress* *- Consult with stakeholders to receive feedback and input*	**Noise:** Noise loggers placed on identified stakeholder properties **Birds & Bats:** Site information sought from Project Landowners and naturalist/bird observer groups **Landscape:** Further info on landscape values sought from local planning authority, and identified local community members/groups
	PF2 – Preliminary Technical Studies	Review feedback received from community & stakeholders. Incorporate and/or consider feedback prior to progressing to planning application		
Planning Application	PA1 – Detailed Technical Studies	Review and revise Project C&C Plan where necessary	Continue to implement Project C&C Plan **Key milestones:** *- Continue seeking feedback and input from stakeholders to understand concerns and opinions and where possible, incorporate into project design* *- Community Information Events*	**Noise:** Provide background noise results to stakeholders (see PF2) **Landscape: :** Significant local community input sought to identify landscape values, potential impacts and mitigation measures **EMI:** Consultation with potentially affected agencies/organisations (ie. Department of Defence. Air Services Australia, Bureau of Meteorology Telecommunications Carriers). Incorporate any concerns raised via project wide stakeholder consultation
	PA2 – Planning Application	Review feedback received from stakeholders and consider / incorporate into design where possible. Prepare Report of consultation conducted to date & outcomes		
	PA3 – Planning Hearings	Provide assistance with coordination of Planning Application Submission & Hearing with approval body, where required	Inform stakeholders of PA lodgement and public hearings. Facilitate community involvement in hearing process.	
Construction	C1 – Finalisation of Management Plans	Review and revise Project C&C Plan. Ensure inclusion of complaints handling process	Implement revised Project C&C Plan **Key milestones:** *- Seek input from stakeholders in final design plans*	**Noise & Shadow Flicker :** Develop complaints handling process **EMI:** Regular consultation with potentially affected stakeholders (agencies, organisations and local community) to identify impacts
	C2 – Construction	Coordinate appropriate signage and public information access points (ie. web, local buildings)	Continue to implement Project C&C Plan **Key Milestone:** *- Communicating construction activities*	**Noise:** Loggers placed at identified stakeholder properties to conduct noise monitoring **Landscape:** Consult with affected parties regarding mitigation
Operation	O1 – Operation	Prepare Operational C&C Plan. Ensure inclusion of Enquiry/ Complaints response process Consider opportunities for community access to facility	Implement Operational C&C Plan **Key Milestone:** *- Announce commencement of wind farm operation* *- Communicating outcomes of monitoring*	**EMI:** Consult with affected stakeholders regarding mitigation (if impacts observed) **Shadow Flicker:** Consult with affected stakeholders regarding mitigation
	O2 - Monitoring (Compliance)			**Birds & Bats:** Reporting to relevant government agencies
	O3 – Monitoring (Confirmation)			**EMI:** Monitor mitigation with affected parties **Shadow Flicker:** Monitor mitigation efficacy with affected stakeholders
Decommiss-ioning	D1- Decision D2 - Decommiss-ioning D3-Redevelopment	Prepare Decommissioning C&C Plan. Consider opportunities for community involvement in rehabilitation	Implement Decommissioning C&C Plan	**EMI:** Consider history of complaints/ impacts to stakeholders (if any) when decommissioning or redeveloping site

Technical Area Community Inputs

At the high-level risk assessment sub-stage, agencies and local bird and bat interest groups (e.g. field naturalists, Birds Australia) may be approached to gather background data to inform the bird and bat risk assessment. Similarly, information may be sought from the local planning authority to inform the landscape high-level risk assessment.

Further detail on technical area community inputs can be found in landscape and birds and bats appendices.

A.6.2 Project Feasibility

Planning & Consultation

The Project Communication and Consultation Plan should be enacted at the start of this stage. Continued consultation with the local planning authority during this phase of the project is recommended, as a resource to assist in identifying and engaging with key stakeholders.

A key focus of consultation efforts during this stage should be establishing dialogue and ongoing relationships with key project stakeholders, such as neighbouring landowners and local community groups. Understanding the position and/or concerns of key stakeholders will assist in identifying potential, opportunities issues or constraints to be considered when preparing the preliminary project design parameters (including the proposed turbine layout). These design parameters should then be used as the basis for detailed technical assessment in the Planning Application stage.

Technical Area Community Inputs

When conducting preliminary noise studies, it may be necessary to place noise monitoring loggers on project landowner and neighbouring landowner properties. Bird and bat specialists may also seek site information directly from signed landowners to inform their assessment.

Further input and involvement in the assessment process should be sought from the local planning authority to inform the landscape feasibility assessment.

Further detail on technical area community inputs can be found under noise (page 50), landscape (pages 76 and 80), birds and bats (page 120-125) and electromagnetic interference (page 172-177).

A.6.3 Planning Application

Planning & Consultation

Once a decision has been made to progress to the Planning Application stage, it is prudent to review and revise the Communication & Consultation Plan to ensure that it is relevant and applicable for the next phase of development. Refer to Section A.4 for further detail on reviewing the plan.

Updates on the progress of technical investigations and details of the planning application process should be provided to the stakeholders at regular intervals, and seeking further input and feedback from stakeholders when conducting detailed technical assessment process is essential.

This should generally occur through face to face meetings, but it is recommended that a community event, such as a community information session, is held to allow the local community to view information on the project and talk directly with project representatives. The planning of this event should consider maximum opportunities for community attendance, and therefore be time and place appropriate. Discussion with a local community member may assist in ensuring this is planned in an appropriate manner (for example, what facilities are best? Is there any seasonal work which may affect attendance, for instance harvests, etc?).

Recording the occurrence and outcome of consultation activities is necessary at all stages; however, an output of this stage could be a consultation report or chapter in the planning application document which should outline:

- Parties consulted
- Consultation activities undertaken
- Nature of feedback
- Key outcomes of consultation (i.e. design amendments).

Once the planning application has been lodged, the relevant authority may require[5] that the wind farm developer, in addition to any statutory public exhibition and consultation requirements, ensure that the community and stakeholders are:

- Aware of the planning application lodgement
- Provided details on how to view the documentation
- Provided details on opportunities to comment on the documentation.

The duration and manner in which statutory public comment can occur will be determined and coordinated by the relevant authority, under the planning legislation requirements of the relevant jurisdiction. Despite this, it remains the responsibility of the developer to ensure that the community and stakeholders are given adequate access to associated documentation and notice of the planning application lodgement. This is required to facilitate community input in the planning assessment process.

Technical Area Community Inputs

A number of opportunities may be available for local community members to be involved in the landscape assessment process. Identification and description of community landscape values and key views, description of potential visual and landscape impacts, and development of mitigation measures should benefit from input from key community stakeholders (particularly those within close proximity to the site).

Dialogue with potentially affected stakeholder agencies may be initiated for the electromagnetic interference assessment. These stakeholders may include agencies such as the Bureau of Meteorology, Department of Defence, telecommunication companies and Air Services Australia.

Furthermore, noise and shadow flicker results should be communicated to relevant stakeholders. Specifically, the outcomes of background noise monitoring should be provided to stakeholders who hosted noise loggers on their property (at a minimum). Noise and shadow flicker compliance with necessary guidelines should be determined at this stage, and the opportunity should be provided for neighbouring landowners to comment further on any identified impacts.

Further detail on technical area community inputs can be found under noise (page 54), landscape (pages 82-86 and 88), birds and bats (page 125) and electromagnetic interference (page 177-179).

A.6.4 Construction

Planning & Consultation

Once again review and revision of the detailed Communication & Consultation Plan, or preparation of a new plan, should be undertaken at the beginning of this phase. This plan should identify construction activity notification measures and handling processes for complaints and enquiries.

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5 This is at the discretion of the approving body, based on the relevant statutory requirements within the relevant state or local government jurisdiction.

It is recommended that the enquiries and complaints handling process is designed to ensure timely response from the developer to all complaints, and clearly defines lines of responsibility for responding to enquiries and complaints. All enquiries, complaints and responses should be logged in an appropriate database.

When finalising construction management plans following project approval, and importantly in accordance with any approval conditions, it is important to conduct further consultation with key stakeholders on matters such as the final turbine layout (micrositing of individual wind turbines), management of site access and the movement of materials during construction.

Once construction has commenced communication of activities and ensuring timely response to enquiries and complaints should be the focus of consultation activities.

Technical Area Community Inputs

As part of the complaints handling process, a response for dealing with noise and shadow flicker complaints should be prepared. Noise monitoring should also be undertaken at key stakeholder properties during the construction process to ensure compliance with guidelines or associated approval conditions.

Prior to the completion of the construction phase, specific landscape mitigation requirements may be implemented in consultation with affected stakeholders. Feedback on the effectiveness of mitigation measures could be sought from affected stakeholders and amendments made where necessary.

Further detail on technical area community inputs can be found under noise (page 56) and electromagnetic interference (page 180).

A.6.5 Operation

Planning & Consultation

A Communication & Consultation Plan should be prepared for the operations stage. The objectives and actions outlined in this plan will probably vary considerably from earlier plans; however, the plan should still be developed in consideration of Section A.4.3.

This plan should clearly outline the enquiries and complaints handling process, and it may also outline opportunities for community access to the wind facility (i.e. tours, open days, etc).

Reviewing the communication and consultation requirements for the wind farm during operation should occur at least annually. Refer to Section A.4.3 for further detail on reviewing the plan.

Technical Area Community Inputs

Monitoring of impacts from the wind farm should be ongoing, ensuring mitigation measures implemented for noise, birds/bats, electromagnetic interference and shadow flicker may be necessary once operation has commenced. Communicating the outcomes of monitoring to the community and stakeholders is recommended.

Reporting to relevant authorities on compliance with conditions will also be required at this stage. It is also important for the wind farm developer to engage with the local planning authority in this phase of the development in relation to any community enhancement contributions or works that may be offered or required as part of the development.

Further detail on technical area community inputs can be found under noise (page 56), shadow flicker (page 155) and electromagnetic interference (page 180).

A.6.6 Decommissioning

Planning & Consultation

The decommissioning of a wind farm project should occur in consultation with project stakeholders. As this will occur many years after construction it is likely that there will have been changes to the makeup of the local community and local area itself. As such, new stakeholders should be identified and the rehabilitation requirements should be cognisant of any changes which may have occurred in the area. Community involvement in assessing rehabilitation requirements is recommended.

Technical Area Community Inputs

It will be necessary to once again determine impacts and mitigation measures associated with landscape and EMI when decommissioning or rehabilitating the site.

A.7 Cumulative Impacts

The cumulative impact of multiple wind farm facilities in a region is likely to become an increasingly important issue for wind farm developments in Australia.

Where multiple wind farm proposals exist in close proximity to the wind farm project under development, the following items should be considered:

- The local community are likely to be familiar with the potential impacts of a wind farm in their region. As such the nature of enquiries may be different to that of a community who have little knowledge or experience of operating wind farms. Community participation activities should be developed cognisant of this fact, and adequate resources for dealing with these queries should be available (for example, the presence of technical experts at community information events).
- The local community may be "fatigued" with community engagement processes. In other words, an abundance of community meetings, information sessions or materials about various developments, may result in community members tiring of attending local events or engaging in local discussions or activities. Consolidating communication and consultation activities with other developers may be beneficial, or developers may wish to consider using alternative methods for engaging the local community. Whilst always encouraged, it may be particularly prudent to ask key stakeholders the method and frequency of consultation they prefer and tailor the consultation plan to meet their requirements.
- Developers should maintain a dialogue with other wind farm developers in the region to ensure that consultation and/or development activities are planned cognisant of each other, and opportunities for collaboration between developers could be explored. Such an approach is encouraged in order to limit the risk of consultation "fatigue" and subsequent disengagement from the process by the community and key stakeholders, which would be to the detriment of both developers.

A.8 Practice notes

A.8.1 Stakeholder Identification Checklist

The checklist presented in Table A-1 is indicative only.

When preparing the Communication and Consultation Plan/s, the relevance of these stakeholders to the individual wind farm development, and the stages when consultation with these stakeholders may be required, will vary considerably between projects.

Furthermore, this list is not exhaustive; stakeholder types who are not listed in this table may also be present and developers should conduct further investigations to identify these.

Table A-1
Potential stakeholders and the development stages where consultation with them may be required

Potential Stakeholders	Consultation ✓ = May be required, * = Optional					
	Site Selection	Project Feasibility	Planning Application	Constructio n	Operation	Decommiss ioning
Local Community Members						
Signed Landowners (i.e. hosting turbines or infrastructure)	✓	✓	✓	✓	✓	✓
Neighbouring Landowners (i.e. within 1-3kms of site)	*	✓	✓	✓	✓	✓
Nearby Landowners (i.e. from 3-10kms from site)		✓	✓	✓	✓	✓
Local community (i.e. Broader regional community, nearby townships, etc)		✓	✓	✓	✓	✓
Traditional landowners	*	✓	✓	✓	✓	✓
Local Community Groups (Recreational, Environmental, Interest, etc)						
Landcare		✓	✓	✓	✓	✓
Field Naturalist		✓	✓	✓	✓	✓
Bird Watching Club		✓	✓	✓	✓	✓
Environment Council / Conservation Society		✓	✓	✓	✓	✓
Sustainability Group / Co-op		✓	✓	✓	✓	*
Historical / Preservation Society		✓	✓	✓	*	✓
Friends of Groups		✓	✓	✓	*	*
Tourism Association		✓	✓	✓	✓	✓
Chamber of Commerce /Business or Economic Development Group		✓	✓	✓	✓	✓
Sporting Clubs (Football, etc)		✓	✓	✓	*	
Sporting or hobby groups which may use site (i.e. Mountain Biking, Bushwalking, Hang-gliding)		✓	✓	✓	✓	✓
Local aviation operators		✓	✓	✓	✓	✓
Landscape Guardians		✓	✓	✓	*	*
Anti-Development Groups		✓	✓	✓	*	*
Residents Association		✓	✓	✓	✓	✓
Local Service Providers / Emergency Organisations						
Local Tourism Business Operators (i.e. Pub/Hotel, Bed & Breakfast Operators, Winery, etc)		✓	✓	✓	✓	✓
Other Local Businesses (i.e. Tradesman, Catering, Post Office, etc)		✓	✓	✓	✓	✓
Country Fire Authority (or similar)		✓	✓	✓	✓	✓
Local Agencies						
Local Council	✓	✓	✓	✓	✓	✓

Potential Stakeholders	Consultation ✓ = May be required, * = Optional					
	Site Selection	Project Feasibility	Planning Application	Constructio n	Operation	Decommiss ioning
Neighbouring Council		*	✓	*	✓	*
Aviation and defence organisations and regulators	✓	✓	✓	✓	✓	*
Catchment Management Authority (or similar)			*			
State Agencies & Regulators						
Dept of Environment (or similar)		✓	✓	✓	*	✓
Dept of Planning (or similar)		✓	✓	✓	*	✓
Dept of Energy / Infrastructure (or similar)		*	✓	✓	*	✓
Dept of Indigenous Affairs (or similar)		✓	✓	✓	*	✓
Dept of Tourism & I industry (or similar)		*	✓	✓	*	✓
Environment Protection Authority (or similar)		*	✓	✓	*	✓
Native Vegetation Council (or similar)		✓	✓	✓	*	✓
Federal Agencies & Regulars						
Dept of Environment, Water, Heritage and the Arts			✓	✓	✓	✓
Dept of Defence (or similar)			✓	✓	*	✓
Civil Aviation Safety Authority		✓	✓	✓	✓	✓
Essential Services Commission		*	*	*	*	*
Electricity Network & Regulators						
Network Service Providers (i.e. Transmission or Distribution Company, Electrical Utility, Small Grid Operator, etc)		✓	✓	✓	✓	✓
Australian Energy Market Operator (AEMO; formerly NEMMCO)			✓	✓	✓	✓
Australian Energy Market Commission			✓	✓	✓	✓
Office of the Energy Regulator (or similar)			✓	✓	✓	✓
Electricity Retailer				✓	✓	✓
Media						
Newspapers (Local, Regional, State, National)		✓	✓	✓	✓	✓
Radio (Local, Regional, State, National)		*	*	*	*	*
Television Outlets (Regional, State, National)		*	*	*	*	*
Publications (i.e. Local Bulletins, Magazines, etc)		✓	✓	✓	✓	✓

Potential Stakeholders	Consultation ✓ = May be required, * = Optional					
	Site Selection	Project Feasibility	Planning Application	Constructio n	Operation	Decommiss ioning
Industry Lobby Groups						
Clean Energy Council		✓	✓	✓	✓	✓
State Landscape Protection Group			*	*		*
State Sustainability / Environment Protection Group			*	*	*	*

A.9 Glossary & acronyms

Communication	The provision of information to individuals or groups.
Consultation	A two-way information exchange between individuals or groups.
Community	Any resident, landowner, business, community or interest group who has an interest in the development of a wind farm at a particular location from an economic, social or environmental perspective. This may include people that have or might have wind turbines or associated infrastructure on their land, neighbours of the wind farm, non-neighbouring residents within the vicinity of the wind farm, local and other businesses (and their customers), tourists visiting the region, and the broader community outside of the region.
Other Interested Stakeholder	An interested stakeholder is a person, business or organisation who has an interest or association with a wind energy facility development. This interest can often be much narrower than the community, generally focussing on individual issues or groups of issues. Other interested stakeholders may include Government Ministers without planning jurisdiction (e.g. environment and energy ministers), the Bureau of Meteorology (BoM), the Civil Aviation Safety Authority (CASA), Department of Defence, fire authorities, bird observers clubs, and telecommunications businesses. .
Planning Authorities	A planning authority is a government body that has a role in providing a policy framework for wind farm development and for assessing and approving applications for wind farm development. They also have a role post-approval in ensuring developments comply with statutory (legal) requirements and development consent conditions (which may be statutory or non-statutory). Depending on the jurisdiction and the size of the project, the planning authorities involved may include local councils, State or Territory government departments or agencies, and the Commonwealth Department of the Environment, Water, Heritage and the Arts.
Local Planning Authority	See description above. Within this appendix the local planning authority refers to the governing body (local council) of the jurisdiction in which the wind farm project is located.
Project Landowner	An individual who has an agreement with a wind farm developer to host wind turbines or associated components on their land.
Neighbouring Landowner	An individual who owns land adjacent or in proximity to a wind farm development (Generally this refers to landowners within 3kms of a wind farm properties boundary).

B Noise

B.1 Introduction

This Appendix addresses the noise emissions from wind farms. The purpose of the Appendix is both to outline the noise assessment process for wind farm neighbours, including stakeholders, and to provide sufficient detail of relevant issues to assist the wind farm developer with a noise impact assessment for a proposed wind farm.

The aim of the information provided here is to ensure that a fair and robust noise impact assessment is carried out, to a nationally consistent standard. This should provide greater certainty not only to the wind farm developer but also to the wind farm neighbour.

The Australian Standard 4959–2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* is recognised herein and should form the basis for any noise impact assessment. Supplementary guidance is provided to complement the Standard and advise on issues which are outside of its scope but are still pertinent to wind farm noise emission. In particular, guidance is provided to establish noise criteria, and recommendations are made to assist with noise emission prediction modelling. Community consultation is also included in appropriate phases of the assessment process and is expected to be a key component of any wind farm development.

Noise impact assessment is addressed in the following phases:

- Noise impact risk assessment
- Preliminary noise impact assessment
- Noise impact assessment
- Preparation of expert evidence, as required
- Construction noise
- Post-construction noise monitoring
- Decommissioning.

A glossary of technical terminology used throughout this appendix is provided in Section B.6. Unless otherwise stated, all wind speeds in this Appendix are referenced to hub height.

B.2 Recommended Form of Noise Criteria

B.2.1 Basic description of issues addressed in the Guidelines

Wind farm noise emission

What distinguishes wind turbine noise emission from more conventional sources of sound is that it tends to increase with increasing wind speed. AS4959–2010 notes that:

> *... it is a unique characteristic of a WTG* [wind turbine generator] *or wind farm that the noise level from each WTG will increase with increasing wind speed and that the background noise within the ambient noise environment at receivers will generally also increase under these conditions.*

This introduces challenges of measuring and assessing noise emission from wind turbines while concurrently considering the presence of wind effects and other noise sources caused by wind in the environment.

Noise impact assessment

A noise impact assessment of wind farm noise emission should be carried out for any proposed wind farm development in order to manage the effects of the noise emission on the amenity of the surrounding area. AS4959–2010 notes that:

> *... it is necessary to consider the unique noise characteristics of both the wind farm and the noise environment of the area around the actual or proposed wind farm. Wind farms are often proposed for areas with rural characteristics where background noise levels are likely to be low, particularly at wind speeds around the cut-in wind speed of a typical WTG when it begins to generate both electricity and noise.*

Noise criteria

Noise criteria for a proposed wind farm development will be set by the relevant authority. AS4959–2010 states the following regarding the setting of noise criteria:

> *...when setting criteria, the Relevant Regulatory Authority should consider the existing ambient noise environment at receivers around the proposed wind farm and the characteristics of wind turbines noise, so as to provide a satisfactory level of protection of amenity.*

While AS4959–2010 sets assessment methods and a framework for noise level limits it does not explicitly prescribe noise limits. The framework recommended by AS4959–2010 is based on noise level limits which vary with background noise level and wind speed, with a minimum noise level limit to be applied during periods of very low background noise.

To complement the recommendations of AS4959–2010 a summary of existing state and territory noise level limits is provided in these Guidelines.

It must be emphasised that compliance with noise level limits will not amount to inaudibility of the wind farm noise emission. Wind farm noise emission will be audible in the surrounding area, including at wind farm neighbours, for periods of time.

These guidelines recommend that certain audible characteristics be assessed as part of the wind farm development but only tonality is assessed at the pre-construction phase. Other characteristics are assessed at the post construction phase. As this poses a risk to an operator it is recommended that a 5 decibel penalty be added automatically to the predicted level of a wind farm to provide certainty and a safety margin in the event that these unpredicted audible characteristics are found at the compliance monitoring stage.

Wind monitoring

To establish how noise level limits should vary with wind speed, it is necessary to monitor background noise levels at relevant receivers in conjunction with collection of wind speed data from the proposed wind farm site.

In accordance with AS4959–2010, this document references all wind speeds to hub height. Similarly, all wind speeds measured on site should be referenced to hub height.

Some guidance documents for wind turbine noise emission (in particular IEC 61400-11: 2006 *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques*), reference wind speeds to a height of 10m above ground level (AGL).

In comparison with a 10m AGL reference, a hub height reference provides for identification of the presence of atmospheric stability and wind shear as it affects the relationship of noise emission levels and background sound levels for the wind farm assessment. A broader discussion of wind shear effects is included in Section B.7.

Also background noise levels at receivers may change significantly with wind direction. For example, where a breeze blows from the coast towards a costal property it may result in relatively higher background noise levels due to the downwind propagation of breaking wave/ocean sound, while a breeze blowing from the property to the ocean may result in the converse. These Guidelines recommend that analysis of wind direction effects on background noise level be carried out as part of the noise impact assessment.

Noise Characteristics

Some industrial noise emissions contain characteristics that may make the noise more annoying: tonality (humming, whining), modulation (regular variation in noise level or pitch) and impulsiveness (hammering, banging). These characteristics can generally be eliminated in the case of wind farm noise emissions; however these Guidelines address their assessment and management.

AS4959–2010 provides some guidance on how to address tonality, but excludes methods of measurement of other characteristics.

In considering noise characteristics, AS4959–2010 notes that:

> *When setting limits of acceptability, the limits should take into account the fundamental characteristics of wind farm noise, including aerodynamic noise from the rotating blades, occasional aerodynamic modulation, the mechanical noise of the gearbox and other components and also other infrequent and short term noises that may occur, such as braking.*

If a wind farm is designed for compliance with reasonable noise limits, this should provide for sufficient buffers between the wind farm and noise-sensitive sites to ensure that the received noise is free of annoying noise characteristics. For example, a wind turbine exhibits a degree of amplitude modulation ("swoosh-swoosh") for a listener nearby. As one moves away and the turbine noise merges with noise from other turbines and the background noise, this characteristic tends to disappear. If however the degree of amplitude modulation at the receiving location was greater than normal and not consistent with the characteristics of a correctly-functioning wind farm then it may be considered an annoying characteristic that would need to be addressed.

The relevant authority may have specific requirements for assessing some noise characteristics and they will be responsible for determining how these characteristics are to be addressed in the process of showing compliance with the noise criterion. These Guidelines provide recommendations for the assessment of noise characteristics during particular phases of the noise impact assessment process as outlined below.

Tonality – as part of the assessment phase the proponent should require the wind turbine supplier to ensure that tonality is not present in the turbine's noise emission at the distances of interest (manufacturers typically accept this). An assessment of tonality may be required as part of the pre-construction phase or the post-construction monitoring phase and a penalty (typically 5dB) may be applied to the received noise level if tonality is present.

Amplitude Modulation and Impulsiveness - An assessment of amplitude modulation or impulsiveness should be required as part of the post-construction monitoring phase and a penalty (typically 5dB) may be applied to the received noise level if any of these attributes are present. These features may only be evident once a wind farm is operational and they would not be dealt with at the pre-construction phase. For example modulation may only be evident when the operation of multiple turbines causes a periodic variation in level due synchronous operation of some of the turbines and remedial actions (such as varying operational speeds to avoid synchronous operation of turbines) would be directed to eliminate such effects.

Low-Frequency Noise and Infrasound – There have been concerns raised about possible health impacts associated with low frequency noise (rumbling, thumping) and infrasound (noise below the normal frequency range of human hearing) from wind farms. Low frequency noise and infrasound levels generated by wind farms are normally at levels that are well below the high levels required to cause any health effects. An assessment of low-frequency noise or infrasound is therefore not required as part of the pre-construction phase or the post-construction monitoring phase. An assessment of these characteristics can be required by the relevant authority where such components are reported as being identified. An expert assessment should aim to determine whether these characteristics are present at levels which may exceed recognised criteria.

These guidelines propose criteria for assessing any such impacts. This should assist investigators where numerical assessment is considered appropriate to provide certainty in response to complaints.

Recommended methods for assessing audible characteristics are provided in section B.4.4

B.2.2 Issues not addressed in the Guidelines

Small wind turbines

The sound characteristics of smaller turbines can be significantly different to large-scale turbines, as can the environment in which they are installed which can often be urban. This Appendix considers noise emission from turbines as defined in Section 1.31.6. Small wind turbine noise emission is beyond the scope of these Guidelines.

Ground-borne vibration

Ground-borne vibration from wind turbines is not likely to be perceptible to humans outside the wind farm site boundary and so has not been specifically addressed in these Guidelines. Such vibration may require consideration if the proposed wind farm site is to be located near to any existing high-sensitivity monitoring equipment such as seismic arrays.[6]

Noise from sources other than wind turbines

These Guidelines address noise emission from wind turbines as they exhibit a unique characteristic that the noise emission generally increases with increasing wind speed. There are likely to be a number of other sources of noise emission, from a wind farm, that do not exhibit this characteristic. That is, as with most sound sources, the noise emission from the source will not vary significantly with changing meteorological conditions (although the propagation of such sound may of course change in different conditions). Common examples include transformers and other equipment associated with connection of the wind farm to the primary electricity grid. As the noise emission from such sources does not normally vary with wind speed there is no reason why conventional noise emission assessment methods should not be used to evaluate their impact on wind farm neighbours. All noise sources associated with the wind farm operation (e.g. substations, switch yards) should be taken into account. Such sources of noise are also subject to existing regulation and, as such, are not addressed within these Guidelines.

B.2.3 Related documents and standards

AS4959–2010

Australian Standard AS4959–2010 provides detailed recommendations on the following issues:

- Guide to form of acceptable noise level limits
- Noise emission prediction procedures
- Background noise level monitoring
- Post-construction noise monitoring
- Documentation (regarding the above items).

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[6] Style, P., Stimpson, I., Toon, S., England, R., and Wright,m. (2005) *Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms. Recommendations on the Siting of Windfarms in the Vicinity of Eskdalemuir, Scotland*. Report by the Applied and Environmental Geophysics Research Group, Keele University. Accessed at http://www.esci.keele.ac.uk/geophysics/dunlaw/Final_Report.pdf.

The Standard should form the basis for any wind farm noise impact assessment. This Appendix complements AS4959–2010 through provision of advice on issues which are outside of its scope but which are still pertinent to wind farm noise emission. Also, a select number of comments are provided where it is considered that the approach to an issue in AS4959–2010 requires further explanation or additional assessment work.

Other documents

A number of other documents are referenced in this Appendix relating to specific areas of assessment. These are detailed in Table B-1.

Table B-1
Additional reference documents

Document reference	Document	Task methodology reference
AS 1055.1:1997	Australian Standard 1055.1: 1997 *Acoustics – Description and measurement of environmental noise Part 1: General Procedures*.	Page 49
DIN 45680:1997	Deutsches Institut für Normung 1997, *Measurement and evaluation of low-frequency environmental noise*, DIN 45680, Deutsches Institut für Normung, Berlin, Germany.	Page 59
IEC 61400-11:2006	International Electrotechnical Commission (2006) *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques, IEC 61400-11 2006*. International Electrotechnical Commission, Geneva, Switzerland.	Pages 44, 49 and 58
WHO guidelines	Berglund, B., Lindvall, T. & Schwela, D. (Eds), 2000, *Guidelines for community noise*, World Health Organisation, viewed 22 June 2009, http://whqlibdoc.who.int/hq/1999/a68672.pdf.	Page 66

B.3 Overview of the Methodology

A noise impact assessment for a proposed wind farm development should include the following key features:

- Determination of assessment criteria including noise level limits and, as required, assessment of noise characteristics.
- Prediction of wind farm noise emission using a suitable prediction method.
- Consultation with the community to provide clarity regarding the steps involved in the noise impact assessment, how wind farm noise emission is managed and what outcomes can be expected from the assessment.

These key issues appear several times throughout the course of noise impact assessment of a wind farm development, as outlined in the phases and methodologies which are discussed in the following section.

To avoid repetition, methods for community and stakeholder consultation are provided in Appendix A. Appendix B focuses on providing guidance on what noise-related information should be provided or made available throughout the development process.

Stage and methodology	Tasks	Task methodology location
Site Selection		
Noise impact risk assessment		
Noise impact risk assessment	High-level review of potential noise impacts considering: • proposed size of wind farm • character of the surrounding area • density of surrounding residential development	Page 44
	Arrange acoustic consulting advice from a suitably qualified professional	Page 44
Project Feasibility		
Preliminary noise impact assessment		
Preliminary noise emission predictions	Carry out noise emission predictions (preliminary)	Page 44
Preliminary noise criteria assessment	Establish noise criteria framework to be used for assessment including: • context and scope of assessable buildings • noise level limit framework • application to cumulative development • application to stakeholders • assessment of tonality	Page 45
	Establish background noise monitoring requirements	Page 49
Preliminary wind monitoring review	Review requirements for wind monitoring data and ensure they can be achieved with the proposed wind monitoring strategy	Page 49
Community consultation	Begin community consultation regarding noise issues	Page 50
Planning Application		
Noise impact assessment		
Detailed noise criteria assessment	Carry out background noise monitoring	Page 50
Detailed noise criteria assessment (cont)	Confirm noise criteria using background noise monitoring data, including: • context and scope of assessable buildings • noise level limit framework • application to cumulative development • application to stakeholders.	Page 51
	Carry out an assessment of tonality	Page 52
Detailed noise emission predictions	Carry out noise emission predictions (detailed)	Page 52
Compliance assessment	Provide input to wind farm layout and design, turbine selection to achieve compliance with noise criteria	Page 54
Community consultation	Continue community consultation regarding noise issues	Page 54
Report preparation	Prepare Noise Impact Assessment Report, including details of noise level limits and detailed noise emission contours	Page 54
Preparation of expert evidence (as required)	Prepare expert evidence, as required, based on the Noise Impact Assessment report and any additional issues not addressed in the Noise Impact Assessment	Page 55

Stage and methodology	Tasks	Task methodology location
Construction		
Finalisation of wind farm design	Address any outstanding issues from the planning permit and provide associated information to the relevant authority	
	Finalise the wind farm design, updating any changes to the design such as: • finalising turbine type • finalising wind farm layout • finalising compliance with noise criteria and requirements for any noise management setting	Page 55
Community consultation	Continue community consultation regarding noise issues	Page 56
Complaints handling	Prepare complaints handling procedures for construction, operation and decommissioning stages	Page 56
Construction noise monitoring	Undertake construction noise monitoring (as required)	Page 56
	Address incoming complaints (as required)	Page 56
Operations		
Post-construction noise monitoring	Continue community consultation Consultation should pay specific attention to operational noise issues and assessment of noise criteria and any additional planning permit criteria	Page 56
	Undertake unattended monitoring to assess compliance with noise level limits: • monitoring at the background noise level monitoring location • monitoring at a secondary location (as required)	Page 57
	Undertake attended monitoring (as required) and report results to the relevant authority to show compliance status	Page 58
	Undertake derived point measurements, including sound power level testing (as required)	Page 59
	Address incoming complaints (as required)	Page 59
	Assess noise characteristics and implement corrective procedures (as required)	Page 59
Decommissioning		
Decommissioning Decision	As per *Preliminary noise impact assessment*	Page 61
Decommissioning	As per *Construction noise monitoring*	Page 61
Redevelopment	As per *Planning Application*, *Construction* and *Operations*	Page 61

B.4 Task methodologies

The Site Selection stage requires a high-level noise impact risk assessment of a proposed wind farm site to establish if there are any issues relating to wind farm noise emission that would prevent development proceeding.

High-level review of potential noise impacts

Carry out a high-level review of the proposed wind farm, specifically addressing the following:

- *Proposed size of wind farm*

  The larger the proposed wind farm, the greater the potential noise impact. Similarly, potential noise impact will be greater where relatively larger wind turbines are proposed.

- *Character of the surrounding area*

  The quieter the surrounding area, the greater the potential for disruption from wind farm noise emission.

- *Density of surrounding noise-sensitive development*

  The denser the surrounding area with noise-sensitive developments, the greater the potential impact from wind farm noise emission.

As a guiding principle in terms of noise impact, large wind farms generally should be sited where significant buffer areas exist, so that the noise levels imposed on neighbours may be limited to a reasonable level. Smaller installations of one or two turbines are likely to be more suitable in areas which are, in relative terms, more densely populated.

Arrange acoustic consulting advice from a suitably qualified professional

At the end of the high-level risk assessment stage, arrangements should be made for supply of acoustic advice for the proposed wind farm from a suitably-qualified acoustic professional with experience in noise impact assessments for wind farms.

B.4.1 Project Feasibility

If the project continues to Project Feasibility, a review of wind monitoring proposals should be carried out to confirm that future requirements for analysis of noise and wind data are able to be satisfied.

Following this, a preliminary noise impact assessment should be carried out. The key objectives of the preliminary assessment are to carry out preliminary noise emission predictions and establish the noise criteria that will be used across the noise impact assessment. The preliminary noise impact assessment should also see the commencement of community consultation regarding noise issues. The extent of works required during the later Planning application stage will depend on the risks identified during the preliminary noise impact assessment. The tasks to be carried out in each phase of this stage are detailed below.

Identify noise-sensitive receivers

Noise-sensitive receivers are locations requiring the prediction of turbine generator noise levels. The relevant authority is responsible for establishing what types of noise-sensitive uses must be included in the noise impact assessment. In general, the following types of land uses are likely to be considered noise-sensitive:

Existing dwellings on residential or rural properties, including 'stakeholders' (residents who are financially associated with the wind farm);

Other noise-sensitive uses such as hospitals, prisons, caravan parks and camps, and educational institutions;

Potential future noise-sensitive developments with development approval, or areas promoted as such by the planning system for that jurisdiction;

Areas where there is a potential risk that a permitted noise-sensitive development – such as a second farmhouse on a rural property – may occur within the life of the project.

An initial assessment of receivers surrounding a site should be undertaken. This may be done either as a desktop study or by visiting the site and noting the location of receivers in the surrounding area.

The approach taken in AS4959–2010, and reflected in these Guidelines, is to carry out preliminary noise predictions at the identified receiver locations under an initial 'worst case' scenario, in order to identify which receivers may be 'relevant receivers' where more detailed assessment is required.

Undertake noise emission predictions (preliminary)

Once receivers have been identified, preliminary wind farm noise emission predictions at each receiver should be carried out in accordance with the guidance in Section 5 of AS4959–2010. The Standard proposes two approaches to noise predictions: a simple prediction algorithm (section 5.2 of the Standard) or the use of more complex noise models. The limitations of the simple algorithm are as follows:

- It provides a slightly conservative estimate of noise emission, ignoring the effects of wind direction, topography, ground absorption etc, not providing for optimal siting of turbines by the proponent;
- It may provide single-point predicted noise levels only, and instead of the graphic noise contours that are needed for community consultation and for assessing potential impacts over future development areas; and
- The simple method may not be accepted in the local jurisdiction.

Given that the developer should already have engaged a suitably qualified acoustic professional by this stage, these Guidelines recommend that the preliminary predictions should be carried out using the more complex method according to Section B.4.2 *Carry out noise emission predictions (detailed)*. The recommended output would be a noise model that shows predicted noise contours over the area covering all identified noise-sensitive receivers. These contours should represent an initial 'worst case' model based on the turbines operating at the wind speed that would result in the highest noise output.

In order that the noise predictions may take into account noise characteristics that may be difficult to eliminate post-construction, the relevant authority may require that the predicted noise levels should include an adjustment, for example +5dB, in anticipation.

Establish noise criteria

The principles of the noise impact assessment criteria should be established at this stage. The relevant authority will be responsible for establishing criteria and they should be consulted to confirm what noise criteria will apply to a particular project.

The following discussion is provided for information and to assist the relevant authority with determining suitable noise criteria.

- *Approach to noise criteria*

  It is recommended that noise level limits be set according to the framework outlined in AS4959–2010 and comprise a minimum noise level limit (that is, a lower bound) and variation of the minimum noise level limit during periods of elevated background noise. The important considerations in relation to establishing noise criteria at this stage include issues such as:

- Establishing the minimum noise level limits for the various noise-sensitive receiver locations outlined above consistent with limit-setting documents published by the relevant authority;
- How to address cumulative development;
- Whether alternative noise criteria are permissible for stakeholders; and
- What penalties may apply for noise characteristics, in particular tonality.

These issues are discussed below.

- *Establishing noise level limits*

  The relevant authority will specify the noise level limits for the proposed development. The developer should consult the relevant authority at an early stage to confirm how the noise level limits will be set for the project.

  As noted above, these Guidelines recommend that the noise level limit framework be as defined in AS4959–2010 using A-weighted decibels, and include a minimum noise level limit (that is, a lower bound) and variation of the minimum noise level limit during periods of elevated background noise (a 'background noise level +' approach). At this stage of the project, where the emphasis is on identifying 'relevant receivers', the criteria of most interest are the minimum noise level limits.

  A summary of minimum noise level limits that are commonly applied across the different states and territories of Australia is provided in the following section.

- *Existing state and territory noise level limits*

  A long term objective of these Guidelines is to provide explicit guidance on suitable noise level limits for wind farm development. The development of such guidance requires considerable coordination with existing state policies regarding noise emission in general and wind farm noise emission in particular. Until such guidance has been prepared, a summary of existing state and territory noise level limits is detailed in Table B-2. This summary is accurate at the time of publication of these Guidelines.

  It must be noted in reviewing the summary information that minimum noise level limits and other summarised information depends critically on the method used to assess compliance and this varies between jurisdictions and will also vary from these Guidelines. The summary information may be used as a rough guide to how noise criteria are currently set across states and territories. However, it may not be suitable to directly compare information across different jurisdictions as the associated assessment methods may vary.

Table B-2
Existing state and territory noise level limits

State/ territory	Guidance document for assessment	Minimum noise level limit*	Penalty for noise characteristics	Comments
Australian Capital Territory	-	-	-	Wind farm guidance has not been prepared in ACT. (Details to be confirmed)
New South Wales	South Australia Environment Protection Authority Environmental noise guidelines: Wind farms, 2003	LAeq, 10 minutes 35 dB(A)	5dB	Penalty applies for tonality only. No other characteristics are assessed directly.
Northern Territory	-	-	-	There is no specific wind farm assessment document. Developments would likely be assessed on a case by case basis.
Queensland	-	-	-	There is no specific guidance regarding wind farms. Developments would likely be assessed on a case by case basis. NZS6808:1998 and SA Guidelines 2003 have been referred to previously.
South Australia	South Australia Environment Protection Authority *Wind farms environmental noise guidelines* 2009	L_{A90} 35-40dB	5dB	Penalty applies for tonality only. No other characteristics are assessed directly.
Tasmania	Department of Primary Industries, Water and Environment (Tasmania), *Noise measurement procedures manual*, 2004 (TNMP)	-	5dB	General guidance on the assessment of wind farm noise emission is provided in the TNMP but limits are not explicitly stated and would likely be assessed on a case by case basis. A 5dB penalty applies for one characteristic. The maximum penalty is 10dB. Amplitude modulation, Impulsiveness, Low frequency noise and tonality are considered.
Victoria	New Zealand Standard NZ 6808:1998 *Acoustics – the Assessment and Measurement of Sound from Wind Turbine Generators*	L_{A95} 40dB	5dB	In addition to NZ6808:1998 requirements, specific assessment of night time noise limits is required. The maximum penalty for noise characteristics is 5dB. Amplitude modulation, impulsiveness and tonality are considered.
Western Australia	Environmental Protection (Noise) Regulations 1997. EPA Guidance for the Assessment of	L_{A10} 35dB depending on zoning	5dB	The WA noise regulations specify adjustments of 5dB for tonality and modulation and 10dB for impulsiveness to be added to the $L_{A\ Slow}$ level, to a maximum of 15dB.

	Environmental Factors No. 8 – Environmental Noise, s3.2.2 (Draft, May 2007)			Additionally the Western Australia government document ***Guidelines for wind farm development*** suggests set backs of at least 1kms.

* Where minimum noise level limits have been established in a state or territory it has generally been in conjunction with a variation of the limit in periods of high background noise.

The above minimum noise level limits cater for the night period as a worst case impact, and will by default protect the day period as well, since the turbines may operate at all times of the day. It is a further recommendation of these Guidelines that consideration be given to establishing minimum noise level limits for wind farms for two periods of the day: the Daytime period may be defined between 0700 hours and 2200 hours, and the Night-time period between 2200 hours and 0700 hours.

The criteria for non-residential uses should only address the common hours of use for the location. For example, assessment of a medical care facility with stay-over patients should include assessment of night-time hours whereas a school would typically only be assessed for daytime hours.

- *Cumulative development*

  Refer to Section B.5 for details

- *Stakeholders*

  Wind farm developers commonly enter into contractual agreements with the owners of land suitable for a wind farm site prior to progressing any significant development activities such as noise studies.

  Such agreements may contain specific clauses related to agreed noise levels from the wind farm on the landowner's property. Often such clauses can take the form of alternative noise criteria. If such agreements are likely, the relevant authority should be contacted to confirm whether alternative noise criteria are permissible at stakeholder properties.

  The Guidelines recommend that where stakeholders are involved in a proposed development and they agree to a relaxed set of noise level limits to apply at their property/properties, the minimum noise level limit may be increased by a suitable margin, for example 5dB. Minimum noise level limits of more than 45dB L_{Aeq} at a receiver are not considered suitable without provision for noise insulation of the dwelling and a suitable protected outdoor living area.

  In establishing stakeholder-specific noise level limits, it is important to clearly communicate the proposed changes in noise level to the stakeholder as well as any occupier of the property and to clearly explain the consequences of the relaxation and any potential effects on amenity at the receiver property.

- *Assessment of noise characteristics*

  The relevant authority should be consulted to identify any specific requirements they may have for assessment of noise characteristics and any resulting penalties that may apply to assessed noise emission levels. It should be noted that some jurisdictions may include an adjustment for potential noise characteristics in the minimum noise level limit, while others may only apply an adjustment to the predicted or measured noise level.

  In the absence of any specific requirements from the relevant authority these Guidelines suggest that where predicted wind farm noise emission includes tonality, a penalty of 5dB should be added to the predicted noise level. The penalty should apply only at those wind speeds where tonality occurs.

Establish background noise monitoring requirements

- *Select relevant receivers*

  Preliminary noise emission predictions should be used to identify 'relevant receivers'; that is, those noise-sensitive receivers where the preliminary noise predictions indicate that the minimum noise level limit (including any adjustments for noise characteristics) may be exceeded. In order to establish noise criteria based on a 'minimum noise level limit + background' basis, background noise monitoring will be required at any receivers (or a receiver judged to be representative of a group of such receivers) identified as relevant receivers.

  If the preliminary predicted levels of wind farm noise emission are less than the minimum noise level limit (including any adjustments for noise characteristics) for the wind speed of maximum noise emission at each receiver, background noise monitoring will generally not be required as there is minimal risk that receivers will be adversely affected by wind farm noise emission. AS4959–2010 notes the following exception:

  > *However, if a location is particularly sheltered and wind-related background noise may be low even when wind speeds on the wind farm itself are high, measurements should still be taken.*

  AS4959–2010 also notes that the assessment of background noise levels at the locations of future development may be of little benefit, as the noise environment is likely to change significantly should the development take place.

  AS4959–2010 further notes that:

  > *When considering a group of receivers it is acceptable to select as relevant the receiver that is likely to be representative of the worst case situation, e.g. a house that has very few likely sources of wind induced background noise that is located amongst a group of nearby houses.*

  Further discussion of representative dwellings is provided in Section B.5.3.

