APPENDIX 15

Sapphire Wind Farm Aeronautical Impact Assessment, Qualitative Risk Assessment and Obstacle Lighting Review

The Ambidji Group Pty Ltd

FINAL REPORT

PROPOSED SAPPHIRE WIND FARM
AERONAUTICAL IMPACT ASSESSMENT, QUALITATIVE RISK ASSESSMENT
AND
OBSTACLE LIGHTING REVIEW

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Report to:

SAPPHIRE WIND FARM PTY LTD

May 2011

AMBIDJI

A.C.N. 053 868 778

Melbourne, Australia

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Distribution: Sapphire Wind Farm Pty Ltd.
Adrian Maddocks

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EXECUTIVE SUMMARY

Sapphire Wind Farm Pty Ltd (SWF) has commissioned The Ambidji Group Pty Ltd (Ambidji) to undertake an aeronautical impact assessment (AIA), qualitative risk assessment (QRA) and obstacle lighting review (OLR) of the Sapphire wind farm to determine the potential impact on the safety of aircraft and aerodrome operations in the vicinity of the wind farm. The proposed Sapphire Wind Farm is located approximately 18km west of Glen Innes and 28km east of Inverell in New South Wales. Figure 1 below shows the location of the wind farm and its proximity to the nearby towns of Glen Innes and Inverell.[1]

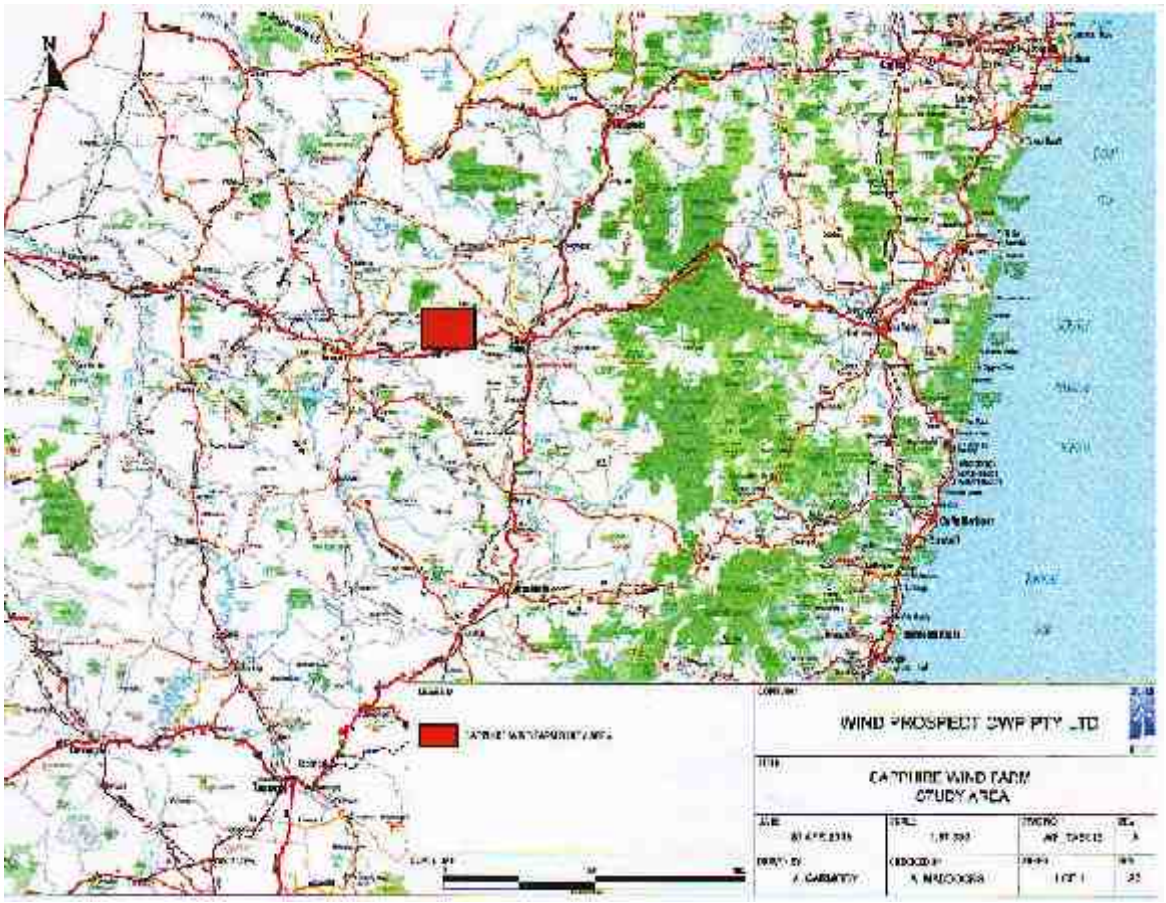

Figure 1: Sapphire Wind Farm - Site Location

Two proposals are being assessed for the Sapphire Wind Farm. The first involves a proposal for up to 125 wind turbines with a maximum tip height of approximately 156m AGL, giving a maximum elevation of 1313m/4310ft AHD. The second involves a proposal for up to 159 wind turbines with a maximum tip height of 140m AGL, giving a maximum elevation of 1298m/4259ft AHD.

[1] Source. Wind Prospect CWP Pty Ltd

The scope of this assessment was to examine the proposed Sapphire Wind Farm development and to carry out the following tasks:

1. Undertake an Aeronautical Impact Assessment (AIA) particularly with respect to the Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Operations (PANS OPS) surfaces of aerodromes in the vicinity of the Sapphire Wind Farm.
2. Undertake an Obstacle Lighting Review (OLR) which considers and comments on current international practice for lighting wind farms, the Civil Aviation Safety Authority (CASA) position and the applicability of their regulations or advice, and the status of trends in lighting decisions with other planned or operating wind farms in Australia.
3. Undertake a Qualitative Risk Assessment (QRA) in regard to the need for obstacle lighting.
4. Prepare documentation to enable SWF to advise relevant stakeholders of the aeronautical impact and the requirement or otherwise for obstacle marking or lighting of the wind farm.

Aeronautical Impact Assessment

A review of the wind farm's potential impacts on aerodrome OLS and PANS-OPS surfaces located in the region was undertaken. Consideration was also given to published air routes in the region.

Two aerodromes in the region have OLS and PANS OPS surfaces; Glen Innes approximately 14km east and Inverell approximately 30km south west of the wind farm boundary. It was determined that the Sapphire Wind Farm does not infringe upon any OLS or PANS OPS surfaces for aerodromes in the proposed wind farm's region. Similarly, there is adequate clearance from published air routes in the region.

Other private airstrips and landing grounds may be located within 30km of the boundary of the proposed wind farm, none of which require OLS. Pilots operating at such private strips are responsible for ensuring that they are aware of the conditions on, and surrounding, these aeroplane landing areas. The Sapphire Wind Farm is located at a sufficient distance from all listed aircraft landing areas so as to not affect their take-off and landing operations.

Obstacle Lighting Review

Ambidji's review of the approach to lighting and consideration of present regulations for wind farms in a number of overseas countries shows that the heights that trigger them to be treated as obstacles and the approach to lighting varies widely.

In Australia, regarding those structures that are outside the obstacle limitation surfaces of an aerodrome and are more than 110m above ground level, CASA's Manual of Standards Part 139 - Aerodromes states that, in general, an obstacle would require obstacle lighting unless an aeronautical study assesses it as being shielded by another object or *that it is of no operational significance.* In addition, CASA previously promulgated an Advisory Circular 139-18 (0) covering the marking and lighting of turbines outside the vicinity of an aerodrome, but this has now been withdrawn. Despite its withdrawal, CASA and Department of

Infrastructure and Transport (DIT) have indicated that the recommendations of the AC still apply if a developer wishes to install obstacle lighting as a risk mitigator.[2]

Ambidji's survey of the current trends in Australia shows that some wind farm proponents are seeking not to provide obstacle lighting of the farms and some existing operators are seeking to reduce or eliminate their existing obstacle lighting.

CASA's current position on obstacle lighting of wind farms that are remote from an aerodrome is summarised as:

a. CASA cannot mandate obstacle lighting for wind farms that are "not within the vicinity" of an aerodrome;

b. Provision of such lighting is a decision for, and the responsibility of, the developer;

c. Any associated requirements placed on developers by planning authorities, insurers or financiers are beyond CASA's scope;

d. A wind farm developer may have a duty of care to the aviation industry and local operators in terms of ensuring obstacles are made conspicuous;

e. Obstacle marking and lighting requirements as specified in the CASA Manual of Standards Part 139, Section 9.4 applies for developers choosing to light a wind farm; and

f. The Advisory Circular information (AC 139-18) is still valid as a recommendation if the proponent wishes to do so as a risk mitigator.[3]

Qualitative Risk Assessment

The Qualitative Risk Assessment was undertaken to consider the wind farm's *operational significance* so as to specifically address whether obstacle lighting is required at the proposed Sapphire Wind Farm.

The Qualitative Risk Assessment is summarised in Table 1 below:

Risk Element	Assessed Level of Risk	Comment
Aerodrome Operations	LOW	
Aircraft Landing Area Operations	LOW	
Agricultural Operations	MEDIUM	In respect of the 156metre turbines this would be HIGH
GA Pilot Training	LOW	
Recreational/Commercial Flying	LOW	In respect of the 156 metre turbines this would be MEDIUM

[2] CASA advice to Ambidji 22 September 2008
[3] Ibid

Known Highly Trafficked Routes	LOW	In marginal weather conditions this would be MEDIUM
Air Ambulance Operations	LOW	
Police Aviation Support Branch	LOW	
Fire Fighting Operations	LOW/MEDIUM	Risk in the immediate vicinity of wind farm is HIGH
ADF Military Operations	LOW	
Published Tracks	LOW	
Night Flying	LOW	
Weather and visibility Issues	LOW	In respect of 156 metre turbines this would be MEDIUM

Table 1: Qualitative Risk Assessment Summary

The key outcomes and conclusions are that:

- With the exception of authorised low flying operations, all aircraft operating in the area are required by prescribed aviation regulations to operate at a height that would exceed the maximum height of the wind turbines for the proposed Sapphire Wind Farm site;
- With respect to pilots undertaking emergency services low level flights, the organisational operations manuals and safety management systems would provide clear guidance to pilots with regard to the planning and conduct of flight in the vicinity of obstructions. It is considered that risks could be mitigated to a low value;
- The presence of wind turbines significantly limits the aerial fire-fighting capabilities of the NSW Rural Fire Service in the immediate vicinity of the wind farm;
- With respect to aerial agricultural activities it is considered that the proposed development presents a medium to high level of risk;
- With regard to all the categories assessed, the development poses an overall low to medium level of risk; and
- At a maximum tip height of 156m AGL, the wind farm is assessed as a potential hazard to aircraft operations.

Recommendations

Ambidji makes the following recommendations:

- As the maximum tip height of 156m AGL is assessed as an obstacle to aircraft operations and the overall risk is qualitatively assessed as low - medium, it is recommended that the developer give consideration to the provision of obstacle lighting as a risk mitigator;

- To improve conspicuity of the meteorological masts and associated guy wires, it is recommended that they be marked consistent with the policy of the Aerial Agricultural Association of Australia;
- To enable inclusion of the wind farm location in relevant aeronautical information publications, the developer is required to notify CASA and Department of Defence in accordance with CASA Advisory Circular AC139-08 “Reporting of Tall Structures”; and
- All relevant stakeholders should be formally advised of the wind farm proposal, including details of the marking and lighting of the turbines, wind monitoring masts and above ground power lines.

1. INTRODUCTION AND BACKGROUND

The proposed Sapphire Wind Farm is located approximately 18km west of Glen Innes and 28km east of Inverell in New South Wales.

SWF commissioned this study to progress planning of the wind farm, particularly in respect of the potential impact to aircraft and airport operations.

Figure 1-1 below shows the location of the Sapphire wind farm and the three distinct clusters within the wind farm.

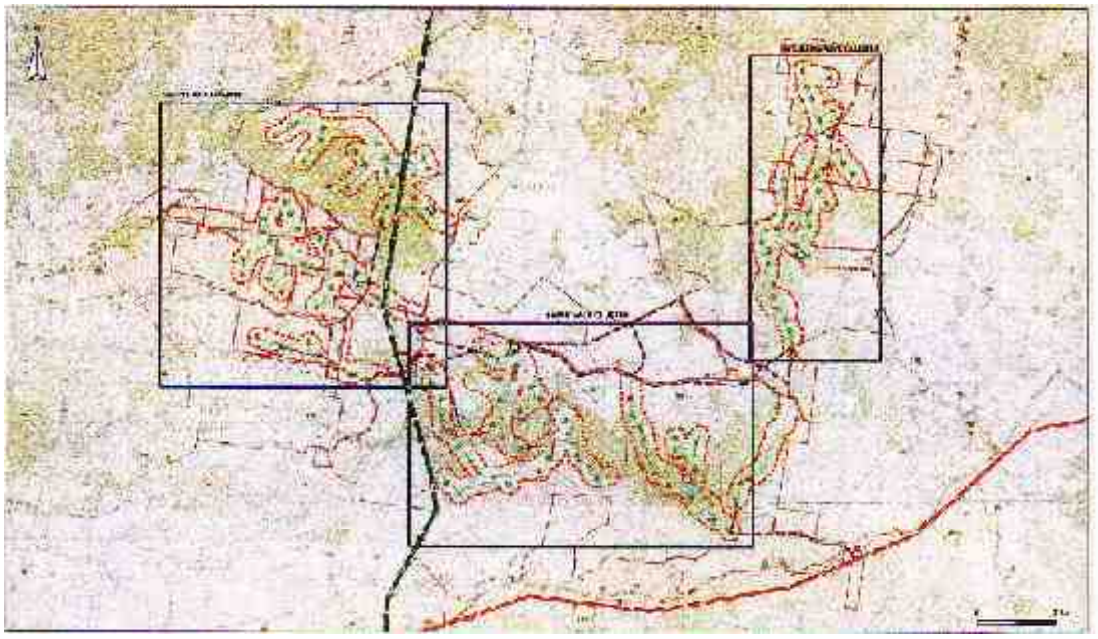

Figure 1-1: Sapphire Wind Farm - Site Location showing Clusters[4]

SWF has indicated that two proposals are being assessed for the wind farm. The first involves up to 125 wind turbines with a maximum tip height of approximately 156m AGL, giving a maximum elevation of 1313m (4310ft) AHD. The second involves up to 159 wind turbines with a maximum tip height of 140m AGL, giving a maximum elevation of 1298m (4259ft) AHD.

To meet the requirements of SWF, Ambidji has undertaken the following:

1. An Aeronautical Impact Assessment;
2. An Obstacle Lighting Review;
3. A Qualitative Risk Assessment in regard to the need for obstacle lighting of the Sapphire Wind Farm;
4. Inspection of the proposed wind farm site and nearby aerodromes;
5. Consultations with airport and aircraft operators that may be impacted by the wind farm; and

[4] Source: Wind Prospect CWP Pty Ltd

6. Prepared documentation to advise CASA, Defence and relevant stakeholders of the aeronautical impact, qualitative risk and obstacle lighting assessments.