- *Review historical wind data*

  Section 6.3.1 of AS4959–2010 notes:

  > *The wind direction or wind directions which will result in the maximum noise impact from the WTG or wind farm at relevant receivers, seasonal variation in the occurrence of these wind directions and the likelihood of obtaining data with the wind from these directions should also be considered prior to the commencement of monitoring.*

  Annual wind historical data should be reviewed to establish the range of wind speeds that are likely to occur at the wind farm site and that should therefore be represented in the monitored data. Wind direction data may also be similarly reviewed.

  In addition, a review of air stability conditions should be carried out. Where a significant trend for stable air is found to occur at the site (particularly during night-time hours), this should be accounted for both in the data covered by the monitoring and also in the setting of noise level limits and the assessment of noise impact from the wind farm.

Review requirements for wind monitoring data

Subsequent phases of the assessment process require monitoring both of background noise levels and, potentially, post-construction noise levels of the operational wind farm. Although these future phases can be 12 months or more away, it is recommended that the proponent review these future requirements with regard to wind monitoring and ensure they can be achieved with the proposed wind monitoring strategy.

The following items should be considered:

- The wind monitoring strategy should include a wind speed monitor at hub height, or near to hub height as described in Section 6.3.3 of AS4959–2010. Wind direction should also be monitored at this height. Wind monitoring equipment should satisfy the requirements of IEC 61400-11:2006.
- Wind speed should be monitored at a second height on the meteorological mast. This height should be less than the hub height and should be sufficient to allow comparison of the wind speeds at the two different monitoring heights to estimate the wind shear at the site during each monitoring period.
- The mast should be located to monitor what are likely to be the highest wind speeds at the proposed site. AS4959–2010 notes, "*Where possible wind speed data used for analysis should be from a location on the wind farm site which reflects or exceeds the maximum wind speed likely to be experienced by WTGs within the site.*"
- For large sites more than one meteorological mast may be required.
- Post-construction noise monitoring will also require wind data. The data used during this later stage should be consistent with that obtained during the noise impact assessment phase, ideally through the use of the same mast location provided this is not affected by turbulent flow downwind from a turbine. Section 6.3.3 of AS4959–2010 provides guidance on this issue.

Community consultation

The following key issues should be addressed during initial consultation with the community:

- The results of the preliminary noise predictions and identification of relevant receivers;
- How noise characteristics will be addressed in the procurement of the turbines and in the management of the wind farm;
- The likelihood of audibility and the potential for masking by background noise;
- Clear avenues should be made available to obtain additional information about wind farm noise and its assessment. A number of information sources should be provided for each issue, to provide the enquirer with the range of views that are available regarding wind farm noise emission.
- The draft concept wind turbine generator layout, based in part on results of the preliminary noise impact assessment, should be used as a starting point for discussions with landowners, authorities and the community.

B.4.2 Planning Application

The objective of this stage is to prepare noise impact assessment documentation suitable for inclusion in the Planning Application. This will require confirmation of applicable noise criteria, detailed noise emission predictions, and liaison with the proponent and refinement of the wind farm design to ensure that noise criteria are able to be satisfied. Additional advice may also be required for planning hearings. Significant community consultation should be on-going during this phase as the wind farm design becomes finalised and information may be passed to wind farm neighbours.

The tasks to be carried out during this phase are detailed below.

Undertake background noise monitoring

Background noise monitoring should be carried out at identified relevant receivers according to Section 6.3 of AS4959–2010. Selection of relevant receivers is addressed in *Establish background noise monitoring requirements* (see page 49).

As noted in Section 6.3.1 of AS4959–2010, background noise levels should be monitored as L_{A90} levels concurrent with wind speed and direction. Monitoring should at least capture all of the significant wind directions and speed ranges which appear in representative wind statistics of wind at the site.

AS4959–2010 recommends that a minimum of 2000 monitored data points should be available for analysis at each measurement location, covering "*the range of wind speeds and wind directions generally to be expected at the wind farm site and in particular the range of wind speeds (at hub height) between the 'cut-in' and 'rated' wind speeds of a WTG of the general type proposed for the site.*"

It is suggested that the range of wind speeds included in monitored data be extended in order to accurately capture the trend between background noise level and wind speed at wind speeds up to rated power. Specifically, it is recommended that monitored wind speeds extend 2m/s beyond the wind speed of rated power. In addition, it is suggested that, where possible, at least 30 daytime and night-time data points should be collected for each monitored integer wind speed bin.

In some cases it may be difficult and overly time-consuming to obtain measured data covering the desired range of wind speeds, wind directions and periods of the day. In such cases it may be suitable to monitor for a lesser, fixed amount of time so long as appropriate reasons for the shorter monitoring period are provided.

Refer to ***Error! Reference source not found.*** (page **Error! Bookmark not defined.**) for guidance on positioning of wind speed/direction monitoring equipment.

All noise and wind monitoring equipment should satisfy the requirements of AS4959–2010, including the requirement for suitable protection of the microphone against wind-generated noise through the use of an appropriate wind sock. The relevant authority may have additional specific requirements regarding the control of wind generated noise over the microphone and should be consulted. All wind speeds and direction should be monitored at hub height or corrected to hub height reference according to Section 6.3.3 of AS4959–2010.

Confirm noise criteria using background noise monitoring data

Noise level limits should be established for all relevant receivers based on the background noise monitoring data collected. Ideally the noise level limits should be specified at nominal wind speed intervals of 1m/s between the wind speed at which the WTG starts to generate electricity ('cut-in' wind speed) and the wind speed at which the WTG reaches its maximum power generation ('rated' wind speed).

Representative background noise level curves may be established for each relevant receiver using the regression analysis techniques described in Section 6.3.4 of AS4959-2010. Noise level Limits should then be established using these background noise level curves.

Section 6.3.1 of AS4959-2010 notes: *Where regression curve analysis does not conform to the expected trends, i.e. there is not a clear relationship between increasing wind speed and increasing background noise levels or there appears to be more than one distribution, then further investigations are necessary to determine possible causes* and section 6.3.4 of the standard notes: *Consideration should be given to carrying out separate correlations of background sound levels with wind speed for different wind directions and/or times of day, particularly where atmospheric stability issues are apparent or are suspected.*

Should background noise levels vary with wind direction in a way that is not in accordance with expected trends then the cause of the variation should be examined. Data may need to be separated and separate limits determined based on wind direction, time of day or atmospheric stability considerations.

If such variations are observed, background noise data should be analysed for significant variations in noise level with the factors identified as causing the different distribution.

Regression analysis should be carried out for each category (e.g. wind direction, time of day, etc) according to Section 6.3.4 of AS4959–2010. Where the different regression curves are within 1-3dB of the regression curve for all data at each integer wind speed, significant variation in background noise level with wind direction is not considered likely and the noise limits should be determined using all the data. **Note:** To avoid excessive analysis, the aim should be to determine the worst-case criteria where this is due to a systematic variation on the distribution of background sound level vs. wind speed due the factors mentioned above.

Where the variation is greater than 3dB, some variation in background noise level with the selected category is likely and that category should be analysed separately. The same analysis process described above should also be used to establish noise level limits for stakeholder properties with agreed alternative noise level limits. The minimum noise level limit should be corrected as per the agreement with the stakeholder, within the upper bounds discussed in Section B.4.1 *Establish noise criteria* (page 45).

Application of noise level limits in the case of cumulative development is discussed in Section B.5.

Undertake a tonality assessment

Tonality should be assessed as part of the noise impact assessment, based on tonality tests included in IEC 61400-11: 2006, or other tonality assessment approved by the relevant authority.

Undertake noise emission predictions (detailed)

As suggested by the flow chart in Appendix A of AS4959–2010, further wind farm noise emission predictions should be carried out once noise level limits have been established at all relevant receivers.

- *Updating preliminary noise emission predictions*

  The wind farm layout is likely to have changed significantly since the time of the preliminary predictions, and the detailed noise emission predictions can be used to optimise the noise received noise levels and to reflect the final layout

- *Detailed noise emission predictions*

  Detailed prediction methods should be implemented according to Section 5.3 of AS4959–2010. Predictions should be carried out for each nominal wind speed at intervals of 1m/s between the cut-in wind speed and the rated wind speed.

  The modelling assumptions should reflect typical (but not extreme) 'worst case' meteorological conditions for sound propagation towards the receiver. The relevant authority should be consulted to identify any specific requirements for modelling assumptions. All modelling assumptions should be clearly stated.

  Where ISO 9613-2 is used,[7] the parameters provided in Table B-3 are likely to provide a generally realistic and conservative assessment of noise emission. It is acceptable to use alternative parameter values. For example, reasonable worst case temperature and humidity levels may be determined from review of annual meteorological data from the Bureau of Meteorology. However, a clear explanation for the reasons for changes in parameters should be provided.

  The use of a single value to represent air absorption across the entire frequency spectrum is not considered suitable for detailed noise emission prediction unless

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7 International Standards Organisation (1996) *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation*. ISO 9613-2:1996, Geneva, Switzerland.

predicted levels are significantly below the noise level limits. Octave band or one-third octave band air absorption coefficients are preferred.

Table B-3
Recommended parameter values for ISO9613-2:1996 in Australia

Parameter	Recommended value
Temperature	15°C
Air humidity	70%
Atmospheric pressure	101.325 kPa

Resulting atmospheric attenuation coefficients, dB/km

Octave band centre frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
0.1	0.4	1.1	2.4	4.1	8.8	26.6	95.0

- *Compliance assessment*

  The detailed wind farm noise emission predictions should present L_{Aeq} levels at the relevant receivers. These predictions should be based on sound power level data described in terms of L_{Aeq}. The predictions should include an adjustment for noise characteristics if required by the relevant authority. These predicted noise emission levels should be compared with the noise level limits determined in accordance with Section B.4.2 to provide an assessment of compliance.

- *Uncertainty*

  An assessment of the uncertainty of the selected prediction method should be carried out. Where there is significant uncertainty in the prediction, which is likely to increase the risk that actual wind farm noise emission will exceed the noise level limits, appropriate allowance should be made in the margin by which predicted noise emission satisfies the noise level limits.

Provide input to wind farm design and turbine selection to achieve noise compliance

Once the detailed noise emission prediction study is complete, some refinement of the wind farm design may be required to demonstrate compliance of predicted noise emission with the noise level limits. Possible areas of refinement include wind turbine number and layout, wind turbine type, wind turbine noise management settings, variable operation of the wind turbines for particular times of day and/or wind directions and wind speeds.

Where refinement of the wind farm design is carried out, the consequences of this refinement on predicted noise emission should be advised to the proponent. Refinement should be ongoing until predicted noise emission satisfies the noise criteria.

Community consultation

Consultation with the community should be on-going during this phase. The results of background noise level monitoring, the final noise criteria and the results of the detailed noise predictions should be made available to the community and in particular to the relevant receiver where the monitoring occurred.

Prepare noise impact assessment report

The noise impact assessment report should include details of background noise monitoring (if required), establishing noise level limits and detailed noise emission predictions, including contours, and all other documentation requirements in accordance with Section 8 of AS4959–2010.

Prepare expert evidence (as required)

Expert evidence should be prepared, as required, for presentation at a planning hearing. The evidence should be largely based on discussion and results provided in the noise impact assessment report. Any additional issues raised during submissions should also be addressed.

B.4.3 Construction

The design of the wind farm should be finalised prior to commencement of construction. This may require revisiting the noise impact assessment due to minor changes in turbine layout or changes in turbine type. Depending on the extent of changes, the relevant authority may require issue of a finalised noise impact assessment report to confirm compliance with the noise criteria for the finalised wind farm design.

A set of complaints handling procedures should also be developed prior to commencement of construction. This should include procedures for handling complaints received firstly during construction, but also during operation of the wind farm and possibly also during decommissioning.

Once construction begins, state regulations may require construction noise monitoring to be carried out.

The tasks to be carried out during this phase are detailed below.

Finalisation of wind farm design

- *Address planning permit conditions (as required)*

  Where a planning permit is issued it may include provision for additional assessment work to be carried out or for clarification/additional details of the noise impact assessment to be provided to the relevant authority. Issues can include:

  - Carrying out background noise level monitoring at additional receivers
  - Revising noise emission predictions

  Any such outstanding issues should be addressed with the supplementary assessment information supplied to the relevant authority.

- *Finalise wind farm design*

  A significant amount of time can elapse between granting a planning permit for a wind farm development and the preparation for commencement of works on site. During this time further minor changes to the wind farm design can be made.

  Likely changes may include:

  - Finalising turbine type.
  - Finalising wind farm layout.
  - Finalising compliance with noise criteria and requirements for any noise management setting.

  Any such changes should be addressed and all new information consolidated into a finalised noise impact assessment report, if required, in order to complete all planning and design application issues prior to construction.

- *Address land use planning considerations*

  In addition to finalising the noise impact assessment report, it is suggested that a set of contour maps be issued to the regulating authority showing the predicted contour of the minimum noise level limit. This may be used by the regulating authority to inform prospective buyers of real estate within the zone defined by the contour of the effects of the wind farm development. This may be particularly helpful during the period of time after planning permission is granted and prior to construction and operation of the wind farm when no visual cues of the development may be easily observed on site. Moreover, the relevant authority should consider restricting future noise-sensitive development in areas which are within the minimum noise level limit contour.

Community consultation

Consultation with the community should be on-going during this phase.

Final wind farm noise emission contours should be made available at relevant authority offices and, if practicable, on their website.

Prepare complaints handling procedures

A procedure should be developed, prior to construction activities commencing, to handle any complaints of construction noise.

Similar procedures should concurrently be developed for implementation during operations and decommissioning stages.

Complainants should be requested to keep a diary or sound log where they can note times of day and associated weather conditions when they consider wind farm noise emission to be particularly annoying. The sound log can include a description of the type of sound heard. This information can be used by the investigating group to help try and identify meteorological conditions, particularly wind speed and direction, where the wind farm noise emission is most problematic.

The complaints procedures should detail how to lodge complaints and the type of response to be expected.

Undertake construction noise monitoring (as required)

Construction noise monitoring should be carried out, as required, in accordance with either specified planning permit conditions or construction noise regulations applicable in the jurisdiction where the wind farm development is occurring.

Address incoming complaints (as required)

Complaints should be addressed according to the complaints handling procedures as well as any requirements of state/territory guidance for complaints about construction noise.

B.4.4 Operations

The Operations stage of the wind farm should include unattended post-construction noise monitoring for a sufficient period of time to demonstrate compliance with the noise criteria under expected worst-case conditions. Additional attended monitoring, assessment of noise characteristics or Sound Power Level (L_W) testing may also be required in particular cases as identified below.

The tasks to be carried out during this phase are detailed below.

Community consultation

Community consultation should be on-going with specific attention to operational noise issues and assessment against noise criteria and any additional planning permit criteria.

Undertake unattended monitoring to assess compliance with noise level limits

- *Approach to sound indices*

  Establishing noise level limits requires review of measured $L_{A90,T}$ noise levels, a process which may be repeated during the post-construction noise monitoring phase to demonstrate actual compliance with noise level limits. Concurrently, noise emission predictions are carried out typically using sound power level data described in terms of L_{Aeq}. This may have caused some confusion in previous noise impact assessments. These Guidelines recommend an approach as follows.

  - The direct measurement of L_{Aeq} from the wind farm, which is outlined in Methodology 2 in Section 7.4 of AS4959–2010, may be a difficult and time consuming process due to the varied amount of extraneous noise. For this reason the method discussed below in *Monitoring at the background noise level monitoring location*, which is comparable to Methodology 1 in Section 7.3 of AS4959–2010, is intended to be a simple method and is likely to be conservative. A minimum of 1.5dB needs to be added to the L_{A90} noise levels to obtain the L_{Aeq} noise levels.

- *Monitoring at the background noise level monitoring location*

  Unattended monitoring should be carried out as detailed in Section 7.3 of AS4959–2010. While the Standard does not consider this monitoring to be required in every circumstance it is the recommendation of these Guidelines that, in most cases, unattended monitoring should be carried out for a sufficient period to demonstrate compliance with noise level limits across a range of weather conditions which, in the least, includes the worst case conditions where the margin between wind farm noise emission and noise level limits is at a minimum.

  If not specified, for example, in planning permit conditions, the proposed length of post-construction noise monitoring should be agreed with the relevant authority prior to commencement of monitoring. Indicatively, at least several months of monitoring may be required to clearly demonstrate compliance with noise level limits. The costs of monitoring should be borne by the operator.

  Monitoring data should be used for analysis and assessment according to Sections 7.3.4 and 7.3.5 of AS4959–2010.

  Where compliance with the noise level limits is demonstrated through the proposed monitoring period without significant issue, further unattended monitoring is unlikely to be required.

  With unattended measurements it is generally only ever possible to demonstrate compliance with assessment criteria. In the case that measurements suggest non-compliance there will be doubt as to whether the measured levels are dominated by wind farm noise emission or some other source.

  One particular scenario when this is likely is where the background noise environment at the monitoring location, in the absence of wind farm noise emission, has become louder. This may be a result of new trees having been planted around the monitoring location, or an increase in foliage on trees relative to when the original background noise monitoring was carried out.

  Where results of unattended monitoring are unclear and it is suspected that the background noise environment at the monitoring location, in the absence of wind farm noise emission, may have become louder unattended monitoring at a secondary location is recommended, as discussed below.

  In other cases where results of unattended monitoring are unclear, particularly if they indicate non-compliance with noise level limits, attended monitoring will be required, as detailed in *Undertake attended monitoring (as required)* (page 58). Lastly, derived point measurements including sound power level testing should be considered, as detailed in *Undertake derived point measurements, including sound power level testing (as required)* (page 59).

Where non-compliance with noise level limits is reasonably confirmed, the wind farm operator should take measures to reduce noise emission until compliance with noise level limits is able to be demonstrated. Suitable measure may include implementation of noise management settings and turning off particular turbines under certain weather conditions.

- *Monitoring at a secondary location (as required)*

  Where it is believed that the background noise environment at the monitoring location, in the absence of wind farm noise emission, may have become louder unattended monitoring should be carried out at a secondary location.

  The unattended monitoring process should be a repeat of that detailed in the above section, with the exception that the location selected for monitoring satisfies the following requirements:

  - The secondary location selected for monitoring should be the same distance from the wind farm, be exposed to noise emission from the same wind turbines and be of the same geographical setting as the original location. The predicted level of wind farm noise emission should be the same at each location.
  - The expected background noise level, in the absence of wind farm noise emission, should be lower at the secondary location. This may be achieved in practice by placing the sound monitoring equipment in a nearby field or other location that may be further away from trees or other sound sources associated with the original location.

Undertake attended monitoring (as required)

AS4959–2010 identifies the following objectives for attended monitoring:

> *The procedure ... below uses attended measurements at a single receiver, to validate prediction model outputs and compliance with criteria.*

Any attended monitoring should be carried out in accordance with Section 7.4 of AS4959–2010. The procedures provided in AS4959–2010 require measurement of wind farm noise emission as well as background noise levels with appropriate areas of the wind farm turned off. It is noted here that such measurements would be best carried out during periods where the background noise environment is less affected by extraneous noise sources such as passing road traffic or agricultural activities. Depending on the location of the wind farm, night time may be most suitable to carry out measurements.

AS4959–2010 requires attended measurements based on a critical wind speed which is defined as "the wind speed at which there is the minimum predicted margin of compliance with the noise criteria as set by the relevant authority." If attended measurements are to address a complaint rather than confirm compliance with planning permit conditions, measurements should be based on an observed critical wind speed which is defined as the wind speed which has been identified through discussion with the complainant and review of their sound log/diary as being most annoying.

Recent advancements in sound level monitoring equipment have included development of specialised equipment which is able to localise the contribution to sound level from particular sound sources. As this type of equipment is relatively new there is, at present, no quality control legislation, such as an Australian Standard, to verify the suitability of the equipment.

Whilst such equipment may be useful in particular circumstances (if not to demonstrate compliance then to identify sound sources contributing to the sound level in the area), its usefulness may need to be discussed with the relevant authority. It should be noted that an assessment of wind farm noise emission can still be carried out satisfactorily without the use of this type of equipment.

Where results of attended monitoring are unclear, particularly if they indicate non-compliance with noise level limits, derived point measurement including sound power level testing should be discussed with the relevant authority.

Undertake derived point measurements, including sound power level testing (as required)

In extreme circumstances, where it has not been possible to demonstrate compliance with noise level limits through both unattended and attended measurements and the relevant authority agrees that compliance is likely to be achieved, sound power level testing of selected wind turbines may be necessary to establish whether data used in noise emission predictions is consistent with the on-site noise emission of the installed turbines.

Testing should be carried out according to the most recent version of IEC 61400-11. Where practicable, the tested wind turbines should be those closest to the Receiver where non-compliance has been demonstrated. The testing requirements of IEC61400-11 are restrictive and testing of some turbines may not be possible.

In addition, derived point measurements should be carried out at a suitable location between the wind farm and the receiver location which is the subject of the assessment. Wind farm noise emission should dominate the background noise level at the selected location. Attended measurements should be carried out and analysed according to *Undertake attended monitoring (as required)* above.

Measured levels of wind farm noise emission should then be compared with predicted levels at the derived point location. The correction factor should be the difference between the measured and predicted levels, determined at each wind speed. The correction factor should be applied to predicted wind farm noise emission levels at the original receiver location to arrive at derived wind farm noise emission levels. These derived levels may be compared with noise level limits at each integer wind speed to determine compliance.

Close liaison with the relevant authority is expected for this process.

Address incoming complaints (as required)

Complaints should be handled as per the procedures developed during the Construction noise phase (*Prepare complaints handling procedures*, page 56).

Assess noise characteristics (as required)

As indicated in A.2.1 above, the characteristics of tonality, excessive amplitude modulation and impulsiveness are not normally expected to occur as part of the noise emission from a correctly-functioning wind farm.

Nevertheless, an objective assessment may be required as part of post-construction noise monitoring or complaint-handling procedures.

These Guidelines offer suggested methods of assessing each of the above characteristics, as detailed in Table B-4 below. Concurrently, the relevant authority should be consulted to identify any specific requirements they may have for assessment of noise characteristics.

Table B-4
Suggested methods for assessment of noise characteristics

Noise characteristic	Suggested assessment procedure	Comments
Amplitude modulation	Tasmania Department of Primary Industries, Water and Environment (2004) *Noise measurement procedures manual*, Also Western Australian Environmental Protection (Noise) Regulations 1997	Amplitude modulation may be present where there is a greater than normal degree of fluctuation of sound level. The suggested assessment procedure indicates the presence of amplitude modulation where there is a regular, cyclic and audible variation in sound level of more than 3dB. It should be noted that $L_{A90,T}$ may not be appropriate for assessing amplitude modulation. L_{Aeq}, L_{A01} or L_{AMax} indices may be more suited to identification measurements. Further, it is noted that any assessment of amplitude modulation should take place at the Receiver location being assessed. It is not suitable to carry out an assessment within the wind farm site as, at the Receiver location, emission from several different turbines may be contributing to the observed effect. Also, the measurement position should not be unduly affected by facade reflections in the area immediately around the measurement location.
Impulsiveness	Australian Standard 1055.1:1997 *Acoustics – Description and measurement of environmental noise Part 1: General Procedures*	This assessment requires the use of a sound level meter with fast response and impulse response time weightings. It is recommended that impulsiveness assessments be carried out on calibrated digital recordings of the suspected impulsive sound, so that the impulsive and fast time weighting may be applied to the same audio sample. In some cases, impulsiveness may be indicated using the AS1055.1 assessment method when, subjectively, it is not considered to be present. These cases should be discussed with the relevant authority
Infrasound	DIN 45680:1997 *Measurement and evaluation of low-frequency environmental noise*, Deutsches Institut für Normung	DIN45680 does not prescribe acceptable noise limits but discusses a method for assessing perceptibility. Although a given low frequency noise or infrasound may be perceptible, this does not imply a negative effect on health. The assessment frequency range of DIN 45680:1997 extends down to 8Hz and so may exclude some frequencies which are considered part of the infrasound range. Complaints resulting from noise emission in this extremely low frequency range are considered unlikely. Nonetheless, it is important to recognise this limitation of the assessment method.
Low frequency noise	DIN 45680:1997 *Measurement and evaluation of low-frequency environmental noise*, Deutsches Institut für Normung	The noise level threshold curves included in the standard are reasonably conservative. However, they are based on a 50% threshold level and some research suggests that a 10-12dB margin to the 10% threshold may exist. Accordingly, it may be that some individuals can hear a sound level which is measured to be less than the threshold limit. Where the measured level is within 12dB of the threshold value and the measured level is greater than the background noise level further investigative work is likely to be required.
Tonality	Assessment procedures as identified in Section 7.2 of AS4959–2010	

Note: The assessment method proposed for amplitude modulation should be considered as nominal and is proposed in the absence of a more suitable method specific to wind farms. It may be used as an indicator of amplitude modulation; however, the assessment should be carried out in conjunction with a subjective assessment of the sound by the assessor and the relevant authority. It may be more suitable in this case to explore adjustments in the operation of particular turbines under certain meteorological conditions, for example by using noise management settings at particular wind speeds, to try and alleviate the issue

B.4.5 Decommissioning

Noise-related tasks during the Decommissioning stage are, in general, a repeat of tasks completed during the Project Feasibility, Planning Application and Construction stages of the wind farm development.

Decommissioning decision

To assess the feasibility of decommissioning or redeveloping the site, the wider assessment work during this stage will involve assessing the historic wind resource at the site, changes in turbines commercially available and a desktop feasibility assessment addressing items identified in the *High-level review of potential noise impacts* (page 44) and *Undertake noise emission predictions (preliminary)* (page 44).

Preliminary noise impact assessment work should be inputted into this decision-making process according to the guidance offered in the Project Feasibility stage (Section B.4.1).

Decommissioning

Studies are to be undertaken to confirm that the wind farm can be decommissioned in accordance with any planning permit conditions. Wider assessment works will involve the development of Decommissioning and Site Rehabilitation Plans. These should be developed in accordance with the any planning permit conditions, but also require modification to accommodate any changes to the local environment, land use and infrastructure.

Guidance on noise related issues during this stage may be taken from the Construction stage (Section B.4.3). In particular, the Decommissioning stage may require construction noise monitoring which should be carried out in accordance with *Undertake construction noise monitoring* (page 56). In addition, a modified complaints handling procedure should be implemented to address any decommissioning construction noise-related complaints. Refer to *Prepare complaints handling procedures* (page 56) for guidance on developing complaints handling procedures.

Redevelopment

If it is decided to redevelop a wind farm site, studies will be required in order to submit a new project for a new planning application. Wider assessment works may involve submission of a new planning application in accordance with these Guidelines for any proposed redevelopment of the wind farm site. Refer to Section B.4.2 for guidance.

B.5 Cumulative impacts

B.5.1 Approach to staged development

Where staged development of a wind farm is proposed, then the total impact of the final wind farm should be planned so that the noise limits will be achieved by the final wind farm, subject to the consideration of the cumulative impacts of other wind farms (see section A.5.2 below). Where background sound levels are assessed at new receivers (not previously assessed at during an earlier stage if the wind farm development) those background measurements should not include wind farm noise from previous stages of the wind farm.

B.5.2 Assessment of staged and cumulative development

Section 4.2 of AS4959–2010 requires assessment of cumulative impacts as follows:

> *To provide a satisfactory level of protection of amenity against the potential adverse effects of wind farm noise, the cumulative impact of all wind farm development in an area should meet the noise limits derived from measurements of the background noise environment at relevant receivers prior to any wind farm development taking place. Where it is not possible to satisfactorily demonstrate that existing developments are not influencing measured background noise levels, predicted noise levels from the wind farm should not be permitted to exceed the minimum noise level limit.*

It is the recommendation of these Guidelines that noise level limits established for a receiver should follow this approach. The practical implication of this is that, where one wind farm is already in operation and its noise emission is near to the noise level limit, any subsequent developments will need to have significantly less noise emission at the same property, in the order of 10dB lower, so that the combined wind farm noise emission does not exceed criteria. It is recognised that such a requirement may render further wind farm development in the area impracticable. Therefore, where it is envisaged that an area may accommodate more than one wind farm, the noise criteria should be established as cumulative limits that include allowable contributions from individual wind farms.

Any wind farm approved for development in the surrounding area, whether constructed or not, should be included as part of a staged or cumulative development assessment.

In addition, some consideration may be given to other known proposed wind farm developments where practicable.

B.5.3 Cumulative assessment scenarios

While the philosophy of addressing cumulative and staged development is reasonably simple, there are undoubtedly many scenarios where the application of the key principles will not be straight-forward and the resulting situation will be very complex. Where there is a lack of clarity, further advice should be sought from the relevant authority to determine an arrangement that they consider to be suitable.

Further, where a second wind farm is being considered in an area the assessment of noise impact will depend critically on the noise emission from the first wind farm. To facilitate this assessment it is suggested that the first wind farm make available sufficient information to allow noise emission from the first wind farm to be incorporated into the prediction model and other assessment requirements for the new wind farm.

A number of possible cumulative development scenarios are discussed briefly below to provide additional guidance.

A stakeholder agreement has been arranged with a receiver for a wind farm development including relaxed noise level limits. What limits should be applied to this receiver for a proposed new wind farm development?

The relaxed noise level limits that have been established for the first wind farm should not, as of right, apply for the second wind farm. Noise emission from the newer wind farm should comply with the conventional noise criteria at the property and also not increase the levels of wind farm noise emission that are being received from the first wind farm.

The exception to this is where the second wind farm also agrees a stakeholder arrangement with the property, in which case relaxed noise level limits may be negotiated with the Stakeholder, provided that the combined emission from all wind farms at the property does not exceed the values recommended in Section B.4.1 *Establish noise criteria* (page 45).

If a significant amount of time has passed between the planning assessment for a wind farm development and the subsequent assessment for a second wind farm in the area, in the order of 5-10 years or more, and it is considered that the background noise in the area may have changed over this time, how are noise level limits to be established for the second wind farm?

If the background noise levels are expected to be lower than when the initial noise impact assessment occurred, they will be hard to measure in the presence of operational noise from the existing wind farm. In this case, the second wind farm should comply with the minimum noise level limit across the assessable wind speed range and not increase the combined level of wind farm noise emission above the established noise level limits.

If background noise levels are expected to be higher, monitoring may be carried out where this is not influenced by emission from the original wind farm. If this is not possible, the second wind farm should comply with the minimum noise level limit across the assessable wind speed range and not increase the combined level of wind farm noise emission above the established noise level limits.

How should cumulative noise limits be considered where other industrial activity such as mining, which changes the character of the background noise environment in the area, commences during the period between wind farm developments?

Issues such as this should be thoroughly examined on a case-by-case basis, in close liaison with the relevant authority. There are likely to be a range of noise emission controls which may be applicable to the various sound sources and consultation with the relevant authority will be critical in achieving a satisfactory outcome.

Where another significant sound source commences in an area after the development of the first wind farm and prior to the second, and this sound source is expected to continue through the lifetime of both wind farms, it is generally expected that new background noise level monitoring would not be conducted. However, if new background noise monitoring was conducted it would be important to ensure that noise emission from the first wind farm does not significantly contribute to the background noise level at the monitoring location, and that the noise limits for the new wind farm do not permit 'creeping noise'.

Where the new sound source is not expected to carry on in the long term, beyond the lifetime of both wind farms, it is unlikely that any new noise level limits would be established at relevant receivers.

How should cumulative noise limits be applied to a group of dwellings where the 'worst case' affected dwelling is different for each proposed wind farm?

The 'worst case' relevant receiver determined for the noise impact assessment of the first wind farm will likely be exposed to the greatest level of wind farm noise emission from the first wind farm as well as experiencing the largest change in the ambient noise environment.

Where an alternative property from the same cluster of receivers is determined to be the 'worst case' receiver for the second wind farm the conservative approach, which is recommended here, is to assume that the second property is exposed to the same noise emission from the first wind farm as the first worst case receiver. The contribution from the second wind farm should comply with noise criteria as outlined in Section B.5.2.

B.6 Glossary & acronyms

A-weighting	A frequency weighting applied to a noise measurement that approximates the frequency response of the normal human ear. The A-weighting provides an accepted measure of the subjective loudness of a sound. See Figure B-1
Above Ground Level (AGL)	A term commonly used to express the height above ground when discussing wind speeds. For example, a wind speed of 8m/s at 10m AGL
Amplitude modulation	A noise characteristic where the sound level exhibits a fluctuation that is regular, cyclic and audible, e.g. loud-soft-loud-soft
Background noise level	For wind farms, AS4959–2010 defines background noise level as "*The derived background sound pressure level at a given wind speed corresponding to the best fit regression curve of the plotted measured background noise data and the wind speed data*"
Background sound pressure level	The background $L_{A90,T}$, when measured in the absence of the noise under investigation
dB	Decibel. The unit of sound level.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. This is roughly equal to the frequency range of the notes on a piano. The audible range of frequencies for humans with normal hearing generally spans from 20Hz to 20,000Hz.
Impulsiveness	A noise characteristic where the sound has a short duration, e.g. banging, hammering
Infrasound	Sound at frequencies below the normal range of human hearing, i.e. less than 20Hz
$L_{A90,T}$	The A-weighted sound pressure level, obtained by using time-weighting 'F' that is equal to or exceeded for 90% of the time interval T, expressed in dB. In wind farm assessments, T is taken to be 10 minutes
L_{Aeq}	The equivalent continuous A-weighted sound level that contains the same energy as the fluctuating sound level. This is commonly referred to as the average sound level and is expressed in dB.
L_{Amax}	The maximum A-weighted sound level occurring during the measurement period, expressed in dB
Low frequency noise	Noise within the frequency range 20Hz to 200Hz
Noise	Unwanted sound
Octave band	The range of sound frequencies may be divided into octave bands for analysis. The audible frequency range is generally divided into 7 octave bands with centre frequencies of 63Hz, 125Hz, 250Hz, 500Hz, 1 kHz, 2 kHz and 4 kHz
Receiver/noise-sensitive receiver	A location requiring prediction of the impact of Wind Turbine Generator noise
Relevant Receiver	A receiver at which preliminary noise level predictions exceed a noise level limit determined by the relevant authority, and which may require further assessment in accordance with AS4959–2010
Sound Power Level L_w (or SWL)	The level of total sound power radiated by a sound source. The sound power level produced by a wind turbine is determined in accordance with IEC 61400-11:2006
Sound Pressure Level L_p (or SPL)	The level of sound pressure at a distance from a sound source. SPL is commonly used to express levels measured with a sound level meter.
Tonality	A noise characteristic where the noise contains a discrete frequency component, e.g. humming, whining
Wind farm neighbour	A generic term to refer to neighbours of a proposed or developed wind farm, generally property owners and occupiers in the surrounding area
Wind farm noise level	The level of wind farm noise emission, typically determined as L_{Aeq}

B.7 Technical discussion of key concepts/issues

B.7.1 Basic acoustic concepts

Sound levels and loudness

Decibel is the unit of sound level and is commonly denoted as dB. The audible range of sound levels for humans is generally considered to span from 0dB, the hearing threshold, up to 120+dB, where such high levels of sound can cause pain to listeners.

The decibel scale is logarithmic, not linear. The effect of this is that, for example, a doubling in the loudness of a sound generally corresponds to a 10dB increase in sound level. That is, when listening to a sound that is 40dB, increasing the sound level to 50dB would subjectively feel like a doubling in loudness. Increasing the sound level again, to 60dB, would feel like a further doubling in loudness. Also, if two instances of the same sound occur at the same time, and each has a sound level of, for example, 30dB, their combined level will be 33dB. The combined level is not 60dB.

Where A-weighted decibels [denoted dB (A)] are used, the A-weighting approximates the response of the human ear over a range of frequencies (Figure B-1).

Sound indices

Sound is often not steady. The sound from traffic, music and the barking of dogs are all examples of sounds that vary over time. When such sounds are measured, the sound level can be expressed as an average level, or as a statistical measure, such as the level exceeded for 90% of the time. Commonly used sound indices are L_{A90}, L_{Aeq}, L_{Amax}, background sound level and wind farm sound level (see Section B.6 for definitions). Figure B-2 provides a time history plot demonstrating key sound indices for wind farm sound monitoring.

Figure B-1
A weighting relative to frequency

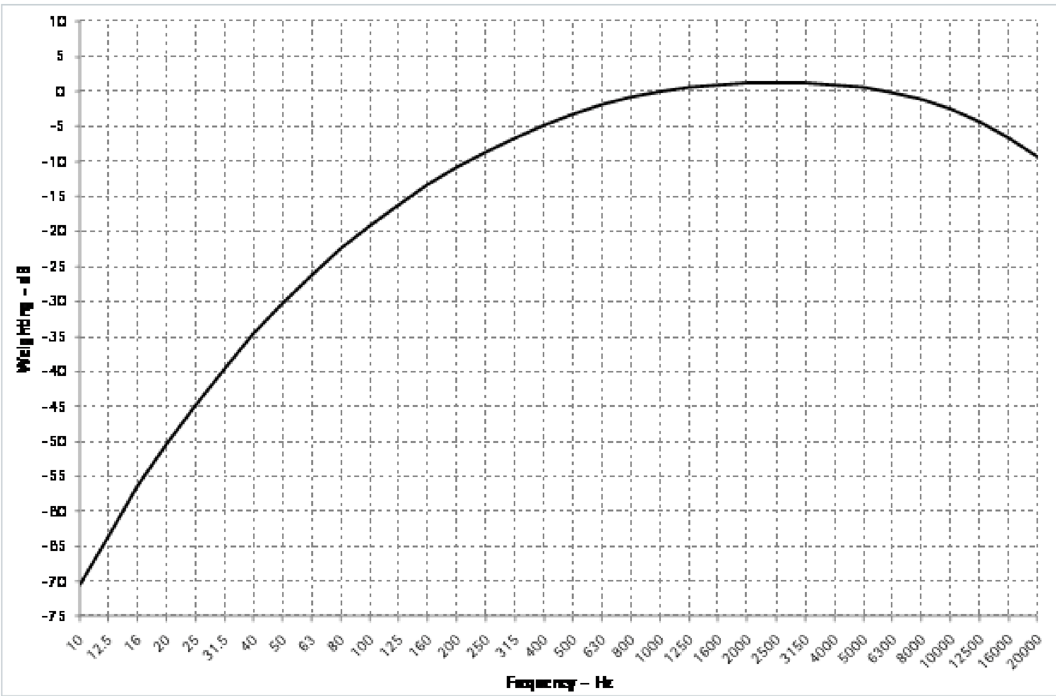
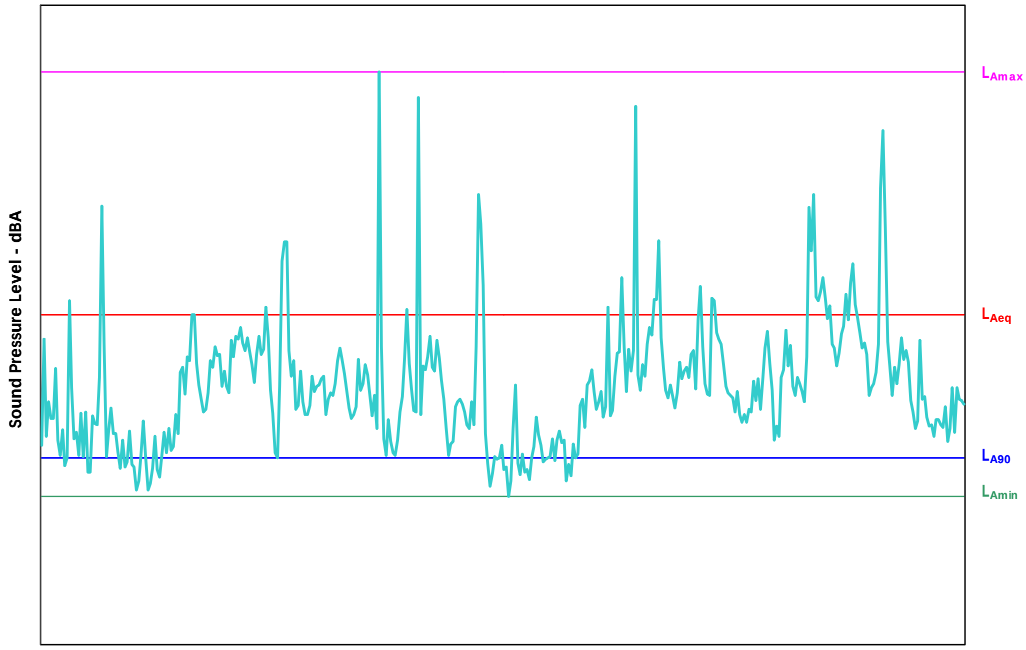


Figure B-2
Example of noise indices that may be used to measure a time-varying sound level



B.7.2 Audible Characteristics

Infrasound

Along with low frequency noise, infrasound is an issue which has been raised in media articles which demonstrate concern about wind farm developments. It can also be raised as an issue by residents in the area of a proposed wind farm.

Unfortunately much of the media coverage has been based on misunderstandings about infrasound, for example:

- that "infrasound can be felt but not heard" – this is not correct. Infrasound can be audible at high levels, and can only cause body vibrations at very high levels
- that "infrasound is harmful at any level" – this is not correct. Infrasound is naturally occurring in the environment, e.g. in ocean waves and wind, and harmful effects are only likely to be observed at extremely high levels

A UK Department of Trade and Industry (DTI UK) report notes that "*Infrasound is noise at frequencies below the normal range of human hearing, i.e. <20Hz*".[8]

Despite the inference by the term itself, infrasound can be audible. The DTI UK report notes that "*... frequencies down to a few hertz are audible at high enough levels*". Infrasound can also be observed through resultant rattling of light weight materials such as a pane of glass.

Recently, several papers have been prepared which include a literature review and consideration of infrasound. In particular, the Aiolos report concludes that "*Wind farm noise do [es] not have significant low-frequency (infrasound) components*".[9]

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8 The Working Group on Noise from Wind Turbines (1996) *The assessment and rating of noise from wind farms (ETSU-R-97)*. Department of Trade and Industry, United Kingdom.

The HGC Engineering report[10] also comments that:

> *While a great deal of discussion about infrasound in connection with wind turbine generators exists in the media there is no verifiable evidence for infrasound production by modern turbines.*

Also, NZS6808:2010 notes that:

> *Although wind turbines may produce some sound at (ultrasound and infrasound) frequencies considered to be outside the normal range of human hearing these components will be well below the threshold of human perception.*

Several points are worth noting:

- Human perception of sound energy in the infrasound frequency range is much less acute than in other frequency ranges. Significant energy is required to produce levels of infrasound which are high enough to be perceived by humans.
- The audible modulating (swoosh – swoosh) sound of a wind turbine is not infrasound
- While early 'downwind' turbines produced pressure pulses at about once per second, high enough to cause vibrations in lightweight buildings nearby, modern 'upwind' turbines produce infrasound pulses at low levels, well below the hearing threshold
- There is no reliable evidence that infrasound at levels below the hearing threshold has an adverse effect on the body

Leventhall[11] states that *"Infrasound can be neglected in the assessment of noise of modern wind turbines".* As a result, these Guidelines do not require an assessment of infrasound from wind farm developments. However, guidance is provided below for situations where infrasound measurements are to be conducted.

It should be noted that while infrasound is able to be measured, this requires specialised sound level monitoring equipment.

DIN 45680:1997 *Measurement and evaluation of low-frequency environmental noise* is suggested for assessment of infrasound[12]. It should be noted that the assessment frequency range of DIN 45680:1997 extends down to 8Hz and so excludes some frequencies which are considered part of the infrasound range, below 8Hz.

Low frequency noise

Leventhall[13] states that "*low frequency noise is defined as from about 10Hz to 200Hz*".

Thus the frequency range for low frequency noise extends into the range of sounds that are readily audible as 'rumbling' sounds. It should be noted that the A-weighted noise level limits which are used to assess general noise emission from a wind farm generally include frequencies as low as about 50Hz. The A-weighting makes these lower frequencies relatively less influential in the A-weighted sound level but they are nonetheless accounted for to some degree. However, under some conditions, the A-weighted assessment will not be suitable, as the WHO *Community noise guidelines* state:

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9 Ministry of the Environment (2007) *Acoustic consulting report prepared for the Ontario Ministry of the Environment – Wind turbine facilities noise issues*. Aiolos report number 4071/2180/AR155Rev3, Queens Printer for Ontario, Ontario.

10 HGC Engineering (2007) *Wind turbines and sound: Review and best practice guidelines*. CanWEA, Ottawa.

11 Leventhall, G., (2006) *Infrasound from Wind Turbines – Fact, Fiction or Deception*, Canadian Acoustics Vol. 34 No.2, pp 29-33

12 This assessment method is also suggested for the assessment of Low frequency noise as discussed in the following section.

13 Leventhall, G. (2004) *Notes on low frequency noise from wind turbines with special reference to the Genesis Power Ltd proposal, near Waiuku NZ*. Genesis Power/Hegley Acoustic Consultants, New Zealand.

When prominent low-frequency components are present, noise measures based on A-weighting are inappropriate.

As with infrasound, there are several points worth noting:

- Low frequency noise is naturally occurring in the environment
- Low frequency noise is not normally a problem with wind farms, except under conditions of unusually turbulent inflow air.

Where a low frequency noise assessment is carried out, it is likely to require the measurement of sound levels indoors. This is in contrast to other measurements associated with wind farm noise emission, including background noise level measurements to establish noise level limits, which are carried out outdoors.

The evaluation method presented in DIN45680:1997 consists of the two following stages:

- Conduct a preliminary investigation consisting in subtracting the A-weighted noise level from the C-weighted noise level. If the resultant is higher than 20dB, then the measured sound is considered to contain low frequency noise.
- Conduct a third octave band assessment where each third octave band level is to be compared against the hearing threshold levels presented in Table B-5.

In addition, the assessment should be able to demonstrate that measured levels of the reported Low frequency noise are sufficiently above the background noise level.

Human thresholds to low frequency noise are much less sensitive than to sound in other frequency ranges, such as the range of speech frequency. For example, the 50% hearing threshold for humans at 20Hz, according to DIN 45680:1997, is 71dB. Where a tone at 20Hz is less than 71dB, 50% of the population of people with normal hearing will not be able to perceive it. In contrast, the hearing threshold for humans at 1000Hz is 0dB.

However, once low frequency noise is perceived, changes in the sound level are more readily observed. Leventhall[14] states that an increase in low frequency noise of 5dB can subjectively be perceived as a doubling in loudness. This contrasts with sound at mid and high frequencies where a doubling in loudness is normally associated with a 10dB increase in sound level.

Table B-5
Hearing threshold levels

Centre frequency of third octave band (Hz)	Hearing threshold level (dB)
8	103
10	95
12.5	87
16	79
20	71
25	63
31.5	55.5
40	48
50	40.5
63	33.5
80	28
100	23.5

[14] Leventhall, G. (2003) *A review of published research on low frequency noise and its effects.* Department for Environment, Food and Rural Affairs, London, United Kingdom.

C Landscape

C.1 Introduction

This Appendix addresses the impacts of wind farms on landscape values. Its purpose is to provide:

- Technical methodologies (i.e. a logical sequence of steps) for the proponent to follow in assessing the impacts of a wind farm proposal on landscape character and features, taking into account community values about landscape
- Clear methodologies that outline the processes required in achieving a preliminary assessment, full assessment and visual impact assessment in terms of landscape and visual character and features, in response to a proposed wind farm development
- A list of tasks (some discretionary) for each Stage of analysis that can be undertaken in conjunction with each other where applicable
- Practice Notes where more technical detail or explanation is needed
- An approach that is explicitly integrated with community engagement and consultation processes (landscape values are held and perceived by communities and stakeholders)

The Appendix contains methodologies for the following **stages** of a wind farm development application:

- Project Feasibility/Site Selection
- Planning Application
- Construction and;
- Decommissioning

The methodology **tasks** for this Appendix are as follows:

- Preliminary Landscape Assessment
- Full Landscape Assessment
- Visual Impact Assessment; and
- Response to Impacts

The methodologies are provided for application where required. Not every methodology task presented in this Appendix has to be utilised. The methods are presented so that proponents and relevant authorities can use components of this Appendix where necessary. Each wind farm application will have its own individual planning issues and requirements. These methods can also be adapted to, and evolve over time, given they are neither prescriptive nor mandatory.

C.1.1 Basic description of issues addressed in the Guidelines

The issues addressed in the Appendix include:

- **Policy context**

  Assessing the existing policy context of the development is an essential early step in the process, because it may reveal certain constraints and statements by which the proponent must comply, depending on jurisdiction. The sources of the policy context for wind farms in different states will be many and varied.

- **Landscape character impacts**

  Given the sheer size and prominence of wind farms, the crux of the issue in respect to landscape character is the *extent* to which a wind farm development may impact on the existing character of the landscape and its features. Some landscapes are more sensitive to wind farms than others. Understanding the existing physical and visible attributes of the landscape are important factors in determining the extent to which its character may be impacted upon by a wind farm development. The rigour of assessment should be consistent despite the size and extent of the wind farm proposal.

- **Landscape significance impacts**

  Depending on the jurisdiction and their relevant planning controls, it may not be feasible to propose a wind farm in a location that will impact upon existing and/or designated significant landscapes. The likelihood that landscape significance has been properly and recently assessed will depend on the location. The absence of statutory landscape protection may not necessarily mean that the landscape lacks significance, in which case the proponent may be required to undertake a significance assessment. The statement of significance should be sufficiently rigorous to clearly outline which aspects of significance (if any) a wind farm would impact on.

- **Impacts on viewsheds and views**

  Visual impacts of a wind farm proposal need to be considered, in part at least, in relation to viewsheds and views. Views can take a number of forms, including panoramas, prospects, point-to-point and so on. Viewpoints – the location of the viewer – can be static or dynamic (an example of the latter is a tourist drive). A viewshed is defined as the area of land visible from a point, or series of points – in other words, the 'seen' area. Identification of important views is fundamental when considering the impact of a wind farm on a landscape. The locations from which these views are accessed are also important. Viewing locations from which the proposed wind farm is likely to be visible range from designated viewing platforms to the more incidental public use locations (such as roads and settlements). In some cases, close-to-viewer mitigation works, such as screening of a view, may resolve identified site level viewing impacts. In most other cases, the siting or layout of a wind farm may need to be adjusted to reach an acceptable level of impact.

- **Impacts on community values**

  The impact of a wind farm on a landscape is not necessarily just visual – other 'values' can be affected. Community values and perception of landscape may include associations, memories, knowledge and experiences or other cultural or natural values. Therefore landscape professionals tend to use the term 'landscape values' when considering the impacts of development on a landscape. However for the purpose of clarification in these Guidelines, scenic, character and visual values are sometimes used interchangeably for 'landscape values'. The central component is working with communities to understand *their* values of the landscape.

  Values are held by individuals and communities, and some values reside predominantly in the subjective territory of human perceptions. Therefore a thorough assessment of landscape character and significance, and of the impacts of a wind farm proposal on landscape character, has to include direct community input.

  Partly this is a question of working with the community in the local area affected by the wind farm proposal. The aim is first to understand the various types of communities of interest that may exist in relation to the landscape, then to understand the values and respond to them. For example, local people often have strong attachment to the outlook from a particular viewpoint, and this knowledge should inform choice of viewpoints for visual modelling.

  Valued landscapes also exist for communities at national and regional level. Examples would be features of national significance such as Uluru or state and/or regional significance such as Victoria's Twelve Apostles. Values at this level need to be considered. Relevant techniques are referred to in the sections on Landscape Significance in the Appendix.

- **Cumulative impacts**

  "Cumulative landscape and visual effects result from additional changes to the landscape or visual amenity caused by the proposed development in conjunction with other developments (associated with or separate to it), or actions that occurred in the past, present or are likely to occur in the foreseeable future. They may also affect the way in which the landscape is experienced".[15]

  Scottish Natural Heritage (2005) describes a range of potential cumulative landscape impacts of wind farms on landscapes, including:

  - Combined visibility (whether two or more wind farms will be visible from one location).
  - Sequential visibility (e.g. the effect of seeing two or more wind farms along a single journey, e.g. road or walking trail).
  - The visual compatibility of different wind farms in the same vicinity.
  - Perceived or actual change in land use across a character type or region.
  - Loss of a characteristic element (e.g. viewing type or feature) across a character type caused by developments across that character type.

  Cumulative impacts may also occur where there are no other wind farms in the area, but by virtue of combination with other major infrastructure or large scale developments (e.g. industrial, urban, large-scale agricultural) and/ or direct or indirect landscape changes (e.g. vegetation clearing) which may alter the overall character or values of an area.

  The assessment of potential cumulative impacts should include proposed developments in the region which have been approved but not yet built. Relevant authorities may provide direction as to the extent to which proposed developments should be considered in assessing potential cumulative impacts. There may, for example, be different considerations for developments which have been approved, but not yet constructed, and those awaiting development approvals.

  Cumulative impacts need to be considered in relation to dynamic as well as static viewpoints. The experience of driving along a tourist road, for example, needs to be considered as a dynamic sequence of views and visual impacts, not just as the cumulative impact of several developments on one location. The viewer may only see one wind farm at a time, but if each successive stretch of the road is dominated by views of a wind farm, then that can be argued to be a cumulative visual impact.

  Cumulative impacts may be visual and aesthetic, but they can also occur in relation to non-visual values about landscape. Non-visual values include sounds/noise, associations, memories, knowledge and experiences or other cultural or natural values. To give an example, locating four wind farms in a valley previously best known for its historic wineries might change the balance of perception about the valley's associational character, irrespective of whether all four wind farms were sited in a single viewshed.

- **Management and mitigation**

  Management and mitigation refers to actions taken to reduce or eliminate impacts as a result of the full landscape assessment and visual impact assessment. It is imperative to note that mitigation measures are very limited for wind farm development and therefore **general location** and **site selection** is of utmost importance.

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[15] *Guidelines for Landscape and Visual Impact Assessment, Second Edition, Spon Press, p85*

C.1.2 Issues not addressed in the Landscape Methodology

This Appendix does not address:

- **Site-specific heritage impacts**

  The methodologies contained in this Appendix place a strong emphasis on identifying and protecting significant cultural and natural landscapes (and features within cultural and natural landscapes) and dealing with any wind farm impacts on them. In terms of 'heritage' per se being assessed, identifying and assessing elements within the natural and cultural features will contribute to this. The process of identifying and protecting individual sites of heritage significance is a separate professional field of analysis that has its own extensive body of regulation, policy and procedure. Investigation of any heritage attributes of the wind farm site, or visual or other impacts on nearby heritage places, may be warranted in locations directly affected by a wind farm proposal.

- **Site-specific environmental impacts**

  The environmental attributes of a landscape are often intrinsic to, or at least a component of, that landscape's significance. Where environmental significance has been identified in a landscape affected by a wind farm proposal, this may become a contributory factor in assessing the significance of that landscape. However the process of identifying and protecting individual sites of environmental / ecological significance is a separate professional field of analysis that has its own extensive body of regulation, policy and procedure. Investigations of environmental and ecological characteristics are often warranted in locations directly affected by a wind farm proposal.

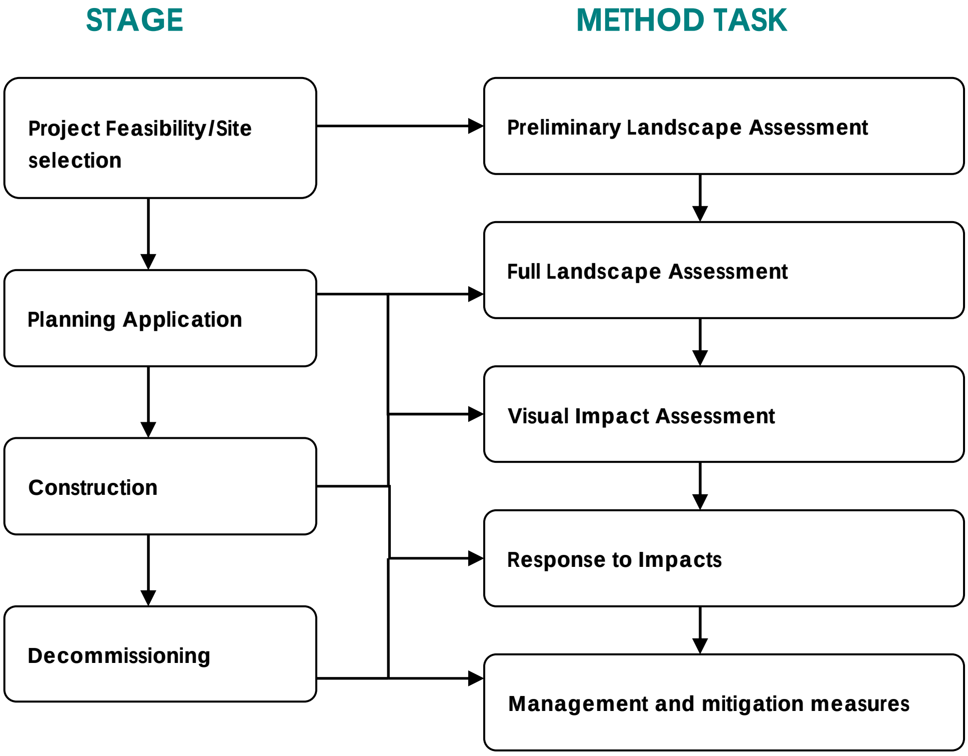
C.1.3 Related documents and standards

Two principal sources have been used in arriving at the methodologies, and should be used in conjunction with this Appendix if more detail and specific guidance is required:

- *Wind Farms and Landscape Values: National Assessment Framework* (Auswind and Australian Council of National Trusts, 2007); and
- *Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design* (Western Australian Planning Commission, 2007).

C.2 Overview of Methodologies

Figure C-1
Simplified Flow Diagram of Landscape Methodology



The staged approach to the assessment of landscape and impacts is summarised below with more detail in the Tasks column.

Stage and methodology	Tasks	Task methodology location
Project Feasibility/ Site Selection		
Preliminary Landscape Assessment	Defining the scope and policy context	Page 76
	Preliminary landscape character and significance analysis	Page 78
	Preliminary views analysis	Page 79
	Preliminary community values analysis	Page 80
	Identification of possible cumulative impacts	Page 80
Planning Application		
Full Landscape Assessment	Landscape character analysis	Page 81
	Landscape significance analysis	Page 82
	Viewshed and views analysis	Page 82
	Community values analysis	Page 83
	Cumulative impacts analysis	Page 84
	Develop objectives/ strategies to manage landscape character	Page 84
Visual Impact Assessment	Assessment of impacts on landscape character and significance	Page 85
	Assessment of impacts on viewsheds and views	Page 86
	Assessment of impacts on community values	Page 86
	Assessment of cumulative impacts	Page 87
Response to Impacts	Options for management and mitigation	Page 88
	Management and mitigation measures consultation	Page 88
	Agreed management and mitigation measures	Page 88
Construction		
Management and mitigation	Ensure all construction is managed within landscape mitigation outcomes and recommendations after assessment	Page 89
Decommissioning		
Rehabilitation: reinstate landscape	Rehabilitate landscape to pre-development condition	Page 89

C.3 Task Methodologies

C.3.1 Project Feasibility/site selection

Project feasibility and site selection directly relate to the preliminary landscape assessment to identify any major constraints to the project in order for successful site selection and project feasibility (i.e. substantial evidence whether the project is feasible given its location in the landscape, size, siting and design).

The Preliminary Landscape Assessment will inform the project feasibility and site selection of the wind farm development. The preliminary assessment is essentially for:

- data gathering such as maps, descriptive material, site visits and photographs, relevant documented landscape assessment studies
- planning policy context, landscape protection policies and designated highly-valued landscapes in the surrounding area, local authority consultation
- preliminary community consultation where possible

Based on the site inspection and local authority consultation, it may be concluded that:

- The project may be not feasible if the wind farm would be sited in a landscape that has is highly sensitive or valued, or would result in a major change to the landscape's character. If the proposed site adjoins or is located on an area statutorily designated as having landscape significance this may also reduce the project's feasibility.
- The project may be feasible if the wind farm would be sited in a landscape that has a relatively 'low sensitivity' and not as highly-valued, or would result in only a minor change to the landscape's character The project may be feasible if the site is located in an area in which no reference is made in statutory planning instruments to significant landscapes.

The Preliminary Landscape Assessment should also consist of the following:

Undertake a site inspection to assess in a preliminary manner the extent to which the character of the landscape would be changed by a wind farm, including:

- Considering the existing characteristics of the landscape (landform, waterform, vegetation and land use) and its likely sensitivity to change (refer to *Best Practice Siting and Design* Practice Note).
- Roughly estimating the extent of the likely 'viewshed' of the wind farm (refer to *Viewshed Mapping* Practice Note, Section C.7.5).
- Assessing whether the change to the landscape's character would be major, moderate or minor.
- Gathering information regarding the community's relationship to the landscape.

This information may be already documented or may require discussion with representatives of the authority. The relevant information includes:

- Whether there is large settlement nearby, and therefore potential for a large local community interest to occur.
- Whether there has been any recent community concern about landscape protection or impact of development on landscapes.
- The extent to which any impacts identified above might be perceived as negative by elements in the local community.
- Any reports that might contain pertinent information about local community values in relation to landscape.

Initial fieldwork and investigation of the area proposed for a wind farm development will assist in the site selection process, and ideally would be done before the wind monitoring process begins.

C.3.2 Preliminary Landscape Assessment

The output from the tasks below is a Preliminary Assessment Report that aims to inform the Broad Landscape Assessment and subsequent Visual Impact Assessment (C.4.1 and C.4.2) by:

- Summarises existing research and fieldwork regarding the landscape character and features in the area that could be affected by the proposed wind farm.
- Identifies regionally and/or locally significant views and viewing locations.
- Draws preliminary conclusions about locations (public and private) from which the proposed wind farm is likely to be visible, or which the development may impact on in some manner, and the relative importance of the landscape character and features in the those locations.
- Identifies any strongly-held community values that might influence the development of a wind farm in this landscape
- Depicts, in a preliminary manner, the visibility of the wind farm development in the landscape.
- Identifies substantial gaps in knowledge to be addressed in subsequent stages.

In compiling the report, the following questions should be considered:

- Are landscapes of significance identified? Do they contain values which the wind farm might impact?
- Have landscapes, features and views/viewing locations held in high regard locally been identified? Can the wind farm avoid impacting on these?
- Have the views of potential stakeholders and identified communities of interest been identified and documented?
- Are there preliminary adjustments to location or scale (e.g. number of turbines) which would provide a better fit in this landscape?
- What should be the preliminary landscape and visual management objectives for the project?
- Is there enough information to proceed to Stage 3, or to determine the landscape impact does not require further assessment?

C.3.2.1 Defining the scope and policy context

Information should be gathered relevant to providing an understanding of the landscape values of the proposed wind farm site and surrounding area. Sources of information should include:

- National
    - National Trust register.
    - Registers held by the Commonwealth including the National and Commonwealth Heritage Lists and the Register of the National Estate.
    - Any relevant Commonwealth policies.
    - Any relevant Commonwealth studies/ guidelines, or studies by national bodies, including those currently in progress.
    - Any relevant decisions made under Commonwealth legislation.

- State
  - Relevant State heritage register.
  - Any relevant State policies on landscape protection/wind farm guidance.
  - Any relevant State studies/ guidelines, or studies by state bodies, including those currently in progress.
  - Any relevant decisions made under State legislation.
- Regional
  - Regional landscape, heritage or environmental studies/ guidelines and policies.
- Local
  - Local government planning schemes / local environment plans / development plans.
  - Any relevant Council studies/ guidelines, or studies by local bodies, including those currently in progress.
  - Informal consultation with stakeholders and local communities.
- Appeal / panel Decisions
  - Relevant planning appeal, planning panel and environmental impact assessment decisions.
- Base Information
  - Aerial photography for the wind farm site and surrounding region. (Note: Where aerial photography is not available, the proponent should consider whether it would be prudent to commission an aerial survey to provide input to the landscape and visual assessment, as well as to other studies (e.g. flora and fauna assessments).
  - All relevant GIS data, for the wind farm site and surrounding region.
  - Contour information will be needed at 10 metre intervals over the assessment area, and ideally 5 metre or 1 metre over the project site to produce 3D modelling, so this task should be commissioned now if the data are not already available. One metre contours will be needed for accurate depiction of visual impact of individual turbines on specific views.

The analysis and reporting should be sufficiently rigorous to:

- Provide the policy context basis for the briefs for all the tasks in the Full Landscape Assessment (page 80).
- Identify opportunities and constraints of the project, as informed by existing policy documents and previous landscape studies.
- Identify any gaps in knowledge about the wind farm site and surrounding area that can be filled by means of a site survey/ fieldwork or expert evaluation.

It should be noted that:

- Local communities will provide the main source of information regarding the significance of the landscape in the area; however, State and local government authorities will also help to point out important sources of existing information.
- Potential evidence of valued landscape character and features may also be found in art and literature sources; through proxy measures such as use and visitation; in tourism information; from past heritage, sense of place or community art projects etc. Some sources may be local while others may be regional.

C.3.2.2 Preliminary landscape character and significance analysis

Building on information gathered in the scope and policy context, desktop research should include gathering descriptive material relevant to understanding the character and significance of the proposed development and surrounding area, sufficient to inform the preliminary assessment.

Identify and describe (in a preliminary manner) the landscape character of the study area and surrounding landscape(s). Consider:

- The individual landscape character units that occur across the region (refer to *Landscape Character Units* Practice Note, Section C.7.2).
- The main natural, rural and built (urban) characteristics.
- Particular locations, features or characteristics of the landscape that are important to understanding its character and significance (including current or historic land uses).
- Prominent and culturally important locations from which the wind farm may be visible.
- The visual character of the landscape(s).

Identify and document in a preliminary manner the communities and stakeholders who may hold values relating to the wind farm site and surrounding landscape (e.g. for a landscape that has State or National significance).

Following the desktop research, the proponent should:

- Prepare a generic base map of the wind farm development and its surrounding context. Supporting information to provide context should include roads, settlements, prominent landform features and landmarks, and shire boundaries/ district boundaries (if applicable).
- Identify and map the landscape character units that occur within the study area and wider region (refer to *Landscape Character Units* Practice Note, Section C.7.2).
- Define and map (in a preliminary manner) the likely extent of the study area for the landscape assessment, which should include a wider contextual study area and a primary study area.

The wider contextual study area should cover an area that:

- Places the broad landscape character unit in which the subject land is located into the context of adjoining landscape character units; and
- Encompasses the location of any existing or proposed wind farms or other major infrastructure works identified in *C.3.2.5 Identification of possible cumulative impacts* (page 80).

The primary study area should equate to the anticipated Viewshed, or Zone of Visual Influence, of the wind farm (refer to *Viewshed Mapping* Practice Note, Section C.7.5). Following the analysis, it is recommended that a preliminary site inspection is conducted to verify assumptions made in the above desktop analysis.

The reporting (which could include photos and sketch maps) should be sufficiently rigorous to:

- Ascertain (in a preliminary manner) the extent to which the character of the landscape would be changed by a wind farm.
- Draw preliminary conclusions about the significance of the landscape(s) in which the wind farm is to be sited.
- Provide the study area for the briefs for all the tasks in the Full Landscape Assessment (page 80).
- Provide the basis for briefs for the *C.4.1.2 Landscape significance* analysis (page 82).

The preliminary landscape character and significance analysis should ascertain (in a preliminary manner) the extent to which the character of the landscape would be changed by a wind farm based on:

- The size of the landscape character unit (refer to *Landscape Character Units* Practice Note, C.7.2).
- The sensitivity to change of the landscape, including its capacity to absorb a wind farm both visually and in relation to non-visual elements such as documented social, cultural and environmental values.

C.3.2.3 Preliminary views analysis

This task should start by identifying all existing regionally and/or locally significant views and viewing locations. Other key locations from which the proposed wind farm is likely to be visible should then be identified (in a preliminary manner). These locations should include both public use locations (such as roads/ tourist drives, settlements, lookouts, recreation areas), within the subject land and surrounding area. With respect to views from private residences in relation to wind farm planning it should be noted that there is a typical understanding that there is no legal right to a view. Views from individual residences should not be included within the assessment and made publicly available. It is suggested that this work, if required, should be carried out as part of the community consultation process, and in particular, consultation with the closest neighbours to the wind farm development.

Sought information (such as the location of buildings/ settlements and towns/ lookouts) can be initially compiled from aerial photography and then followed up and verified through fieldwork. It may also be worthwhile seeking information from local relevant authorities about the possibility of future developments/ dwellings within the subject land and surrounding area.

Particular attention should be given to locations from which the proposed wind farm is likely to be visually prominent. These locations should be recorded on site using a hand-held GPS. All preliminary views should then be subsequently verified and documented through on site photography.

At this stage, it is highly recommended that a preliminary 3D 'wireframe' computer model that accurately depicts the wind farm development in the landscape is prepared (see *3D Computer Modelling* Practice Note, Section C.7.4). Preliminary 'wireframe' depictions can be useful at this early stage to provide an accurate assessment of the wind farm development. This 'dynamic' assessment system allows the proponent to make preliminary adjustments to the location or scale (e.g. number of turbines) to provide the best fit in this landscape.

If warranted (and given a preliminary 'wireframe' model has been prepared), the task could map the likely 'viewshed' of the wind farm (see *Viewshed Mapping* Practice Note, Section C.7.5).

Furthermore, the task could prepare preliminary 'wire frame' photomontages that accurately demonstrate the visibility of the wind farm development in the landscape from key locations from which the development will be viewed (*Photomontage* Practice Note, Section C.7.6). This would normally be undertaken in the Full Landscape Assessment (page 80), but could justifiably be undertaken during this preliminary assessment phase if landscape impacts are anticipated to be potentially decisive when the application for the proposal is assessed.

While models and photomontages should be accurate, they do not need to be of high quality presentation level at this stage.

C.3.2.4 Preliminary community values analysis

In consultation with the local Council (and other relevant agencies or groups if appropriate), identify and document in a preliminary manner:

- The various groups in the local community who may hold values relating to the wind farm site and surrounding landscape.
- Any strongly-held community values which may not be formally recognised, but which may influence the development of a wind farm in the landscape.
- Opportunities for direct consultation with stakeholders and local communities in the Full Landscape Assessment (page 80). Options for establishing contact should also be considered in conjunction with the Community and Stakeholder Consultation specialist. These options may include telephone or face to face surveys, and focus groups.
- Community/stakeholder *types* include any individual, business or group who may live or work in proximity to a wind farm, or who may have an interest or association with a wind farm development or its potential impacts. Stakeholders may include community members (including the Aboriginal community), statutory and non-statutory agencies, businesses, interest groups and organisations.

Depending on the project and the landscape risks identified, it may be worthwhile establishing a dialogue with some or all of the stakeholders identified above at this stage.

The community values analysis should also assess existing documentation (such as tourism brochures and guidebooks) for indications about community and other values attached to landscapes in the vicinity of the subject land.

Documentation (which could include material collected such as tourism brochures) should be sufficiently rigorous to:

- Draw preliminary conclusions about the likely strength of community feeling about the landscape in which the subject land is sited.
- Draw preliminary conclusions about the potential for landscapes in the vicinity of the wind farm to be later found to have significance even if not presently subject to statutory protection.
- Provide the basis for the brief for the *C.4.1.4 Community values analysis* (page 16).

C.3.2.5 Identification of possible cumulative impacts

Other wind farms, major infrastructure and/or large scale developments (e.g. industrial, urban, agricultural) in the study area or region need to be identified.

Furthermore, information should be sought from local relevant authorities about other projects in the region that have been approved but not yet built or that are being developed in parallel with the wind farm. Such projects would include other wind farms, major infrastructure and/or large scale developments (e.g. industrial, urban, agricultural) in the study area or region.

A map needs to be prepared to illustrate the base cumulative impact of the wind farm development (see *Cumulative impact mapping* Practice Note, Section C.7.9).

C.4 Planning Application

C.4.1 Full Landscape Assessment

The output from the tasks below is a Full Landscape Assessment Report that aims to inform the next phase - Visual Impact Assessment (C.4.2.) by:

- Identifying and describing (in words, maps and images) the natural and cultural characteristics and associated values of the landscape of the wind farm site and surrounding area.
- Outlining any documented or recognised valued landscape character and features, along with any likely impacts of a wind farm on these values.
- Evaluating the significance of the landscape character and features, and identifying elements of local, state or national significance.
- Identifying the community and stakeholder groups for whom the landscape is or might be held in high regard, including those involved in contributing values to the study.
- Identifying and describes features in the landscape, views and viewing experiences, characteristics or associations that are valued by communities.
- Providing maps and other graphic material to support the description of landscape and visual values.
- Providing reliable, objective data to inform the Visual impact Assessment (page 18) and assist communities to understand the development and its potential impacts on the landscape character and features.
- Providing objectives and/or strategies to manage valued landscape character, prior to the visual impact assessment stage.

In compiling the report, the following questions should be considered:

- Is there sufficient information to describe all the potential impacts of the wind farm on the landscape?
- Has information been provided about the purpose of the wind farm, its size, location and life-span?
- Have the accuracy and reliability of the visual models been reported and justified?
- What information will support impacted community and stakeholder values to make informed decisions about the potential impacts of the wind farm on landscape character and features?
- Is the landscape and visual assessment report sufficiently resolved to assist in assessment of impacts in the Visual impact assessment (page 85)?

For a contentious project, a peer reviewer with professional expertise in landscape analysis could be appointed to review the detailed methodology proposed in the following tasks prior to commencement of works, and make recommendations for improving the methodology, if necessary. This is not an essential part of the process and is only undertaken if the development has sensitive elements that may need to be validated. The consultant should then discuss the results with the peer reviewer and resolve either to modify the methodology (in whole or in part) in accordance with the peer reviewer's recommendations, or implement the peer reviewer's recommended methodology in parallel with the analysis by the primary landscape consultant as a means of presenting a second opinion to the assessing relevant authority.

The reporting for each task should provide written justification for the choices made and details on the method and reliability of the models used in the analysis, including any margins of error.

C.4.1.1 Landscape character analysis

The starting point for this task should be the wider contextual study area and the primary study area for the landscape assessment established in the *C.3.2.2 Preliminary landscape character and significance analysis*. In describing the landscape character of the area, the proponent will need to take into account the regional context in which the wind farm development is located.

A site survey should then be undertaken to identify and document (through photographs, mapping and descriptions) the key characteristics of the landscape of the proposed wind farm site and surrounding area. The survey should consider, identify and describe:

- Landform scale and physical features
- Contours/ topography
- Vegetation type and cover
- Water bodies
- Current land use and built structures
- Any forces of change in the landscape (natural and human-induced) (e.g. evolving agricultural practices, revegetation of degraded river valleys, expansion of townships)

It is also recommended that a desktop study be undertaken to identify and review additional secondary materials (e.g. landscape, cultural and natural heritage studies) which may assist in understanding the landscape character of the wind farm site and surrounding area. Visual arts and literature sources may also assist in describing the characteristics of a landscape that may be valued by communities.

If necessary, it may be worthwhile to support this with information about historic landscape character and past land uses, if this is available.

The outcome of this task should be a report (including photos and maps) documenting the key characteristics of the landscape of the proposed wind farm site and surrounding area, using information gathered in the *C.3.2.2 Preliminary landscape character and significance analysis* and identified as part of this task. Firm conclusions should be drawn regarding the extent to which the character of the landscape would be changed by the wind farm proposal.

C.4.1.2 Landscape significance analysis

To inform an understanding of landscape significance, relevant materials from the ecological and cultural heritage (indigenous and non-indigenous) studies for the wind farm site and surrounding area should be reviewed. These should include existing studies and those being undertaken for the project.

Informal documentation should also be gathered from secondary sources to assist in identifying additional indicators of landscape significance, such as highly visited tourist routes, key landscape features and destinations. These materials may be sourced from tourism brochures, art, literature and internet.

The values of the wind farm site and surrounding area should then be detailed based on all information collected, potentially including descriptions of social, aesthetic (including visual, scenic) and other cultural and natural values.

On the basis of analysis work in this task and in *C.3.2.2 Preliminary landscape character and significance analysis*, firm conclusions should be drawn about the significance of the landscape characteristics of the wind farm site and surrounding area and elements within it (see *Levels of Significance* Practice Note, Section C.7.3).

C.4.1.3 Viewshed and views analysis

A viewshed map should be prepared that illustrates the wind farm development and surrounding area (see *Viewshed Mapping* Practice Note, Section C.7.5).

A 3D computer model should be prepared, that accurately depicts the wind farm development in the landscape (see *3D Computer Modelling* Practice Note, Section C7.4).

Advanced photomontages should also be prepared that accurately depict the visibility of the wind farm development in the landscape from key locations identified in the *C.3.2.3 Preliminary* views analysis (see *Photomontage* Practice Note, Section C.7.6). Any preliminary 'wire frame' photomontages developed in the *C.3.2.3 Preliminary* views analysis should be used as a base for developing these advanced presentation level outputs.

It may also be worthwhile to prepare a number of cross-sections that accurately illustrate key residences and their proximity to proposed wind farm turbines and ancillary infrastructure.

If landscape impacts are anticipated to be potentially decisive when the planning application is assessed, it may be worthwhile to prepare 3D simulation(s) (or animations) and/ or virtual reality (VR) modelling of the proposed wind farm and surrounding context to accurately illustrate the impact of the wind farm development on the landscape, as experienced by a person moving through the subject landscape (see *3D Simulation* Practice Note, Section C.7.4, and *Virtual Reality (VR) Modelling* Practice Note, Section C.7.8).

In developing computer-generated representations, it should be recognised that wind farms have a number of attributes which contribute to their potential impact on the landscape. All depictions should include accurate information about the type, size, location and design of the wind farm turbines and all ancillary infrastructure (e.g. substations, transmission lines, access tracks, roads, buildings) associated with the development, in order to clearly understand potential impacts. The depictions also need to address the 'combined visual envelope', namely the visual impact of all other wind farms, major infrastructure and/or developments identified in the *C.3.2.5 Identification of possible* cumulative impacts, and should include proposed developments in the region that have been approved but not yet built.

The assessment of impacts should also consider the requirements of other authorities and how these may alter the nature of the project and its potential landscape impacts. For example, in some locations, the Civil Aviation Safety Authority may require aircraft warning lights to be located on turbines.

Consideration should also be given to undertaking site visits to existing wind farms in order to test assumptions and assess visibility under diverse viewing conditions (e.g. in different weather conditions).

C.4.1.4 Community values analysis

A detailed approach to facilitate the identification of community-held values about the landscape should be developed. This should include opportunities for communities and stakeholders to be involved in describing and evaluating the landscape character and features and significance of the proposed wind farm site and surrounding area. It may be necessary to refine the community stakeholder list developed during the *C.3.2.4 Preliminary community* values analysis prior to consulting with communities and stakeholders.

The consultation process will provide an opportunity for stakeholders and communities to identify and describe the values they hold about landscapes, and allow the consultant to examine the nature and strength of values within each community and the aggregated values at a local, regional, state and national scale.

On the basis of analysis work in this Task and in the *C.3.2.4 Preliminary community* values analysis, the analysis should then draw firm conclusions about community-held values about the landscape of the wind farm site and surrounding area (and elements within it), particularly with regard to:

- The strength of the values of identifiable groups in the local community.

- The extent to which values are likely to be shared between the various communities or cultural groups.

Any consultation should be coordinated through the Community and Stakeholder Consultation specialist.

It should be noted that:

- Consultation opportunities should be readily accessible by the local community and relevant stakeholder groups. They should also, where possible, be undertaken as part of a broader community engagement program for the project.
- Various techniques can be used to establish community-held values about landscapes; however, preference should be given to techniques that include direct contact with community members.
- Care needs to be taken to identify the range of communities and community sectors that may have particular associations with the landscape. It is not just the 'local community' that may have associations with a landscape. Nor can it be assumed that only people living within the viewshed of the wind farm will have an interest that should be recognised and explored.
- It may be important to consult with relevant communities to determine the best ways for them to be involved, considering their resources, priorities and cultural protocols. Different methods may be needed for different stakeholders and communities. For example, seeking input from non-resident land owners is likely to require a different approach compared with consulting with local government representatives.
- Information also needs to be provided to communities about the place (including its historical development, cultural heritage and natural values) as these will contribute to the community-held values of the landscape.

C.4.1.5 Cumulative impacts analysis

A map should be prepared to illustrate the base cumulative impact of the wind farm development (see *Cumulative Impact Mapping* Practice Note, Section C.7.9).

This map, together with the photomontages and 3D simulations developed in the *C.4.1.3 Viewshed and views analysis*, should be used to illustrate the cumulative impacts resulting from the proposed wind farm development in conjunction with other developments in the region. This analysis should recognise that cumulative impact is fundamentally experienced as a traveller moving through the landscape affected, and is therefore particularly important for tourist and scenic routes and where a one view spot analysis is not adequate.

C.4.1.6 Develop objectives/ strategies to manage landscape character

Building on the outcomes of the *Full Landscape and Visual Assessment*, the proponent should develop objectives and/or strategies to manage the valued landscape character and features prior to the Visual Impact Assessment. Consider:

- What are the appropriate landscape and visual management objectives for each landscape character unit; and how can they be achieved?
- What are the appropriate strategies to address landscape and visual management objectives for each character unit?

Objectives and strategies should include (but are not limited to): best practice siting and design (see Practice Note C.7.1), protection and maintenance of landscape character, restoration of degraded character, or enhancement of opportunities, for example, for viewing.

C.4.2 Visual Impact Assessment

The output from the tasks below is a Visual Impact Assessment Report that:

- Describes the wind farm proposal and surrounding landscape(s).
- Describes the identified landscape and visual impacts, and the values on which they impact.
- Evaluates the acceptability of individual landscape and visual impacts and of the wind farm as a whole.
- Describes the method used to identify and rate impacts.
- Includes supporting material including graphic depiction of impacts.

The Visual Impact Assessment Report should clearly identify:

- Any high-level negative impacts (e.g. those on landscapes of state or national significance, or which totally and irreversibly alter a value).
- Any impacts on significant values for which there are unlikely to be any practical mitigation measures available.
- Any impacts on significant values for which there are likely to be practical mitigation measures available.
- Any positive landscape and/or visual impacts or benefits (e.g. enhanced scenic or visual values) of the wind farm, including those described by community-stakeholders.

For a contentious project, the peer reviewer could test the results of the following tasks by using either the same method as the consultant or the peer reviewer's recommended methodology. The decision to undertake a peer review is at the discretion of the relevant authority and proponent, if so required.

C.4.2.1 Assessment of impacts on landscape character and significance

The impacts (positive and/or negative) of the proposed wind farm (including all components) on the character and significance of the landscape should then be identified and described.

Particular consideration should be given to:

- Specific features of the wind farm development which impact on the identified values of the landscape.
- The degree to which character or significance is lost or altered by the wind farm development.
- The scale, nature, duration and reversibility of impacts.

The impact of the proposed wind farm (including all components) on the character and significance of the landscape should then be evaluated. The following questions should be addressed in the evaluation:

- How does the wind farm impact on identified on valued landscape character and features?
- Is the impact on values of local, state, national or international importance?
- Do the effected stakeholders and communities understand the potential impacts on the landscape and its surrounds?
- Is the landscape character and features completely/partially lost or altered?
- To what extent are the negative impacts balanced by positive landscape benefits?
- What is the likelihood for removal of the wind farm and reinstatement of the landscape following decommissioning?

It may be worthwhile contacting local tourism operators, travel agents and regional tourism organisations to assist in identifying potential impacts of the proposed wind farm on values held by non-local communities and visitors.

C.4.2.2 Assessment of impacts on viewsheds and views

The assessment should identify, rate and describe the visibility and relative visual intrusion of the wind farm development on identified viewsheds and views. Particular consideration should be given to:

- Regionally and/or locally significant views and viewing locations, as identified in the *C.4.1.3 Viewshed and views analysis*.
- Key views and viewing locations from which the wind farm will be viewed (public and private), as identified in the *C.4.1.3 Viewshed and views analysis*.
- The expected number of viewers at each viewing location, taking into consideration land tenure and access, occurrence of tourism and recreation locations.
- The distance from which the wind farm, or elements of it, will be viewed (from identified key public and private locations) (identification of distance zones may be appropriate).
- The benefit of keeping the outlook from at least one side of a dwelling free of views of the wind farm development.
- Local transient, seasonal and climatic influences on visibility (e.g. atmospheric effects).
- Occurrence of other buildings and structures and vegetation which will affect visibility.
- Attributes of the wind farm turbines or ancillary infrastructure relevant to understanding visual intrusion (e.g. movement, colour, materials, reflectivity, transparency).

C.4.2.3 Assessment of impacts on community values

Input should be sought from community stakeholders to assist in describing potential impacts (positive and/or negative) of the proposed wind farm on identified valued landscape character and features. Ideally input would be sought from those individuals involved in identification of values of the subject landscape (see *C.4.1.4 Community values analysis*).

In seeking community stakeholder input, the proponent should provide sufficient information to inform the assessment, including:

- Information reflecting the conclusions of the Full Landscape Assessment, including those informed by direct community input or derived from other sources (e.g. research or previous studies).
- A description of the development, cross-sections, photomontages, viewshed mapping analysis), 3D simulations and the Full Landscape Assessment report (see page 80).
- Any other technical reports which assist to understand landscape impacts (potentially including reports by other consultants).
- The proponent may also choose to provide information relating to other studies (e.g. flora and fauna, cultural heritage) to assist community understanding of landscape values.

This information should then be analysed to evaluate the impact of the of the proposed wind farm (including all components) on community-held values of the landscape and surrounding area.

C.4.2.4 Assessment of cumulative impacts

Illustrative materials developed as part of the **Preliminary Landscape Assessment** (e.g. cumulative impact mapping, viewshed mapping, 3D simulations) should be used to describe and assess the cumulative impacts that may occur as a result of the proposed wind farm development.

The assessment needs to consider the full suite of changes (direct and indirect) that may occur as a result of the wind farm development, including the introduction of turbine towers into the landscape, vegetation clearing on the site for foundations and access roads, site substation and office/storage infrastructure, and off-site works (e.g. new quarries).

Consideration should be given to impacts arising from:

- Adding to or expanding an existing wind farm (where relevant).
- The occurrence of two or more wind farms visible from one location.
- The effect of seeing two or more wind farms along a single journey (e.g. a major route between two towns, identified tourism trail or walking track).
- The visual compatibility of different wind farms in the same vicinity (e.g. are they of the same design and style?).
- Perceived or actual change in land use across a landscape character type or region.
- Loss of a characteristic element (e.g. a sense of openness, or a specific landscape feature) across a landscape character type caused by multiple developments across that character type.

The assessment should then evaluate the cumulative impacts on the landscape (positive and/or negative) that may occur as a result of the proposed wind farm development. Questions that should be addressed include:

- Will the combined impact create an unacceptable degree of adverse effect on the community and observers within the area?
- Will the local presence of wind turbines combine to become the strongest characterising influence such that a new or more general landscape character area would be formed?

C.4.3 Response to Impacts

The output from the tasks below is a Landscape and Visual Assessment Recommendations Report that:

- Responds to the outcomes of the Full Landscape Assessment and Visual Impact Assessment
- Responds and addresses impacts identified and assessed in terms of the regional and local landscape, and visual impacts at the site level.
- Describes the opportunities and constraints for the overall siting and design of the wind farm in response to identified impacts.
- Describes the opportunities and constraints for the layout and design of turbines and ancillary features in response to identified impacts.
- Develops options and evaluates the suitability of these measures with members of communities and relevant stakeholders.
- Identifies commitments that have been made to respond to impacts.
- Includes a description of the remaining negative impacts and the likely potential to mitigate these impacts.

C.4.3.1 Options for management and mitigation

The assessment of options for management and mitigation of landscape impacts should:

- Identify whether any changes to the overall siting of the wind farm are warranted in response to impacts identified in the Landscape and Visual Impacts Assessment report.
- Identify whether any changes are required to the layout and design of turbines and ancillary features in response to impacts identified in the Landscape and Visual Impacts Assessment report.
- Identify other impacts for which smaller-scale mitigation measures might be available.

A suite of options should then be developed to remedy impacts either by directly addressing the impact or seeking to provide off-sets to communities and stakeholders. Questions that should be addressed include:

- Is the measure appropriate/viable?
- Does the measure mitigate the impacts?
- What other alternative design options should be considered?

It may be worthwhile to engage an expert in landscape planning, landscape architecture or design to advise on sympathetic or effective siting and design strategies.

Other measures which do not respond directly to impacts might also be considered, including landscape improvements in and around the wind farm site or off-sets (the protection or management of other landscapes). However, these should not be considered to mitigate identified impacts but rather provide trade-offs which might be used in considering the overall acceptability of the wind farm and its impacts on the landscape. .

C.4.3.2 Management and mitigation measures consultation

In identifying options for management and mitigation of landscape impacts, it may be prudent to develop and/or review these measures with members of the community and, where necessary, relevant experts. Once again, questions that should be addressed include:

- Is the measure appropriate/viable?
- Does the measure mitigate the impacts?
- What other design options should be considered?

The purpose of this task is to facilitate transparent information flow and community understanding regarding the potential impacts of the wind farm on identified and assessed landscape character and features. A number of different methods should be used to support a two-way flow of information and community feedback.

In seeking community input, it is important to recognise that different methods will generate different kinds of responses and some may be suited to particular kinds of stakeholders.

C.4.3.4 Agreed management and mitigation measures

This task is to document management and mitigation measures as agreed with members of communities and relevant experts. Specific details should be provided on commitments that have been made to respond to impacts and how these commitments will be achieved.

Finally, the Full Landscape Assessment and Visual Impact Assessment reports should be reviewed to determine whether any negative impacts on the landscape remain following the implementation of agreed changes. Should gaps be identified, consideration should be given to the following questions:

- How significant are the remaining negative impacts (e.g. on values of local, state, or national importance)?
- To what extent might they be reversible at a future date?

C.5 Construction

At the construction stage, all findings from the Preliminary and Full Landscape Assessment processes, visual impact assessment and responses should be implemented for construction. The management and mitigation measures resulting from these assessments should be adhered to, ensuring there is minimal impact at the construction stage. The Practice Note Siting and Design Guidelines, provide guidance at site level for minimising construction impacts.

C.6 Decommissioning

It is possible and is strongly encouraged, for decommissioning and reinstatement of the landscape to be required as a condition of approval. Many wind farm developers set up trust funds to provide for the decommissioning and/ or reconditioning of the facility.

If reinstatement of the landscape is required as a condition of approval, consideration should be given to ensuring that:

- The landscape and surrounding area is rehabilitated to its original condition prior to the development of the wind farm.
- Topography is restored to its pre-existing state to avoid soil erosion and changes to the surface water runoff.
- All formally constructed roads and tracks are fully rehabilitated with fill and revegetated to re-establish the natural land features that existed prior to the wind farm development.
- All remnant physical components of the wind farm are to be removed entirely.

C.7 Practice notes

C.7.1 Landscape character units

What is a Landscape Character Unit?

Landscape character units refer to areas of homogenous (similar) patterns of visual, physical, environmental and cultural characteristics such as landform, vegetation, water form and land use as well as individual features.

What is a Landscape Character Unit used for?