Inverell and Glen Innes aerodromes are the only aerodromes in the vicinity that have PANS OPS surfaces that overlay the proposed wind farm site. Glen Innes aerodrome is located approximately 15km to the east of the wind farm site. Inverell aerodrome is located approximately 30km to the south west of the wind farm site.

The Visual Navigation Chart VNC4, Brisbane, shows an unlicensed airfield located at Inverell North which, although within 15km of the wind farm site, does not have instrument approach procedures.

2. SCOPE

To meet the requirements of SWF, the study required Ambidji to examine the proposed Sapphire Wind Farm development and to carry out the following tasks:

1. Undertake an aeronautical impact assessment particularly in respect of the Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Operations (PANS OPS) surfaces in the vicinity of the proposed Sapphire Wind Farm.
2. Undertake an Obstacle Lighting Review (OLR) which considers and comments on current international practice for lighting wind farms, CASA's position and the applicability of their regulations or advice, and the status of trends in lighting decisions with other planned or operating wind farms in Australia.
3. Undertake a Qualitative Risk Assessment (QRA) in regard to the need for obstacle lighting which included:
    a. The identification and assessment of potential aviation risk elements through:
        i. Reference to CASA Aeronautical Publications;
        ii. Site visits and regional appreciation; and
        iii. Consultations with key relevant stakeholders;
    b. Assessment of the perceived impacts of the turbines and lighting on the operation of aerodromes and airstrips in the immediate vicinity of the wind farm;
    c. Assessment of the perceived impacts of the turbines on aerial application operations in regard to airstrips used and/or the safety of actual operations into adjoining properties;
    d. Assessment of the perceived impacts of the turbines and lighting on other aviation activity including:
        i. General aviation training;
        ii. Recreational aircraft activity;
        iii. Instrument Flight Rules (IFR) operations;
        iv. Any known Visual Flight Rules (VFR) highly trafficked routes;
        v. Published air routes;
        vi. Night Visual Meteorological Conditions (VMC) operations;
        vii. Emergency Services Air Ambulances (fixed and rotary wing);
        viii. NSW Rural Fire Service (Air Wing); and
        ix. Military Low Flying Operations;
    e. Assessment of any implications for the above from topographical, weather and visibility issues;
    f. Assessment of other issues as identified through consultations and the assessment process;

g. Conclusions on the degree of aviation risk posed by the above described issues with commensurate recommendations on whether any obstacle lighting is necessary with or without any mitigating actions; and

h. Prepare documentation to enable SWF to advise relevant stakeholders of the wind farm development and, in particular, the intention regarding obstacle lighting.

3. METHODOLOGY

3.1 Obstacle Lighting Review

The methodology for the review covered:

1. A review of international and national aviation documentation applicable to aeronautical hazard assessments and obstacle marking and lighting requirements, with particular consideration of wind farms and wind turbines;
2. References to ongoing discussions with CASA and a review of their current position for marking and lighting of obstacles for wind farms;
3. A review of other Australian wind farm developments and operations to consider recent approaches to the installation, removal or avoidance of obstacle lighting; and
4. The implications, from the above, in regard to the requirement or non requirement of aviation lighting for the proposed Sapphire Wind Farm.

3.2 Aeronautical Impact Assessment

A review was undertaken of the Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Operations (PANS OPS) surfaces applicable to the nearby Glen Innes and Inverell aerodromes. The methodology employed for the preparation of this report focuses on consideration of:

1. the applicable elements of Civil Aviation Safety Regulations (CASR) Part 139 Manual of Standards (MOS), particularly Chapter 7 (Obstacle Restriction and Limitation) and Chapter 11 (Standards for Other Aerodrome Facilities); and
2. PANS OPS surfaces as published in relevant Aeronautical Information Publications (AIPs)

Civil Aviation Orders (CAO) specify the minimum requirements for clearance of obstacles by an aircraft that has suffered a failure of a critical engine during take-off. The contingency procedures analyse the minimum safe altitudes (and therefore relate to maximum allowable obstacle heights) required in such a circumstance. The influence that development on the wind farm site would have on contingency procedures was considered.

3.3 Qualitative Risk Assessment

The methodology followed in undertaking the Qualitative Risk Assessment was as follows:

1. Aeronautical Information Publications (AIP) produced by CASA and Airservices Australia were reviewed in regard to identifying relevant physical and operational aviation issues that may impact on the requirement for lighting of the wind farm;
2. Current topographical maps were studied to assess the local terrain and identify local airstrips and any other relevant features;
3. A visit was made to the proposed wind farm site and its immediate environs;

4. As an extension of the site visit, the owners and operators at nearby airports were consulted in regard to local aviation activity around the proposed wind farm site, the existence of any informal low flying areas, the existence of private airstrips and any highly trafficked air routes over or near the proposed wind farm site;
5. Similarly, telephone consultations were undertaken with other aviation operators and relevant stakeholders in the region in regard to local aviation activity, any potential operating issues and the location and use of local airstrips;
6. Based on the above, the nature of any impacts as a consequence of the operation of the wind farm was considered and discussed in regard to:
    - General aviation training;
    - Recreational and sport aircraft activity;
    - Any known VFR highly trafficked routes;
    - Published tracks (flight paths);
    - Night VMC light aircraft flying.
    - IFR operations;
    - Emergency Services, (aerial ambulance, fire service and police);
    - Aerial agricultural operation activities; and
    - Military Low Flying Operations.
7. In addition, further consideration was given to the consequences (for the above elements) of the potential influence of topography and poor weather; and
8. The degree of risk posed by the wind farm in regard to the above elements was assessed and recommendations made regarding the need for obstacle lighting.