Landscape character is the interplay of geology, topography, vegetation, water bodies and other natural features, combined with the effects of land use and built development, which makes one landscape different from another. Establishing the various Landscape Character Units of an area provides the basis for understanding the different features, views, and combinations that are important, and how different types of development sit within various landscapes.

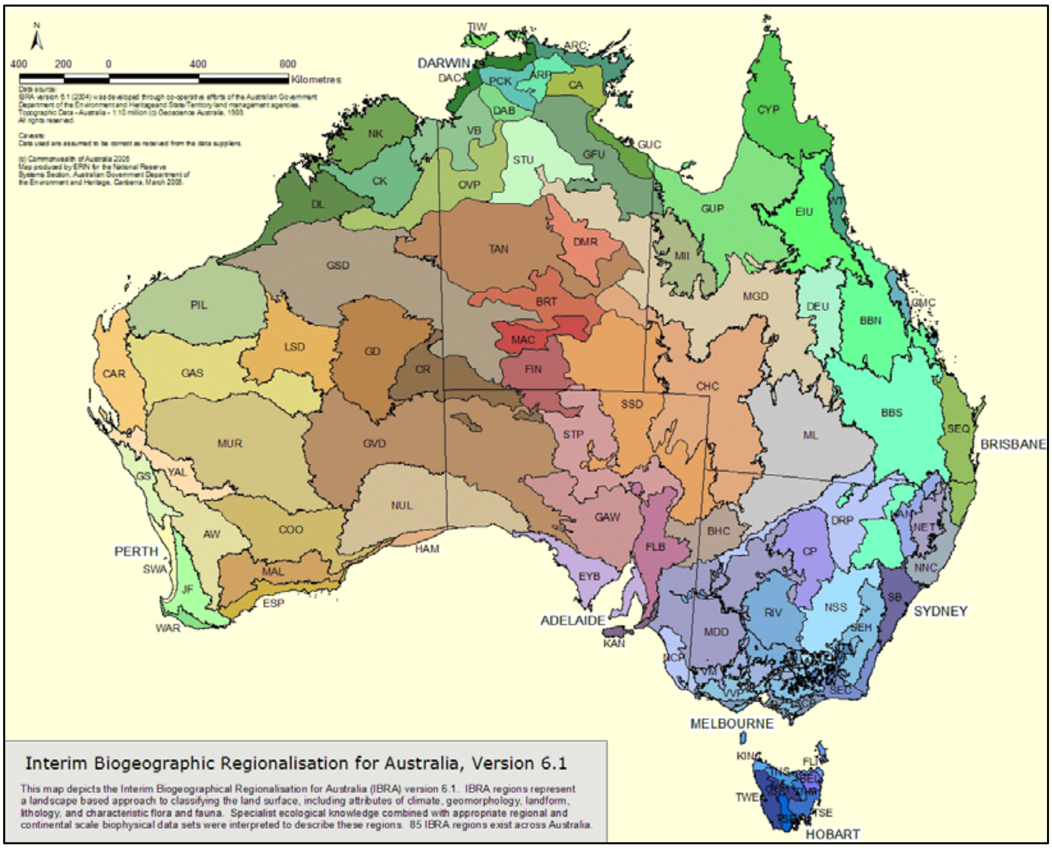
How do I go about it?

Identifying Landscape Character Units

Begin with a general analysis of the landscape of the entire study area; highlighting the major landform, vegetation, water form and land use (such as natural, rural or built) characteristics.

Landscape Character Units can then be roughly defined through identifying and defining areas that reveal similar characteristics. Established landscape IBRA (Interim Bio-geographic Regionalisation for Australia) data, developed by the former Department of Environment and Heritage, divides the Australian land mass into 85 bioregions. Each bioregion is a large geographically distinct area of similar climate, geology, landform, vegetation and animal communities. The 85 identified bioregions have then been further refined to 403 subregions (Figure C-2). These bioregions and subregions are the reporting unit for assessing the status of native ecosystems, their protection in the National Reserve System. As a starting point, established landscape IBRA classification methodologies can be used as a reference to inform the identification of broad Landscape Character Units. These bioregions and subregions do not have to be the final identified Landscape Character Units, but can provide a useful starting point.

Figure C-2
IBRA mapping of Australia's 85 bioregions



Source: Department of the Environment, Water, Heritage and the Arts

Describing Landscape Character Units

In describing the Landscape Character Units, focus on visual landscape character - which refers to the appearance of the basic landscape elements; landform, vegetation, water bodies and human land use that make an area identifiable or unique. A range of terms may be used. The examples provided in Table C-2 can be used as a guide, however not all terms are appropriate to every landscape. Modify the descriptions where appropriate.

There are many sources of references that provide descriptive inventories of the varied and unique landscapes that occur across Australia, which can provide useful frames of reference to assist in describing the landscape.

In conjunction with the description of the overall visual character of the landscape study area, the landscape character units can also be described in terms of the basic land use categories: natural, rural and built characteristics. Table C-3 provides examples of elements (natural, rural and built) that may be described at each stage of application: Regional, Local and Site.

Table C-2
Examples of terminology for describing visual aspects of landscape character

Scale	Intimate	Small	Large	Vast
Enclosure	Tight	Enclosed	Open	Expansive
Diversity	Uniform	Simple	Diverse	Complex
Texture	Smooth	Textured	Rough	Very rough
Form	Vertical	Sloping	Rolling	Horizontal
Line	Straight	Angular	Curved	Sinuous
Colour	Monochrome	Muted	Colourful	Garish
Balance	Harmonious	Balanced	Discordant	Chaotic
Movement	Dead	Still	Calm	Busy
Pattern	Random	Organised	Regular	Formal

Source: Adapted WAPC 2007 Visual Landscape Planning in Western Australia - from Guidelines for Landscape and Visual Impact Assessment (The Landscape Institute, 1995).

Table C-3
Describing landscape character units at each scale of application: Regional, Local and Site

Regional	Describe the natural character of national parks, state forest, coastal reserves and areas of partially cleared or little used lands. Describe rural character in terms of broad patterns of land use, tenure and settlement. For built landscapes, focus on broad aspects, such as large-scale natural features including hills, escarpments, rivers and large water bodies; and related large-scale patterns of urban form, regional parkland, transport corridors and ranges of development densities.
Local	Describe the natural character of large uncleared reserves, or unique landform. Describe rural character using more detail about types of buildings or stands of remnant vegetation.
Site	Describe the natural character of areas of remnant vegetation, individual trees or rock outcrops. Describe rural character using even more specific detail, such as type of fencing or species of wind break vegetation.

Source: Adapted from Visual Landscape Planning in Western Australia - a manual for evaluation assessment, siting and design, (WAPC 2007)

Mapping Landscape Character Units

After undertaking a broad analysis and description of the visual landscape character, divide the study area into character units for the purpose of evaluation; and developing strategies to manage and plan for each character unit.

Table C-4 assists in the mapping of landscape character units and individual features responsible for the general landscape character of an area. Landscape character maps incorporate character units and prominent individual features and landmarks that contribute to the overall character of an area. In some cases the boundaries of character units may need to be arbitrary (see Figure C-3). This should be noted in the character description.

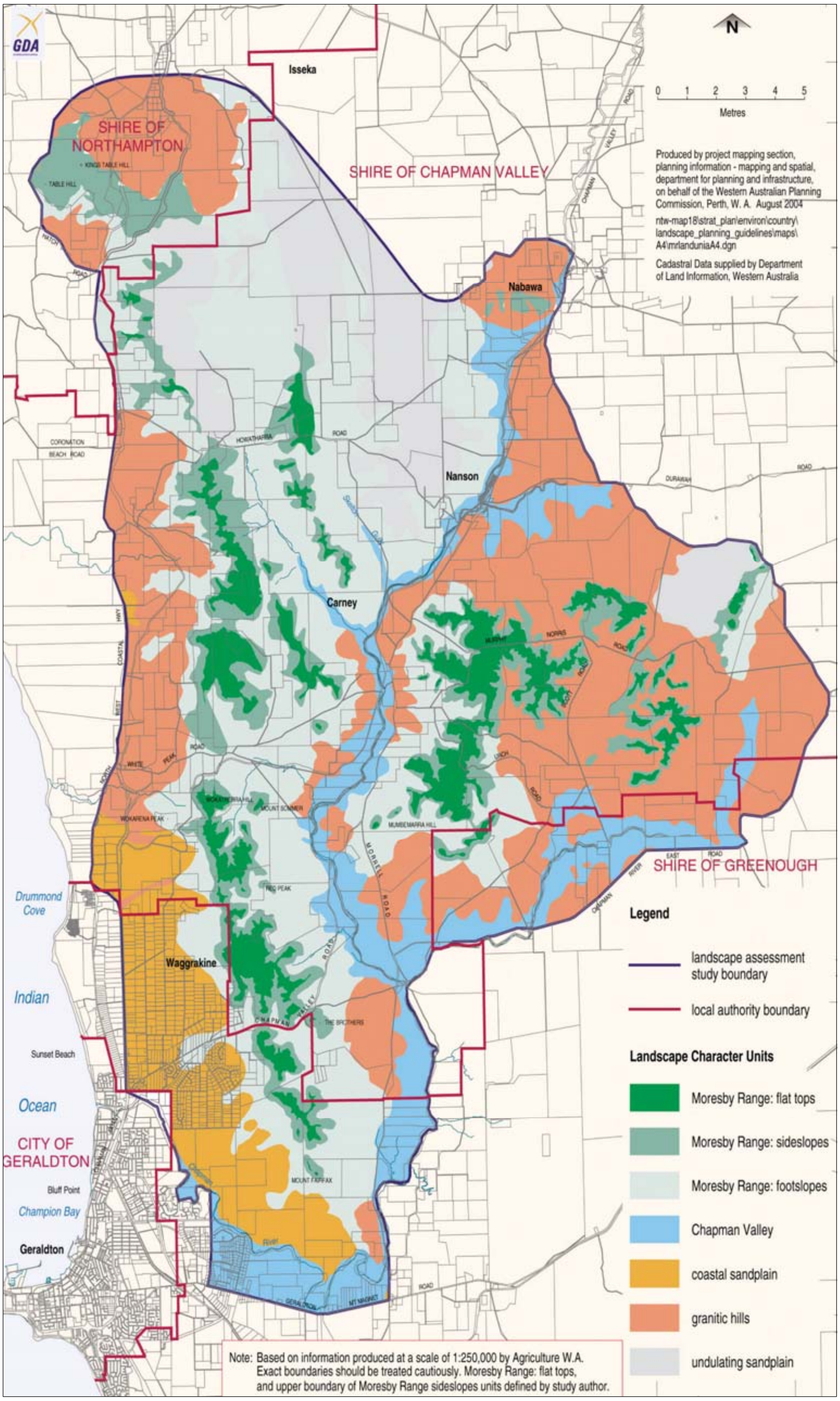
Aerial photographs can form a useful base for mapping Landscape Character Units, especially at a local or site level. Satellite images may assist in regional level assessments.

Table C-4
Mapping of landscape character units at each scale of application: Regional, Local and Site

Regional	Established landscape IBRA (Interim Bio-geographic Regionalisation for Australia) datasets (available online), can provide a useful reference in mapping the broad landscape character units that occur, based on the divisions of bioregions and subregions across Australia. Map the three land use categories where applicable: natural, rural, built.
Local	The landscape character units mapped at a regional level may be subdivided into smaller units at the local level. Map landscape features such as ridges, creek-lines, wetlands, rural hamlets and prominent individual buildings superimposed on landscape character units.
Site	Units from the local level should be further subdivided for application to individual sites. Map specific individual landscape features such as tree stands, heath and scrub, small water bodies, rock outcrops and varied vegetation species. Note that at a site level character units may not be needed and/or appropriate. Description and determination of individual features may be adequate for mapping at a site level.

Source: Adapted from Visual Landscape Planning in Western Australia - a manual for evaluation assessment, siting and design (WAPC 2007)

Figure C-3
Example of landscape character mapping



Source: Visual Landscape Planning in Western Australia - a manual for evaluation assessment, siting and design, (WAPC 2007)

C.7.2 Levels of significance

What are *Levels of Significance*?

Significance is the weighting of the relative importance of identified values. Valued landscape character and features that are likely to be significant are those which contribute to existing quality of life, high scenic quality, help understand the past, enrich the present, and which will be of value to future generations.

The rating of significance usually involves comparison with other similar places alongside the consideration of the extent to which values are likely to be held across communities or cultural groups (e.g. at local, regional, state, national, international scales), and/or the strength and importance of the values within the community who holds them.

The significance of any one value is usually given a rating of either local, regional, state, national or international importance.

What are *Levels of Significance* used for?

Assessing and rating landscapes for their relative significance assists in providing a sound strategic basis for future decision making. The *Wind Farms and Landscape Values: National Assessment Framework* (2007) concludes that '*applying a rating of significance to landscape values is essential to defining and assessing the acceptability or otherwise of impacts upon those values*'.

A preliminary assessment of landscape significance is essential to allow for early identification of highly significant landscapes and to inform site selection and locational decisions.

How do I go about it?

Determining Levels of Significance

Increasingly, strategic assessments consider the relative significance of landscape character and features for the purpose of informing the application of controls or guidelines for management. Some states have completed partial strategic landscape evaluation studies across regions, including Victoria (e.g. Planisphere, 2006); South Australia (e.g. Lothian, 2005); Queensland (e.g. Caboolture Shire, n.d.), which aim to identify highly significant landscapes (or to provide frameworks for their identification). In each case, these assessments are primarily concerned with visual character and scenic values, however they all have some relevance and can provide a sound starting point for assessing and rating the significance of potential wind farm locations.

There are many examples (such as the ones listed above) that provide guidance on how the relative significance of landscapes should be measured. In Victoria, the *Coastal Spaces Landscape Assessment Study* (Planisphere, for the Department of Sustainability and Environment, 2006) identified the different levels of significance (local, state and national) for all landscapes along the Victorian coastline (with state and national being the highest priority for application of planning controls). The methodology used in determining levels of significance is outlined below:

Apply the 'Visual' Significance Criterion

A single criterion is used to assess whether a landscape is visually significant:

> *The landscape is significant for its visual qualities, including landform features, views, edges or contrasts, and for its predominantly natural or undeveloped character, in which development is absent or clearly subordinate to natural landscape characteristics.*

Visual significance is determined with reference to the 'landscape components' referred to in the criterion: landform features; views; edges or contrasts; and natural or undeveloped character. These are rated as having moderate, high or exceptional visual qualities, as shown below:

Landform Features	A topographical feature or landmark such as a headland or a volcanic cone that provides contrast with the surrounding landscape.
Views	The viewpoint is open and publicly accessible; the view is a panorama, a broad prospect, or a linear view to a defined object or group of objects; and it offers a cohesive viewing experience.
Edges or Contrasts	The boundary between two landscape elements e.g. the coastline (the boundary between sea and land); the edge of a forest or a forest clearing; the boundary between vegetation types or different landform types; the intersection between a range of hills and a plain; a cliff or a beach; an incised valley.
Natural or Undeveloped Character	A landscape that is devoid of any development, or a landscape in which its natural characteristics visually predominate over any development that may be present.

Determine Levels of 'Visual' Significance

For each level of visual significance (local, regional and state), a threshold is defined for each landscape component in the significance criterion. A place is designated of state significance if any one of its landscape components (landform features; views or edges; and natural or undeveloped character) is rated 'exceptional'. Similarly, a place is designated of regional significance if any one of its landscape components is rated 'high'; and designated of local significance if any one of its landscape components is rated 'moderate' *

The following table explains how different ratings can be applied to arrive at levels of significance.

	Moderate Visual Qualities	**High Visual Qualities**	**Exceptional Visual Qualities**
	← = =	= =	= = →
Landform features Views Edges or contrasts Natural or undeveloped character	If one or more of the landscape components is rated as having **moderate** visual qualities, then the landscape is considered to be of **Local Significance.**	If one or more of the landscape components is rated as having **high** visual qualities, then the landscape is considered to be of **Regional Significance**.	If one or more of the landscape components is rated as having **exceptional** visual qualities, then the landscape is considered to be of **State Significance.**
Supporting Evidence	Further confirmed by supporting evidence.	Further confirmed by supporting evidence.	Further confirmed by supporting evidence.
Level of Significance	**Local**	**Regional**	**State**

Source: Adapted from Coastal Spaces Landscape Assessment Study, 2006

* Note that when utilising the table of significance criteria, that a landscape with exceptional visual qualities, even high visual qualities would automatically have local level significance as well as at state and regional level.

Consider 'Supporting Evidence'

Assessments should seek to find and integrate other sources for understanding impacts upon the landscape character of the proposed wind farm site, including previous landscape assessments, heritage studies, environmental and visual impact studies as well as occurrence in media, art and literature.

Levels of significance are further confirmed by consideration of the 'supporting evidence' categories (see table below). Supporting evidence comprises other elements, as opposed to visual qualities, that support, but do not determine, in their own right, a landscape's significance. The supporting evidence categories consist of:

Exemplar landscape	How representative is the landscape of a landscape character type?
Scarce landscape	How uncommon, rare or endangered is the landscape character type or unit?
Iconic landscape	Is the landscape instantly recognisable as a place that represents the valued qualities of the wider region? *Example sources: Artworks, tourism brochures, other publications etc.*
Documented cultural/ heritage value	Does the landscape have documented cultural / heritage value? *Example sources: Local planning scheme Heritage Overlay, AAV register, Register of the National Estate, National Trust Register etc.*
Documented environmental value	Does the landscape have documented environmental value? *Example sources: Local planning scheme Environmental Significance Overlay, Ramsar Convention etc.*
Established social/ community value	Does the landscape have established social / community value?
Visitor attraction	How important is the landscape as a visitor destination?

A template for assessing 'supporting evidence' categories is provided below*****:

SUPPORTING EVIDENCE CATEGORIES	LOCAL SIGNIFICANCE	REGIONAL SIGNIFICANCE	STATE SIGNIFICANCE (OR HIGHER)
Exemplar landscape	Demonstrates many of the characteristics and features of a landscape character type.	Demonstrates most of the characteristics and features of a landscape character type.	Demonstrates all of the characteristics and features of a landscape character type.
Scarce landscape	Few or no other examples of the landscape character type or unit in the Local or Municipal area.	Few or no other examples of the landscape character type or unit in the Region.	Few or no other examples of the landscape character type or unit within the State.
Iconic landscape	Iconic within the local context	Iconic within the regional context.	Iconic within the state context.
Documented cultural/ heritage value	Documented in a formally recognised heritage study or register as being of Local significance.	Documented in a formally recognised heritage study or register as being of Regional significance.	Documented in a formally recognised heritage study or register as being of State significance.
Documented environmental value	Documented in a formally recognised environmental study or other indicator as having Local environmental value.	Documented in a formally recognised environmental study or other indicator as having Regional environmental value.	Documented in a formally recognised environmental study or other indicator as having state environmental value.
Established social/ community value	Primarily important to the local community.	Important to both local and regional communities.	Important to both the local and statewide communities.

Visitor attraction	Visitors are predominantly from the local area.	Attracts visitors from within the region.	Attracts visitors from around the State.

* Note that when utilising the table for supporting evidence, that exemplar and iconic landscapes (exceptional visual qualities and high visual qualities) would automatically have local level significance as well as at state and regional level significance

Gather Community Opinion

The views of members of local communities, community groups, agencies and others with an interest in the area should be sought by various means during the assessment process. These views should be considered in the following ways in relation to the topic of landscape significance:

- As input to the formulation of the significance criterion and supporting evidence categories;
- The extent to which they supported the identification of a landscape already provisionally identified by the study team as being significant, including the geographic extent of the area;
- For the attention they drew to the possible significance of a particular landscape not already identified by the study team;
- For the information they provided as to the reasons justifying the designation of a landscape as significant;
- For the information they provided in relation to any of the supporting evidence categories, or any other information that could assist in determining the level of significance of a landscape.

Determine Overall Levels of Significance

Using the evidence gathered in the above analysis (i.e. levels of visual significance, supporting evidence and community opinion), conclusions should be drawn about the relative level of significance in regards to the landscape character of the wind farm site and surrounding area, and elements within it. Ideally the levels of significance should be tabulated or scored in a way that highlights the areas of highest significance.

There are at least two dimensions of significance to consider in rating the importance of the landscape character and features of the wind farm site:

- Strength and importance of the values within the community who holds them; and
- Extent to which they are likely to be held across communities or cultural groups (e.g. at local, regional, state, national or international scales).
- Landscapes of high visual qualities, exemplar or iconic qualities would automatically be significant at the local level, as well as the state and regional levels.

Note: The value and significance of the place ought to be assessed in the absence of the proposed development. That is, as far as possible, valued landscape character and features that existed prior to the development being proposed should be sought and documented.

What are the limitations of this technique?

Existing strategic landscape evaluation studies are limited in providing a full scope of valued landscapes due to the fact that they are primarily concerned with visual character and scenic values.

Thoroughly undertaken comparative analysis is a sound way to ensure a robust and defensible understanding of relative significance. However, it is reliant on the adequacy of information available for other sites or places and at present this is lacking in Australia for most landscapes. Existing strategic landscape evaluation studies are more than often partial and therefore cannot provide a complete picture of information across a particular state or region.

C.7.3 3D computer modelling

What is *3D computer modelling*?

3D computer modelling is the creation of an accurate three-dimensional (3D) digital representation of a site and/or its context. 3D computer models are generally built using a combination of GIS and animation software, which offers a diverse range of possible output types.

What is *3D computer modelling* used for?

3D computer modelling is used to provide an accurate 3Dimensional representation of a proposed development in its surrounding context. A 3D computer model provides a rigorous tool in understanding and assessing development proposals that produce changes to the visual landscape.

3D computer models can be used to produce a broad range of possible outputs (as outlined in the following practice notes). Traditionally 3D computer models are used to produce static images such as photomontages, however increasing computer hardware capabilities have resulted in an increasing use of pre-rendered "flythrough" animations and real-time 3D environments, often referred to as Virtual Reality (VR). It is important to always keep in mind that different circumstances require different representation methods. The intended audience needs to be determined at an early stage, in order to select the most appropriate output and its corresponding technique.

Not only does a 3D Model provide the base for a range of representation outputs, it can also be a very useful 'dynamic' design tool if generated at an early stage in the design process. A 3D Model (even if it is just 'wireframe'), can allow the proponent to visualise the potential impacts that a proposed wind farm development could have on an area — ultimately, influencing and informing decisions regarding the siting and design of a wind farm and its components.

How do I go about it?

Producing a 3D computer model

A 3D Model can be created by draping aerial photography over digital terrain (contour) data. Other layers of information such as vegetation, proposed development plans and settlement areas can then be incorporated to provide a more accurate picture of the existing environment and the proposed development. A step by step process is outlined below:

- Using a 3D modelling program, produce a digital terrain model (DTM), based on 1 to 5 metre contours. The smaller the contour interval used, the more accurate the model will be. Intervals of 1 metre (or smaller) are always preferable.
- Accurately drape aerial photograph over the digital terrain model (DTM) to provide a base 3D model for assessment. Aerial photography should be at a resolution of at least 1pixel = 0.5m.
- Accurately model the height, type, colour and other features of the turbines and associated buildings and structures.
- Locate turbines and other ancillary infrastructures (if deemed necessary) onto the digital terrain model (DTM).
- Accurately model vegetation massing where appropriate.

Always use the standard scale of 1 unit equal to 1m in real world units in producing a 3D computer model. Ensure the model is created using a GIS datum (i.e. MGA 94), and if you decide to shift your model, make sure you record the translation so that it is easy to bring additional data in at a later date.

What are the limitations of this technique?

Computer modelling is sometimes portrayed as a time consuming and expensive exercise that is undertaken only for the benefit of the wider public. Often proponents overlook the usefulness of this effective design tool.

As technologies continue to change and evolve at a high rate, it is becoming increasingly difficult to keep track of best practice 3D modelling techniques. In order to provide an accurate representation, the proponent should engage in a relevant expert in this field.

A 3D computer model has different limitations depending on the extent of elements modelled. For example, if the simulation models topography and proposed turbines only, it can be assumed that the model provides an appreciation of the potential views and the form and massing of the proposed development, but does not provide an accurate representation of the final outlook. To provide a more accurate picture, a higher level output is required (such as a photomontage, 3D simulation (animation) or virtual reality (VR) modelling).

There are potential inaccuracies in digital data (e.g. limitations of contour data) that need to be considered.

C.7.4 Viewshed mapping

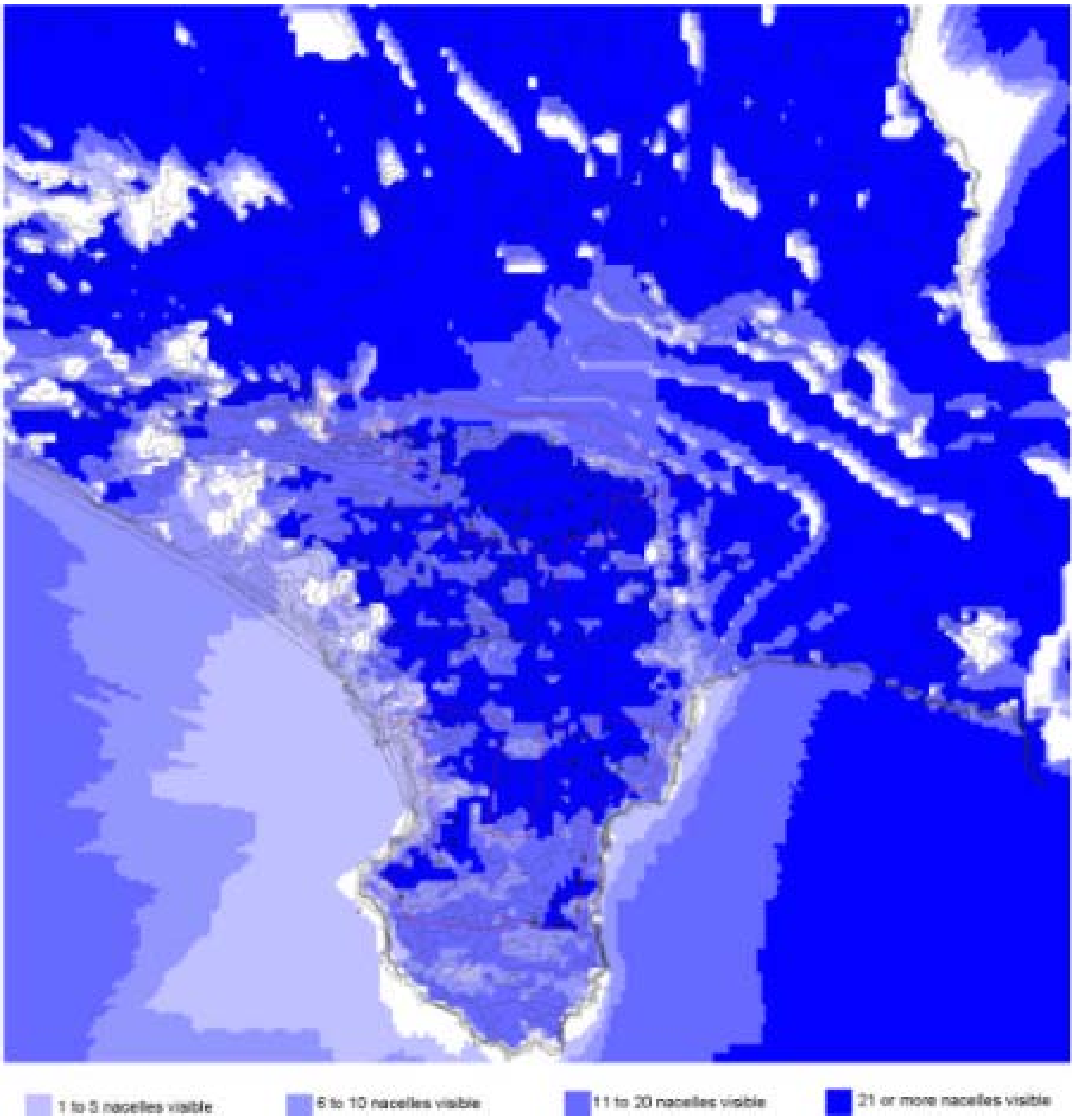
What is *Viewshed Mapping*?

A viewshed (or 'seen area') is defined as the land visible from a point, or series of points. In its most basic form, a viewshed map, or 'zone of visual influence' (ZVI) analysis, identifies an area of landscape and/or object(s) that would be visible assuming that it had no vegetation cover or built structures.

What is *Viewshed Mapping* used for?

Viewshed mapping is undertaken early in a project to assist professionals and communities in identifying locations from which the development will be visible, and to assist in determining the appropriate boundaries for the study area. It is also a useful tool in the early stages of a development proposal to identify the most useful locations for photomontages and similar computer generated simulations.

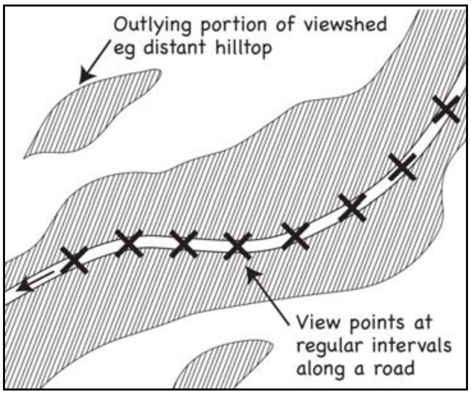
Figure C-4
Example of viewshed mapping



Source: EDAW Portland Wind Energy project EES

Amalgamating a series of viewsheds from individual points at regular intervals along a specified route identifies the composite viewshed of a linear feature such as a road or river. In this way, a series of individual viewsheds is combined into a single viewshed. This is particularly useful in demonstrating the overall visibility of a wind farm, as experienced by a person moving through the subject landscape on a particular route.

Figure C-5
Hypothetical viewshed from a road, comprising combined viewsheds from viewpoints at regular intervals along the road.



Source: Visual Landscape Planning in Western Australia - a manual for evaluation assessment, siting and design, (WAPC 2007)

How do I go about it?

Producing a Viewshed Map

The surface generated in the 3D computer model is used to generate individual viewshed maps for each origin or key vantage point towards the proposed wind farm alignment at strategic points on the wind turbine (i.e. top of hub, tip of blades, etc).

Producing a Composite Viewshed Map

Amalgamate a series of viewsheds from individual points at regular intervals along a specified route to achieve a composite viewshed map. Note that the interval used on a route through flat terrain should be greater than that used for undulating terrain (e.g. every kilometre versus every 100 m), and the scale of analysis should also be taken into account.

What are the limitations of this technique?

Viewshed maps are often based only on landform alone and do not take into account elements of the landscape including vegetation, built form and other ancillary infrastructure.

The concept of a viewshed map and what it is showing is often very hard to explain to lay-people and the general public.

C.7.5 Photomontage

What is a *Photomontage*?

Photomontage is the process of making a composite image by combining elements of real imagery and 3D digitalisation (see Figure C-6).

Figure C-6
Example of photomontages

Source: ASPECT Studios and ERM, 2007

What is a Photomontage used for?

The primary purpose of a photomontage is to accurately portray a proposed activity, modification or change in the viewed landscape. Photomontages are useful when assessing proposals that produce changes to the visual landscape, by providing realistic 'before and after' depictions. Photomontages assist in visualising the potential impacts a proposed development could have on an area from an array of viewpoints that have been recorded digitally. They can also be used to illustrate projections of how a development will appear over time; growth of vegetation screening for example.

Static images such as photomontages are best for printed media and some web delivery situations.

How do I go about it?

Photograph the site

In photographing the site, consideration should be given to:

- Photos covering view to the site should be taken from key vantage points from which the proposed development will be most visible. Photo points for photomontages can also be selected in consultation with the relevant planning authority and ideally in consultation with the local community.
- Photos should be taken from a normal human viewing height, for example, from eye level on a road or roadside rather than from the top of roadside banks or from the roof of a vehicle. The exact location and height should be mapped and documented using a GPS device where possible. The camera should be mounted onto a tripod which has been leveled so that as the camera swings around, the horizon remains flat in each image. This is fundamental to achieving an accurate simulation.
- To best represent the view seen by the human eye, panoramic views should be a combination of photographs, taken with a long focal length rather than with a wide angle lens. Most landscape professionals have their own camera specifications and equipment, however if specifications are needed, there is a considered standard practice of SLR camera with 50mm lens or digital equivalent.
- The focal length (or degree of zoom/wide angle) should be recorded for each photograph. In most cases, the focal length should remain exactly the same for each image of a panorama.

- Photographs to be used in a stitched panorama should be taken with a 1/3 overlap.
- The date, time of day and weather conditions such as shadows, glare, reflections and colour intensity should be noted, as they can influence visual qualities. Optimal or typical weather conditions are preferable.
- Identifiable reference points should be included in the image to enable accurate positioning of overlays depicting a proposed development.

Create a Photomontage

Once photographs covering views to the site from key vantage points have been taken and recorded, and computer software has been used to model the site in 3D (see *3D Computer Modelling* Practice Note, Section C.7.4), a photomontage image can be produced. In creating a photomontage:

- Individual photographs should be linked to virtual cameras in your modelling package, and aligned such that the panorama is correct. Check that the position of contextual elements such as buildings, vegetation and roads in photographs lines up with the corresponding 3D model elements. If these do not line up, that is an indication something has gone wrong with either your model or your on-site photography recordings.
- Depictions should not exceed 124° horizontal field of view or 55° vertical primary field of view.
- Photomontages should include both before and after depictions to provide a useful comparison. Using photo merging software with both "before" and "after" photos (on separate layers) can then be set up, making it easy to produce before/after images that align accurately. This technique also allows for the efficient reproduction of depictions if the layout of wind turbines in the 3D model were to change.
- It is important to illustrate all components of a wind farm development including ancillary elements that may include fencing, powerlines, other utilities, roads, structures, vegetation removal, drainage works and all planting as much as possible.
- The depth of colour of proposed objects needs to be accurately depicted, taking into account the weather and time of day. Consideration should be given to depicting the development in a variety of weather and atmospheric situations, including a 'worst case' or 'most visible' scenario (information about the likely frequency or occurrence of a particular scenario should be provided).
- All technical detail of photomontage construction needs to be documented.

What are the limitations of this technique?

Photomontages are a very valuable tool to help people visualise a proposed development. However, whilst they can be produced accurately to a specified method, they should always be considered a representation of the views of the wind farm. To maximise accuracy effectiveness, the method of photomontage production should portray true scale, perspective, observer position, angle of view, colour, texture, angle of the sun and distance from the observer.

Depictions are taken from a prescribed viewing location. This often presents limitations as it does not allow stakeholders to see the view from a specific location that may be of interest to them.

Photomontages do not give the viewer any indication of how the layout/ design or the proposed development evolved, and often appear 'final' to the general public.

C.7.6 3D Simulation

A *3D simulation* is a dynamic "fly-through" of a 3D model of a site. At one end of the spectrum are diagrammatic animations, which are low on detail, and used to communicate broad-scale ideas and planning issues. At the other end of the spectrum is the photorealistic animation, depicting every feature of a landscape, including all vegetation, buildings, and sometimes even residents. There are an unlimited number of ways to represent information using a simulation. It must be noted that many 'fly-throughs' are at aerial level, which misrepresents the wind farm, as people do not 'fly-through' a wind farm. If 'fly-through' software is used, they should be produced showing ground level simulations of the landscape and development to be realistic.

What is a *3D Simulation* used for?

3D simulations allow for a greater level of immersion within a simulated environment. They are generally used for media events, CD send-outs or web-based communication initiatives.

How do I go about it?

Using the 3D computer model, create an animated camera path in your modelling package, and then render it to an animation.

What are the limitations of this technique?

Producing a simulation can be overly time consuming and expensive.

Each simulation is pre-rendered and cannot be changed without re-rendering the entire model. This can be problematic when the design is constantly changing as rendering is very time consuming.

Animations work along a prescribed camera path. This often presents limitations as it does not allow stakeholders to 'fly to' and view specific areas that may be of interest to them. Also fly-throughs mostly are represented at an aerial view which is unrealistic. They should be represented at ground level to have the most realistic effect.

C.7.7 Virtual Reality (VR) Modelling

What is *Virtual Reality (VR) Modelling*?

Virtual reality (VR) is a technology which allows a user to interact with a virtual 3-dimensional environment through the use of standard computer input devices such as a keyboard and mouse.

What is *Virtual Reality (VR) Modelling* used for?

Virtual Reality Modelling is used to provide an accurate real-time 3D environment of a site and its surrounding context. The simulated environment can give a highly realistic and accurate picture of a development proposal from any location the user chooses to be in; allowing very precise assessments of the visual impact of changes to the existing environment.

Virtual reality modelling is ideal for communicating spatial issues to large numbers of people and facilitating a meaningful discussion with complete control over viewing angles and areas of interest.

How do I go about it?

Use the 3D computer model to build it up to an advanced level of representation.

What are the limitations of this technique?

It is currently very difficult to create a high-fidelity virtual reality experience, due largely to technical limitations on processing power, image resolution and communication bandwidth. Producing a VR Model can be overly time consuming and expensive.

However, those limitations are expected to eventually be overcome as processor, imaging and data communication technologies become more powerful and cost-effective over time.

C.7.8 Cumulative impact mapping

What is *Cumulative Impact Mapping*?

Cumulative effects are those which occur, or may occur, as a result of more than one large scale infrastructure project located within a particular area or region.

The degree of cumulative impact is a product of the number of and distance between individual wind farms, the inter-relationship between their associated viewshed (or ZVI), the overall character of the landscape and its sensitivity to wind farms, and the siting and design of the wind farms themselves.

What is *Cumulative Impact Mapping* used for?

Cumulative impact mapping is used to illustrate (in 2-Dimensional form) the summation of possible visual overlap that may occur as a result of the proposed wind farm development in combination with other developments (associated with or separate to it), or with actions that occurred in the past, present or are likely to occur in the foreseeable future.

Mapping possible cumulative impact is usually undertaken at an early stage of a landscape and visual assessment to determine where problem areas may occur (i.e. where large scale infrastructures have the potential to become the dominant or defining visual characteristic of the landscape), consequently resulting in a loss of landscape character and diversity.

How do I go about it?

Illustrating the base cumulative impact

Identify, record and map other wind farms, major infrastructure and/or large scale developments (including projects that have been approved but not yet built, or that are being developed in parallel with the wind farm) in the study area or wider region, as identified in the *Preliminary landscape and visual assessment* (*Identification of possible cumulative impacts*, page 80). A table such as the one below should be used to record multiple wind farm developments (if applicable).

Using circle distance cones of 3km, 6km and 12km radii, illustrate the potential visual impact of each of the identified infrastructures/ developments.

- <3km = High visual impact
- 6km = Medium visual impact
- >12 km = Low visual impact

Depending on surrounding context, alternative distance cones can be mapped. The table below can be used to help determine the appropriate measurements based on the likely visual impact of a wind turbine.

Table C-5
Mapping other wind farms

Location	Status	Height (to rotor tip)	No. of turbines
Bald Hills	Approved / Planning phase, constructed, pre feasibility stage etc.	106m	52
Dollar			
Toora			

Table C-6
Determining the likely Visual Impact of a wind turbine

Distance from an observer to a 100m high wind turbine	Likely Visual Impact
>12km	**Visually Insignificant** A very small element in the viewshed, which is difficult to discern and will be invisible in some lighting or weather circumstances. Rotor blade movement can often be seen on a clear day.
6-12km	**Potentially noticeable but will not dominate the landscape** The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer, however the wind turbines do not dominate the landscape.
2.5-6 km	**Potentially noticeable and can dominate the landscape** The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer.
1-2.5 km	**Highly visible and will usually dominate the landscape** The degree of visual intrusion will depend on the wind turbine placement within the landscape and factors such as foreground screening.
<1.0 km	**Will always be visually dominant in the landscape** Dominates the landscape in which they are sited.

Source: Adapted from Peer Review Report: Dollar Wind Farm, ASPECT Studios, 2000

Using the map as a guide, identify and note the distances and areas of visual overlap using a table similar to the one below. Where there is an overlap, the developments are, in theory, inter-visible at the relevant distances- thus a cumulative impact may be generated.

Table C-7
Identifying areas of visual overlap

Viewshed radius	Wind farms (or major infrastructures)	Visual overlap (distance)	Visual overlap (Area)
6km	Wind farms 1 & 2	X km	X sq km
	Wind farms 3 & 4	X km	X sq km
12km	Wind farms 1 & 2	X km	X sq km
	Wind farms 3 & 4	X km	X sq km

Determine whether the cumulative visual effect of all wind farms, major infrastructure and/or large scale developments in the area would combine to become the strongest characterising influence, such that a new or more general landscape character would be formed.

It is important to remember that cumulative impacts can arise in the following ways:

- *In combination* – as a result the occurrence of multiple wind farms or similar scaled infrastructure/developments visible from the one 'static' location.
- *In succession*- the sequential or 'dynamic' visibility; fundamentally experienced as a traveller moving through the landscape. Particularly important for tourist and scenic routes where a one view spot analysis is not adequate.
- *Perceived*- the reoccurrence of wind farms or similar scaled infrastructure/developments within a particular region that results in a changed perception of the overall landscape character; irrespective of whether all wind farms/developments are sited in a single viewshed.

What are the limitations of this technique?

Mapping the base cumulative impact is used primarily as an indicative technique during the preliminary stages of the landscape and visual assessment process. This 2-Dimensional method is useful in determining where *potential* cumulative impacts *may* occur. It does not draw firm conclusions on the overall cumulative impact of a wind farm proposal. Determining the overall cumulative impact requires further judgement and verification, using techniques such as composite viewshed mapping, 3D computer modelling and 3D Simulation (or animation).

C.7.9 Glossary & acronyms

Australian Wind Energy Association (Auswind, currently Clean Energy Council)	Wind energy industry association. Currently known as Clean Energy Council, following an amalgamation of the Australian Wind Energy Association and the Australian Business Council for Sustainable Energy.
Community	A group with shared culture, beliefs, traditions, ethnicity, activity, experiences or locality. Consultation generally occurs with 'communities' (plural), as multiple values (and groups) exist and these often overlap. Where necessary, the term 'local community' is used to specifically refer to people who inhabit (live or work) in a locality (that is the community of a town or rural area) and similarly regional community, state-wide community, Australian community.
Community values	Community values comprise the values that residents as well as various interest groups and stakeholders, place upon their environment and surrounds.
Consent authority	The government department or agency (Commonwealth, State or local) responsible for considering and approving or rejecting an application for development of a proposed wind farm.
Consultant	A suitably qualified practitioner engaged by the wind farm proponent for the purposes of completing assessment of the value of landscapes and the potential impacts upon these, under these Guidelines. The Tasks listed in these Guidelines are allocated to 'the proponent', even though in many instances it may be carried out by a professional consultant.
Cumulative effects	The summation of effects that result from changes caused in conjunction with other past, present or reasonably foreseeable actions.
Cumulative impact	Cumulative landscape and visual effects result from additional changes to the landscape or visual amenity caused by the proposed development in conjunction with other developments (associated with or separate to it), or actions that occurred in the past, present or are likely to occur in the foreseeable future. They may also affect the way in which the landscape is experienced.
Environmental Impact Assessment (EIA)	The evaluation of the effects on the environment of particular development proposals.
Geographical Information System (GIS)	Computerised database of geographical information.
Indigenous community	Indigenous people holding traditional, historical or contemporary associations with a locality or landscape. An Indigenous community may include formal Indigenous organisations, family groups and individuals. In these Guidelines, reference to communities and stakeholders is interpreted to include Indigenous communities who may or do hold values of the landscape. Particular approaches may need to be considered in seeking to understand values held by Indigenous communities.
Indirect impacts	Impacts on the environment, which are not a direct result of the development but are often produced away from it or as a result of a complex pathway. Sometimes referred to as secondary impacts.
Landscape	The physical environment as perceived by people. An area made up of a distinct association of forms, both natural and cultural. The sum total of the characteristics that distinguish a certain area of the land's surface from the other areas. These characteristics are a result not only of natural forces, but also of human occupancy and the use of land, that changes over time.
Landscape Assessment	Is the process of assessing the character and features of areas of land, usually with reference to an agreed set of criteria based primarily on community preferences. It also is an overarching term for the description, classification and analysis of landscape.

Landscape capacity	The degree to which a particular landscape character type or area is able to accommodate change without unacceptable adverse effects on its character. Capacity is likely to vary according to the type and nature of change being proposed.
Landscape character	Landscape character is the interplay of geology, topography, vegetation, water bodies and other natural features, combined with the effects of land use and built development, which makes one landscape different from another. Landscape character can also encompass social / cultural elements.
Landscape character types	The distinct and recognisable pattern of elements that occur consistently in a particular type of landscape, and how it is perceived by people. It reflects particular combination of geology, landform, soils, vegetation, land use and human settlement. It creates a particular sense of place of different areas of the landscape.
Landscape character units	Landscape character units refer to areas of homogenous (similar) patterns of visual, physical, environmental and cultural characteristics such as landform, vegetation, water form and land use as well as individual features.
Landscape features, characteristics or elements	A prominent feature in the landscape (i.e. dominant hill, watercourse, corpse of remnant trees) or a landmark that influences the landscape character of an area. These elements can be natural or cultural.
Landscape impacts	Changes in the character and quality of the landscape that occur as a result of development. Impacts can either be positive (i.e. beneficial or an improvement) or negative (i.e. adverse or detraction). Where an impact is positive the term 'landscape benefit' may be used.
Landscape sensitivity	The extent to which a landscape can incorporate change of a particular type and scale without unacceptable adverse effects on its character and features.
Landscape values	Landscape values include the existence value of a landscape or its value to present or future generations. Landscape values might be visual, cultural, spiritual, environmental, based on memories and perceptions. Understanding landscape values involves identifying essential characteristics of the landscape and working with communities to understand the meaning of the landscape to them.
Management and mitigation	Management and mitigation refers to actions taken to reduce or eliminate impacts as a result of a visual impact assessment.
Proponent	The individual or company proposing to develop a wind farm, the applicant for regulatory approval. All tasks in the Guidelines are allocated to 'the proponent', even though in many instances they may be carried out by a professional consultant.
Scenic quality	Scenic quality is the relative nature or character of landscape features expressed as an overall impression by people after perceiving an area of land. The degree of harmony, contrast and variety within the landscape; the overall impression retained after driving through, walking through or flying over an area of land.
Significance	Significance is the weighting of the relative importance of identified values. Landscape values that are likely to be significant are those which help understand the past, enrich the present, and which will be of value to future generations.
Stakeholder	A party who has been identified as potentially having an interest in the wind farm site and surrounding landscape. This will include local communities, non-local communities and visitors (as well as future generations for whom the landscape is held in trust). Some stakeholders may not be readily identifiable as members of a community – they may be more commonly thought of as institutions, agencies, companies and the like.
Study area	The combination of the wind farm site and surrounding area (s).
Subject land	The immediate area of land in which the wind farm development is sited.
Surrounding area	The surrounding area encompasses both the study area (immediate site) and all landscape areas and features in the wider contextual area.