4. OBSTACLE LIGHTING REVIEW

4.1 Comparison and Summary of International Standards for Obstacle Lighting of Wind Farms

CASA is Australia's aviation safety regulator and is responsible for setting standards applicable to the protection of airspace and the safety of aircraft and airport operations. The International Civil Aviation Organization (ICAO) sets the international standards and recommended practices and Australia, as a member state, applies the international standards to Australian aviation except where a "difference" is formally lodged with ICAO.

The relevant ICAO recommendations regarding wind farms are detailed in Annex 14.[5]

ICAO has recommended that a wind turbine shall be marked and/or lit if it is determined to be an obstacle. Section 4.3 of the Annex defines "*Objects outside the obstacle limitation surfaces",* and Section 4.3.2 in particular states, inter-alia*:*

Annex 14 — Aerodromes

4.3.2 **Recommendation.**— *In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 150 m or more above ground elevation should be regarded as obstacles, unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes.*

Note.— This study may have regard to the nature of operations concerned and may distinguish between day and night operations.

Until recently, wind turbines were treated as any other obstacle. However, ICAO has issued a new Section 6.4 to the Annex specifically dealing with marking and lighting of wind turbines, a copy of which is included in Appendix A.

Under ICAO's definition it can be taken that the wind turbines at Sapphire (at 156m AGL) are considered to be obstacles and under this definition and recommendation, would be required to be lit unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes. Although a significant reference, it should be highlighted that ICAO Standards and Recommended Practices (SARPS) do not necessarily apply to domestic aviation activities.

As part of this assessment, a review has been undertaken of the standards and recommended practices in several countries and is included at Appendix B. The main issues that have emerged from this review of international practices are:

- There appears to be considerable variation between countries as to the determining criteria relating to the height and the spacing of wind turbines that are recommended to be lit;
- Some countries including New Zealand, UK and USA are taking into account the impact on visual amenity of obstacle lighting and require an assessment to be

[5] Annex 14 - Aerodromes: contains ICAO's international standards and recommended practices for aerodromes.

made of the wind farm in this regard *"by virtue of its nature and location"*. In essence, this has been interpreted to mean that if the wind farm is not within the vicinity of an aerodrome (i.e. more than approximately 30km from an airport) or air traffic routes, then the turbines should *"not be routinely lit"* but rather an assessment made to assess the hazard based on its *"nature and location"* and to justify provision of obstacle lighting. Factors that are taken into account for such an assessment include the total height of the turbine, the wind farm location with regard to aerodromes and air routes, the volume and type of air traffic in the area, the surrounding terrain, the number of wind turbines in the wind farm and environmental restrictions; and

- Countries including Canada, Norway and USA have approved an alternative to continuous obstacle lighting of the wind farms. This alternative uses a radar sensing obstacle lighting system that is activated by the presence of an aircraft in proximity of a wind farm during day or night operations of aircraft (www.ocasinc.com). This system results in the obstacle lighting being in a quiescent state until activated when it provides both a visual and aural warning to the pilot. As a consequence, the reduced periods of lighting results in an improved amenity for local residents.

4.2 Consideration of CASA's Current Views on Wind Farm Lighting

For the Australian aviation environment, the general standards for obstacle marking and lighting are prescribed in CASA's Manual of Standards (MOS) Part 139 and apply in respect of obstacles or potential hazards, such as wind farms. In particular CASA may determine that an object or proposed object which intrudes into prescribed airspace may require obstacle lighting.[6]

In regard to those structures that are outside obstacle limitation surfaces of an aerodrome, and are more than 110m above ground level, CASA's Manual of Standards Part 139 - Aerodromes, states that in general an obstacle would require obstacle lighting unless, an aeronautical study assesses it as being shielded by another object or "*that it is of no operational significance".*[7]

The RAAF Aeronautical Information Services (AIS) is responsible for maintaining the database of tall structures of any obstacle that is above 30m within 30km of a registered aerodrome, or above 45m everywhere else.[8]

In December 2005, CASA produced a Draft Advisory Circular AC139-18(0) providing guidelines for "Obstacle Marking and Lighting of Wind Farms". After consideration of industry comment on the draft, the document was formally promulgated in July 2007.[9]

This AC was withdrawn by CASA in September 2008 after CASA considered a number of complaints from stakeholders and identified a number of issues with the AC, not the least being questionable legal grounds for the CASA AC.[10] At the time of withdrawal, CASA issued a statement[11] on their web page which is reproduced in Appendix C.

[6] MOS Part 139-Aerodromes, Section 9.4: Obstacle Lighting
[7] MOS Part 139-Aerodromes, Section 9.4.1.2: Requirements of Obstacle Lighting
[8] AC 139-08(0): Reporting of Tall Structures, April 2005.
[9] CASA AC 139-18(0) Obstacle Marking and Lighting of Wind Farms, July 2007.
[10] Hart Aviation: Wind Energy and Aviation Interests, Study for Sustainability Victoria, July 2009.
[11] Source: CASA Briefing Newsletter, October 2008.

CASA indicated that a review would be undertaken of safety issues associated with obstacles remote from an aerodrome. On 1 March 2011, CASA indicated that this review will now be undertaken by Department of Infrastructure and Transport (DIT) as the subject matter was raised in the DIT paper "Safeguards for Airports and the Communities around them". A copy of the CASA advice is at Appendix C. At some point a redrafted Advisory Circular, CASA regulation or departmental policy may be released to the industry for comment to be ratified either by CASA or DIT. Discussions with DIT have indicated that the recommendations of the withdrawn AC will most likely apply.

Since issue of the CASA October 2008 Briefing Newsletter, attached in Appendix C, there has been correspondence relevant to obstacle marking and lighting of wind farms between the wind farm industry, aviation consultants and CASA. The following summarises Ambidji's understanding of some of the applicable issues from this correspondence.

- The Civil Aviation Safety Authority's (CASA) statutory power to require obstacle marking and lighting on obstacles under Civil Aviation Safety Regulation Part 139 only applies within the vicinity of an aerodrome. CASA cannot mandate the lighting or marking of obstacles unless structures intrude prescribed airspace or within the vicinity of an aerodrome. It is CASA's view that the decision for the lighting of obstacles outside the vicinity[12] of aerodromes is the responsibility of the developer. Any associated requirements placed on developers by planning authorities, insurers or financiers are beyond CASA's scope.
- In 2007, CASA published Advisory Circular 139-18 (0) to provide guidance to wind farm developers on their hazardous potential for aviation and to provide guidance on means of marking or lighting them to mitigate such hazards. The advice contained within that circular gave the impression that CASA could require the lighting of obstacles not in or near the vicinity of an aerodrome.
- CASA's Industry Complaints Commissioner (ICC) considered industry complaints regarding AC 139-18 (0) which identified a number of issues with the circular. After considering the report of the ICC, the Chief Executive Officer (CEO) directed that CASA withdraw Advisory Circular 139-18(0). The CEO also directed that CASA undertake an appropriate safety study into the risk to aviation posed by wind farms and develop a new set of guidelines. This process will include appropriate consultation with industry and stakeholders on wind farms and a risk management approach with respect to aviation.[13] As indicated above, this project is now being handled by DIT.

Notwithstanding the withdrawal of the CASA AC, in response to specific queries as to lighting standards to apply to wind farms that are remote from an aerodrome, CASA has previously advised:

> "*Even though a CASA assessment is not required it is important to point out the wind farm developer may have a duty of care to local aviators, such as aerial spraying and private flight operators, whose aeroplane landing area may be*

[12] For the purposes of this report, Ambidji defines being "in the vicinity" of an aerodrome as within 15kms of any aerodrome with an OLS and/or PANS-OPS procedure.
[13] CASA's Industry Complaints Commissioner (ICC) Findings.

located in the vicinity of the wind farm, and who may want the wind turbines made conspicuous for night flying and during periods of low visibility.

If the wind farm developers wish to provide additional conspicuity this may be achieved by installing obstacle lighting which meets the standards set out in the CASA Manual of Standards (MOS) Part 139 Aerodromes, Chapter 9, Section 9.4 – Obstacle lighting."[14]

and

"… *the Advisory Circular information (AC 139-18 (0)) is still valid as a recommendation if the proponent wishes to do so as a risk mitigator*…"[15]

Based on the above, CASA's current position on obstacle lighting of wind farms that are remote from an aerodrome (as for the Sapphire Wind Farm) is summarised as:

a. CASA cannot mandate obstacle lighting for wind farms that are "not within the vicinity" of an aerodrome;
b. Provision of such lighting is a decision for, and the responsibility of, the developer;
c. Any associated requirements placed on developers by planning authorities, insurers or financiers are beyond CASA's scope;
d. A wind farm developer may have a duty of care to the aviation industry and local operators in terms of ensuring obstacles are made conspicuous;
e. Obstacle marking and lighting requirements as specified in the CASA Manual of Standards Part 139, Section 9.4 applies for developers choosing to light a wind farm; and
f. The Advisory Circular information (AC 139-18) is still valid as a recommendation if the proponent wishes to do so as a risk mitigator.

4.3 Obstacle Lighting Arrangements at other Australian Wind Farms

Ambidji has reviewed the provision or non-provision of obstacle lighting at approximately 80 Australian wind farms, either existing, proposed or currently in the course of construction. A summary of this review is in Appendix D.