Viewpoint	The point from which a view is observed.
Viewshed or 'Seen Area'	A viewshed is defined as the area of land visible from a point, or series of points - defined by landform alone and not taking into account vegetation cover/ screening or built structures.
Visual impact	Visual impact refers to the change in appearance of the landscape as a result of development. This can be positive (i.e. beneficial or an improvement) or negative (i.e. adverse or detraction).
Visual Impact Assessment	The analysis of changes in the appearance of the landscape as a result of development. Impacts may be negative or positive.
Wind farm	Those areas of land or property containing the known, likely or potential development footprint of the wind farm.
Wind farm site	One or more wind turbines located together for electricity generation. It includes all associated and ancillary infrastructure such as roads, substations and transmission lines.

D Birds and Bats

D.1 Introduction

This Appendix outlines a national best practice approach to the assessment of the impacts of wind farm projects on birds and bats, and presents assessment methods and tasks for each stage of a wind farm development.

Note that general impacts through vegetation clearance and habitat loss are similar to other developments and are adequately dealt with by existing statutory processes. They are not addressed in this appendix.

These Guidelines deal with natural animal populations and ecosystems. As such, they cover an infinite number of possible variables of bird and bat population numbers, differing biology that is specific to numerous potential species and behaviours that may be characteristic to variables of habitats and particular locations. With this in mind, the Guidelines do not deal in absolute values, which would be arbitrary. Rather they set out to provide a framework for assessment and management processes that will be valid and flexible to account for such variables and to permit the development of evaluation and practices that will be specific to the requirements of individual species and particular sites.

D.1.1 Principles

The following principles underpin the Guidelines in relation to the assessment and management of birds and bats:

- The entire process is focussed on resolution of a clearly defined, tractable set of questions. Investigations of birds and bats should be designed to inform evaluation of impacts on their populations.
- They incorporate a risk-tiered approach in which decisions about the requirement for each phase of the wind farm assessment is contingent on the results of the proceeding phase.
- They address the potential for cumulative impacts.
- They incorporate processes for drawing on community sources of information (e.g. local bird observers clubs, etc.).
- Investigations that require quantified results should be designed from their outset to both permit statistical analyses and to provide data that are statistically robust. However, it is acknowledged that, in reality, developing surveys/monitoring of avifauna and bats in a statistically defensible manner is often logistically impossible, either due to unachievable sample sizes, or excessively high inherent variability in the data (particularly behavioural data). Hence, it is neither feasible nor desirable that all surveys conducted at all stages of wind farm development be potentially statistically defensible, as broad trends over a long period may also be useful in managing the wind farm and should be considered in conjunction with statistically defensible results.
- In order to permit direct comparisons between wind farms and of a given wind farm over time, studies should use a common set of metrics. For example, bird and bat utilisation of sites should be measured using a common standard which is replicable and allows direct comparison of the same taxa between different wind farms or at different times at the same site.
- Recognising that techniques, methods and technologies have capacity to increasingly improve data collection and assessment processes, the methodologies will be flexible and the wind industry is encouraged to responsively explore advancements for enhancing bird and bat risk assessment protocols. Information collected and measures of impact will still be quantified according to standard metrics.

D.1.2 Underlying approach

The underlying object of the following guidance is to evaluate the potential effects on key bird and bat species, with the aim of developing a wind farm that is sited and designed to avoid and minimise impacts.

The Guidelines encourage assessment of the potential for a wind farm development to have impacts on birds and/or bats using an approach designed to address clearly defined questions that will lead to an objective determination of the likely effects on particular bird or bat populations. The underlying concept is the scientific principle of hypothesis testing, but it is recognised that some necessary practicalities will prevail and that uncertainties are usual in ecological impact assessments including those for birds and bats at wind farms.

The fundamental approach is the 'Before – After – Control – Impact' (BACI) research design. Bird and bat use of a site can be measured before the wind farm is built and on that basis an assessment can be made of the potential impacts it might have on important species. Once the facility is built and operating the same measures can be used to ascertain the real effect it has. Wherever feasible these assessments should be compared with a 'control' site where no wind farm is built. Use of a control site provides the capacity to assess whether any changes observed are attributable to the wind farm or to other causes. Determination of an appropriate control site may be difficult in some instances because wind farm sites are often large and contain complex habitat features so that sites with similar features that are truly comparable may not exist. It is also the case that birds and bats of concern are generally threatened species whose use of any given site may be unique.

The feasibility stage component of assessment is necessarily dependent on determining the values of the site for birds and bats prior to development of a wind farm. Conditions for birds and bats and their use of a site may change over the life of a wind farm for various reasons which may include responses to the wind farm. The BACI design of investigations allows for such changes to be explored and assessed.

In harmony with the principles outlined above the objective of the Guidelines is to provide a ***process*** that focuses evaluation of birds and bats on substantive issues, and their resolution.

Any taxon of interest at any site will be a unique situation. The aim of these Guidelines is to provide a framework within which choice and design of investigation and assessment methods can be made that are appropriate to the particulars of the site and species. It is vital that the assessment is robust and founded upon current understanding of ecology.

D.2 Background

D.2.1 Basic description of issues addressed in the Guidelines

Concern about negative effects of wind farms on birds and bats is widespread and the issue has been raised in the assessment processes for many commercial wind farms worldwide and for every commercial wind farm that has been proposed or built in Australia. Principal concerns are about mortality resulting from interactions with turbine rotors. The earliest large-scale wind energy facility at Altamont Pass in California has experienced high levels of bird mortality, mainly of raptors. However the design of turbines and layouts of wind energy facilities have advanced considerably since that time. Negative impacts at modern wind farms are generally of a lower order, but bird and bat fatalities continue to be recorded at new facilities.

This history has led to community concern and, as a consequence, the specific issue of impacts on birds and bats is a regular facet of assessment processes for the wind energy industry. Some reviews (e.g. Sovacool 2009), have suggested that other industries and forms of development may have equivalent or greater effects on bird and bat populations, but assessments for those are generally not required to quantify their effects on birds and bats in the manner usually required of the wind industry. For example, despite the incidence of wildlife collisions with traffic, major new road developments are not routinely required to predict the number of fauna collisions that might occur once they are operational nor to quantify the effects such developments might have on fauna populations.

The effects of wind farms on birds and bats should be properly assessed in order to determine the real impacts they may have. Negative effects on birds and bats can be caused by:

- Direct loss of habitat.
- Reduction in habitat suitability resulting from aversion to the presence of turbines, associated infrastructure and other disturbance caused by the wind farm.
- Injuries and fatalities resulting from interactions with turbine structures.

It should be noted that there are two distinct values that can be placed on any impact on birds or bats. Both may be valid but it is vital to have clarity about the two concepts and to distinguish them.

The first is the purely biological effect on the functioning of a bird or bat population. The second is the level of community and political 'acceptability' of the impact. The latter may be subjective and indefinable and some iconic species clearly rate higher than others in public perception. This measure is a reality and should not be ignored in decision-making.

However, objective evaluation should principally be concerned with the first measure which relates to the persistence of populations. Whatever the cause, all individuals die and thus impacts should be measured in terms of the effect they may have on the functioning of populations and any consequent change in the conservation status of bird or bat taxa. This is clearly of most relevance to threatened species.

A principle of ecology is that, all other things being equal, naturally functioning populations maintain equilibrium through regular turn-over as individuals that die are replaced by those that are born and survive to adulthood. The population size is regulated by a host of natural factors, such as availability of food and nest-sites, numbers of predators, etc. Such naturally functioning populations are limited only by such factors and if their influences remain reasonably constant then the population can be expected to continue to replace itself and remain relatively stable. Such a population is considered to be density-dependent and, so long as appropriate resources are available, the death of any individual is of no consequence to the population as it will be replaced by another. Some fluctuations due to minor environmental variables are normal and usually do not affect the long-term stability of secure populations. Where this equilibrium is upset, such as by the sudden increase or decrease in numbers of a key predator, a population may decline or increase despite the influence of other resources. Ultimately, it will then either reach the point of extinction or of a new equilibrium in an altered ecological state.

Despite this underlying ecological principle, density-dependence, or –independence is difficult to demonstrate in wild populations. In part, this is often an issue of geographic scale. Populations can usually be studied only at a local level in which local fluctuations may mask the stability or otherwise of the entire broader population.

Any impacts on bird and bat populations should be assessed from this ecological perspective. Alienation or direct loss of habitat can be expected to reduce the local population in proportion to the loss. However, if resources required by the population are not lost but some individuals die due to collisions, this may not necessarily have an impact on the population because deaths due to the collisions may simply replace deaths due to other causes and the individuals lost may be replaced by births or increased survivorship of other individuals. On the other hand, an artificially increased mortality rate could be deleterious and deaths may be of much greater importance for populations already in decline due to other causes. They may also influence local populations if particular age- or sex-classes are more susceptible to wind farm mortalities than are other classes. This could occur if particular components of the population (e.g. breeding males or females, first-year juveniles, etc.) behave in ways differently from others.

All of the above is generally applicable to the effects of a single wind farm on bird and bat populations and to the cumulative effects of multiple wind farms.

D.2.2 Issues not addressed in the Guidelines

These Guidelines are focussed on potential impacts of wind farms on birds and bats. Primarily, this is because birds and bats fly and have some potential for collisions with wind turbines. Thus the Guidelines do not cover more generic potential effects of wind farms on terrestrial fauna and flora as these are considered to be similar to those of other comparable developments and guidance for their assessment is provided elsewhere by relevant authorities and must be considered on a site-by-site basis in the planning phase of a wind farm. For the same reason, the Guidelines provide limited coverage of straightforward loss of habitat for birds and bats that a wind farm may entail.

At present, off-shore wind farms have not been developed in Australia and the Guidelines cover only on-shore facilities.

D.2.3 Related documents and standards

Mandatory regulations for assessment of matters related to birds and bats for wind farms apply in a number of Australian jurisdictions. The present Guidelines are designed to compliment relevant legislative requirements and guidance documents provided by relevant authorities.

The following legislation and government policies specifically relating to the issue are current as at mid 2009:

- International
    - *Convention on the Conservation of Migratory Species of Wild Animals* (the Bonn Convention) and its *Resolution 7.5 Wind Turbines and Migratory Species* (2002).

      Australia's principal mechanism to meet its obligations as a signatory to the Bonn Convention is the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* for migratory species.
- Australia (Commonwealth)
    - *Environment Protection and Biodiversity Conservation Act 1999* and *EPBC Act Policy Statement 2.3 Wind Farm Industry* (DEWHA 2008)
- New South Wales
    - *NSW Wind Energy Handbook* (Sustainable Energy Development Authority NSW 2002)
- South Australia
    - *Planning Bulletin – Wind Farms – Draft for Consultation* (Dept. of Planning & Local Govt. S.A. 2002)
- Tasmania
    - *General Guidelines for the preparation of a Development Proposal and Environmental Management Plan for Wind Energy Projects* (Environment Division, DPIWE 2004)
- Victoria
    - *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria* (Dept. of Planning & Community Development revised 2009)
    - *Planning and Environment Act 1987 Model Permit Conditions* (released 2008) of *Planning and Environment Regulations 2005*
    - *Guidelines for bat surveys in relation to wind farm developments* (Draft 2007, prepared by Dr L. Lumsden, Dept. of Sustainability & Environment Vic.)

- *Guidelines for the Assessment of Potential Windfarm Impacts on the Brolga* (Draft 2009 Dept. of Sustainability & Environment Vic.)

- Western Australia
  - *Guidelines for Wind Farm Development Planning Bulletin No. 67* (Western Australian Planning Commission 2004)

The former Australian Wind Energy Association (now incorporated into the Clean Energy Council) produced *Wind Farms and Birds: Interim Standards For Risk Assessment* (AusWind 2005). The Interim Standards have provided a voluntary code for the wind energy sector. They recommend a risk-tiered approach, whereby assessment becomes more intense with increased potential for impacts. They are confined to assessment for birds, are somewhat prescriptive and do not offer a flexible scope for adaptation to new and advancing technologies for use in assessments. They have provided a foundation for further development of the present Guidelines.

A substantial literature on the subject exists and has been reviewed in preparation of these Guidelines. A selected pertinent bibliography is provided in Section D.8.

D.3 Overview of the Methodology

The process for evaluation of bird and bat issues for wind farms is set out as a sequence of phases. Each phase has a fundamental question to be answered. Once a given question is answered it provides the basis for whether the impact assessment investigation needs to proceed to the subsequent phase. This process provides a tiered or incremental approach to evaluation of risks.

For the purposes of these Guidelines the development and operation of a wind farm is considered according to five development stages. These are:

- Project Feasibility
- Planning Application
- Construction
- Operation
- Decommissioning.

Table D-1 shows the bird and bat assessment phases for each of these stages. The phases and their questions for the feasibility stage of a wind farm development are set out in the following decision flow-chart (Figure D-1).

Section D.4 provides detailed guidance to the stages of a wind farm. Section D.5 provides information about cumulative effects of wind farms on key bird and bat taxa. Section D.7 offers further information about some methods and techniques that have been used to investigate birds and bats at wind farms.

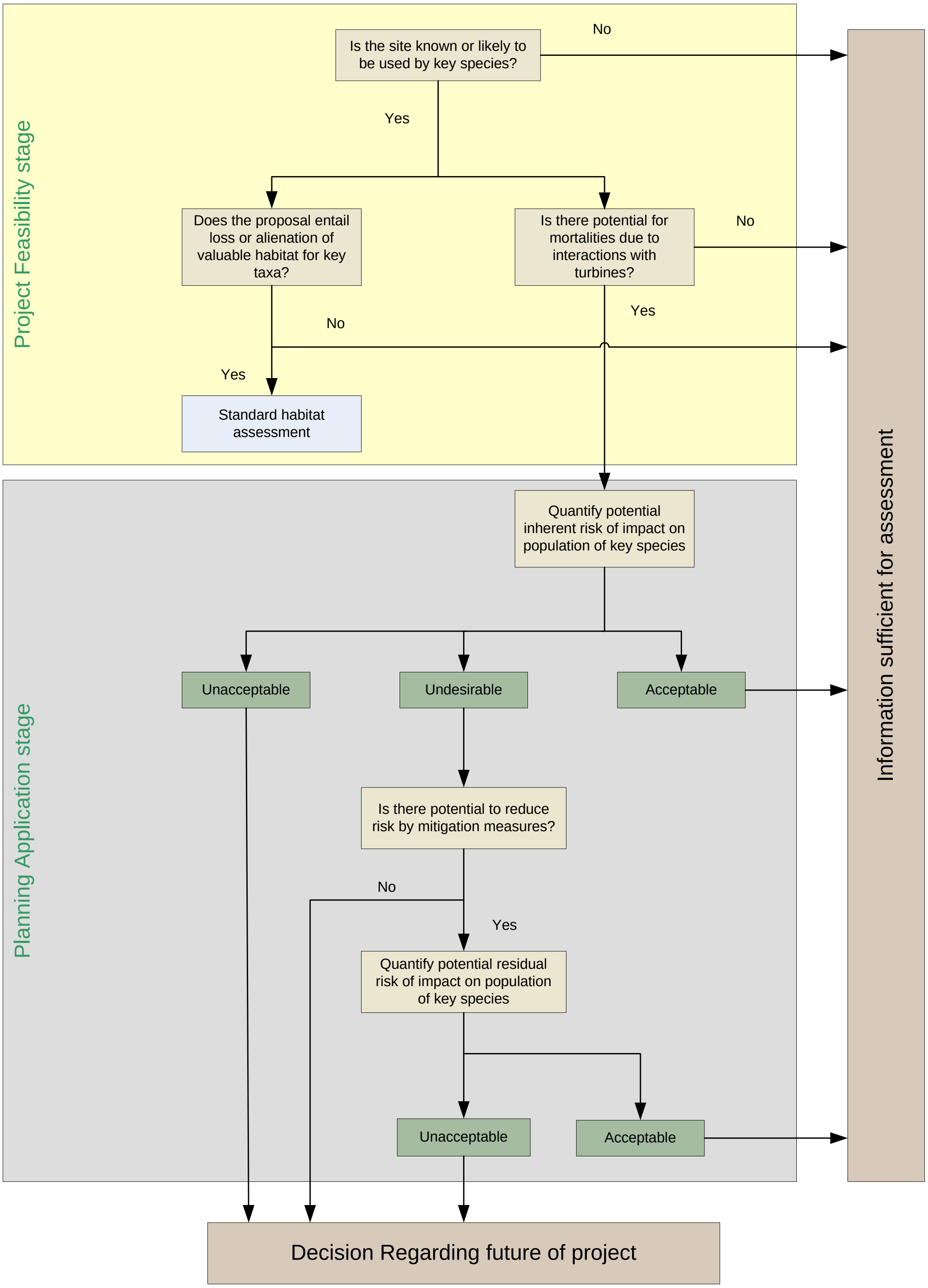
It should be noted that, while Section D.7 provides information about some survey methods used to inform impact assessment studies, it is not the intent of these Guidelines to be prescriptive about methods to be used. Flexibility in specifics of research design and technologies that may be used to obtain the requisite data is vital to allow for particulars of taxa and sites and to permit adaptability to emerging technologies and techniques. The most important aspect is that bird and bat studies at various wind farm sites are quantified to standard measures and that appropriate statistical approaches and analyses are used. Statistical tests such as power analyses are valuable in design of investigations to ensure they are both efficient and have capacity to answer questions about effects on birds or bats. The design of studies and interpretation of their results should be provided by individuals with relevant expertise and knowledge of the standards to be achieved.

Over the course of a wind farm development, the focus of the bird and bat studies changes. In the period prior to commissioning of a wind farm investigations are designed to ascertain what effects the wind farm ***might*** have on birds and bats, while monitoring of the operational wind farm is aimed at determining what effects the wind farm ***actually*** has.

Table D-1
Phases of bird and bat assessment relative to development and operation of a wind farm

Stage and methodology	Tasks	Task methodology location
Site Selection		
	Initial screening of potential sites to exclude locations of highest biodiversity values	
Project Feasibility		
Bird and bat impact risk assessment	Determine potential for key species to use the site	Page 120
	Preliminary assessment of potential for negative effects on key species due to loss or alienation of habitat	Page 122
	Preliminary assessment of potential for fatal turbine collisions by key species	Page 123
Planning Application		
Bird and bat impact assessment	Quantitative assessment of risk of fatal collisions for key species	Page 125
	Evaluation of ecological importance of predicted impact of proposed wind farm design (inherent risk) on population of key species	Page 126
	Assessment of any reduction or mitigation of impacts that can be achieved	Page 128
	Evaluation of ecological importance of predicted impact of revised wind farm design (residual risk) on population of key species.	Page 129
Construction		
	Review Environmental Management Plans to ensure necessary actions and timing for bird and bats are identified	129
Operations		
	Determination of actual impacts of the operational wind farm on key bird & bat populations	Page 130
	Evaluation of adaptive management aimed at further reducing impacts	Page 132
Decommissioning		
	Assessment of possible impacts on key bird & bat species of decommissioning and of re-powering	Page 133

Figure D-1
Assessment flowchart for key bird and bat taxa



D.4 Task methodologies

D.4.1 Site Selection

At the earliest stage of selecting a wind farm location a number of potential sites are likely to be evaluated. A high level appraisal of the potential for impacts on biodiversity values, including birds and bats, should form an integral part of these considerations. These are expected to take the form of a desktop review of information available from government fauna databases and liaison with relevant government agencies to provide a regional overview. If this information suggests that a site is of critical importance for key species of birds and/or bats, consideration should be given to excluding the site from further consideration as a wind farm site.

D.4.2 Project Feasibility

The initial stage for any particular wind farm requires a determination of project feasibility. The three phases of bird and bat assessment outlined below for the Project feasibility stage of a wind farm development are all essential. They offer rapid means to determine whether key bird or bat species are considerations that may influence feasibility of the proposal. These initial 'screening' investigations of a potential site have been developed so that, to the extent that is practicable, issues for both birds and bats can be assessed in unison. The questions underlying these three phases provide fundamental pre-requisites to scoping of any further assessment processes for birds and bats.

Determine potential for key species to use the site

Principal question:	Do key species use or have potential to use the site?
Purpose:	To ascertain which, if any, species of birds and bats require assessment for the wind farm proposal.
Methods:	For this task, the studies will predominately be qualitative and will include: • desktop assessment of general fauna databases • information from local sources • broad identification of likely species based on habitats ascertained from desktop assessment & confirmation by preliminary site visits

Species to consider

The following criteria must be taken into account in the scoping process to determine bird and bat taxa that require impact assessment. Use of criteria here provides a process that focuses on those taxa that are important for consideration for a particular site.

The following categories of taxa are of primary importance for assessment and are subsequently referred to in these Guidelines as 'key' taxa:

- Taxa listed under any category of threatened conservation status by legislation of any jurisdiction in which the site is located.

- Taxa that meet IUCN[16] criteria for any category of threatened conservation status whether or not yet listed under provisions of legislation in any jurisdiction in which the site is located.
- Taxa listed under provisions of relevant legislation that provide protection for particular categories of taxa whether threatened or not (for example species listed under provisions of the EPBC Act that provide specific protection for international migratory and marine fauna and encompass national obligations under international agreements).
- Taxa naturally occurring at low densities because of their ecological function high in the trophic order. This will primarily relate to taxa like raptors that are top-order predators.
- Taxa that have special cultural significance.
- Any other taxa that relevant authorities require to be considered for a particular site such as species not included in the categories above but for which the site is especially significant.

Advice to assist the determination of key species relevant to the site should be sought from the relevant authorities at the earliest possible stage of the assessment process.

Consideration may be required of the fact that some iconic species that are not covered by categories listed above may rate highly in public perceptions and it thus may be prudent to include such species in assessments of birds and bats.

Determining site usage

Scoping of the impact assessment process must be informed by taking account of known or potential use of the site by birds and bats. This should be determined from:

- Known use of the site by bird and bat taxa based on pre-existing confirmed records.
- Inferred or potential use by the taxon based on geographic range and presence of suitable habitat at the site or presence of known or suitable habitat distributed such that the taxon is likely to fly through the site. These may include important and limited breeding, roosting or feeding sites or defined migratory pathways.
- Pilot investigations of the site.

Known or likely use of a site will be determined from preliminary investigations. These include:

- Scrutiny of relevant fauna databases for a prescribed search area, in particular databases managed by government agencies responsible for fauna and professional organisations, such as Birds Australia.
- Information canvassed from relevant wildlife agencies.
- Information canvassed from local sources. Consultation with the local community, especially with naturalist and bird observer groups should be actively undertaken for this purpose. Speleological societies may have information about cave-dwelling bats. Information should also be sought from relevant landowners.

  - Care must be taken to evaluate pre-existing data and associated meta-data about the area as many datasets do not have a systematic or coordinated collection protocol. For example, historical information about species of shorebirds may have been collected incidental to annual pre-duck shooting season investigations of waterfowl. This may be the only body of information about presence or numbers of shorebirds in a local area, but is unlikely to be representative of their annual use of the

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16 The International Union for Conservation of Nature, Species Survival Commission (IUCN 2001) provides standard criteria for categories of threat status applicable to all species of fauna and flora.

area as it was not collected according to a research protocol designed to achieve knowledge of annual usage by shorebirds. Such pre-existing data need to be carefully appraised to ensure that they are not accepted uncritically for the purposes of the wind farm assessment.

- Preliminary field studies to characterise habitat occurrence and distribution at the site and surrounding region for their potential values to bird and bat species.
- Pilot surveys to obtain some indicative data about bird and bat utilisation of the site.

  At this stage of the assessment the primary objective of bird and bat utilisation surveys on-site are to provide a simple indication of the characteristics of the site. They are usually necessary as an adjunct to desktop assessment because generic fauna databases and other such sources of information most often contain little information from the site itself. Whilst these investigations will be short and should be designed to be indicative only, it is best that they use methods such as timed point counts for birds. In that way data they obtain can subsequently be included with any collected by later, more rigorous studies and the effort and time they entail is of maximum value.

If preliminary investigations undertaken in this task do not provide certainty about likely use of the site by a key taxon, targeted investigations as recommended in further tasks should be designed and undertaken at the site and at potential local habitat to obtain further information.

If there is no, or very low, likelihood of key species using the site in question relevant authorities may determine that no further assessment of risk is required for birds or bats.

Determine potential for impacts on birds and bats due to loss or alienation of habitat

Principal question:	Is there potential for negative effects on key species due to loss, alienation or disturbance of habitat?
Purpose:	To assess potential for loss, modification or alienation of habitat for key species of birds and bats due to the wind farm proposal.
Methods:	For this task, the studies will include: • desktop & field-based interpretation of focal habitat requirements for key species • assessment of direct or indirect habitat loss using standard methods applicable to such effects • application of expert advice re adequate buffer distances to protect important habitat

Physical loss of habitat at wind farms is generally small and confined to the footprint of infrastructure including turbines, construction lay-down areas, roads, powerlines, switchyards, etc. These facilities are generally scattered across the landscape and wholesale loss of habitat is not usual.

Assessment for direct losses of habitat should be carried out using standard methods applicable to other fauna and is not considered further in these Guidelines.

It is feasible that little or no actual loss of habitat occurs, but that birds or bats may be alienated from the habitat by the presence of turbines or other infrastructure. Whilst this has been demonstrated for some birds in the marine environment at offshore wind farms in Europe, there is little evidence for this effect at onshore facilities. It appears also that, even if there is an initial disturbance response, many species habituate to the presence of turbines. Offshore wind farms are not currently envisaged for Australia and the present Guidelines relate only to onshore wind farms.

The most appropriate means to manage for potential alienation effects on birds and bats is to site turbines with adequate buffer distances from focal habitat resources for key species. Focal resources will be features such as known or potential nesting microhabitats for raptors, wetlands or mudflats routinely used by aggregations of shorebirds, etc. Determination of what constitutes a suitable buffer distance is likely to be species-specific and dependent on individual characters of habitat and topography of the site. For some species that use particular and identifiable resources, such as breeding on wetlands with defined characteristics, home-range or territory mapping may provide an indication of the *minimum* zones that should be retained free of turbines and other infrastructure. A further radius will generally be required beyond the minimum home-range as a buffer from disturbance. Limited investigation of appropriate buffer distances from turbines has been undertaken in Europe, but empirical evidence for Australian species is not currently available. Wherever feasible and relevant, buffer distances between turbines and focal resources should be applied in design of the wind farm layout. For the present, determination of adequate buffer distances to reduce or eliminate disturbance and/or alienation for particular species should rely on expert opinion. Taking a precautionary approach, it will be better to err on the side of larger buffer distances based on such opinion. This approach is also likely to minimise risks of collision with turbines (see also *Assessment of any reduction or mitigation of impacts that can be achieved*, page 128).

In general, migration by birds and bats is geographically diffuse in Australia and there are few known locations through which heavy aggregations of flying birds or bats are ‘funnelled’ (for instance between the closest peninsulas of adjacent land masses; passes through mountain chains; and narrow corridors between mountains and the coast). Dense concentrations of fruit bats do occur in northern Australia en route to and from their camps and where island colonies may cross the coast. Similar concentrations of cave-dwelling bats also occur in proximity to relevant caves. Inappropriately sited wind farms could pose barriers to passage of birds and bats at locations where such concentrations occur. Initial site selection and project feasibility phases should identify and investigate such locations and, if studies indicate that a wind farm might create a barrier effect or present a collision risk (see below) at such locations, consideration should be given to excluding them from further consideration as wind farm sites.

Assessments for direct or indirect loss of habitat for birds and bats should be carried out using methods applicable to other fauna and are not considered further in these Guidelines.

Preliminary assessment of potential for turbine collisions by key species

Principal question:	Does potential exist for impacts on key species due to interactions with turbines?
Purpose:	To undertake a preliminary, qualitative evaluation of the potential for risk to exist, determine the necessity for further phases of assessment, and scope any such investigations.
Methods:	For this stage, the studies will include: • qualitative assessments and opinions • pilot surveys

This final component of the scoping process entails a qualitative evaluation of the potential for interactions by key bird and bat taxa with turbines to occur based on the preceding preliminary evaluation of whether key species use the site. (The term ‘collision’ is used throughout these Guidelines as a term of convenience for all causes of bird and bat deaths that may result from interactions with wind turbines. These include barotrauma, potential traumatic effects of turbulence caused by rotors, and direct collision strikes (see Section D.6 for a glossary of terms).

Account should be taken of the fact that mortalities due to turbine collisions are either not possible or are not considered to be an issue for some species of birds. Assessment of collision risk for the following categories of birds is not necessary or is unlikely to be required for most sites within Australia:

- Introduced and feral taxa.
- Flightless and near-flightless birds.
- Other taxa that rarely fly within or through rotor-swept-height.

Some species routinely fly within or through rotor-swept-height (which for current turbines is generally in the range 30-130 metres above the ground), but many other species rarely if ever fly in that height range. Flight-height data collected in south-eastern Australia indicates that many bird taxa rarely fly above 25 metres (Biosis Research unpublished data) and that interactions with turbines do not need to be assessed for these birds other than for exceptional sites or circumstances (see also Section D.7). The potential for exceptional circumstances should be evaluated for each wind farm. Examples may include locations on defined routes of migration or other long-distance movements if birds there fly at greater heights than they do during the majority of their routine activities. Unless the species in question is also a key taxon, assessment is unlikely to be required.

All Australian bat species have capacity to fly within rotor-swept height and, while some may do so less than others, current knowledge is insufficient to suggest the exclusion of any key bat taxa from this component of the assessment.

If key taxa with capacity to fly at rotor height are known from the site, further preliminary investigations of those taxa will be necessary. For resident species, their home range requirements should be considered and for all key species that might use the site their foraging, roosting, breeding and other species-specific needs are to be considered at this phase. Other aspects that should be given preliminary consideration relative to potential risks for the species involved are typical sizes of flocks, behaviours, where they are most readily detected and particular behaviours or habitat preferences that may expose them to high risk.

This phase does not require full or detailed assessments, and information gathering at this phase does not need to be of a standard that might provide inputs to detailed risk assessment. The information does, however guide later evidence gathering studies, and is critical to ensure full alignment of pre- and post-construction assessments using BACI (Before – After – Control – Impact) designs. Local or otherwise expert knowledge gleaned during this preliminary phase may be supported by targeted pilot studies to establish background methodologies and necessary parameters that will guide later phase surveys and assessments. Pilot surveys are short field studies to further identify and to scope potential issues. They allow approximation of relevant information such as typical population on site, number of movements on site, seasonal dependencies, observability and detectability. If occurrence of key taxa at the site is likely to be seasonal, then pilot studies must be timed to maximise potential to obtain such information.

The principal purpose of such trials is to establish a sound basis for the need and subsequent design of any more detailed investigations of risk for key species specific to the site.

If there is an identified potential for a key species to interact with turbines, the assessment should proceed to the next phase. If not, relevant authorities may determine that no further assessment of risk is required for birds or bats.

D.4.3 Planning Application

The following tasks are likely requirements of any assessment process.

Quantitative assessment of risk of fatal collisions for key species

If preliminary assessments outlined in previous phases determine there is potential for mortalities of key species resulting from interactions with turbines, then investigation to quantify this risk will be required as follows.

Principal question:	What is the quantitative risk to key species of collision mortalities?
Purpose:	To quantify the inherent risk to key species of the wind farm as proposed.
Methods:	For this stage, the studies will include: • *qualitative* ▫ Geographic Information Systems – habitat models ▫ behavioural studies • *quantitative* ▫ population surveys ▫ collection of data for estimation of annual number of flights at risk of collision ▫ collision risk modelling to predict potential mortalities

The definition of exactly which species are "key species" will need to be confirmed by the relevant authorities before this task can be finalised.

Habitat modelling, mapping of territories and/or mapping activity patterns of key species at the site should be undertaken to gain insight into whether parts of the site pose greater risk of collision than others. Results may have application in design of a turbine layout to avoid or reduce impacts. (see also *Assessment of any reduction or mitigation of impacts that can be achieved*, page 128).

Risk modelling approaches can range from the use of sophisticated mathematical models to qualitative evaluation and the approach used will depend on the availability of information. Collision modelling is the preferred method of assessing risk and is likely to be required by the relevant authorities when sufficient information is obtainable.

When a numerical assessment of potential impact on particular species is undertaken, the appropriate approach will be use of a peer-reviewed mathematical risk model. A number of such models are in use internationally. This type of collision risk modelling is a predictive mechanism used to quantify the potential annual number of flights made by key species that are at risk of collision and may result in bird or bat mortalities. Inputs required to undertake such modelling include standardised bird or bat utilisation data (quantified as outlined below); number and geographic layout of turbines; and dimensions and other parameters of turbines. Pre-requisites for an outcome measured in terms of an expected annual number of mortalities, are both the number of individuals that might interact with turbines and the estimated number of their flights that are at risk of collision.

The ultimate justification of any mathematical model is how well its predictions are verified by measured outcomes. To date there are no examples of Australian wind farms where both pre-construction bird utilisation studies and post-construction mortality monitoring have been undertaken sufficiently rigorously to confirm the accuracy of the relevant collision risk model with a high degree of confidence. In the absence of such verification, the predictions of any collision risk model should be evaluated against any other available indicators of likely mortalities, such as experience with comparable bird species at existing wind farms. Such data from existing wind farms may inform the ongoing evolution of collision risk modelling and facilitate the "calibration" of a collision risk model for particular species in order to provide greater confidence in its predictions.

Various sources of uncertainty are necessarily inherent in risk modelling and these should be explicitly stated in reporting of the process. Wherever feasible, statistical confidence levels should be provided for results of modelling.

Some fundamental parameters are necessary for measuring the activity of birds or bats that contribute to their annual risk of collisions. In combination, these are termed 'bird, or bat, utilisation' for the site. Studies should be undertaken to obtain empirical utilisation data from the site for key species according to standard metrics. Standard measures allow utilisation rates to be compared between sites and to be combined for the purposes of assessing cumulative impacts of multiple wind farms.

Standard metrics that contribute to measures of utilisation for particular species and sites include the following:

- Census or estimation of the annual maximum numbers of individuals of key species that could encounter and interact with the turbine array.
- Estimated annual number of flights at risk of collision made by key species. This should be extrapolated from surveys designed to document numbers of flights made within rotor-swept-height per unit time and space.
- Amount of available flight time per annum for key species. This must account for annual and diurnal/nocturnal cycles that affect presence at the site and/or frequency of flights.

Field studies should be undertaken to a design regime that will obtain empirical information about these aspects for the site.

For scarce bird species, for migratory species that may move through a site during a brief episode or for microchiropteran bats it may not be feasible or practicable to obtain empirical, or statistically valid, data for all of these parameters. In such cases a precautionary approach based on a set of informed assumptions should be adopted. It should use confirmed information available for the taxon and/or closely related taxa. All assumptions to be used and uncertainties inherent in the process should be agreed by the relevant authorities and reviewed by experts on the taxon in question. They should also be explicitly stated in reporting the assessment process.

Results of collision risk modelling provide projections of bird or bat mortalities that can be used as inputs to the subsequent evaluation of impacts on populations of key species.

Evaluation of predicted inherent impacts on populations of key species

Principal question:	Is the forecast impact of the proposed wind farm ecologically important?
Purpose:	To determine if the potential risk of loss identified in the previous phase is significant to the population in question.
Methods:	For this stage, the studies will include: • Population Viability Analysis (PVA) • Potential Biological Removal assessments (PBR)

Evaluation of predicted mortalities of key species due to the wind farm should be based on the degree to which they might affect maintenance and functioning of the species' population. 'Acceptability' or otherwise of impacts is thus based on the species' ecology and not on a simple number of mortalities that may occur.

In order to determine whether predicted effects on populations are ecologically important or not, the following should be taken into account:

- Unless otherwise advised by the relevant authorities, the definition of the 'population of a species' should follow that provided in Matters of National Environmental Significance: Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (DEWHA 2009), i.e. "A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable threatened species, occurrences include but are not limited to:
  - a geographically distinct regional population, or collection of local populations, or
  - a population, or collection of local populations, that occurs within a particular bioregion."
- Migratory and nomadic birds or bats at a wind farm site may comprise or include animals from populations that breed in distant locations.
- Whether mortalities are expected to affect particular demographic components of the population (e.g. sex or age classes, breeders/non-breeders).
- Whether mortalities are expected to have an effect on demographic functioning of the population.
- Due to the small numbers of individuals usually considered in these predictions, actual number of mortalities that might occur at a wind farm will almost certainly fluctuate from year to year around an average over the life of the facility and this should be expected and taken into account in evaluation of effects on populations.

Population Viability Analysis (PVA) is an appropriate mechanism to model and predict the effects in terms of altered extinction probability for the population. However, demographic parameters — which are pre-requisites of PVA — are not well known for many taxa and some informed assumptions will usually be integral to this component.

In the instance where a PVA model is not deemed appropriate or achievable, an alternate is Potential Biological Removal (PBR) value. This can be assessed with estimates of just the mean annual mortality resulting from the wind farm, the estimated total population size and basic demographics (adult survival and age at first reproduction) of the relevant key species.

On the basis of such an analysis a determination can be made about the likelihood that projected levels of mean annual mortality due to the wind farm will negatively affect maintenance of the population of the key species under consideration. This is measured in PVA as a material increase in extinction probability and in PBR by the estimated number of mortalities caused by the wind farm relative to the calculated PBR value. The mortality rate in any animal population varies around a mean value from year to year and according to natural environmental variables. A minimum objective for any development should be that any impact it causes is well within the range of such natural variation.

While such quantitative analyses have a sound ecological basis, demographic information about the taxon in question may not be sufficient to permit analysis by methods such as PVA or PBR. In such cases a qualitative evaluation of potential impacts on the population can be undertaken. This can use criteria such as those provided in guidelines such as *Matters of National Environmental Significance: Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2009).

Once the results of effects on the population are available a judgement can be made about the acceptability, or otherwise of any potential impact of the proposed wind farm. In general, an acceptable outcome will be a zero net impact on the population in question. Judgements of the levels of impacts that are considered undesirable or unacceptable will at the discretion of relevant authorities. The project impact will be considered *acceptable*, *undesirable*, or *unacceptable* and can be expected to lead to one of the following outcomes:

- If relevant authorities consider predicted impacts on key species population(s) to be ***acceptable***, the feasibility stage assessment process for birds and bats will generally be complete at this point.
- If the level of impact is considered to be ***undesirable*** by relevant authorities, but not to have totally unacceptable implications for the population of the key taxon, consideration must be given to mechanisms to reduce or mitigate impacts to a lower level. This will entail proceeding to the following phase of the assessment process.
- If relevant authorities consider the projected mortality or other effects to be ***unacceptable***, a review of the wind farm proposal should take place to determine whether it is appropriate for assessment processes to proceed.

Assessment of any reduction or mitigation of impacts that can be achieved

If, based on the preceding assessment phases, the level of impact is considered to be undesirable, planning and design of the wind farm may be able to be altered to reduce or mitigate predicted collision effects. Any such re-design should be incorporated into the basic inherent design of the proposal as 'passive' measures aimed at reduction of risks.

Principal question:	What, if any, reduction or mitigation of potential impacts can be achieved?
Purpose:	To utilise information gained through the assessment process thus far to guide final design of the wind farm aimed at further reduction of impacts on key species.
Methods:	Wind farm redesign, if applicable.

Re-design measures are dependant upon different site characteristics and key species. Examples of re-design measures that have been applied at some sites in Australia include:

- Redesign to preferentially site turbines into areas of the site posing least danger to key taxa.
- Reduction of the number of turbines.
- Identification and establishment of appropriate, infrastructure-free buffers around locations of habitat resources of importance or attraction to key taxa.
- Changing the model of turbine to be used or altering hub height.
- Consideration of requirements and design for aviation warning lighting

A note about aviation warning lighting

Aviation warning lights may be required on turbines and meteorological masts at a wind farm. Civil Aviation Safety Authority (CASA) *Manual of Standards* provides information relevant to obstacle lighting.

Artificial lights on tall structures can be disorienting to birds and the cause of disabling responses that may 'trap' large numbers of birds within a pool of light. Lights may also attract insects that are prey for bats. There is thus potential for aviation lighting to exacerbate collisions risks for birds and bats. An empirical study of lighting on towers (Gehring et al. 2009) found that the use of flashing or strobe lights substantially reduced attraction of birds to tall structures when compared with steady burning lights. The colour of flashing or strobe lights (red or white) made no significant difference to results.

Planning to reduce predicted impacts is considerably more cost effective at this point in development of a project than implementation of 'active' management interventions aimed at reduction of impacts after a wind farm is in operation. The latter may prove to be necessary during the operational life of a wind farm but their efficacy will always be uncertain until tested for a given location and species. Achievement of an acceptable level of impact on the population of any bird or bat population should be integral to the planning of a wind farm, and must not be dependent on instigation of 'active' reduction or mitigation measures once the facility is operating. 'Active' management measures should remain only as options available to be tested in the event that they are demonstrably necessary during the life of the wind farm.

Evaluation of predicted residual impacts on populations of key species

Principal question:	Will any residual risk have an important impact on population function of key taxa?
Purpose:	To determine if the potential risk of loss identified in the previous phases, after mitigation effects are considered, is significant to the population in question.
Methods:	For this stage, the studies will include: • Assessment of acceptability of predicted mortalities

This phase will ascertain the ecological importance or otherwise of any impacts on the populations of key taxa that might result from the proposed wind farm following mitigation or reduction of potential impacts as identified in *Assessment of any reduction or mitigation of impacts that can be achieved* (page 128). Wherever feasible and applicable, this part of the assessment should account for any contribution these impacts might make to a cumulative impact from other wind farms (see Section D.5).

At completion of this task a final assessment can be made of whether the number of mortalities expected to occur over the life of the facility are ecologically and socially acceptable. If so, the bird and bat impact assessment process will generally be complete at this point. If there is a residual risk of some mortality of any key species, a plan for management of relevant bird and bat issues at the operational wind farm will usually be required as a condition of approval. It is important that conditions to be met by the operational wind farm are based on levels of ecologically acceptable impact for the population of a key species over the projected life of the wind farm, as identified in this final phase of assessment.

If the number of mortalities expected to occur over the life of the facility are not ecologically and socially acceptable, the proponent may choose to withdraw the proposal from the statutory assessment process. If the proponent chooses to proceed with the statutory assessment process, this information will be considered by the relevant authorities when they make their decision on the approval, or otherwise, of the proposed wind farm. .

D.4.4 Construction

At the commencement of construction, plans for management of relevant bird and bat issues and associated documentation should be reviewed to ensure necessary actions are identified.

The physical construction of a wind farm does not usually entail particular impacts on birds and bats other than those of habitat loss or modification which should be included in assessment outlined in *Assessment of any reduction or mitigation of impacts that can be achieved* (page 128). In a case where unusual or specific potential impacts of the construction phase are identified during planning of the facility, they must be fully encompassed in assessments required as part of the assessment process.

D.4.5 Operations

Some degree of verification of the impacts predicted in the assessment documentation should be undertaken irrespective of the level of impact. Where significant impacts on key species are anticipated it is likely that investigation of actual impacts that occur in the operational wind farm will be required as a condition of approval. Implementation of management measures, including adaptive management, may also be required depending on the outcomes of investigations.

The intensity and temporal scale over which post-construction monitoring should occur will be determined by the predicted level of impact to key species. It may be best to spread monitoring so that it samples impacts during the life of the wind farm, rather than concentrate it into a short period at the commencement of wind farm operation. This may assist in understanding whether effects alter with time (e.g. due to any habituation by birds and bats, some of which may be quite long-lived, to the presence of the wind farm, or due to fluctuations in local populations over time).

Determination of actual impacts on key bird & bat populations (page 130) and *Evaluation of adaptive management aimed at further reduction of impacts* (page 132) cover investigation and management of the functioning wind farm. These aspects are complementary to each other and will operate in parallel during the life of the wind farm.

Determination of actual impacts on key bird & bat populations

Principal question:	What are the actual impacts of the operational wind farm on key bird & bat populations?
Purpose:	To determine the actual effects of the operational wind farm on population(s) of key species. To inform adaptive management of the wind farm. To maximise capacity to learn about and improve understanding of bird and bat interactions with wind farms.
Methods:	For this stage, the studies will include: • bird and bat utilisation studies • detection and documentation of fatalities • ascertain effects on populations by evaluation of numbers of mortalities against results of previous PVA or PBR analysis.