In general, existing obstacle lighting has been installed in accordance with the recommendations of the withdrawn AC139-18 (0) for wind farms with turbine heights in excess of 110m AGL. However, there are many instances of wind farms which do not have obstacle lighting installed where the height of the wind turbines exceeds the determining height of 110m AGL.

For example, Capital Wind Farm's submission to the State Government planning authority seeking approval for this wind farm indicated the following:

[14] CASA advice to NSW Department of Planning 5 March 2009
[15] CASA advice to Ambidji 22 September 2008

> "*CASA's submission did not find that the wind farm would be a hazard or an obstacle, nor is the wind farm located within the vicinity of an aerodrome, or in proximity to airspace used by aircraft at night. The wind farm is also located in hilly terrain, where numerous local features are taller than most of the turbines*". [16]

A similar finding by CASA appears to have been made in respect of the proposed wind farm at Gunning in NSW. This project, which is currently being constructed, will have 32 turbines with a maximum height of 120m AGL. The Environmental Impact Statement for this project indicated that:

> "*Based on the information supplied, CASA has assessed the potential for the proposed structures to represent hazardous objects due to location, height or lack of markings or lighting. CASA has advised that the structures do not represent obstacle or hazards and no restrictions or conditions have been applied to them. However, CASA has requested that details of the structures be provided prior to construction so that structures can be recorded on relevant databases and maps*"[17]

In addition to the wind farms mentioned above, Ambidji's research has also revealed the following Table 4-1:

Operating Wind Farms over 110m AGL, non-installation of aviation lighting or extinguished	**Proposed Wind Farms over 110m AGL non-installation of aviation lighting**
Alinta Wind Farm (WA) has 54 turbines at 118m AGL which are not lit.	The proponents of Lexton Wind Farm in Victoria have conducted assessments to determine whether their proposal will include obstacle lighting, and have yet to confirm if the turbines will be lit.
Hallett Wind Farm (SA) Stages1 and 2 have turbines at 124m AGL. Its aviation safety lights have been switched off.[18] Hallett Wind Farm (SA) Stages 3 and 4 have turbines at 124m AGL. The two stages are currently under construction and have no lighting planned.	The proponents of Dandaragan Wind Farm in WA are considering having assessment work undertaken to determine whether their proposal will include obstacle lighting.
Snowtown Wind Farm (SA) has 47 turbines at 124m AGL, its lights have or are about to be switched off.[19]	The proponents of the newly approved Macarthur Wind Farm in Victoria at this stage are not planning to fit the turbines with aviation lighting.
Clements Gap Wind Farm (SA) has 27 turbines at 123m AGL, are planned to be switched off.	The proponents of proposed Collaby Hill Wind Farm in SA are currently having assessment work conducted to determine if the wind farm will include aviation lighting.

[16] Letter from Renewable Power Ventures to NSW Department of Planning, 26 May 2006.
[17] Gunning Wind Farm Environmental Impact Statement - Chapter 12, February 2004, Delta Electricity
[18] Conversations with AGL in regards to Hallett Wind Farms confirmed that a risk assessment was commissioned to determine whether the lights could be extinguished without impacting on aviation safety. On the basis of an assessment concluding that the lights could be turned off, AGL sought a revision to the original planning permit with local council, to enable this action.
[19] Yorke Peninsula County Times, "Lights go out for turbines", 11th May 2010

Operating Wind Farms over 110m AGL, non-installation of aviation lighting or extinguished	Proposed Wind Farms over 110m AGL non-installation of aviation lighting
Capital Hill Wind Farm (NSW) has 67 turbines at 125m AGL which are not lit.	The proponents of Yass Valley Wind Farm in NSW are currently undertaking assessment work to determine whether their proposal will include obstacle lighting.
The proponents of Cullerin Wind Farm in NSW, following a review of the requirement for obstacle lighting, switched off the lights on 1 November 2010	The proponents of Mt Gellibrand Farm in Victoria are currently undertaking assessment work to determine whether their proposal will include obstacle lighting.
The proponents of Waubra Wind Farm in Victoria are planning to extinguish aviation lighting, once confirmation with DPCD and notification of CASA and Airservices Australia is complete.	The proponents of Coopers Gap Wind Farm in QLD are currently undertaking assessment work to determine whether their proposal will include obstacle lighting.

Table 4-1: Summary of relevant wind farms in Australia

It should be noted that there have been instances in the past where wind farms with turbine heights less than 110m have been fitted with lighting. However, it is believed that these wind farms were constructed prior to the issue of the CASA Advisory Circular applicable to wind farms. Importantly, it is understood that some of these wind farms are located in the vicinity of airports.

5. PANS OPS AND OLS - AERONAUTICAL IMPACT ASSESSMENT.

5.1 Sapphire Wind Farm Elevation

The maximum turbine height for the Sapphire Wind Farm is 156m AGL (512ft) and the maximum terrain elevation across the wind farm site is 1157m AMSL (3796ft).[20] This establishes a maximum altitude of 1313m or 4310ft AHD for the highest turbine.