If the wind farm is approved and there is a residual risk of some mortality for any key taxon, a program should be designed and instigated with clear objectives to investigate the following:

- Whether use of the site by birds and bats changes once turbines have been installed and are functioning.
- Capacity for relevant species of birds and bats to avoid collisions when flying in the presence of turbines.
- The species and numbers of collision fatalities and any effect of these on populations of key species.

Each of these aspects is discussed further under respective subheadings below.

An important objective of these investigations is to inform adaptive management of the operational facility (see *Evaluation of adaptive management aimed at further reduction of impacts* page 132). The program should also be designed to indicate whether pre-construction processes were appropriate and predictions of impacts were valid.

These studies will often be reflected in conditions of approval for the wind farm and it is a usual requirement that results of these studies are reported to relevant authorities. The fundamental rationale for undertaking the studies and for reporting their results should include the capacity they offer those agencies to:

- Evaluate impacts on populations.
- Improve guidance that can be given to the wind energy sector with the aim of improving wind farm design, siting criteria and assessment processes, and to the general community as information about key birds and bats improves.
- Function as central repositories of data which will permit them to oversee assessments of cumulative impacts of multiple wind farm developments (see Section D.5).

While conditions of approval will be specific they should give consideration to these underlying objectives. Conditions should also be established with clear and achievable goals. Trial investigations may be necessary to ensure that investigations, such as carcass searches, have a reasonable chance of attaining their objectives. If compliance to a condition cannot be achieved or monitored, the condition itself should be reconsidered.

Compliance monitoring will often deal with operational information that is sensitive to the wind farm operator and such sensitivity should be respected in the way the data are collected, reported and used.

Bird and bat utilisation studies

Bird and bat utilisation surveys should be undertaken following construction and commissioning of a wind farm. Their purpose is to assess whether use of the site by birds and bats changes once turbines have been installed and are functioning. In order for pre- and post-construction utilisation to be validly compared it is essential that methodology, sampling design and sampling intensity used for the operating wind farm are directly comparable with those undertaken in pre-construction studies.

Behavioural responses to wind turbines

Information about capacity for any Australian species of birds and bats to avoid collisions is poor or non-existent and this knowledge cannot be obtained from counts of dead birds and bats. If key species occur at a wind farm then targeted studies should be designed to obtain data on the rates at which relevant species of birds and bats avoid collisions when flying in the presence of turbines.

Documenting bird and bat fatalities

Investigation should be required to determine species and numbers of collision fatalities, however determining how many birds or bats are killed is not an objective of itself. The reason for doing so is to ascertain effects of any turbine collisions on the functioning and maintenance of key species' populations. To achieve that aim, the number of recorded mortalities should be used to determine an estimate of overall mortality rate, by factoring in search frequency and intensity, scavenging rates and search efficiency. This should then be evaluated against results of population analyses undertaken as part of the assessment process. Where quantifiable population data are not available from pre-construction surveys population level impacts should be estimated in conjunction with the relevant authorities.

In order for data about collisions to meaningfully inform assessment of effects on populations it is essential that a monitoring program is designed on sound statistical research principles. With these objectives in mind, the research design, including level of monitoring effort will usually require approval by relevant authorities.

Searches for dead birds and bats around turbines should be undertaken to a rigorous regime that accounts for variables in detectability of carcasses. Practical considerations and limits on detectability will necessitate that the study is designed to obtain an index of mortalities rather than an absolute count. Careful consideration will be required to the following aspects in design of a regime to locate and document fatalities:

- frequency of searching;
- proportion of turbines to be searched;
- radius around turbine to be searched;
- influence of vegetation within searched areas;
- potential efficiencies of human observers or dogs;
- accounting for carcass removal by scavengers; and,
- accounting for injured birds or bats that might move prior to death.

The information outlined above to be gathered in the course of monitoring the operational wind farm should also be collected with the purpose of informing strategies to deal with mortality events if they occur and particularly if they exceed pre-determined thresholds for impacts on the populations of key taxa, as determined in the pre-construction assessment stage (see *Evaluation of adaptive management aimed at further reduction of impacts* page 132).

Evaluation of adaptive management aimed at further reduction of impacts

Principal question:	Can adaptive management further reduce impacts?
Purpose:	To further reduce or mitigate any validated impacts occurring during operation of the wind farm.
Methods:	Site- and species-specific adaptive techniques to be tested for their efficacy and adopted if demonstrably effective and necessary.

Reduction and mitigation of impacts will be most effective and less costly when implemented at the planning and design phases of the development through informed site selection and wind farm design, however a bird and or bat management plan will generally be required for any wind farm where key species may be impacted. This plan should be based on information obtained for the site prior to commissioning of the turbines. It is essential that the plan has capacity to adapt at any time according to information obtained at the facility once it is in operation. Studies to determine the actual impacts of the facility will be designed to that end (see *Determination of actual impacts on key bird & bat populations*, page 130).

Whilst it will be usual for a wind farm to be approved only when an assessment undertaken as per the preceding steps of these Guidelines indicates that an 'acceptable' level of impact on any key species might occur, results of investigation of effects of the operational wind farm will be used to inform strategies for further reduction of any impacts found to be occurring.

An adaptive approach to this management is vital because experience at the operating wind farm may differ from what was forecast prior to its commissioning. This may happen for a number of reasons, for example:

- Despite pre-construction assessment, some uncertainties about behavioural responses of birds or bats to the wind farm at the particular location will be inevitable and may prove to contribute to a greater or lesser impact than anticipated.

- Due to the relatively long life of a wind farm, environmental changes may occur over time so that utilisation of the site by various bird or bat species alters in ways that were not able to be forecast prior to commissioning of the facility.

Regardless of the level of any impact that actually occurs, strategies should always have the goal of further reducing negative effects on key birds or bats. Such 'active' adaptive management are likely to be required if impacts exceed quantified limits as determined by population modelling for key species undertaken prior to commissioning of the wind farm. Various management strategies may be applicable for different sites and species (see also *Assessment of any reduction or mitigation of impacts that can be achieved*, page 128

Some adaptive management measures implemented to further reduce impacts at operational wind farms in Australia have included:

- Land management practices aimed at reducing flights of key taxa within the area occupied by turbines (e.g. reducing the attraction for large raptors by removal of stock carcasses; after-births and improved control of pest prey species like rabbits; provision of 'diversion' food sources away from turbines, etc.).
- Turbine shut-down protocols for situations of highest risk (e.g. in response to wind speed and/or direction; at particular seasons; in response to particular bird behaviours).

Such management measures are clearly not ideal and may be costly to an operating facility. It is stressed that the best means to avoid such measures is pre-construction planning and design aimed at minimising potential impacts on birds and bats.

Further technological developments may offer new methods to reduce or mitigate impacts. Any mitigation strategies should be based upon the best knowledge available. At their outset all mitigation strategies should be treated as test plans and should have a study design clearly aimed at determining their efficacy.

This approach will facilitate improved knowledge and increase in the number of mitigation and impact reduction strategies available to the wind energy sector.

'Off-set' mitigation may be an acceptable way to compensate for bird or bat deaths due to the wind farm. This approach will include actions to improve the status of the taxon in question and may be applied at locations not directly associated with the wind farm. The value of actions of this kind may not be directly measurable against effects of the wind farm, but in some instances have capacity to achieve effective conservation outcomes. Examples (only) of such measures include:

- Establishment with landowners of covenants and other protective measures for nest sites.
- Implementation of feral predator control.
- Habitat protection and management, such as improved water management for wetlands of particular value to birds.
- Programs for removal of road-killed wildlife to reduce the incidence road traffic collisions with scavenging raptors.

D.4.6 Decommissioning

Assessment of possible impacts on key bird & bat species of decommissioning and of re-powering, if applicable

Decommissioning of a wind farm, is not usually likely to entail impacts on key birds or bats and it is expected that rehabilitation will take account of the needs of this fauna especially in restoration of any lost or modified habitats. If the wind farm is proposed to be repowered after the life of turbines and other infrastructure, then an evaluation of the renewed facility should be informed by the experience of the original facility and a new assessment is likely to be required.

D.5 Cumulative impacts

D.5.1 Definition

For the purposes of these Guidelines, cumulative impacts on birds and bats are defined as the effects on key taxa of more than one wind energy facility. While effects on populations of birds and bats may result from numerous anthropogenic changes to the environment, it is not feasible to consider cumulative impacts other than those from wind farms in the current context. In part this is because methods of impact assessment differ across different industries and because some sources of impacts are not readily subject to any form of assessment. For example, environmental assessments for no other industry sector in Australia routinely require forecasts of the number of bird or bat fatalities that they might cause. The statutory environment for assessments can most readily apply a consistent approach to only a single industry.

D.5.2 Scope

In the Australian context, the appropriate scale for evaluation of cumulative effects of wind farms on key species of birds and bats is the breeding gene pool for the taxon under consideration. Unless the individuals at risk are part of a geographically or genetically constrained gene pool (e.g. isolated to an island or other geographically discrete portion of the species' distributional range), consideration will be of effects on the entire geographic population of the taxon.

D.5.3 Data standardisation

Standard metrics (i.e. a 'common currency') for evaluation of effects on birds and bats for all wind farms is necessary in order to consider any cumulative impacts of multiple wind farms. Standard bird or bat utilisation information should be obtained for each relevant wind farm as outlined in assessment processes outlined for individual wind farms in these Guidelines.

The real cumulative effects of wind farms can be determined only from investigations of the effects of operational wind farms and pre-construction predictions of cumulative impacts will have significant limitations. This is an important reason for soundly based studies of the true impacts of functioning wind farms to be undertaken and for the information they obtain to be made appropriately available.

Evaluation of cumulative impacts on key species will be feasible only after the establishment of a central repository, or repositories, for results of bird and bat impacts at individual wind farms. Evaluation of the cumulative effects on a particular species entails a strategic overview that must be independent of any individual wind farm and, since cumulative impact assessments are of primary interest to the relevant authorities for conservation of bird and bat species, they will most naturally be the responsibility of government, but could be taken by the wind energy industry as a body. A centralised accumulation of data is a vital prerequisite and cumulative impact assessment cannot proceed without it.

D.5.4 Method

Overview

The process of determining a cumulative impact on a key species is one of combining the various impacts for all of the relevant individual wind farms and it is thus necessary to have a comparable and quantified assessment of the effects on relevant species of each of the wind farms involved. The processes outlined below require that demographic information for the species in question is available for use in population modelling.

Some key differences between the ways in which different birds and bats use their distributional ranges should be recognised and accounted for in the cumulative process.

In species that are sedentary, the risk of colliding with turbines exists only for the local portions of the overall population whose home ranges coincide with wind farms. Thus, for example adult Wedge-tailed Eagles *Aquila audax* in temperate south-eastern Australia generally reside permanently within stable home ranges (albeit that young birds may be dispersive). So only those adult Wedge-tailed Eagles whose home ranges intersect with wind farms are at risk of turbine collisions, while the great majority of the breeding population is at no risk from this source at all.

Species that migrate seasonally from one part of their distributional range to another present a different situation. These species vacate one area, such as their breeding range, entirely for part of the year and take up seasonal residence elsewhere. Some migrate along quite narrow flyways and outside of the breeding season may move about within a non-breeding range. For such species it is possible that large numbers, or even the entire population, might pass through multiple wind farm sites in the course of an annual migratory cycle. The Orange-bellied Parrot *Neophema chrysogaster* and Swift Parrot *Lathamus discolour* are examples of such migrants.

Other less predictable usage of habitats within an overall distributional range, such as nomadism, is characteristic of some Australian birds and bats, but such behaviours are difficult to quantify for individual sites and consideration of cumulative risks for such species is not likely to be feasible.

Determining cumulative impact

For sedentary, year-round resident species, the cumulative impact on the entire species is simply the sum of the impact experienced by those parts of the population that are at risk of collisions. The first step will be to determine the annual survivorship rate for the species in question for each wind farm within the species' range. From those rates calculation should be made of the mean survivorship rate for the portion of the population interacting with all wind farms. The mean must be weighted according to the relative numbers of birds and bats resident at the various wind farm sites. The cumulative impact of wind farm collisions on the entire population of the species is found by multiplying the annual survivorship rate for the portion of the population at risk of turbine collisions by the background survivorship rate for the remainder of the population that is not affected by collisions. The measure of cumulative impact is the difference between the newly derived rate and the background survivorship rate for the species.

All or part of the population of a migratory species may encounter a number of wind farms during the course of its annual cycle. The cumulative impact is derived by assessing the probability of birds and bats surviving their encounters with one wind farm after another for as many wind farms as it is believed they might pass through. The survivorship rate of each wind farm provides a measure of the proportion of the population that survives annual encounters with that particular farm and thus has potential to encounter another wind farm, and so forth sequentially through the geographic spread of wind farms within the range of the species. The cumulative population survivorship rate for wind farms will thus be the product of the survivorship rates of relevant wind farms.

If the population is segmented into geographic portions during parts of its migration cycle, or only portions of the population are believed to encounter particular wind farms, then the process outlined above may be applied to the relevant portion(s) of the population and to applicable wind farms.

A migratory population may encounter wind farms during only a portion of its annual cycle. The effects of turbine collisions will then be a seasonal one. For the purposes of calculating this in terms of an annual survivorship rate, this is no different from the seasonal variations in survivorship that affect populations over the course of a year due to natural variables of climate, breeding and non-breeding behaviours, fluctuations in predator and prey numbers and the like. However, it is important to determine the seasonal duration of the collision effect and factor that appropriately into the annual survivorship rate.

As for sedentary species, the cumulative population survivorship rate for wind farms should be multiplied by the background annual survivorship rate that effects the entire population in the absence of any turbine collisions. The measure of cumulative impact will be the difference between the newly derived rate and the background survivorship rate for the species.

It is assumed that impacts of collision caused by an established wind farm on a bird population will function as a constant over time, provided aspects of the wind farm do not change. For this reason use of demographic rates (annual survivorship or mortality) are appropriate to quantify impacts because they are independent of population size and can be applied to determine the number of birds and bats predicted to be killed, or to survive, for any given population size. This is also allows for fluctuations in bird or bat population size that may occur over the operational lives of the relevant wind farms.

Population Viability Analysis or Potential Biological Removal Assessment are appropriate tools for modelling effects of any impact (for single facilities or for the cumulative effects of multiple wind farms) on bird and bat populations. They can be undertaken where sufficient demographic information is available for a species under consideration and will utilise altered mortality rates due to wind farm collisions, as described above, to indicate effects on maintenance and functioning of the species' population.

D.6 Glossary & acronyms

Barotrauma	Traumatic respiratory tract injury documented in some bat species as a result of sudden air pressure differential that may occur near moving wind turbine rotors.
Before – After – Control – Impact (BACI)	In the current context, a research protocol designed to permit comparison of bird or bat use of a wind farm site before and after the wind farm is established. The 'control' component entails use of another, comparable site where no wind farm is built and which acts as an experimental control throughout the process. Valid control sites are not usually available because wind farm sites are often large and contain complex habitat features so that sites with similar features that are truly comparable do not exist. It is also the case that birds and bats of concern are generally threatened species whose use of any given site is often unique. As a consequence, a more limited, but achievable, Before – After - Impact design may be applicable.
Collision	As used here includes all causes of bird and bat deaths that may result from interactions with wind turbines. These include barotrauma, potential traumatic effects of turbulence caused by rotors, and direct collision strikes.
Collision risk model	A mathematical construct designed to predict a rate at which taxa of birds or bats might collide with wind turbines. Currently available collision risk models provide capacity to account for numerous variables of the flight characteristics of particular species and of the design of a wind farm.
Cumulative impacts	The combined effects on key bird or bat taxa of more than one wind energy facility.
Model	Any mathematical representation of events or processes in the real world. In the present context, models include those designed to explore possible risks such as those inherent in interactions between birds and bats and wind turbines and those that explore influences on, and effects of, the dynamics of animal populations. Models are 'transparent' in that the parameters, values and assumptions they make can be fully evaluated and readily adjusted to suit new or improved information. In these respects they are superior to their only alternative, which is subjective judgement.
Population	A group of animals that are part of a single gene-pool. For the purposes of the current context this will most often be the species or subspecies.
Population Viability Analysis (PVA)	'… a process of using species-specific data and models to evaluate the threats faced by species in terms of their risks of extinction or decline …' (Akçakaya 2004). For wind farms it can be used to evaluate the potential influence on extinction risk for a population of animals of a quantified number of mortalities that might occur due to the wind farm. A pre-

	requisite to undertaking PVA is a sound understanding of the demography of the population under consideration.
Potential Biological Removal assessment (PBR)	A process to model the annual number of additional mortalities that a population can sustain (e.g. Dillingham & Fletcher 2008). Simpler, but potentially less sensitive and robust than PVA, PBR can function with less demographic information than PVA. Requisite inputs are just estimated population size, maximum annual recruitment rate and a number of additional mortalities - in this context, additional mortalities due to the wind farm.
Qualitative	Relating to or based on the quality or character of something, as opposed to its size or numerical quantity.
Quantitative	Relating to, measured, or measurable by size or numerical quantity.
Taxon (plural: taxa)	A name designating a group of biologically related organisms as a taxonomic unit (e.g. species, genus).
Utilisation	The use of an area by a particular species expressed as quantified activity (for the purposes of collision risk, the number of flights) per unit of time and space.

D.7 Technical discussion of key concepts/issues

As outlined previously, it is not the intent of these Guidelines to be prescriptive about methodologies. Flexibility in specifics of research design and technologies that may be used to obtain the requisite data is vital to allow for particulars of taxa and sites and to permit adaptability to emerging technologies and techniques. The most important aspect is that bird and bat utilisation of various wind farm sites is quantified to standard measures and that appropriate statistical approaches and analyses are used. Peer review of study design and of its results should be provided by individuals with relevant expertise and knowledge of the standards to be achieved.

This section is provided as an adjunct to the preceding discussion of assessment processes to provide examples of methods that may be employed for monitoring and collection of birds and bat data for wind farm assessments and as a guide to some further sources of relevant information.

The first section may be applicable to birds and/or bats while the second section is specific to bats other than fruit bats (Pteropodidae). In a number of respects relevant to assessment of wind farms, the flight behaviours of fruit bats are more similar to those of crepuscular and nocturnal birds than they are to other bat taxa. It may be feasible to obtain information for fruit bats that permits risk to be assessed in a fashion similar to assessments for birds. This has been achieved for a wind farm development in Fiji (Smales 2005).

D.7.1 Potential investigation & assessment methods

Determining bird and bat utilisation rates

Estimated annual number of flights by key species at risk of collision should be extrapolated from samples documenting numbers of flights within rotor-swept-height per unit time. Standard and replicable timed counts of bird flights should be documented from a series of locations across the site. The basis for this methodology is the Point Count (Reynolds et al. 1980). Standard texts outline the fundamentals and limitations of this technique (e.g. Bibby et al. 2000). Note that the technique is adapted from its original purpose of counting numbers of birds to the counting of bird movements. Locations of count sites should be selected to be representative of turbine sites. Counts should be made in all seasons in which the species may be present and at all times of the daily cycle and conditions in which birds might fly. Statistical power analysis is applicable to determine the appropriate number of count locations and of counts that will adequately detect and document variables of bird flights for a given site. Records should be collected that document the height above ground and horizontal distance of a bird from the observer at the instant that it was first observed. Where more than one individual is seen simultaneously each bird provides a separate flight record.

A utilisation rate should incorporate the amount of available flight time per annum for key species. This must account for variables of seasonal, diurnal/nocturnal and tidal cycles that may affect presence at the site and patterns of bird activity. In addition to truly nocturnal birds, many diurnal birds also fly during the hours of darkness.

Visual counting by trained ornithological observers is the usual method employed for point count surveys of birds. Similar techniques may be applicable to visual counting of crepuscular flights of fruit bats and cave-dwelling bats as they fly from colony locations. However this method is not applicable to documenting truly nocturnal activities of birds or bats. It is also limited during daylight when weather conditions reduce visibility, and even due to observers' capacity to detect birds over distance. Vertical and horizontal marine surveillance radar have been used to document diurnal and nocturnal birds and bat movements at some overseas wind farm sites (Johnson and Strickland 2003, 2004; EchoTrack 2005) and has potential for this application in Australia. Data from radar does not readily permit identification of species and generally requires calibration against simultaneous visual observation of birds during daylight hours, monitoring of the calls of nocturnal birds and use of acoustic bat detectors as means to identify species in flight.

Representative sampling of bird and bat utilisation should encompass all variations that occur in the course of a year.

Flight height

Flight-height data for birds collected in the course of wind farm assessments in south-eastern Australia indicates that many bird taxa rarely fly within rotor-swept height and that interactions with turbines by such taxa are thus unlikely (Biosis Research unpublished data). For these taxa assessment for collision risk will not be required other than for exceptional sites or circumstances. Liaison with relevant authorities should be undertaken to determine taxa that may not require assessment for a particular location.

Data requiring heights of bird flights may require calibrated estimation of heights. More precise data for height above the ground may be obtained from vertical radar. Long-range thermal imaging and some range-finding technologies offer capacity to record distance from observer to a bird or bat and may allow height above ground to be derived from data records. However, such technologies are not without limitations which should be evaluated in determining whether they are applicable to a particular wind farm site. The cost and precision of such methods may also not be warranted in all situations. Flight heights or height estimates should be recorded rather than simple allocation of flight records to 'below-', 'within-, 'above rotor-swept zone'. This permits data to be used for analysis regardless of any changes to turbine dimensions that might occur during planning of the wind farm.

Site population census

Collision risk modelling may require a census or estimation of the annual maximum numbers of individuals of key species that could encounter and interact with the turbine array. For birds, this may be obtained from appropriately designed simultaneous counts designed to document the complement of birds present across the site. Any available historical records of maximum numbers should also be taken into account. There is a substantial literature on bird census techniques and Bibby et al. (2000) provides a good introductory overview.

Collision risk modelling

Quantified collision risk modelling is a predictive mechanism used to project the annual number of flights made by key species that are at risk of collision and may thus result in fatalities. Inputs required to undertake such modelling include standardised bird utilisation data; number and geographic layout of turbines; and dimensions and other parameters of turbines. Pre-requisites for an outcome measured in terms of an expected annual number of mortalities, are both the number of individuals that might interact with turbines and the estimated number of their flights that are at risk of collision. An overview of collision risk modelling used in Australia is provided in Smales (2006).

Behavioural responses to wind turbines

Bird and/or bat utilisation studies within an operational wind farm must be undertaken according to protocols that permit results to be compared directly with those obtained prior to construction. On the basis of such Before – After investigations any response of birds or bats to the presence of the wind farm may be evaluated. This will include responses to loss or modification of habitat and any disturbance caused by proximity to turbines.

Where applicable, targeted studies should be designed to obtain data on the rates at which relevant species of birds and bats avoid collisions when flying in the presence of turbines. This will require documentation of how birds and/or bats behave when flying within a turbine array. Techniques outlined elsewhere here for recording bird and bat flights can be applied for this purpose.

Documenting collision fatalities

The reason for determining the species and numbers of individuals killed by turbine collisions is to ascertain any effects on the functioning and maintenance of key species' populations. In order to achieve that aim, the number of fatalities should be evaluated against results of PVA or PBR analysis undertaken as part of the assessment process.

Determining how many birds or bats are killed is not an objective of itself and it is of minimal scientific value to simply record carcasses noticed during the course of other activities on the site. A program for monitoring fatalities should be designed according to sound statistical research principles. Searches for dead birds and bats around turbines are likely to be required and it is essential that these are undertaken to a rigorous regime design that accounts for variables in detectability of carcasses. Practical considerations and limits on detectability will necessitate that the study is designed to obtain an index of mortalities rather than an absolute count.

Trials to determine carcass scavenging rates and capacity to detect carcasses should be undertaken at the site. It is important that statistical power analyses are applied to assess the efficacy of trials after they have been run. Scavenger exclusion fencing around some turbines may reduce scavenging rates and thus increase capacity for carcass detection. The use of trained dogs may be considered as an aid to detecting carcasses. If trials demonstrate that detection of carcasses is not able to be effectively achieved then the situation should be reviewed in conjunction with the relevant authorities.

The monitoring strategy employed should be focussed on key species of interest, scavenging rates for the site and the capacity of techniques and observers to detect carcasses. It is important to employ techniques and parameters that are specifically tailored to the site and relevant species. Meta-data relevant to collisions must be documented in order to determine patterns or trends that might exist. These will include information about the turbine involved and weather and other environmental conditions when a collision is believed to have occurred.

D.7.2 Specific investigation methods for bats

Guidance for methods of investigating bats at wind farm sites is provided for an Australian context in Lumsden (2007). Ministry of Natural Resources, Ontario (2007) is another valuable resource for this purpose. The following discussion is primarily focussed on bat taxa other than fruit bats. It offers an outline of methods and techniques that may be applicable but sources such as those cited are recommended for the further detail they provide.

Methods for detection of insectivorous bats that have been used to-date in Australia do not permit quantification of bat utilisation of sites in measures such as numbers of individuals or bat flights per unit time, with the precision required for analytical assessments like collision risk modelling and Population Viability Analysis. For the present, it will generally be the case that assessment for bats, including usage of a site and the potential for impacts on key bat species, will be qualitative. Use of radar combined with acoustic and/or visual methods has potential to improve capacity to obtain quantified bat activity data (see *Determining bird and bat utilisation rates*, page 137).

Survey design considerations

Survey must coincide with peak activity season(s) for bat taxa local to the site. The relevant authorities can advise on appropriate periods for bat survey.

Surveys to detect the presence of bat species should be undertaken on nights with optimal weather conditions, which includes; light winds, relatively mild temperatures and no rain. A key criterion for a potential wind farm site is its wind yield, so windy conditions may be unavoidable. However, survey during very strong wind conditions should be avoided as bat activity drops off markedly in such conditions. Any form of survey intended to obtain representative utilisation rates for bats should attempt to survey the site during a sample of all weather conditions.

Acoustic monitoring of bat activity

Bat detectors are standard equipment for use in bat surveys. They record the high frequency calls produced by the bats when they are in flight and store recorded calls directly to a memory card. Most species produce characteristic calls and detector records can thus be used to identify species present in the area surveyed.

This method of sampling allows for analysis of the number of flight passes by bats within the detection range of the detector microphone, but cannot be used to determine numbers of bats making the calls and the method is thus not indicative of bat abundance.

Due to limits on the distance over which bat calls can be detected by the equipment and differences in preferred flight height ranges between bat species, sampling of various heights should be undertaken wherever feasible to maximise capacity to detect all species present. Whilst most detectors are usually deployed close to ground level, at least one other should be set-up to record calls closer to rotor-swept height. In practice this has been achieved by placement of a detector microphone high on a wind monitoring tower, where available, or on a portable tower.

Since a variety of calls are emitted by any one species and there is geographic variation in calls within species, all call identifications must be undertaken by experts experienced in bat call analysis, and with a thorough understanding of the range of bat calls produced. Calls must be analysed by comparison with a reference library of calls for each species from the relevant region.

Other technologies for documenting bat activity

Use of radar is outlined above. Thermal imaging and some light-enhancing (night vision) equipment have been used to monitoring bat movements. Any such system must have adequate focal distance capacity in order to detect small bats at distances of up to 130 metres above the ground. Due to the relatively narrow field of view they offer they have limited applicability to detection of bats in the broad landscape. Thermal imaging, in particular, appears well suited to monitoring bat behaviours in the presence of turbines.

Collision Risk Modelling

In the absence of numerical bat utilisation rates, collision risk modelling based on empirical data is not currently feasible for key bat species. Modelling can be undertaken using informed scenarios but as at 2010 there is little basis for making informed assumptions about rates of wind farm mortality for key bat species.

Population Viability Analysis

Without sound capacity to predict mean annual mortality numbers and very little background information about the demography of key bat species, which are essential pre-requisites for Population Viability Analysis, this form of modelling of potential impacts of turbines on key bat populations is also not presently applicable.

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E Shadow Flicker

E.1 Introduction

This Appendix discusses the shadow flicker phenomenon and presents a best practice methodology to assess and mitigate against its affects. Specifically, the Appendix provides:

- An explanation of the nature of shadow flicker.
- Consideration of suggested impacts of shadow flicker, identifying impacts with negligible risk and impacts with significant risk.
- An explanation of the shadow flicker assessment method with practice note;
- Linkage between the shadow flicker assessment method and the phases of wind farm development and operation.
- The purpose of this Appendix is to provide the technical detail necessary to:
- Explain the phenomenon of shadow flicker, its causes and consequences.
- Specify wind farm design methods necessary to minimise the impact of shadow flicker on wind farm stakeholders.

E.2 Background

E.2.1 What is shadow flicker?

The rotating blades of wind turbines can cast intermittent shadows that appear to flicker for an observer at a fixed ground position. Since wind turbines are tall structures, shadow flicker can be observed at considerable distances but usually only occurs for brief times at any given location. The most common effect of shadow flicker is annoyance. These impacts are most closely associated with the duration of shadow flicker experienced above a certain intensity.

The duration of shadow flicker, its intensity and the locations it affects are most strongly determined by the relative position of the Sun, the turbine, and the receptor. The relative position of the Sun varies with latitude, time of day and time of year. Other influential factors include:

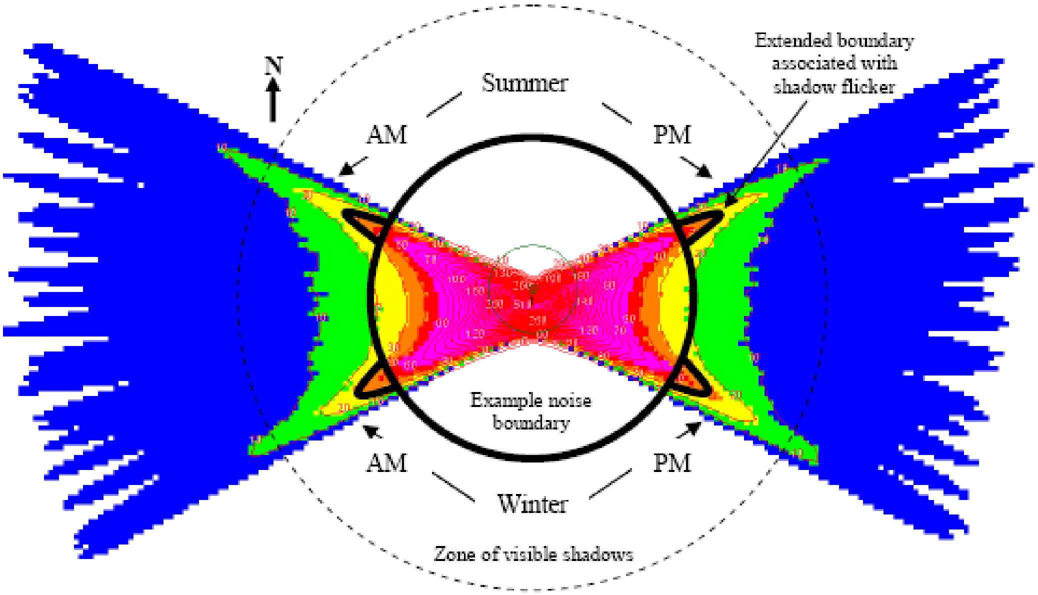
- The size of the wind turbine rotor and height of the tower
- Surface topography
- Intervening vegetation
- Direction of the wind (and hence the rotor plane of the wind turbine)
- Weather (particularly cloud cover)
- General visibility (including presence of mist, smoke and other particulates)

The typical effect of shadow flicker for a single turbine is shown in Figure E-1. This figure shows a plan view of a typical turbine with associated areas affected by shadow flicker. The following features are exhibited:

- The different colour bands represent different annual exposure to shadow flicker (blue 0-10 hr/yr, green 10-20 hr/yr etc)
- The areas (directions) affected at different times of day and year are shown
- The zone within which shadows are likely to be visible is shown. Intensity decreases with distance and only shadows occurring within a certain distance of a turbine are likely to be visible

- An example boundary is shown that represents an area that may be affected by shadow flicker, while not being significantly affected by noise.

Table 4-3
Typical areas of shadow flicker from a single turbine showing number of hours of shadow flicker per year



There are a range of impacts that have been suggested as being a consequence of shadow flicker. Each of these have been examined and it has been determined that the risk of some of the suggested impacts is, in fact, negligible and does not need to be addressed in the guidelines (see Section E.2.2).

The key risk associated with shadow flicker is annoyance of residents, and this risk is addressed in the Guidelines.

Shadow flicker can theoretically extend many kilometres from a wind turbine. However, the intensity of the shadows decreases with distance. While acknowledging that different individuals have different levels of sensitivity and may be annoyed by different levels of shadow intensity, these guidelines limit assessment to moderate levels of intensity (i.e. well above the minimum theoretically detectable threshold) commensurate with the nature of the impact and the environment in which it is experienced. Details of the intensity of shadow to be considered are provided in Section E.4.2.

Annoyance of residents can occur over a long term basis if they are repeatedly subject to shadow flicker, or on a short term basis as a consequence of an extended period of continuous exposure. Both are considered important impacts. However for any location within Australia, the recommended limits for continuous exposure are inherently satisfied if the limits for long term exposure on an intermittent basis are satisfied. The methodology reflects this, requiring only assessment of the long term exposure.

E.2.2 Issues not addressed in the Guidelines

Annoyance of land users other than residents

There is a negligible risk associated with impact on amenity of land users other than residents, such as where a recreation facility such as a park or gardens experiences shadow flicker. These risks are not covered in the Guidelines for the following reasons:

- The use of recreational facilities by any given individual is typically sporadic and infrequent, it is very unlikely that the annual exposure of shadow flicker they experience would come close to the limits designed for residents
- The impact (annoyance) would be relatively minor

Distraction of vehicle drivers

There is a negligible risk associated with distraction of vehicle drivers who experience shadow flicker, for the following reasons:

- Shadow flicker is little different for a vehicle in motion than the effect of shadows from trees on the side of the road or high passing vehicles, neither of which represent a significant risk in terms of road transport.
- In spite of extensive searches, no references to motor vehicle accidents caused by this phenomenon have been found

It is noted, however, that until wind farms become widespread in Australia they will represent a novelty that could cause distraction for drivers (regardless of shadow flicker). Consideration should be given to development of viewing areas for wind farms close to high volume roads.

Initiation of epileptic seizures

There is a negligible risk of epileptic seizures being caused by conventional horizontal axis wind turbines, for the following reasons:

- Less than 0.5% of the population are subject to epilepsy at any one time, and of these, approximately 5% are susceptible to strobing light (Epilepsy Action Australia, 2009).
- Most commonly (96% of the time), those that are susceptible to strobe lighting are affected by frequencies in excess of 8 Hz and the remainder are affected by frequencies in excess of 2.5 Hz. Conventional horizontal axis wind turbines cause shadow flicker at frequencies of around 1 Hz or less.
- Alignment of three or more conventional horizontal axis wind turbines could cause shadow flicker frequencies in excess of 2.5 Hz; however, this would require a particularly unlikely turbine configuration.

To summarise, the chance of conventional horizontal axis wind turbines causing an epileptic seizure for an individual experiencing shadow flicker is less than 1 in 10 million. There is a possibility that the risk is higher for some types of non-conventional turbine; however, such turbines are outside the scope of these Guidelines and should be considered on an individual basis. For the purposes of these Guidelines, a non-conventional turbine can be considered as one that causes a shadow flicker frequency of 2.5 Hz or greater. This effectively aligns these guidelines with BERR (2008), which acknowledges the low risk associated with this issue but nevertheless includes a requirement that the turbine frequency be les than 2.5 Hz.

E.2.3 Related documents and standards

Australian

At the time or writing, planning regulations typically note shadow flicker as an issue that must be addressed but only two examples provide guidance on how this should be done. These are the Victorian guidelines (SEAV, 2003), which specify a limit of 30 hr/yr for shadow flicker, and the South Australian development plan (Department of Planning and Local Government, August 2002) which suggest that shadows only need be considered out to a distance of 500 m. Victorian Department of Planning and Community Development also provides model planning permit conditions which indicate that application of 30hr/year does not apply to dwellings on the wind farm site; however, this condition is not applied directly in the guidelines.

In practice, assessment of shadow flicker in Australia generally refers to the Victorian guideline to provide some limit to assess against.

Under these standards, there is considerable scope for variation in the method used in the assessment. These Guidelines aim to resolve this situation, and to provide a consistent approach for assessment.

International

International regulations vary widely. By far the most comprehensive and well researched regulations are implemented in Germany. These are described in German Ministry for Environment and Climate Change (2002). These regulations included detailed limits:

- 30 hr/yr and 30 min/day modelled shadow flicker
- 8 hr/yr actual shadow flicker
- Limits apply within a distance of 2 km of the turbine or where there is a 20% blockage of sunlight.

They also include a detailed method and assumptions to be used in calculations including:

- Minimum angle of the sun above the horizon of three (3) degrees
- Model the Sun as a point
- Include effects of topography
- Do not adjust for atmospheric refraction
- Receptor height 2 m above ground (or window height)
- Receptor locations. all dwelling entry points (windows and balconies)
- Document assessment for at least a one year period (365 days, 24 h/day

Possible mitigating circumstances and supporting evidence for limits and approaches is also included.

Other international standards and regulations are discussed in further detail in Section E.7.1.

E.3 Overview of the Methodology

The method aims to address and limit the impact of shadow flicker on amenity of residents. The following points provide an overview of the method:

- Developers may use .rules of thumb. for selecting wind farm sites that have a reasonable chance of satisfying shadow flicker requirements; however, these do not ultimately factor in the technical requirements of these Guidelines and so are not included in these Guidelines.
- The method provides criteria to identify the region around turbines within which shadow flicker is considered to have the potential to cause annoyance. Only residences inside this region require detailed assessment. The size of the region is specified in Section E.4.3.
- The method specifies annual duration of shadow flicker at a residence as the performance measure for assessing shadow flicker impacts. See Section E.4.3 for these limits.
- The method describes a complete set of modelling assumptions and allowable mitigations enabling consistent calculation of the duration of shadow flicker at affected residences (see Section E.4.3).

- The method is inherently linked to the applicable limit for duration of shadow flicker. That is, limits on shadow flicker should not be set independent of the method. The reasons for this are as follows:
  - The method does not include a daily limit for shadow flicker exposure as this is inherently satisfied by the annual exposure limit. However, if the annual exposure limit is changed from that specified in these guidelines, this assumption fails and the method would need to include a separate calculation for daily exposure
  - The method returns a calculated value of shadow flicker, which is different from the actual value likely to be experienced. The calculated value is that which would occur in worst case conditions and is therefore a conservative estimate. The limits must therefore take into account the expected difference between calculated and actual duration, which is determined by the assumptions in the method.
- The method addresses the high sensitivity in duration of shadow flicker to location, by ensuring some conservatism in the assessment (see Section E.4.3).
- The method provides for assessment of cumulative impacts (see Section E.5.1).
- The method provides for post construction assessment and remedy (see Section E.4.5).

The recommended steps in considering and assessing shadow flicker, as they align with the phases of wind farm development, are shown below.

Stage and methodology	Tasks	Task methodology location
Site Selection		
-	-	-
Project Feasibility		
-	-	-
Planning Application		
Shadow flicker impact assessment		
Shadow flicker modelling	Carry out modelling using appropriate software, modelling parameters to determine annual exposure to shadow flicker for affected residences. If sensitive receivers are within the extent of shadows, carry out modelling using appropriate software, modelling parameters to determine annual exposure to shadow flicker for affected residences	Page 153
Mitigation	Introduce mitigation measures or revise layout to achieve compliance with specified limits for annual duration of shadow flicker.	Page 154
Construction		
Finalisation of wind farm design	Address any outstanding issues from the planning permit and provide associated information to the relevant authority	
	Finalise the wind farm design, updating any changes to the design such as: • finalising turbine type • finalising wind farm layout (micro-siting)	Page 155
Micro-siting	Revise shadow flicker modelling following turbine micro-siting.	
Community consultation	Continue community consultation regarding noise issues	

Stage and methodology	Tasks	Task methodology location
Complaints handling	Prepare complaints handling procedures for operation stage	
Operations		
Post-construction shadow flicker monitoring	Continue community consultation	
	Subject to community complaints, arrange for independent modelling for verification purposes	
	Undertake attended monitoring if required	Page 155
	Implement mitigation measures if required	
Decommissioning		
-	-	-

E.4 Stage and Task methodologies

E.4.1 Site Selection

There are no shadow flicker impact assessment requirements in this stage. Developers may choose to use .rules of thumb. in selecting sites likely to comply with the requirements under Section E.4.3; however, the nature of these will depend on the developer's risk profile and the area under investigation and so are not included here.

E.4.2 Project Feasibility

A developer may choose to undertake assessment as per Section E.4.3; however, shadow flicker is not normally an issue affecting project feasibility. Adhering to the section of these guidelines on noise assessment in the project feasibility phase is likely to eliminate any project feasibility issues associated with shadow flicker. This is because the distance required for turbine noise to dissipate to an acceptable level is, for most conventional turbines, roughly equivalent to the distance required for shadow flicker intensity to diminish to an acceptable level. This coincidence has relatively little dependence on site conditions. Any non-compliance issues can generally be addressed through micro-siting or mitigations in the planning application phase (Section E.4.3)

E.4.3 Planning Application

Assessment of proposed layout

The optimum method of assessment is as follows:

- Determine the extent of shadows from turbines being a distance of 265 x maximum blade chord (no assessment is required for residences beyond this distance). Section E.7.2 provides the basis for this limit.
- Identify all residences within the extent of shadows from proposed turbine positions.
- Use modelling software with relevant modelling parameters, as identified below, to calculate the theoretical annual shadow flicker duration at each residence, accounting for topography and cumulative effects (see Section E.5.1).
- If necessary, modify turbine layout and repeat calculations, or introduce mitigation measures (described below), to achieve compliance with the specified limits in Table E-1.
- Depending on jurisdictions, shadow flicker assessment may not be required for participating landowners.

Table E-1
Recommended exposure limits

Impact	Measure	Assessment procedure	Acceptable Level
Annoyance	Hours / year (hr/yr)	Modelled*	30 hours / year modelled
		Measured*	10 hours / year actual

* Calculation of shadow flicker in an ideal model (with the assumptions specified here) will provide a conservative estimate of the actual shadow flicker. In most circumstances where a dwelling experiences a 'Modelled' level of shadow flicker less than 30 hours per year, no further investigation is required. However, if this level is exceeded in the modelled scenario, mitigation measures may be introduced and the 'actual' or 'measured' level of shadow flicker will need to be determined. The modelling approach includes a number of assumptions and, as such, the 'Modelled' exposure limit is set higher to account for these conservatisms. The assumptions used in the modelling approach should produce an outcome equivalent to 10 hours per year actual exposure.

Modelling software

Appropriately validated modelling software will need to be used as part of this assessment.

For post construction testing, a detailed assessment by an independent consultant is recommended as per Section E.4.5.

Sensitivity

Shadow flicker duration can be very sensitive to location, varying by up to approximately 0.8 hours per metre of horizontal displacement. Thus in an extreme case, one end of a house may experience no shadow flicker while the other end may exceed the limit. For this reason, the assessment method requires reporting of the maximum value of shadow flicker duration within 50 m of the centre of a dwelling. This addresses a range of other sensitivity considerations such as the offset between rotor and towers, and some minor inaccuracies in the modelling equations, as well as annual variation in shadow flicker. Topographical variations will also need to be considered.

It does not, however, address the variation that may be possible due to micrositing. This requires separate reassessment prior to construction, as detailed in Section E.4.4.

Recommended modelling assumptions

Table E-2 summarises the assumptions or settings recommended for use in modelling shadow flicker.

The basis for these assumptions is described in Section E.7.2. These sections are for information only and do not include information necessary to complete an assessment.

Means of mitigating modelled estimates

The mitigation measures identified in Table E-3 may be used to reduce the modelled exposure to shadow flicker. No other mitigations are noted at this time:

Table E-2
Summary modelling assumptions

Model parameter	Setting
Zone of influence of shadows	265 x Maximum blade chord
Minimum angle to the Sun	3 degrees
Shape of the Sun	Disk
Time and duration of modelling	One full year representing a non-leap year 12 to 15 years after the date of DA submission
Orientation of the rotor	Sphere or disk facing the Sun
Offset between rotor and tower	Not required
Time step	Ten (10) minutes or less
Effects of topography	Include
Receptor height	1.5 m – 2 m and window / balcony height where dwellings have more than one storey
Receptor location	A map should be provided and the highest level of annual shadow flicker within 50 m of the centre of a dwelling reported.
Grid size for mapping and assessment of shadow flicker at a receptor location.	Not more than 25 m

Table E-3
Summary of allowable mitigations

Mitigation	Constraints
Cloud cover assessment	Annual limit reduced to 10 hours/year Use recommended method of assessment described below
Vegetation blocking shadows	Where it can be shown that the view of a source turbine is completely blocked, the contribution of that turbine may be ignored.
Scheduling turbine operation	Annual limit reduced to 10 hours/year

The recommended method for assessment of cloud cover is to:

- Obtain Bureau of Meteorology data on cloud cover from the closest site (reporting at least 9am and 3pm cloud cover) with at least three years of data.
- Determine monthly averages separately for the 9 am and 3 pm proportion of cloudy days.
- Reduce shadow flicker occurring in a given month by the proportion of cloudy days (evening shadow flicker should be reduced using the proportion from 3 pm and morning shadow flicker using the proportion from 9 am).
- Sum the reduced monthly totals to determine the revised annual exposure.

Section E.7.3 explains the basis for these mitigation measures, and for some other types of mitigations that have been considered but not recommended here. *These sections are for information only and do not include information necessary to complete an assessment.*

E.4.4 Construction

Assessment of the micro-sited layout

Shadow flicker is very sensitive to turbine position. Micro-siting, even within the limits allowable for an approved development application, can significantly change the duration of shadow flicker at some locations. Following micro-siting, shadow flicker should be reassessed, as described in Section E.4.3.

The revised assessment should be submitted to the relevant authority.

If the assessment of the micro-sited layout results in the exposure limits being exceeded, mitigation measures should be introduced.

E.4.5 Operations

Assessment of the actual shadow flicker

The limits and method recommended in these guidelines are such that complaints from affected residents are unlikely. In the event that complaints do arise, the following actions are recommended.

Independent modelling of shadow flicker, using as-constructed turbine positions, should be carried out according to the method presented in Section E.4.3 noting that this need only be carried out once, regardless of the number, timing and source of complaints. In the event that this shows the wind farm does not comply with these Guidelines, mitigation strategies such as planting of vegetation or scheduling turbine operation should be implemented to achieve compliance (see Section E.4.3).

In the event where a complainant is not satisfied by the outcome of this approach, an observational study may be recommended. It is difficult to determine the level of shadow flicker observationally, because of the range of variables (especially cloud cover) that will reduce the duration below that modelled. Additionally, a full years monitoring against which the annual exposure can be judged is likely to be impractical. As an alternative, it is recommended that observational study of shadow flicker on one day (when shadow flicker is present and there is no cloud cover) be carried out. This should be carried out using a video recorder placed at the receptor and monitored by an independent observer. A comparison of the time and duration of shadow flicker on that day would effectively validate or invalidate the predictions of the shadow flicker model, (which will need to be modelled for the same day). Validation of the model (within a tolerance of ±3 minutes) should be considered to demonstrate compliance with these Guidelines.

In the unlikely scenario where a wind farm is shown to comply with these Guidelines but a sensitive resident is still annoyed by the shadow flicker, the resident should be recommended to take the following steps:

- Plant screening vegetation between their property and the turbine(s).
- Install heavy blinds or shutters on affected windows.

E.5 Practice notes

E.5.1 Cumulative impacts

The approach to addressing cumulative impacts is common to many aspects of wind farms. This section addresses requirements specific to shadow flicker, and in particular defines the information to be provided by a developer in order to assess potential cumulative impacts in the future. Cumulative impacts from shadow flicker are generally unlikely; however, there are a number of practical instances where they can occur and so the potential for such impacts to arise should be addressed.

A developer should provide a list of annual duration of shadow flicker at any affected receptor, along with a map showing the annual number of shadow flicker hours at all locations within the zone of influence. Any subsequent development will then be required to take this information into consideration in their assessment. The combined impact of all developments should not exceed the recommended limits. In the case where new receptors are created between one development and the next, the impact of the first development(s) on these should be determined from the map provided.

At the time of submission, the application should consider cumulative impacts only from approved developments (including micro-siting where this is complete and submitted) and existing wind farms. As the development progresses (say from approval to a micro-sited layout), it must consider any changes (formally submitted) to the suite of approved and existing developments, including any new developments that have subsequently been submitted.

In effect, this defines a maximum shadow flicker time (initially 30 hr/yr) at each residence. When a Development Application is submitted, or resubmitted, to a planning authority, the duration of shadow flicker at each residence is reported. This is registered and subtracted from the maximum shadow flicker time. Subsequent applications will have less 'available' shadow flicker time. If there is insufficient 'available' shadow flicker time, then an application wishing to submit an application or change from its current status is responsible for mitigation of any negative impacts.

E.6 Glossary & acronyms

Intensity The contrast in lighting between alternating shadow and no shadow. When the Sun is (temporarily) fully obscured by a turbine blade, lighting will vary from full sun to full shade. When the Sun is (temporarily) partially obscured by a turbine blade, lighting will vary from full sun to partial shade. The proportion of the Sun that is obscured by the blade is defined as the intensity.

Blade chord The distance from the trailing edge of the blade to the leading edge of the blade, typically the longest dimension of the blade cross-section.

Receptor The location, in three dimensional space, at which measurement of shadow flicker is of interest. In these guidelines, the receptor generally corresponds to a dwelling.

Developer The party who owns the wind farm or the wind farm application.

Impact A potential negative effect of shadow flicker.

Measure The metric (with units) used to quantify an impact.

Micro-siting Small adjustments to turbine position (typically less than 100m) subsequent to planning approval but prior to construction, usually to account for practical factors affecting constructability.

Exposure The quantity of an impact at a receptor.

Level The allowable exposure.

Consequence The severity of an impact (quantified as 'trivial, some nuisance value', 'minor, possibility of injury', 'major, possibility of fatality', 'major, . possible multiple fatalities').

Likelihood The probability of an impact occurring (quantified as 'extremely rare, <1/1,000,000', 'rare, <1/100,000', 'unlikely, <1/10,000', 'likely, <1/1000', 'almost certain, >1/1000').

Risk Combination of consequence and likelihood (quantified as none, low, medium, high, extreme).

E.7 Technical discussion of key concepts/issues

E.7.1 Other international standards

The regulations in most other European and British countries refer to the German standard with some minor modifications. For instance the Danish / Swedish regulations allow an actual number of shadow flicker hours per year of ten (10) compared to eight (8) in the German regulations. In the USA, regulations and standards vary widely between jurisdictions. Some apply no requirements, assuming the issue is implicitly satisfied by the site location and noise requirements, while others apply extensive requirements, over and above those used in Europe and Britain.

Some examples of the various conditions are described here. Some regulations require shadow flicker to be calculated for a single location representing each dwelling, others require calculation for each window of a dwelling, or for an area extending some distance outside each dwelling. Two instances were identified where the regulations were applied equally to dwellings and roads (with the exception of roads where average annual daily traffic (AADT) is less than 500 vehicles). These jurisdictions are Shawano County (2008) and Eveline Township (Weed, 2006) in the USA.

The basis for each of the above regulations was not specified or easily determined. In the context of a road, annoyance caused by shadow flicker could conceivably by elevated to a safety issue because of its distraction value and may have been included in regulations purely on this basis (i.e. without objective assessment). BERR (2008) also introduces the assessment of turbine frequency, because of its potential impact on sufferers of epilepsy. It is noted that this is usually not a problem because wind turbines operate at around 1 Hz, well below the minimum level of 2.5 Hz that may trigger a seizure.

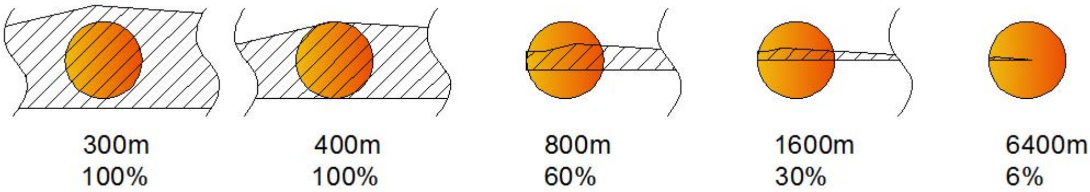
One commonality in regulations is the 30 hr/yr limit. This appears to be based on a German court ruling (propagated through various sources such as the Danish Wind Industry Association, 2003) which set this as the acceptability limit for a particular wind farm. Subsequent studies have supported its use as a reasonable determinant for acceptable levels of annoyance (Dudleston, 2000). However, one study concludes that setting a limit based on hours per year is overly simplistic, as survey results show that the time of day and year at which shadow flicker occurs is important in determining its annoyance value (Widing et al, 2004). In the above court ruling and in the subsequent studies, the 30 hr/yr limit is taken as the modelled limit, not the actual amount of shadow flicker, which may be considerably less because of cloud cover. This interpretation is not, however, universal and some regulations (notably in Australia) use 30 hr/yr as the actual limit (not the modelled limit).

E.7.2 Explanation of modelling parameters

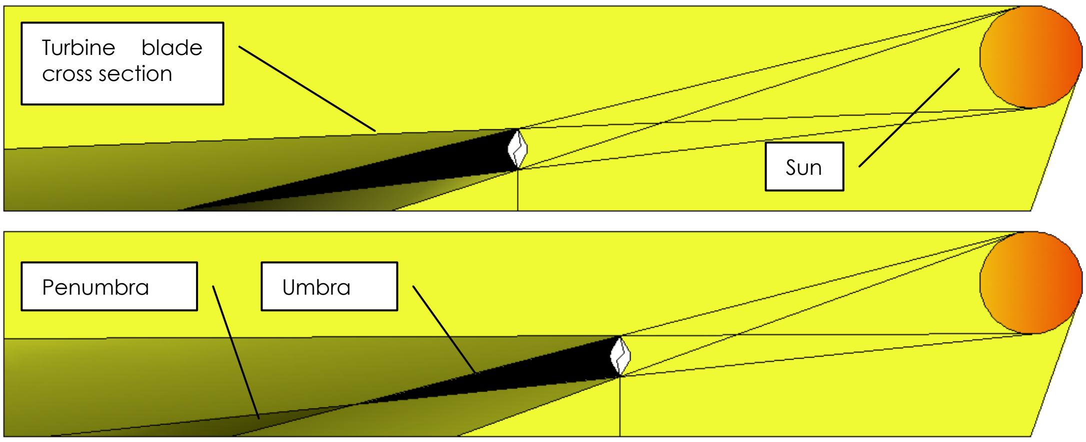
Zone of influence of shadows

The intensity of the shadow associated with shadow flicker is directly related to the amount of sunlight blocked by the blade. When the receptor is close to the turbine, 100% of the sunlight is blocked as the blade passes in front of the Sun, and the receptor experiences alternate full sunlight and full shade. As the receptor moves away from the turbine, the apparent size (angle) of the Sun remains effectively constant but the apparent size of the blade decreases (because the distance between turbine and receptor is large relative to the size of the blade but insignificant compared to the size of the Sun). At some point, the blade will no longer fully cover the Sun as it passes in front of it, and the receptor will experience alternate full sunlight and partial shade. The variation in blocking effect with distance is illustrated in Figures F-2 and F-3 for a typical blade (2 MW turbine).

Figure E-2
Blockage of sunlight for various distances (typical 2 MW turbine blade)



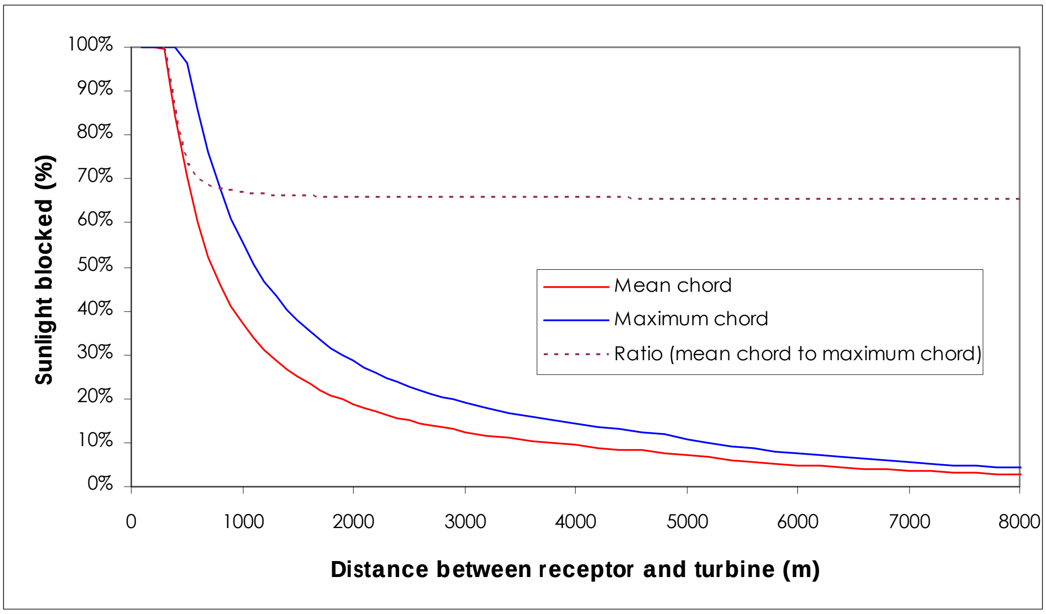
FigureE-3
Shadow intensity regions and the geometric relationship between the Sun, turbine blade, and shadow intensity



Since turbine blades narrow towards the tip, the actual amount of sunlight blocked depends on which part of the blade is blocking the Sun. The shadow from the root of the blade will extend further than that from the tip. The German regulations (Ministry for Environment and Climate Change, 2002) use the mean chord (calculated from the mean of the maximum chord and the chord at 90% of the blade length) to determine blockage. They set a limit of 20% of the solar surface blocked before regulations come into effect, while acknowledging that differences in light of as little as 2.5% can be detected by humans. The limit of 20% appears somewhat arbitrary, designed to achieve a balance between what is detectable and what may be practical. 2 km is offered as an alternative limit if the calculation of 20% blade chord is not undertaken.

Determining the distance at which the mean chord causes 20% blockage of the solar disk is not straightforward because the necessary information on blade profile is not always easily accessible. An alternative approach, recommended here, is just to use the maximum chord (which is easily accessible) with a higher threshold for blockage. The relationship between these two approaches is shown in Figure 4. It is worth noting that this figure also shows that to achieve no more than 2.5% blockage, the receptor would need to be at least 7.6 km from the turbine.

Figure E-4
Variation in shading with distance (typical 2 MW turbine blade)



Considering Figure F-4, when the mean chord causes 20% blockage, the distance is around 1,600m. This is in contrast to current Australian approaches. These approaches typically either cite BERR (2008), which states that shadows are negligible after approximately ten (10) rotor diameters (around 900m for a typical turbine; 1,000m is commonly used as a conservatism) or South Australian Department of Planning and Local Government, (2002), which states that shadows are negligible after approximately 500m. A distance of 500m is considered insufficient on the basis of Figure F-4, as this still represents on average 70% of sunlight blocked. A distance of 1,000m is more reasonable, representing on average 33% sunlight blocked (or 50% for areas shaded by the blade root). To achieve some consistency with previous work, it is recommended that this limit of 50% based on the maximum chord be adopted. For easy implementation, this translates to 265 x maximum chord. Note that a simple limit of 1,000m is not recommended as this will not allow for increases in turbine and blade size that may occur in the future.

Minimum angle to the Sun

In modelling shadow flicker it is common practice to only consider times when the Sun is above some minimum angle relative to the horizon. The basis for this is that the intensity of direct sunlight drops off considerably as the Sun approaches the horizon, and other factors, such as shading from vegetation or development become predominant (Ministry for Environment and Climate Change, 2002). The threshold angle commonly (and practically exclusively) used for such assessments is three (3) degrees. This choice is somewhat arbitrary; however, for consistency with past assessments, and the standards on which the levels of acceptable shadow flicker are based, it is recommended that this value be adopted.

An argument can also be made that when the Sun is below a certain angle to the horizon, the sunlight will pass under the turbine blades rather than through them. This, however, will depend on the local topography. It is also affected by the atmospheric refraction that occurs near the horizon, which causes the Sun to appear higher than it actually is (Young, 2004). These factors can all be calculated and accounted for; however, this would reduce the transparency and consistency of the approach. It is not recommended that a limit on the minimum angle to the Sun be set on this basis, but rather on the intensity of direct sunlight as described above.

Shape of the Sun

The Sun can either be modelled as a point source or a disk. In some sources (Garrad Hassan, 2006) the disk is considered the more conservative and in others (Garrad Hassan, 2007), the point is considered more conservative. The basis on which the point source can be considered more conservative is that shadow intensity does not decrease with distance using this method (whereas it does with the disk). Since the shadow intensity is considered separately as a means to determine the region of influence in all approaches to modelling shadow flicker (including that proposed here), this argument is mute. The disk can be considered more conservative from the point of view that it leads to a slightly larger area of coverage, and is more realistic. On this basis, the Sun should be modelled as a disk.

Time and duration of modelling

It is common practice to produce a model for a single year (arbitrarily selected), to determine the shadow flicker that occurs in that year and assume this will apply to all years of the wind farm's operation. This is slightly flawed, as the orbit and orientation of the Earth change marginally from year to year. Also, there could be some increase in the amount of shadow flicker during a leap year relative to any other year.

The assumptions made here have little influence on the result; however, the annual limit is based on a non-leap year, so this should be used in the assessment. To account for variation in the Earth orbit, a year at approximately the middle of the lifespan of the wind farm should be chosen. Given a typical 25 year lifetime, calculation is recommended for a year between 12 and 15 years after the year in which the planning application is assessed.

Orientation of the rotor

The rotor can (typically) be modelled in one of the following ways:

- As a disk lying in a plane whose normal points to the Sun (also referred to as a sphere).
- As a disk lying in a plane whose normal is horizontal and points towards the azimuth of the Sun.
- As a disk whose direction is determined probabilistically by the seasonal and time of day wind distribution.

Of these models, the first is the most conservative as it generates the largest area of shade at any time. It is most inaccurate when the Sun is overhead and actually passes through a narrowed rotor plane (as opposed to the full rotor plane as assumed); however, this is when shadow flicker is of least concern and thus the assumption is of little consequence.

Modelling the rotor as a disk whose normal is horizontal and points towards the Sun is also conservative. It is essentially the same as the sphere model but includes the effective narrowing of the rotor plane when the Sun is overhead.

The third approach is theoretically most accurate but is difficult to implement in practice and is a statistical approach that is hard to test. It is non-conservative. Thus, the first or second approaches are recommended.

Offset between tower and rotor

Garrad Hassan (2007) notes that it is important to include the offset between the tower and rotor because the modelling is quite sensitive to the rotor position. While it is considered prudent to include this information in the model if available, such a high level of sensitivity is considered best addressed by other means, particularly given that micrositing of turbines during construction could result in far greater errors in the modelled position. Further consideration of sensitivity is included under *Sensitivity* (page 153).

Time step for calculations

When modelling shadow flicker, shadows are typically calculated at some time of day, the time of day is then incremented by a fixed amount and the process repeated. The increment in time can impact on the accuracy of the calculations. The increment used in common practice varies between one (1) and ten (10) minutes (usually one or ten minutes). Ministry for Environment and Climate Change (2002) requires that one minute steps be used. The impact of the difference is relatively minor and the only difference in effort is additional computational time. Given that measures are recommended to reduce the sensitivity of the modelling (see *Sensitivity*, page 153), it is recommended that steps of ten minutes or less be used.

Effects of topography

The local topography will partially determine at what Sun angle a receptor is subject to shadow flicker. Commercial modelling software provides the capability to include the impact of topography. On this basis, it is recommended that effects of topography be included in shadow flicker models.

Receptor height

The receptor height is meant to allow for the typical height at which a person would experience shadow flicker (i.e. eye level). Values of 1.5 – 2 m are commonly used. The results are relatively insensitive within this range, and so it is recommended that the receptor height of 1.5 – 2 m be used.

An exception exists in the case where dwellings are higher than single storey. In this case, shadow flicker may be experienced at other heights. Existing multi-storey buildings should include assessment at window height on all storeys.

Receptor location

The location of the receptor is important as in some areas, shadow flicker can change rapidly for small movements. With reference to Figure E-1, shadow duration may increase from zero to 50 hr/yr over a distance of 100 m. This is an important issue as shadow flicker is normally reported for a single point, which may represent a window, or the centre of a dwelling. Someone just outside the building may experience considerably different results. This is also a particular issue for public spaces and recreation areas, if they are to be included in the assessment.

Shadow flicker maps can be calculated that show the variation with distance. These are produced in most current assessments but not actually used. It would be productive to use these maps to identify the highest value of shadow flicker within 50m (or some distance limit) of the receptor, and to use this as the reportable amount.

The particular advantage of this approach is that it accounts for both the reasonable extent of use by residents (and others) at a site, and for the sensitivity in the modelling discussed in the Sensitivity section.

Due to the effort required to interpret the output available from modelling packages, it is only considered feasible to use this approach in assessing the annual exposure. Daily exposure should be calculated for the dwelling centre only.

Grid size for mapping

Given the receptor location recommends using the maximum shadow flicker within 50m of a dwelling, it is necessary to define the grid size for which shadow flicker is calculated. A grid size of 25m x 25m is practical and should achieve sufficient resolution. This should be set as the upper limit on grid size.

E.7.3 Basis for mitigation measures

The wind is not always blowing – shadow flicker will not occur when the turbine is not rotating

While the statement is true, many wind turbines will continue rotating slowly even below their cut-in wind speed to maintain lubrication to all parts. The alternative case where a turbine is stopped because the wind speed exceeds the turbine cut-out wind speed occurs relatively rarely (generally less than 1% of the time based on the author's experience). As a consequence, this consideration will have little or no impact on the actual amount of shadow flicker experienced.

It is true that the assumption that the turbine is always rotating is conservative, but its impact is considered negligible. This assumption should not be used to mitigate shadow flicker impacts.

Shadow flicker will not occur when the turbine is facing away from the Sun

Again, this statement is true, however, only fully applies when the turbine is approximately perpendicular to the line to the Sun. At any other angle, shadow flicker will still occur but its area of influence will be reduced. To help quantify this, two-thirds of the possible range of orientations will deliver at least 50% of the full coverage.

The actual amount of time spent at different angles will depend on the wind distribution and its diurnal and seasonal variation. There is a valid case to be made in some circumstances, where, for instance, the wind is predominantly from a direction that is perpendicular to the direction to the Sun at times of year when shadow flicker is occurring. For instance, if a southerly wind is blowing during the late afternoon. However, significant data analysis would be required to complete the level of detailed modelling required to appropriately analyse this scenario, and it would be difficult to validate such modelling without full access to (typically confidential) wind monitoring data.

It is true that the assumption that the turbine is always facing the Sun is conservative. It may be conservative in some cases. However, given the considerable extra computational burden in making this calculation (and the lack of transparency and consistency that it introduces), it is recommended that use of this assumption not be used to mitigate shadow flicker impacts.

Aerosols reduce the effective distance of shadows

This is true as aerosols create some dispersion of sunlight and effectively reduce the intensity of shadows, particularly as distance increases. However, assessment is difficult and introduces considerable additional uncertainty. Furthermore, assumptions made in *Zone of influence of shadows* (page 157) already accounts for this argument.

Cloud cover prevents shadows

The most substantial reduction in the number of hours of actual shadow flicker experienced, relative to that modelled, will typically occur as a result of cloud cover blocking the Sun. In Australia, analysis of cloud cover (by one of several methods) is widely used as a means of achieving compliance with the 30 hr/yr limit for receptors that otherwise would not comply. However, this approach is contrary to that widely used internationally. The international approach is to use the 30 hr/yr as the modelled limit, not the actual limit (this is supported by Dudleston (2000), which shows that more than 30 hr/yr modelled shadow flicker generally results in complaints from residents).

In the case where clouds are accounted for, such as where scheduling is used to shut down a turbine when shadow flicker is actually occurring, the limit is reduced (to eight (8) hours in Germany and ten (10) hours in Sweden / Denmark, as well as in Shawano County (amongst others) in the USA)). This identifies a considerable disparity between past Australian assessments and internationally accepted levels. A move towards the international approach is strongly recommended because it is more closely associated with actual impacts, as supported by Dudleston (2000) and Widing *et al.* (2004). Under the current Australian approach, a receptor could easily be subject to more than 30 minutes of shadow flicker every summer evening.

It is worth noting that the Jones Consulting Group Ltd. (2007) identifies a subsequent German court ruling, applying to an existing wind farm that is used to justify the 30 hr/yr limit as the actual limit, rather than the conservative limit. As described above, most regulations, including the German regulations, have eliminated this 'loop-hole' by specifying limits for actual and modelled.

As with international approaches, it is still desirable to allow proponents a mitigation strategy for receptors where modelling shows more than 30 hr/yr. Mitigation may either be via scheduling or an approved calculation method to account for clouds. In this case, a lower threshold should apply. 10 hr/yr is recommended as the threshold. Although this is slightly higher than the German limit, it is consistent with a number of other jurisdictions and, reflects the less conservative approach of current Australian practices.

Vegetation, topography and development can block shadows at certain locations

Vegetation, topography and other developments (buildings, factories, etc.) that block sunlight at times when shadow flicker occurs effectively eliminate that shadow flicker. In Effects of topography (page 161) it is recommended that topography be included as part of the modelling; however, vegetation and development are not, by default included. These obstructions may be included on a case-by-case basis as a means to mitigate shadow flicker. However, it is not straightforward to include such obstructions in commercial models, and extracting the relevant details from the model to do the calculations externally is also difficult and time-consuming.

To maintain transparency and simplicity, it is recommended that this approach only be allowed where the obstruction completely blocks the view, from the receptor, of a turbine that is contributing to shadow flicker (photomontages or other means should be provided to demonstrate this). In this case all hours of shadow flicker attributable to that turbine may be discounted.

F Electromagnetic Interference

F.1 Introduction

Wind turbines can produce electromagnetic interference (EMI), in two ways. Firstly in the form of an electric and magnetic (electromagnetic) field that may interfere with radiocommunications services, and secondly, due to the obstruction of radiocommunications services by the physical structure of the wind turbines.

Under the Australian *Radiocommunications Act 1992*, "interference" is defined as:

- **In relation to radiocommunications:** Interference to, or with, radiocommunications that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device; or
- **In relation to the uses or functions of devices:** Interference to, or with, those uses or functions that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device.

In using this definition, the Radiocommunications Act deals with the radiocommunications interference caused by electromagnetic fields and provides protection for users where such interference is caused. It does not, however, deal with radiocommunications interference caused by physical obstructions. These guidelines will assist proponents by establishing best practice for managing the EMI that may be caused by the physical structure of the wind farm turbines, as well as that which may be caused by electromagnetic fields.

The intention of the guidelines, in relation to EMI, is to minimise the potential for EMI from wind farms by providing best practice advice on how wind farm proponents should:

- Identify all the parties potentially affected by EMI due to the construction of the wind farm.
- Assess all potential EMI impacts.
- Consult with the parties.
- Mitigate against any potential EMI effects.

This should enable the developer to site and design a wind farm development to avoid adverse impacts to licensed radiocommunications services.

F.2 Background

F.2.1 Types of EMI considered

EMI may affect various radiocommunications systems, including broadcast radio and television, mobile phones and radar.

As with the sites often selected for wind farm developments, telecommunications infrastructure is also often located on high points in the landscape to maximise their performance. This is because broadcast radiocommunications service providers seek to reach as many customers' receivers as possible, with signals above a certain threshold level, in order to provide an acceptable service level in terms of performance and reliability. Radar services also seek a broad coverage area in order to detect their target, and point-to-point radiocommunications services require an unobstructed line-of-sight path between a single transmitter and receiver pair in order to operate effectively.

Any obstructions between a transmitter and receiver will cause degradation to a radiocommunications signal. Obstructions in the vicinity of a radiocommunications service may also cause reflections or refraction which can degrade a radiocommunications signal, and signals from a transmitter located on a high point in the landscape are less likely to be obstructed. Radiocommunications services are designed to cater for any existing obstructions in the service area. However, the construction of a new wind farm can create new obstructions that may affect existing radiocommunications services.

Where a wind farm is proposed for development in the vicinity of telecommunications infrastructure or in the line-of-sight of a radiocommunications service, radio-communications service providers and the users of their services may have concerns about electromagnetic interference and degradation of signals as a result of a proposed wind farm development.

A diverse range of radiocommunications service providers could be involved in any particular development. These may include radio and television companies, mobile phone companies, local and national utilities, the defence services, civil aviation service providers and emergency services using microwave communications systems (such as ambulance and coastguard). In some cases wind farm proponents may need to comply with statutory separations from certain telecommunications equipment. For example, those associated with aerodromes.

The scope for wind turbines to impact such systems is summarised as follows:

- The turbine tower may obstruct, reflect or refract the electromagnetic waves used in a range of radiocommunications systems for transmission.
- The rotating blades may have similar effects, on a time-variable basis. In some cases ghosting of TV receivers may occur where turbine blades act as an aerial to on-transmit, or scatter, the radiocommunications signal. This can also cause impacts to radar and other services due to scattering. This effect can be reduced by minimising the use of turbines with metal blades or those with metallic cores or metal components such as the lightning protection system.
- The turbine's electrical generator itself can produce electromagnetic interference, which may need to be suppressed by shielding design and maintenance of turbines (although in practice, a generator is little different from a typical electrical motor and it is quite rare for a wind turbine generator to present such a problem).

It is usually possible for the potential for the electromagnetic interference effects mentioned above to be minimised, if not eliminated altogether through special technical solutions and appropriate turbine siting.

F.2.2 Services potentially affected

A description of each type of radiocommunications service that may be affected by a wind farm, together with the potential effects, is given below.

Point-to-point and broadcast (point-to-multipoint) radiocommunications services

In general, the most susceptible of the radiocommunications services to the location of wind turbines are analogue television services and point-to-point radio links which rely on line-of-sight between transmitter and receiver. Any obstruction in the vicinity of a straight line between these two points may cause interference and signal degradation. Near-end reflections are also an issue for broadcast services such as analogue television services. Digital television is much less susceptible to EMI from a wind farm, but can be affected in low signal areas.

Wind farms operating within close proximity of a navigation aid or trig stations can also impact on the operation of equipment at these facilities.

Aviation radar

Wind farms operating near airports, or in prominent positions with a line-of-sight to radar installations, can affect radar in a number of ways. Radar line-of-sight can be hundreds of kilometres.

Primary Surveillance Radar (PSR) transmits a pulse of energy that is reflected back to the radar receiver by an obstacle that is within Radar Line-of-Sight (which is different to Optical Line-of-Sight). The amount of reflected energy picked up by the receiver will depend upon factors such as the size, shape and density of the obstacle. The extent to which an object reflects or scatters the radio energy is related to the object's Radar Cross Section (RCS). This is affected by the physical size and height of the wind turbine and its proximity to the radar station.

However, a characteristic that makes wind turbines more unpredictable is the fact that, because the turbines rotate to follow the wind, the cross-sectional area presented to the radar will vary depending upon wind direction. Additionally, the position of the blade when reflecting the radar's energy pulse will determine the RCS of the turbine at that instant.

For PSR, the major effects are that the spinning turbines may show up as false targets on the radar screen, or cause shadows that may obscure an aircraft being detected by radar. These effects change over time with the rotation of the blades.

Secondary Surveillance Radar (SSR) does not rely on reflections from objects for detection. Instead, aircraft to be detected are required to carry a transponder, which replies to radar interrogations.

For SSR, the effects of EMI are that the aircraft transponder may respond to a reflected signal and give a false position reading, or an obstruction may cause shadows as is the case for PSR.

Radar technology is continually evolving and it may be that, in the future, radar installations may be able to detect wind turbines and adequately distinguish them from other objects.

Meteorological radar

Radar is also used extensively in meteorology for two quite distinct purposes known respectively as "Windfinding" and "Weather Watch". The former is concerned with the measurement of winds in the upper atmosphere, while the latter is used for determining the location of rain and storm activity. The radar instruments used in both these applications contain a high-powered microwave radio transmitter. A sensitive receiver allows reflected energy (or "echoes") to be detected from objects, or areas of rain, at distances up to some hundreds of kilometres from the radar. The Bureau of Meteorology (BOM) operates a nationwide network of radar stations.

Wind profiles are of great importance for the safe and economical operation of aircraft and, in addition, provide a most important source of data for the Bureau's general forecasting system. Due to radar's ability to estimate the intensity of rainfall over wide areas, it has a useful role to play in monitoring weather situations which might result in serious flooding, with particular attention being paid to the northern coastal areas which are subject to destructive tropical cyclones. Radar is able to indicate the possibility of severe storms to 250 km or more. There are implications for public safety if severe weather is not predicted due to EMI masking the presence of approaching severe weather.

Wherever possible, BoM Weather Watch radars are located on high ground in order to clear local obstructions and give the best possible coverage of the surrounding area down to a low height above ground level. Wind farms developments can therefore impact on the weather watch radar coverage area. While experienced operators are able to recognise the clutter from a wind farm, software used to automatically interpret radar signals is not currently able to make this interpretation.

Wind finding radar is used to track a radar target tethered to a balloon as it ascends through the atmosphere. Wind farms located at a reasonable distance, say 5km, from a BoM field station are unlikely to affect wind-finding radar operations.

Licensed radiocommunications services

The Australian Communications and Media Authority (ACMA) is a government agency responsible for the regulation of broadcasting, the internet, radiocommunications and telecommunications. ACMA's responsibilities include managing access to the radio-frequency spectrum. It is also responsible for compliance with licensing requirements and investigating complaints of interference to services.

There are three types of radiocommunications licences — apparatus licences, class licences and spectrum licences.

An apparatus licence typically includes stations operating in the Outpost, Amateur, Broadcasting, Maritime, Aircraft and Land Mobile services bands. Licence fees are payable for the operation of equipment under an apparatus licence, and individual licences are issued for authorisation.

Class licences allow anyone to operate particular radiocommunications equipment provided that the operation and the device meet the conditions of the licence. Class licences do not have to be applied for and no licence fees are payable. Examples include citizen band radios, mobile phone handsets, cordless telephones and a range of other low power devices such as remote controlled garage door openers.

Spectrum licensing is a form of licensing introduced in Australia by the *Radiocommunications Act 1992*. Spectrum licences are a tradeable, technology neutral spectrum access right for a fixed non-renewable term. Instead of authorising the use of a specific device, spectrum licences authorise the use of spectrum space and give licensees the freedom to deploy any device from any site within their spectrum space, provided that the device is compatible with the core conditions of the licence and the technical framework for the bands.

Generally speaking all radiocommunications transmitters must be licensed. The only exceptions relate to emergency situations.

ACMA maintains a Register of Radiocommunications Licences that lists most licensed radiocommunications services in Australia. Some services are not listed, for example, radiocommunications devices used under a class licence such as mobile phones are not listed as the operation of these individual devices is unknown to ACMA. Users of such devices would need to come forward at the community consultation stage.

Summary

In summary, the various types of radiocommunications services have different interference mechanisms, and they may require different mitigation measures where potential issues are identified.

F.2.3 Issues not addressed in the Guidelines

Transmission line electromagnetic field effects

The electrical power collection system ('transmission lines') within wind farms and any external connection to the power grid need to be considered as part of the development and approvals process; however, these requirements are not unique to wind farms. The transmission of electricity via underground or overhead powerlines is required between any generation source and the users of the electricity generated. It is acknowledged that wind farms generally require an array of power distribution cables over a large area, which is considered somewhat unique.

Transmission line effects on electromagnetic interference (e.g. radio signal strength) or health (human or animal) are considered to be negligible if the internal collection system and the external connection from the wind farm to the power grid are located in accordance with contemporary best practice.

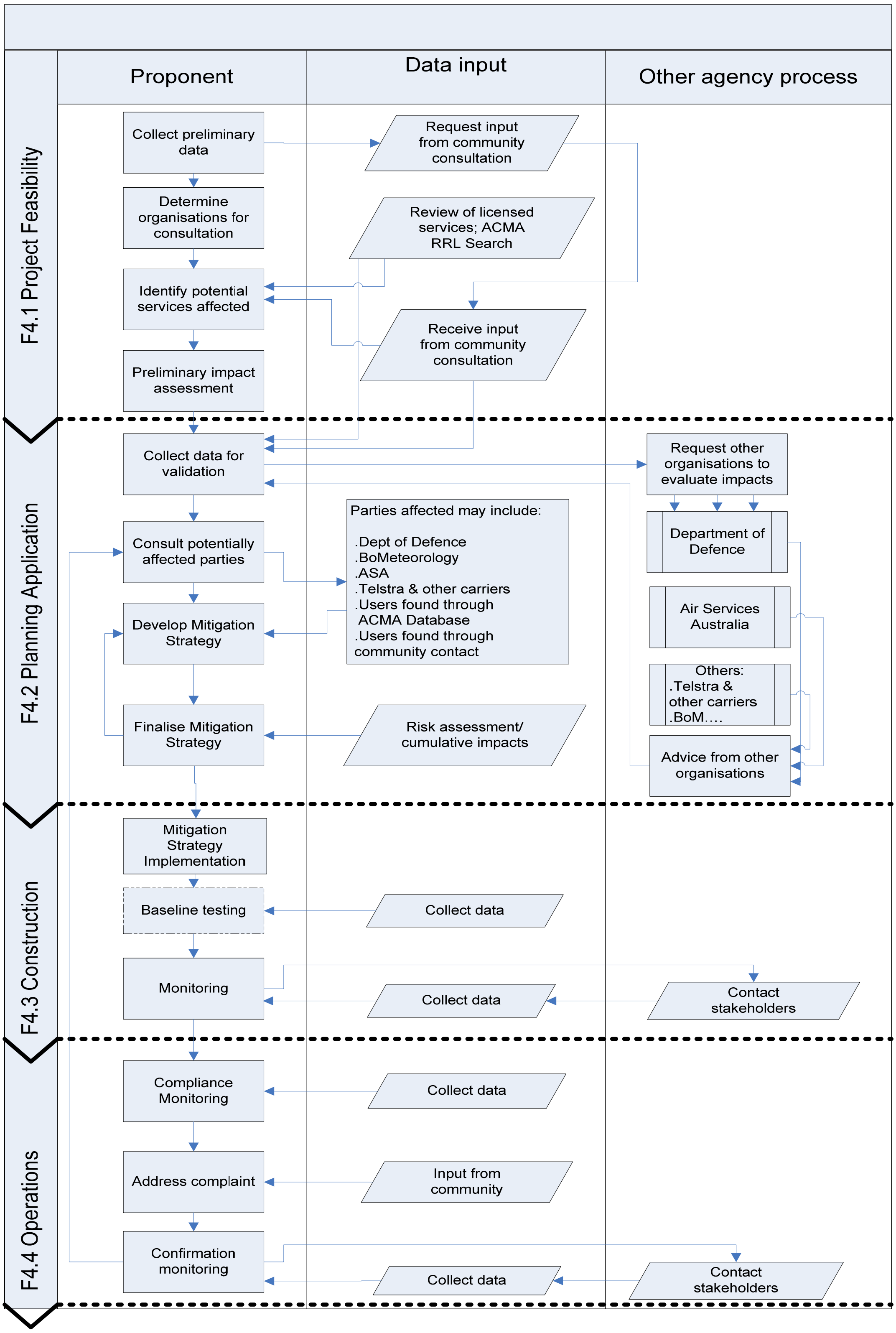
For both reasons above, the electromagnetic field effects of wind farm transmission lines has not be covered in these Guidelines. The developer is encouraged to apply the same design principles used by the local power distribution authority and work with them to resolve any issues.

F.2.4 Related documents and standards

The following documents have been considered in development of these Guidelines:

- Australian Standard AS/NZS 2344:1997 *Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 to 1000 MHz*.
- Australian Standard AS/NZS 4251.2: 1999 *Electromagnetic compatibility (EMC) - Generic emission standard - Industrial environments*.
- Auswind 2004. *The Electromagnetic Compatibility and Electromagnetic Field Implications for Wind Farming in Australia*. Australian Wind Energy Association.
- Auswind 2006 *Best Practice Guidelines for Implementation of Wind Energy Projects in Australia*. Australian Wind Energy Association.
- Bacon, D.F. 2002. *A Proposed Method for Establishing an Exclusion Zone around a Terrestrial Fixed Link outside of which a Wind Turbine will cause Negligible Degradation of the Radio Link*, Ofcom Uk Report Ver 1.1
- *CAP 764 – CAA Policy and Guidance on Wind Turbines, Second Edition*. UK Civil Aviation Authority, February 2009.
- DPIWE 2004. General Guidelines for the Preparation of a Development Proposal and Environmental Management Plan for Wind Energy Projects. Department of Primary Industry, Water and Environment, Tasmania.
- Greving, G., and Malkomes, M. 2008. *Weather Radar and Wind Turbines – Theoretical and Numerical Analysis of the Shadowing Effects and Mitigation Concepts*. Fifth European Conference on Radar in Meteorology and Hydrology (ERAD 2008), Helsinki, Finland.
- IEC 2007. *IEC 61400-25 Ed 1.0 Communications for monitoring and control of wind power plants*. International Electrotechnical Commission.
- IWEA 2008. *Best Practice Guidelines for the Irish Wind Energy Industry*. Irish Wind Energy Association.
- NOAA (undated) *How the ROC analyzes wind turbine siting proposals*. Radar Operations Centre, National Oceanic and Atmospheric Administration, United States. http://www.roc.noaa.gov/windfarm/how_ROC_analyses_proposals.asp
- ODDRE 2006. *The effect of windmill farms on military readiness*. Report by the Office of the Director of Defence Research and Engineering to the Congressional Defense Committees.
- OFCOM (2009) *Tall structures and their impact on broadcast and other wireless services*. http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/tall_structures/tall_structures.pdf
- Poupart, G.J 2003. *Wind farms impacts on radar aviation interests – final report*. FES W/14/00614/00/REP, DTI Pub URN 03/1294. Report by QinetiQ to the UK Department of Trade and Industry.
- Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria, 2009
- WAPC 2004. *Guidelines for Wind Farm Development Planning Bulletin 67*. Western Australian Planning Commission.

Figure F-1
EMI mitigation methodology



F.3 Overview of the Methodology

The assessment of potential EMI impacts will require a range of tiered studies to be undertaken commencing during Project Feasibility and culminating in the Planning Application stage. After that, some monitoring and mitigation works may need to be undertaken during the early part of the Operations stage.

An overview of the works that should be considered by the developer is presented in the table below.

Stage and methodology	Tasks	Task methodology location
Site Selection		
-	-	-
Project Feasibility		
Preliminary EMI impact assessment		
Preliminary data collection	Request input from community through consultation process Initial review of licensed services in the area Determine agencies that need to be contacted Identify whether there are any exclusion zones that may affect development at the site	Page 172
Potentially affected services	Identify those services which may be affected	Page 175
Preliminary impact assessment	Undertake preliminary EMI impact assessment	Page 177
Planning Application		
EMI impact assessment		
Detailed EMI assessment	Collect data for validation	Page 177
	Consultation with potentially affected operators	Page 177
	Develop mitigation strategy	Page 178
	Finalise mitigation strategy	Page 179
Construction		
Monitoring program baseline	Mitigation strategy implementation	Page 179
	Baseline testing	Page 179
	Monitoring during wind farm construction	Page 180
Operations		
Operational EMI monitoring	Compliance monitoring during wind farm operation	Page 180
	Addressing community complaints during operation	Page 180
	Confirmation monitoring during wind farm operation	Page 180
Decommissioning		
Decommissioning Decision	Addressing community complaints post-decommissioning	Page 181
Decommissioning	-	-
Redevelopment	As per *Planning Application*, *Construction* and *Operations*	

F.4 Task methodologies

F.4.1 Project Feasibility

Collect preliminary data

Data should be collected from a number of sources in order to confirm the existence of any radiocommunications services that may be impacted. This data should be collected via:

- *Community consultation*

  The general community consultation process for the wind farm development should also canvass any community concerns regarding potential electromagnetic interference, particularly in relation to those services which may not be listed in the ACMA Register of Radiocommunication Licences such as those covered by an ACMA Class Licence. An example of this type of service could include fixed mobile phones, which are often used as part of irrigation telemetry systems.

  Any concerns raised by the community should be captured by this process for validation and mitigation in the Planning Application stage.

- *Review of licensed radiocommunication services*

  Conducting a search of the Australian Communications and Media Authority (ACMA) Register of Radiocommunications Licences can provide a listing of all licensed radiocommunications services within a specified area around the wind farm. A radial distance of 50-60km from the centre of the wind farm would normally capture all of the potentially affected services in the area. This register is available on the ACMA website. However some services may not be covered by this register and the users of these services may need to be consulted with directly (see ***Determining** relevant organisations for consultation* below).

  ACMA also produces a spreadsheet "Broadcast Transmitter Data" containing information on licensed broadcasting transmitters that lists AM, FM, analog TV, digital TV, and current and future temporary transmitters (for Special Events, Test Transmissions, Temporary Community Broadcasting Licences, and other temporary licences that make use of the broadcast services bands). This can also be searched is updated monthly and is available from the ACMA website.

  If the wind farm development process is prolonged, or if the turbine layout changes significantly, this data may need to be periodically refreshed.

  It is not possible to determine whether users of radiocommunications devices operating under a class licence exist in the area. Such users would need to come forward during the community consultation process.

  It is also not possible to determine whether unlicensed services operate in the area of the wind farm from the ACMA database. These users are operating illegally and are therefore not considered in these Guidelines.

- *Determining relevant organisations for consultation*

  Where there is a statutory obligation, these organisations must be advised of the proposed wind farm development.

  The following organisations should also be contacted in the planning stage of the wind farm development in relation to potential electromagnetic interference so that they can conduct their own assessment of the potential impact in relation to EMI:

  - Department of Defence
  - Air Services Australia

- Bureau of Meteorology
- Relevant Telecommunications Carriers including Telstra
- Relevant TV broadcasters

The criteria for initiating such contact, any known exclusion zones, the information each organisation requires, the method of approach and the timeframe for receiving a response from the assessment by each organisation is tabulated below (excluding the Department of Defence who have not communicated their requirements).

It is recommended that these organisations are consulted at the beginning of the Planning Application Stage, however determining whether any known exclusion zones apply to the development, which organisations are to be contacted, and what information they require should be done at this stage.

Please note, this information was correct at the time of issue, but these requirements may change with time.

Air Services Australia	
Known exclusion zone	Not specified
Criteria for notification	Information below is from ASA information sheet "Airport-Related Developments"

Information required	• Site plans with the exact location of the proposed activity
	• Drawings of Tower Line of Sight to movement areas with apron boundary clearly defined
	• Detailed drawings including:
	  • exact dimensions
	  • maximum heights in AHD and the above ground height for all structures including crane operations
	• The exact location of the development, including coordinates and datum for each structure or crane operation, with:
	  • coordinates in latitude / longitude or easting / northing
	  • datum as WGS84 or equivalent (not the airport reference point datum)
	• A description of each structure to be built, including details of proposed external cladding, materials, and the structure's proposed use
	• Where possible, MicroStation.dgn files (or AutoCAD) that include 3D wireframes of buildings and tower line-of-sight.

Contact details	Manager, Airport Relations Air Services Australia, Canberra
Expected timeframe for evaluation response	Allow 6-8 weeks for the endorsement process.
Bureau of Meteorology	
Known exclusion zone	Not specified
Criteria for notification	All wind farms
Information required	As a minimum: • Site location and extent • Turbine locations and dimensions, including maximum blade tip height As Bureau models for assessing interference potential become more comprehensive, more parameters may be required in the future.
Contact details	windfarmenquiries@bom.gov.au Head Policy and Strategy Section

	Observations and Engineering Branch Bureau of Meteorology PO Box 1289 Melbourne VIC 3001
Expected timeframe for evaluation response	Based both on the requirements of the proponent and on the priorities and work load of the responsible Bureau staff. The internal BoM policy under development may specify a set timeframe in which the proponent can expect a response.
Telstra	
Known exclusion zone	Not specified
Criteria for notification	Within the vicinity of Telstra infrastructure
Information required	• Initial letter of intent to develop • Number of turbines • Heights of turbines • Coordinates of turbines locations • Diameter of blade • Diameter of pole
Contact details	Area Planner
Expected timeframe for evaluation response	• *Acknowledgement letter* Area planner to ensure acknowledgement letter is sent out to developer within 2 days of receiving proposal. • *Initial response letter* Result of preliminary analysis to be summarised and sent out to wind farm proponent no later than 1.5 weeks from receipt of proposal from team leader. • *Final response letter* The time taken to send out a final response letter depends on the complexity of the project. The developer should be kept informed on a regular basis of the progress of the project if extended time is required.
Department of Defence	
Known exclusion zone	• Sites which impacted on radar (this will be assessed on a case-by case basis • Locations within gazetted Defence Areas Control Regulations or infringing airfield Obstruction Clearance Surfaces (OCS) • Sites within any easements controlled by Defence or obstructing communications path (e.g. microwave links)
Criteria for notification	• All wind farms on land or offshore
Information required	• Map showing the location of the wind farm boundary extent • Site plans showing individual turbine locations, wind monitoring masts and associated electrical works • Construction details (turbine heights to blade tip zenith (in metres above ground level), number of turbines, construction materials, details of crane use, batching plant, etc) • Any aviation lighting plan • A description of any other structure to be built (including materials height AGL and lighting) • Any other information deemed relevant by Defence (e.g. timing of construction, construction crane information, potential wind farm expansion plans)
Contact details	• Land Planning and Spatial Information, LPSI.Directorate@defence.gov.au
Expected timeframe for evaluation response	• Allow a minimum of 4-6 weeks for a response • More complex assessments may require additional time and information

Identify potentially affected services

Having determined the licensed services in close proximity to the wind farm, received any early community input and reviewed any known exclusion zones for the organisations listed above, proponents can determine which services may be affected by the wind farm development.

This involves a calculation of the distance between line-of-sight radio paths and the proposed wind farm, down to individual wind turbines if necessary, for any turbine (including blades) within a line-of-sight radio path or within close proximity to a broadcast site or if it may impact on the performance of a radar facility.

The following distances are considered to be general exclusion zones outside which a wind turbine will not interfere with a radiocommunications service:

- *Obstruction to a radio line-of-sight path*

  This is when the location of a wind turbine causes radiocommunications signals to be partially or fully obstructed, resulting in a reduction or loss of signal.

  It is generally accepted that effects from obstruction by wind turbines can be avoided by placing the turbines, including blades, outside the second Fresnel Zone of the line of sight path of a point to point radio link. This is a conservative approach.

  The second Fresnel zone at any point can be calculated and is dependent upon the frequency of the signal, the length of the radiocommunications path, and the distance of the particular point in question along the radiocommunications path.

  The maximum second Fresnel zone distance of a link occurs at the mid point along the path.

  The formula for calculating the second Fresnel zone distance at any given point is:

  $$F_2 = \sqrt{\frac{2\lambda d_1 d_2}{d_1 + d_2}}$$

  where

  F_2 = Second Fresnel zone radius

  λ = Wavelength in metres

  d_1, d_2 are distances from each end of radio path to the point under consideration

- *Obstruction to radar services line-of-sight*

  Radar services may be affected by wind turbines hundreds of kilometres away if they are located within the radar operating range and line of sight.17 As a guide, long range 23cm (1300MHz) radars, such as those used for en-route surveillance, can have an operating range in the order of 200 nmiles (radius of search volume in nautical miles), a 10cm (3000MHz) approach radar 60 nmiles, and 3cm (9000MHz) final approach radar 15 nmiles.

  Individual radar operators will need to evaluate the development and advise whether there may be any potential impact on their services.

- *Near-field effects*

  This occurs when a wind turbine is located in such close proximity to an antenna that it changes the characteristics of that antenna.

  Transmitting and receiving antennas have a “near-field” zone, which requires freedom from any object that can conduct or absorb radio waves.

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17 CAP 764 provides a method for determining radar line-of-sight.

The near field zone can be calculated, and is dependent upon the frequency of the signal, the gain and orientation of the antenna.

Typical calculations give the "near-field" zone for:

- High Band Ultra High Frequency (UHF) signals, such as cellular telephones (800MHz to 1900MHz) as approximately 20m.
- For point-to-point Microwave links as approximately 720m.
- For Low Band VHF paging systems approximately 4m.

As can be seen from the above examples the near-field zone varies widely depending upon the service type. It is recommended that a conservative criterion for discussing potential impact due to near-field effects with a potentially affected party is if the wind farm proponent intends to locate a wind turbine within, say, 1km of any telecommunications site.

- *Reflection/scattering*

  This occurs when Radio signals are reflected (scattered) from the wind turbine blades and interfere with a wanted radiocommunications signal.

  A ratio of the scattered signal to the received signal can be used to determine the full effect of this form of interference. This can be calculated and is dependent upon the distance of the receiver and transmitter to the wind turbine tower. Some methods use worst-case Radar Cross Section (RCS), which is very conservative, or a variant on the second Fresnel zone calculation for users close to a wind turbine. Please note that RCS is relevant to all radiocommunications services, not just radar services.

  Required signal-to-noise ratio (SNR) for different services is variable, but can be of the order of 30dB.

  An exclusion zone to meet the SNR requirement can be calculated and is dependent upon the gain and radiation pattern of the antenna, the worst case RCS and the distances between user, transmission tower and wind turbine. Higher frequency signals generally utilise antenna patterns with higher gain.

  As there is no single criterion for potential impact on radiocommunications services due to scattering, it is recommended that the criterion for discussing potential impact due to reflections/scattering with a potentially affected party is if the wind farm proponent intends to locate a wind turbine within 2km of any telecommunications site.

  Consultation with the organisations listed earlier in this section will reveal any effects on radar services.

In summary, the recommended criteria for discussions with a potentially affected party are, if the wind farm proponent intends to locate a wind turbine:

- Within the maximum second Fresnel zone of a point-to-point radio link.
- Within 2km of a radiocommunications site or a receiver.
- Within 250 nmiles of Aeronautical and Weather Radar operations.

It should also be noted that the accuracy of radiocommunications site coordinates in the ACMA database is variable, and also that it relies upon the accuracy of individuals providing the correct data when applying for a new service. It also does not guarantee that a particular service is operating, or operating in accordance with ACMA regulations. Therefore, should there be an indication that any individual services may be impacted, or are within, say, 5 km of causing an impact, then it is recommended that independent verification of the radiocommunications site co-ordinates is carried out to confirm the existence of any issues.

Preliminary impact assessment

Having determined which services may be potentially affected by the wind farm, a risk assessment should now be conducted to determine the level of impact expected for each identified service.

This will assist in a preliminary determination of the mitigation methods to be considered at the next stage.

If there is a low risk of impact, or the impact cannot be easily quantified, then mitigation methods may be proposed for implementation after construction, when the actual effects can be measured.

There may also be the opportunity to reduce any general exclusion zones due to the specific circumstances of the development.

For example, some exclusion zones are based on methods using worst-case RCS to determine signal loss due to scattering. However, while RCS can be minimised, the actual RCS is difficult to determine accurately. Using the worst-case RCS can result in overly conservative exclusion zones. This may be a subject for discussion with the individual organisations affected at the next stage.

Following the risk assessment, a preliminary determination of which organisations or individuals require consultation at the Planning Application Stage can be made.

F.4.2 Planning Application

Collect data for validation

When the decision has been made to progress to a Planning Application, data should be validated by taking the following actions:

- *Community consultation*

  Any concerns raised in the community consultation phase of the project should now be validated and included in the list for consultation.

- *Review of licensed radiocommunications services*

  If it has been some time since the Review of Licenced Radiocommunication Services in Section F.4.1 was undertaken, or the proposed turbine layout has changed, it is recommended that this data be refreshed and reviewed for any relevant changes.

- *Evaluation by relevant organisations*

  Those organisations identified in Section F.4.1 should now be contacted to conduct their own assessment of the development for the potential of electromagnetic interference with their radiocommunications services.

Consultation with potentially affected operators

Having verified the radiocommunications site co-ordinates, and determined which services may be affected, those operators should now be contacted to jointly assess the impact. This is important as initial discussions may reveal that the service is no longer in use, and therefore there will be no impact.

A more detailed risk assessment of the potential impacts would be carried out with the affected parties at this stage, and potential mitigation options can then be discussed.

Where an organisation specifies a general exclusion zone, it is recommended that this is confirmed as being applicable to the specific services identified as impacted.

Develop mitigation strategy

As a starting point, best practice to reduce the effects of EMI, involves designing the wind turbines to their minimise Radar Cross Section (RCS). This reduces the extent to which the turbines will reflect or scatter radio energy. This can be achieved by:

- careful choice of tower and nacelle shape and available construction materials
- the use of absorbing (or non-reflective) materials from those available for blade construction
- consideration of the spacing of wind turbines in relation to any affected services

As mentioned above, RCS is relevant to all radiocommunications services, not just radar services.

In addition, there is a hierarchy of mitigation options that can be explored with the individual affected parties, to eliminate any specifically identified EMI effects. They are:

- Re-location / removal of individual turbines
- Replacement of the existing radiocommunications service equipment with another less affected type (e.g. UHF link → Microwave link; Analogue TV → Digital TV)
- Re-location of radiocommunications services to another existing radiocommunications site
- Re-location of radiocommunications services to a new telecommunications site. (Such a site may need to be established to provide telecommunications services to the wind farm itself, and provide a dual purpose solution)
- The use of underground or overhead optical fibre as a telecommunications medium in lieu of a radiocommunications service, thereby avoiding the wind farm interference effects
- Enhanced radar filters (able to remove the returns from wind turbines, careful spacing of turbines in relation to the radar service can also assist with this solution)

The mitigation options selected may be different for each individual service affected, depending on the type of service and the level of interference expected. For example, there may be several point to point radio links that are affected. It may be agreed to relocate one turbine for one of the links, and move the other to another site which is then linked by optical fibre.

Where the effects cannot be easily quantified, and are intended to be dealt with after construction, the mitigation process could be:

- Baseline testing prior to construction
- Post-construction monitoring
- Validation of any issue and mitigation

For example, where the proposed wind farm development is within close proximity to houses, say within 10km, it is recommended that baseline testing of television signals is carried out prior to construction, for picture quality and signal level. This may also apply to other broadcast and point to multipoint services such as mobile phone, commercial radio etc.

Should post-construction monitoring identify an issue, the following mitigation options are available after commissioning:

- For general broadcast services, including analogue or digital television:
    - Review and improve the receive antenna orientation and state of repair
    - Installation of a more directional and/or higher gain antenna
    - Relocation of the antenna to a less affected position

- Installation of an appropriate amplifier
- For analogue television:
  - Installation of a digital set-top box (and new antenna if required)
  - Installation of a digital TV transmitter for an affected area
- For analogue or digital television:
  - Installation of a digital TV translator for an affected area
  - Provision of satellite TV services

Finalise mitigation strategy

Through consultation with the affected parties in relation to the available mitigation options, a mitigation strategy should be developed and documented. In preparing this document a risk assessment of the mitigation strategy should be conducted to determine whether there may be any unintended consequential effects, such as:

- Introducing any new EMI issues to existing telecommunications services.
- The cumulative effects of additional turbines, or additional wind farms.
- Cumulative effects of any mitigation methods.
- Any interaction with regard to other existing or proposed wind farms, or telecommunications facilities, in the area.

For example, relocation of a radio path may impact on other telecommunications services or other wind farms that have been approved for construction in the area.

Once the preferred options have been determined through consultation, it is recommended that the mitigation strategy be documented, and agreed with the affected parties. This document could then be included in the Planning Application.

F.4.3 Construction

Mitigation strategy implementation

If there has been a significant period of time between preparation of the mitigation strategy and the commencement of construction, then it is recommended that a brief review of the data collected is undertaken to determine whether any new services have been introduced.

Any changes required as a result of the review should be made, and the mitigation strategy implemented prior to construction.

Baseline testing

If baseline testing and post-construction monitoring have been recommended by the mitigation strategy, it is first necessary to establish what the standard of the telecommunications signal levels is, prior to construction. This is done as part of the baseline testing by performing a baseline radio frequency (RF) survey.

Once the wind farm has been constructed it will then be necessary to perform the tests again during post-construction monitoring, so that a comparison can be made between results recorded before and after construction of the wind farm. If it is found that local radio communications services have been adversely impacted by the presence of the wind farm, then mitigating measures can be devised and implemented.

There are two methods by which a baseline RF survey can be performed — that is, a sample baseline RF survey which involves the collection of qualitative and quantitative data at discreet locations throughout the area under consideration, or a continuous baseline RF survey which involves the collection of quantitative data throughout the area under consideration.

The surveys can be undertaken as follows:

- *Sample Baseline RF Survey*

  The sample baseline RF survey involves selecting a discreet number of representative sites or residences within a defined radius test zone, say 10km, of the wind farm. It is then necessary to visit each one of those representative sites, take measurements of the signal levels and make observations about the quality of the telecommunications services and the condition of the receiving equipment and antennas, etc.

  Before the advent of the global positioning system (GPS), this was the traditional method of conducting a baseline RF survey.

- *Continuous Baseline RF Survey*

  The continuous baseline RF survey involves setting up a test rig in a vehicle. The test rig comprises RF receiving equipment (spectrum analyser), a GPS unit and a computer with appropriate software. The test rig will then be used to log the radio signal strength and location data on a continuous basis whilst the vehicle is driven over the planned drive route.

  If signal strength is poor in an area and it is apparent that property owners have installed high masts or towers to receive broadcast signals it may be necessary to stop and conduct sample testing for those properties as well, as the test equipment configuration does not completely emulate all conditions that the property owner may experience. For example television signal "ghosting" is not a phenomenon that can be observed or predicted using signal strength testing.

Monitoring during wind farm construction

Regular contact with the stakeholders identified during planning stage should be maintained during construction, and any concerns fed into the process of validation and mitigation.

F.4.4 Operations

Compliance monitoring during wind farm operation

If baseline testing was conducted prior construction, then post-construction testing should be carried out and any anomalies fed into the process of validation and mitigation. Mitigation options available post-construction were identified in ***Develop mitigation strategy*** above (page 178).

Addressing community complaints during operation

The general procedure for responding to complaints in relation to the wind farm development should also cover any community concerns regarding electromagnetic interference. Any concerns raised by the community should be fed into the process of validation and mitigation. Mitigation options available post-construction were identified in ***Develop mitigation strategy*** above (page 178).

Confirmation monitoring during wind farm operation

Finalise contact with the stakeholders identified during planning stage and maintained during construction, and feed any concerns into the process of validation and mitigation. Mitigation options available post-construction were identified ***Develop mitigation strategy*** above (page 178).

F.4.5 Decommissioning

Addressing community complaints post-decommissioning

The decision-making with regard to decommissioning or redeveloping the site should consider the history of complaints received during operations and changes to services in the area over the working life of the wind farm. These complaints should be assessed in the light of technology changes to ascertain whether redevelopment of the farm would face less or more stringent constraints in seeking approval to redevelop the site.

F.5 Cumulative impacts

The potential for cumulative impacts needs to be considered when developing and finalising the mitigation strategy (see page 179).

F.6 Glossary & acronyms

ACMA	Australian Communications and Media Authority
BOM	Bureau of Meteorology
EMI	Electromagnetic interference
Fresnel zone	This is an ellipsoid around and forming a path between the transmitting and receiving stations based on transmission, frequency, distance and local atmospheric conditions. If unobstructed, radio waves will travel in a straight line from the transmitter to the receiver. But if there are obstacles near the path, the radio waves reflecting off those objects may arrive out of phase with the signals that travel directly. A Fresnel zone is the ellipsoid surface from which reflected signals will arrive at the same time later than the direct radio signal.
2nd Fresnel zone	The second Fresnel zone is the ellipsoid zone within which a reflected signal will arrive up to 270 degrees out of phase with the direct signal.
nmiles	Nautical miles
PSR	Primary Surveillance Radar
RCS	Radar Cross-Section
RRL	Register of Radiocommunications Licences
SSR	Secondary Surveillance Radar
UHF	Ultra High Frequency
VHF	Very High Frequency

G Wind Farm Development Process

G.1 Introduction

This section provides a more detailed description of the typical wind farm development process and guidance on how and when to address the issues covered by this document. Proponents should refer to the requirements of the relevant authority and to the appendices for detailed methodologies that deal with community consultation, noise, landscapes, birds and bats, shadow flicker and electromagnetic interference. Other readers are encouraged to read the appendices for a better understanding of each issue.

G.2 Detailed description of the development process

The following overview of the development process by reiterates the purpose of each sub-stage of the process from and summarises the works to be undertaken in each sub-stage. It provides a greater level of detail than presented in Section 4 of the Introduction to these Guidelines and should be reviewed in conjunction with the flowchart presented in that section.

The works outlined below, and detailed in Appendices A-F, are also consistent with the best-practice principles detailed in Section 1.9.

G.2.1 Site selection

Regional site selection: (S1)

Regional site selection normally involves a desktop study focussed on the wind resource, generally by checking national or state/territory wind atlases and proximity to an adequate electricity network. Locations remote to the grid or requiring major upgrades to the network and significant funding may make a wind farm project economically unviable.

Major incompatible land use activities, such as urban areas, national parks and sensitive ecosystems (among others), are avoided at this stage.

Some states/territory's and regions have policy initiatives to assist wind farm developments and a number of state/territory governments have produced wind atlases and guides to help identify potential areas for wind development. Refer to the relevant state/territory agency to source these tools.

Local site selection: (S2)

Once the broad area has been selected, consideration turns to property-specific locations within identified wind resource areas. At this level, factors such as the geographical extent of the site, the topography, the size of the properties, and the proximity to electrical and road networks are assessed.

The local site assessment provides an indication of how many wind turbines and of what size may be possible for the site which will enable a broad economic analysis.

As a number of wind farm sites may have been developed, under construction or approved in the area it is important to consider the greater potential for cumulative impacts to increase community interest and add competition for network access.

As for the regional site selection process, local site selection can mostly be done via a desktop study. A visit to the area to better understand site characteristics, like road quality, power lines, and the general location of houses is usually done as a final check to decide whether to proceed to the next stage.

The site selection process concludes by identifying properties that should be considered further in the high-level risk assessment to ascertain a boundary and a preliminary layout for detailed investigation and discussion with the community.

Preparation of a preliminary Communication and Consultation Plan, to support stakeholder consultation activities for the High Level Risk Assessment process (Sub-Stage S3) should commence at this time. The Plan may include discussion with the local planning authority in order to obtain further background information on the site/s investigated. This can assist in determining the appropriateness of the site/s for wind farm development.

High-level risk assessment (S3)

At this stage the assessment is designed to provide a high-level, preliminary overview of the likelihood of critical impediments that may prevent the development from proceeding.

From the broad overview of the major issues of the site the regulatory approvals context should be mapped out identifying what consents/permits are likely to be required at:

- Commonwealth level - through the operation of the ***Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)***. This should consider EPBC Act Policy Statement 2.3 (2009) ***Wind farm industry***, which is designed to provide detailed guidance to assist wind farm proponents decide whether or not they should submit a referral under the EPBC Act
- State/territory - level through the state/territory legislation (most state/territory's have an assessment threshold in terms of energy generation capacity).
- Local level through the local planning/development processes (often containing triggers related to matters differing from the state/territory assessment process).

This stage should also map the stakeholders, processes and timeframes for the approvals pathway. Commonwealth, state/territory and/or local planning requirements and assessment processes will need to be identified in discussion with their planning authorities. Consideration should also be given to how state/territory agencies may support the assessment of planning applications submitted to local governments.

The outcome of this process is to identify an initial group of landowners who may be approached regarding land access, wind monitoring and options for longer term land use. Negotiations with landowners should commence in accordance with the preliminary Communication and Consultation Plan. The detailed Project Communication and Consultation Plan should be drafted outlining the objectives of the consultation program for the development stages.

Following the outcomes of the risk assessment process, and decision to progress investigations at this site, initial communications with the broader community should begin. This should occur through a formal announcement in numerous publicly accessible forums of intentions to progress wind farm development investigations.

Project Sub-stages		Activities to be Undertaken
Site Selection		
S1	Regional Site Selection	**Purpose:** To identify the general locality in which to site a potential wind farm.
		Activity: Assess via desktop study: • broad regional wind resource • proximity to electrical network • high-level critical impacts (e.g. urban areas, national parks, culturally significant sites, sensitive ecosystems and habitats).
		Consultation: Nil. Proponent to conduct background research on local area, including any previous community experiences with wind farm

Project Sub-stages		Activities to be Undertaken
		developments in the region.
S2	Local Site Identification	**Purpose:** To identify the properties that may form the site and identify the possible boundary of the wind farm site.
		Activity: Assess via desktop study: • local wind resource • land-ownership and land-use patterns • ease of construction • potential size of wind farm • status of other developments in the region (constructed, approved, planned or known). • potential for environmental impacts A site inspection to confirm the validity of the desk top studies should also be undertaken.
		Consultation: The proponent may wish to seek background information on site/s and local area from the local planning authority, environmental and land use authorities. A preliminary Communication and Consultation Plan should be started.
S3	High-Level Risk Assessment	**Purpose:** To ascertain whether there are any critical impacts that may prevent development at the site, to select a site boundary and negotiate with landowners, and to develop a preliminary farm layout.
		Activity: Assess via brief desktop study: • ecology (flora, fauna and habitats) • landscape • noise • cultural heritage • planning constraints (including identifying necessary approvals) • social impacts. • investigate landscape constraints for project feasibility and site selection Some studies may involve a field work component.
		Consultation: Discussions with landowners of properties identified as potentially suitable wind turbine hosts should commence (in accordance with preliminary Communication and Consultation Plan) Information should be sought from relevant government agencies, and/or the local planning authority to inform the Landscape Risk Assessment and Birds & Bats Risk Assessment. If a decision is made to progress development investigations at this site the proponent should: • commence preparation of a detailed Project Communication and Consultation Plan • make a formal announcement to all stakeholders

G.2.2 Project feasibility

Wind monitoring (PF1)

Wind monitoring of a high priority site is necessary in order to confirm the reliability of the wind resource. Once landowner consent has been negotiated, one or more wind monitoring towers will be installed on the site. These towers should be of a height comparable to the hub height (i.e. height without blades) of the turbines likely to be deployed at the site, with anemometers installed at varying levels to measure wind speed and direction. Monitoring usually occurs over a 12 month period before a commercial decision can be made to pursue development at the site, although this period may be shorter or longer depending on the proponent's financing requirements. If the project is to proceed further, the monitoring towers will remain on site to further confirm the available wind resource.

It should be noted that the installation of monitoring towers does not mean that a wind farm will necessarily be developed or that a final site layout exists — it merely means that the initial site selection has identified this site as possibly suitable for development and a high-level risk assessment has not excluded the site from consideration.

As some planning processes do not require a consent/permit for the erection of wind monitoring towers, unless removal of vegetation is required, proponents should satisfy themselves as to the local planning scheme or development plan provisions in their particular circumstance. The proponent should also satisfy themselves that the monitoring tower will not impact other areas of the environment that may trigger other permit requirements.

Establishing a dialogue with identified stakeholders should be a key milestone at this stage, in accordance with the Project Communication and Consultation Plan. Stakeholders, including local community members and organisations, should be provided information on the proposed site, wind monitoring progress and the proposed development stages.

This stage will determine what approvals and consents are required, their interdependencies, the responsible authorities, the level of information required for the applications and the likely timeframe necessary for the collection of data and assessment. The scope of the documentation should cover approvals and consents needed for not only the development itself (e.g.: land use permit) but those for specific aspects (e.g.: vegetation clearance) or related matters (e.g.: road works).

Input into the studies for a number of technical areas should be sought from a range of stakeholders, including local planning authorities, landowners hosting wind turbines and neighbouring landowners.

Preliminary technical studies (PF2)

The preliminary technical studies establish baseline conditions and are primarily used for data collection to inform the preliminary wind farm layout. This layout will be revised through iterations as more data becomes available and community needs are identified.

Preliminary Technical Studies	Issues to consider
Noise	
Noise impact risk assessment	High-level review of potential noise impacts considering: • proposed size of wind farm • character of the surrounding area • density of surrounding residential development
Preliminary wind monitoring review	Review requirements for wind monitoring data and ensure they can be achieved with the proposed wind monitoring strategy
Preliminary sound predictions	Carry out sound emission predictions (preliminary)
Preliminary noise criteria assessment	Establish noise criteria framework to be used for assessment including: • context and scope of assessable buildings • noise level limit framework • application to cumulative development • application to stakeholders • assessment of SACs • Establish background monitoring sound requirements
Community consultation	Begin community consultation regarding noise issues
Landscape	
Preliminary Landscape Assessment	Defining the scope and policy context Preliminary Landscape Character and Significance Analysis Preliminary views analysis Preliminary community values
Consultation	Information on landscape values sought from local planning authority and identified local community members/groups
Birds & Bats	
Preliminary assessment	Determine potential for key species to use the site. Preliminary assessment of potential for negative effects on key species due to loss or alienation of habitat. Preliminary assessment of potential for fatal turbine collisions by key species
Consultation	Site information sought from Project landowners (wind turbine hosts) and naturalist/bird observer groups
Shadow Flicker	
Community consultation	Begin community consultation regarding shadow flicker issues
EMI	
Preliminary data collection	Request input from community through consultation process Initial review of licensed services in the area Determine agencies that need to be contacted Identify whether there are any exclusion zones that may affect development at the site
Potentially affected services	Identify those services which may be affected
Preliminary impact assessment	Undertake preliminary EMI impact assessment
Community Consultation	
	Implementation of Project Communication and Consultation Plan to continue. The proponent should regularly provide updates to stakeholders on the progress of investigations, and outcomes. Importantly, feedback and input into the investigation and development process should be sought from stakeholders.

<table>
<tr><th colspan="2">Project Sub-stages</th><th>Activities to be Undertaken</th></tr>
<tr><th colspan="3">Project Feasibility</th></tr>
<tr><td rowspan="3">PF1</td><td rowspan="3">Wind Monitoring</td><td>Purpose:
To confirm the wind resource at the site in order to decide whether the site is worth pursuing commercially.</td></tr>
<tr><td>Activity:
These works will involve negotiation with landowners and installation of a wind monitoring tower on the site.</td></tr>
<tr><td>Consultation:
Discussions with identified stakeholders should commence, in accordance with the Project Communication and Consultation Plan.
Stakeholders, including local community members and organisations, should be provided information on the proposed site, wind monitoring and the proposed development stages.</td></tr>
<tr><td rowspan="3">PF2</td><td rowspan="3">Preliminary Technical Studies</td><td>Purpose:
To provide initial site-specific data that should enable development of a draft project layout.</td></tr>
<tr><td>Activity:
Assess via desktop and site studies:
• geotechnical conditions
• site access
• landscape
• noise
• ecology (flora and fauna)
• aircraft safety
• electromagnetic interference
• power system studies.
This stage will culminate in the determining the relevant authority and their requirements for the planning application.</td></tr>
<tr><td>Consultation:
Information on the progress and outcomes of technical studies should be provided, and feedback should be sought from stakeholders to inform continued investigations and design of the site.</td></tr>
</table>

G.2.3 Planning Application

Detailed technical studies (PA1)

Once the project has been assessed as suitable to progress to this stage, the majority of the detailed technical data collection, analysis and conclusions commence. The level of information is determined through consultation with stakeholders including the planning authorities which may be a formal process to determine assessment guidelines.

The analysis of certain issues, particularly those which are seasonal or targeted in nature, may require significant or specific periods of data collection and need to be included in an overall project plan.

These assessments inform an optimal design for the wind farm. The regulatory approvals process identified in the previous stage should be reviewed on the basis of the findings of the detailed technical studies.

Significant stakeholder input will be required for a number of technical assessments at this stage, including Landscape and EMI. Feedback and input from stakeholders should continue to be sought, through the implementation of the Project Communication and Consultation Plan, to understand any opinions and incorporate them into project design as far as possible.

Planning application (PA2)

The planning application stage of a wind farm development is crucial, as it ultimately determines whether the project goes ahead (and in what form) or not. This may include commonwealth, state/territory and local level applications as well as any required environmental impact considerations.

The documentation submitted should be in accordance with the requirements of the relevant authority's assessment process and include, as a minimum:

- A detailed summary of the proposal identifying the key issues and any required mitigation measures in a form suitable for consultation.
- A planning assessment specifically addressing all relevant planning provisions.
- The detailed technical studies on the basis of which the conclusions are drawn.

Approved forms, lists of detailed application requirements etc can be sourced from the relevant authority.

The documentation may contain commitments by the proponent to undertake various actions. Approval consents/permits are likely to contain conditions of approval requiring actions to be undertaken and, in some cases, documentation to be submitted for secondary consent.

Care needs to be taken by the proponents and regulators when formulating these commitments and conditions that they follow the following principles:

- That they are relevant.
- That they are clear in:
    - What objective is to be achieved.
    - What work is to be undertaken.
    - When the work is to be undertaken and when the need for the action ceases.
    - What level of reporting or auditing is required.

Planning hearings (where required)(PA3)

Planning hearings may be required in some jurisdictions and may include a panel or commission of inquiry, which is often the regulatory process for large state/territory-assessed developments. Some may be held before an appeal tribunal or court. However, not all approval processes may get to this stage. Planning hearings are generally public and provide an opportunity for proponents and other interested parties to present their proposal to the relevant authority and answer questions that the authority may have.

The detailed technical studies may need to be revised for presentation as evidence and authors of reports may be required to attend the hearings and answer questions from the panel members and, in some cases, in cross-examination from other parties.

Detailed Technical Studies	Issues to consider
Noise	
Detailed noise criteria assessment	Carry out background sound monitoring
	Confirm noise criteria using background sound monitoring data, including: • context and scope of assessable buildings • noise level limit framework • application to cumulative development • application to stakeholders.
	Carry out an assessment of tonality
Detailed sound emission predictions	Carry out sound emission predictions (detailed)
Compliance assessment	Provide input to wind farm layout and design, turbine selection to achieve compliance with noise criteria and identification of mitigation options
Community consultation	Continue community consultation regarding noise issues
Report preparation	Prepare Noise Impact Assessment Report, including details of noise level limits and detailed sound emission contours
Landscape	
Full landscape assessment	Landscape Character Analysis/Assessment Landscape Significance Analysis View shed and View Analysis Community Values Analysis Develop Objectives & Strategies
Visual impact assessment	Assessment of Impacts on Landscape Character and Significance Assessment of Impacts on Viewsheds and Views Assessment of Impacts on Community Values Cumulative Impacts Analysis
Response to Impacts	Options for Management and Mitigation Management and Mitigation Measures Consultation Develop Management and Mitigation Measures
Birds & Bats	
Birds & bat impact assessment	Quantitative assessment of risk of fatal collisions for key species
	Evaluation of ecological importance of predicted impact of proposed wind farm design (inherent risk) on population of key species
	Assessment of any reduction or mitigation of impacts that can be achieved
	Evaluation of ecological importance of predicted impact of revised wind farm design (residual risk) on population of key species.
Shadow Flicker	
Shadow flicker modelling	Carry out modelling using recommended software, modelling parameters to determine annual exposure to shadow flicker for affected residences.
Mitigation	Introduce mitigation measures or revise layout to achieve compliance with specified limits for annual duration of shadow flicker.
EMI	
Detailed EMI assessment	Collect data for validation
	Consultation with potentially affected operators

	Develop mitigation strategy
	Finalise mitigation strategy

Project Sub-stages		Activities to be Undertaken
Planning Application		
PA1	Detailed Technical Studies	**Purpose:** To provide detailed site-specific data to enable optimisation of the project layout and assess the impacts of the project.
		Activity: Assess via desktop and site studies: • survey and mapping of the locations of residences and other infrastructure • planning (strategic policy context, development approval and permit requirements) • representative wind turbine generator selection • electrical connections and on-site infrastructure • noise • shadow flicker • landscape • ecology (flora and fauna) • cultural heritage • geotechnical conditions • water quality impacts • waste management • traffic and transportation management • aircraft safety • electromagnetic interference • socio-economic impacts. A best-practice planning application should also include: • the preferred wind farm layout • details of the proposed power connection options • details of the community and stakeholder management programme • Environmental Management Plan, including decommissioning • Emergency and Incident Management Plan • Fire Hazard Management Plan.
		Consultation: Significant stakeholder input will be required for the Landscape and EMI Technical Investigations. A Community Information Event or Events should be conducted at this stage to present the preliminary outcomes of the technical investigation process. Stakeholder feedback on the investigations and project design should be considered for incorporation and/or amendment in the project design as far as possible. A report of consultation conducted to date and its outcomes should be prepared for inclusion in the planning application documentation.
PA2	Planning Application (in accordance with jurisdictional requirements)	**Purpose:** To present the proposed project and its impacts in a form suitable for planning authority and community assessment of the project.
		Activity: Prepare a planning application and supporting documentation incorporating the all technical reports and a summary of findings in plain English.
		Consultation: The planning application submission will be available for public exhibition. Stakeholders will have an opportunity to comment on the application to the relevant authorities, according to their statutory requirements.

Project Sub-stages		Activities to be Undertaken
PA3	Planning Hearing (where required)	**Purpose:** To present the planning application to the appropriate regulatory forum and respond to queries from the regulators and community.
		Activity: These works will involve preparation of witness statements and specialist technical consultants, and the appearance of some (but not necessarily all) consultants, to support the application at an appropriate planning forum.
		Consultation: Stakeholders should have an opportunity to comment on the application during the hearing.

G.2.4 Construction

Development of Construction & Operation Environmental Management Plans (C1)

Project approvals often have conditions attached to the various consents/permits that will need to be complied with during the construction of the project. It is important to ensure that any construction conditions are clearly distinguished from conditions that relate to the operational stage.

A plan should be prepared to manage the impacts of the construction stage. This document is often referred to as the Construction Environmental Management Plan (CEMP).

The form of the CEMP is not critical but, as it will need to be applied to construction contracts, it is important that the plan identifies what actions must occur, suitable methods, what the action's roles and responsibilities are, what timeframes are involved, reporting requirements and detail a method of compliance and monitoring.

The Project Communication and Consultation Plan should be revised at this stage to effectively respond to the changing communication and consultation needs associated with this phase of the development process. This includes inclusion of a detailed enquiries and complaints handling process for matters relating to construction activities and communication methods for construction schedules.

Further input from stakeholders may be sought when finalising design plans, such as micro-sitting of turbine locations, transportation planning, access and more.

Construction (C2)

Ongoing monitoring is needed through the life of the construction to ensure that the requirements of the CEMP are implemented and maintained. This monitoring regime is a risk management response and aspects of it may require auditing to ensure the permit conditions have been met.

Regular communication to stakeholders of construction activities and the timely response to enquiries and/or complaints is critical at this stage.

Environmental Management Plans	Issues to consider
Noise	
Finalisation of wind farm design	Address any outstanding issues from the planning permit and provide associated information to the relevant authority
	Finalise the wind farm design, updating any changes to the design such as: • finalising turbine type • finalising wind farm layout • finalising compliance with noise criteria and requirements for any noise management setting
Complaints handling	Prepare complaints handling procedures for construction, operation and decommissioning stages
Construction noise monitoring	Undertake construction noise monitoring
	Address incoming complaints (as required)
Birds & Bats	
	Review EMPs to ensure necessary actions and timing for bird & bats are identified
Shadow Flicker	
Finalisation of wind farm design	Address any outstanding issues from the planning permit and provide associated information to the Relevant Authority
	Finalise the wind farm design, updating any changes to the design such as: • finalising turbine type • finalising wind farm layout (micro-siting)
Micro-siting	Revise shadow flicker modelling following turbine micro-siting.
Complaints handling	Prepare complaints handling procedures for operation stage
EMI	
Monitoring program baseline	Mitigation strategy implementation
	Baseline testing
	Monitoring during wind farm construction
Community Consultation	
	Review and revise detailed consultation and communication plan
	Ensure inclusion of complaints handling process
	Coordinate appropriate signage and public information access points
Landscape	
Management and mitigation	Ensure all construction is managed within landscape mitigation outcomes and recommendations after assessment.

Project Sub-stages		Activities to be Undertaken
Construction		
C1	Development of Construction & Operation Environmental Management Plans	**Purpose:** To ensure health, safety and environmental management plans (and associated documentation) addresses the conditions of project approval prior to commencement of construction.
		Activity: Finalisation of the required management plans and documents (including work method statements).
		Consultation: The proponent should seek input from stakeholders in the final design plans prior to construction (i.e. micro-siting of turbines, site access, etc)
C2	Construction	**Purpose:** To undertake construction of the wind farm as described in the planning application and in accordance with the management plans and associated documentation.
		Activity: Undertaking the works in accordance with the construction conditions of the permit, management plans and associated documentation, and demonstration of this through an approved audit programme. The outcomes of all audits should be available for public review.
		Consultation: Regular communication to stakeholders of construction activities Including opportunities for local businesses and employment opportunities. Timely response to enquires and/or complaints arising from construction operations should be provided to stakeholders.

G.2.5 Operation

Operation (O1)

Similar to the construction stage, a number of conditions attached to the various consents/permits will be required to be complied with during the operation stage. It is important for regulators to ensure that these commitments and conditions are clearly distinguished from those that relate to the construction stage.

A plan should be prepared to manage the impacts of the operation of the facility and is referred to as the Operation Environmental Management Plan (OEMP).

The form of the OEMP is not critical but, as it may need to be applied to contracts, it is important that the plan identifies what actions must occur, suitable methods, what the action's roles and responsibilities are, what timeframes are involved, reporting requirements and detail a method of compliance and monitoring.

Formal announcement of the commencement of wind farm operations to all stakeholders should occur.

An Operational Communication and Consultation Plan should be prepared. This plan should outline the ongoing community participation activities for the wind farms operational life.

Monitoring: compliance (O2)

Similar to the construction stage, some monitoring is likely to be needed through the life of the operation of the wind farm to ensure that the requirements of the OEMP are implemented and maintained. This monitoring regime is a risk management response and aspects of it may require auditing to ensure the consent/permit conditions have been met.

Monitoring: confirmation (O3)

Confirmation monitoring should be undertaken for a period of time to validate assumptions made or conclusions drawn during the detailed technical studies in the Planning Application stage. However, it should be clearly articulated as to what level and timeframe of confirmation monitoring is sufficient in order to validate the data.

This monitoring is different to compliance monitoring in that it is not aimed at verifying processes that have been put in place and implemented correctly, but is broader and the studies are more scientific in nature.

Operation	Issues to consider
Noise	
Post-construction sound monitoring	Undertake unattended monitoring to assess compliance with noise level limits: • monitoring at the background sound level monitoring location • monitoring at a secondary location
	Undertake attended monitoring (as required)
	Undertake derived point measurements, including sound power level testing (as required)
	Address incoming complaints (as required)
	Assess noise characteristic (as required)
Birds & Bats	
	Determination of actual impacts of the operational wind farm on key bird & bat populations
	Evaluation of adaptive management aimed at further reduce impacts
Shadow Flicker	
Post-construction shadow flicker monitoring	Addressing community complaints during operation
	Undertake attended monitoring if required
	Implement mitigation measures if required
EMI	
Operational EMI monitoring	Compliance monitoring during wind farm operation
	Addressing community complaints during operation
	Confirmation monitoring during wind farm operation
Community Consultation	
	Prepare Operation Consultation and Communication Plan
	Ensure inclusion of enquiry/complaints response process
	Consider opportunities for community access to facility

Project Sub-stages		Activities to be Undertaken
Operation		
O1	Operation	**Purpose:** To undertake the operation of the wind farm in accordance with any operational conditions of the planning permit.
		Activity: Operate the wind farm in accordance with the Operation Environmental Management Plan.

Project Sub-stages		Activities to be Undertaken
		Consultation: Formal announcement of the commencement of wind farm operations to all stakeholders should occur, especially aviation operators (RAAF, CASA and agricultural etc)
O2	Monitoring (Compliance)	**Purpose:** To undertake studies to confirm that the operation of the wind farm complies with any planning permit conditions.
		Activity: Monitoring by the appropriate specialist technical consultants. These works may also include procedures for responding to complaints, if and when they arise.
		Consultation: The proponent will report the outcomes of monitoring programs to the necessary relevant authority. Updates to community stakeholders on the outcomes of monitoring during operations are recommended.
O3	Monitoring (Confirmation)	**Purpose:** To undertake studies to confirm that any assumptions made in the planning application are tested. Mitigation measures or modification of the wind farm operations maybe necessary where actual conditions differ from those assumed in the planning application.
		Activity: Monitoring by the appropriate specialist technical consultants. Monitoring should be designed to provide sufficient information to identify effective changes to management practices and provide data suitable for future planning assessments.
		Consultation: Where stakeholders have been affected by the wind farms operations, and mitigation has been applied, the effectiveness of this mitigation in reducing or removing impacts should be monitored.

G.2.6 Decommissioning

Decommissioning decision (D1)

At the end of the design life of the wind farm (typically 25 years), a decision will need to be made as to whether to decommission the wind farm or to redevelop the site.

Redevelopment of the site will require the submission of a new Planning Application. This will, in turn, require the proponent to consider:

- The environmental and social issues related to the site, which are likely to have changed since the initial development approval.
- Their performance in discharging their environmental and social responsibilities.

The potential issues to be considered include; replacing or upgrading turbines, the potential relocation of turbines, and replacing or upgrading supporting infrastructure (e.g. access tracks, substations, transmission connections).

A Decommissioning Communication and Consultation Plan should be prepared. This plan should identify project stakeholders (which may have changed significantly since operation commenced), and identify how stakeholder input into the decommissioning process should occur.

Decommissioning (D2)

Once a decision has been made to decommission the site, then a detailed plan should be prepared considering the issues of decommissioning in light of the assessment issues and any relevant conditions of approval.

Given the time period between when the approval was given and the need to decommission, particular consideration should be given to any regulatory changes that have occurred in the meantime and the need to address any additional issues.

The likelihood of decommissioning should have been identified in the permit application along with an expected life of facility and a new permit should not be needed to undertake this work. In the absence of such a consent, a new application may be required in order to decommission the facility.

A permit condition should be applied requiring a decommissioning plan to be submitted at this time for secondary consent.

Decommissioning	Issues to consider
Noise	
Decommissioning Decision	As per *Preliminary noise impact assessment*
Decommissioning	As per *Construction noise monitoring*
Redevelopment	As per *Planning Application*, *Construction* and *Operations*
Landscape	
Decommissioning	Site rehabilitation will need to consider the landscape character that existed pre-development and should ensure this character is rehabilitated to it's original (or previous) form
Redevelopment	As per *Planning Application*, *Construction* and *Operations*
Birds & Bats	
	Assessment of possible impacts on key bird & bat species of decommissioning and of re-powering (upgrade of turbines)
EMI	
Decommissioning Decision	Addressing community complaints post-decommissioning
Redevelopment	As per *Planning Application*, *Construction* and *Operations*
Community Consultation	
	Prepare Decommissioning Consultation and Communication Plan
	Consider opportunities for community involvement in rehabilitation

Project Sub-stages		Activities to be Undertaken
Decommissioning		
D1	Decommissioning Decision	**Purpose:** To assess the feasibility of decommissioning or redeveloping the site.
		Activity: Assessing the historic wind resource at the site, changes in turbines commercially available and a desktop feasibility assessment addressing items identified PF1 and PF3.
		Consultation: Stakeholder input should be sought.

Project Sub-stages		Activities to be Undertaken
D2	Decommissioning	**Purpose:** To undertake studies to confirm that the wind farm can be decommissioned in accordance with any planning permit conditions, and to decommission the wind farm.
		Activity: The development of Decommissioning and Site Rehabilitation Plans. These should be developed in accordance with the any planning permit conditions, but also require modification to accommodate any changes to the local environment, land use and infrastructure. The works should involve monitoring by the appropriate specialist technical consultants.
		Consultation: Stakeholder input should be sought.
D3	Redevelopment	**Purpose:** To undertake the necessary studies required to submit a new project for a new planning application (feeding back into the process at sub-stage PA1.
		Activity: Submission of a new planning application in accordance with these guidelines for any proposed redevelopment of the wind farm site.
		Consultation: Stakeholder input should be sought.

Redevelopment (D3)

Redevelopment of the site, or repowering, will require new approval processes. Essentially these Guidelines should be reapplied with particular consideration given to any regulatory changes that have occurred in the meantime.