5.2 PANS OPS – Glen Innes and Inverell Aerodromes

The Procedures for Air Navigation Services – Operations (PANS OPS[21]) assessment is based on Aeronautical Information Publication (AIP) Departure and Approaches Procedures[22] (DAP) effective 10 March 2011.

The nearest aerodromes with PANS OPS surfaces are Glen Innes and Inverell aerodromes, approximately 15km and 30km to the east and south-west of the wind farm site respectively. Assessment of the impact on PANS OPS surfaces by the proposed wind farm was undertaken with respect to:

- published Decision Altitudes and Minimum Descent Altitudes;
- Obstacle Infringement Surfaces (protection surfaces) as published in the AIP Departures and Approach Procedures (DAP) effective 10th March 2011, associated Aeronautical Information Circulars (AIC), Aeronautical Information Supplements and NOTAMS relevant to this edition of the AIP DAP; and
- Circling Minima and Minimum Sector Altitudes.

The results of this assessment are summarised in Tables 5.1 and 5.2 below. At the calculated maximum height of the highest turbine at 1313m (4310ft) AHD, the Sapphire Wind Farm development will not affect the PANS OPS surfaces at either Inverell or Glen Innes aerodromes.

INVERELL

APPROACH PROCEDURE	IMPACT/COMMENTS
GPS ARRIVAL PROCEDURES SECTOR A, SECTOR B and SECTOR C	The development is located outside the protection surfaces. No impact.
NDB RWY 16	The development is located outside the protection surfaces. No impact.
RNAV (GNSS) RWY 34	The development is located outside the protection surfaces. No impact.

[20] Source – Sapphire Wind Farm Pty Ltd
[21] Procedures for Air Navigation Services - Aircraft Operations which are the airspace protective surfaces for designed instrument approaches at specific airports. Such procedures are used to allow aircraft to land under Instrument Meteorological Conditions.
[22] Aeronautical Information Publications are produced by Airservices Australia. DAPs provide approach and departure guidance for IFR operations at nominated airports.

APPROACH PROCEDURE	IMPACT/COMMENTS
25NM MSA	The development is located beneath a protection surface of 1590m /5216ft AHD. No impact.
CIRCLING PROCEDURES	The development is located outside the circling area surfaces. No impact.

Table 5-1 Non Precision Approach Procedures - Inverell

GLEN INNES

APPROACH PROCEDURE	IMPACT/COMMENTS
GPS ARRIVAL PROCEDURES SECTOR A	The development is located beneath a protection surface of 1493m/4900ft AHD. No impact.
GPS ARRIVAL PROCEDURES SECTOR B	The development is located beneath a protection surface of 1341m/4400ft AHD. No impact.
NDB RWY 14	The development is located outside the protection surfaces. No impact.
RNAV (GNSS) RWY 14	The development is located outside the protection surfaces. No impact.
25NM MSA	The development is located beneath a protection surface of 1315m/ 4316ft AHD. No impact. *(Note: the highest WTG has a top height of 1313m/4310ft AHD)*
CIRCLING PROCEDURES	The development is located outside the circling area surfaces. No impact.

Table 5-2 Non Precision Approach Procedures – Glen Innes

5.3 Obstacle Limitation Surfaces (OLS) – Glen Innes and Inverell Aerodromes

The analysis of the proposed Sapphire Wind Farm development in relation to the OLS and any relief that may be provided by shielding of the development by existing obstacles has been undertaken in accordance with the requirements of CASR Part 139 Manual of Standards. The Obstacle Limitation Surfaces at Glen Innes and Inverell extend to a radius of approximately 4.5km from the Aerodrome Reference Point (ARP). The closest point of the wind farm to the Glen Innes aerodrome is approximately 15km and to the Inverell aerodrome approximately 30km. Therefore, there is no infringement of the OLS for either Glen Innes or Inverell Aerodromes.

Other nearby aerodrome landing areas, including Inverell North, are not licensed and are not required to have Obstacle Limitation Surfaces.

5.4 Lowest Safe Altitudes Associated with Nearby Air Routes

Aircraft operating under Instrument Flight Rules are required to conduct their flights along prescribed Air Routes that are published on Enroute Charts (ERC). Fig 5-1 below is an extract of ERC L3 and shows air routes in the vicinity of the wind farm.

In order to ensure their safe operations a buffer of 1000ft is applied above obstacles within a prescribed area surrounding the air route (depending on navigation aids, etc.) to determine a Lowest Safe Altitude (LSALT). This is the lowest altitude that an aircraft can travel along the particular air route, in poor weather conditions in which the pilot cannot maintain visual contact with terrain.

There are 4 Air Routes with protection areas overlying the proposed Sapphire wind farm. As indicated in Table 5-3 below, the wind farm turbines do not infringe the air route protection surfaces.

AIR ROUTE - LSALTS

AIR ROUTE	IMPACT/COMMENTS
W893 –LSALT 5800ft	The development does not infringe the protection surface of 1462m /4800ft AHD. No impact.
W598 – LSALT 6400ft H623 – LSALT 6400ft W267 – LSALT 6400ft	The development does not infringe the protection surface of 1645m /5400ft AHD. No impact.

Table 5-3: Air Route – LSALTS

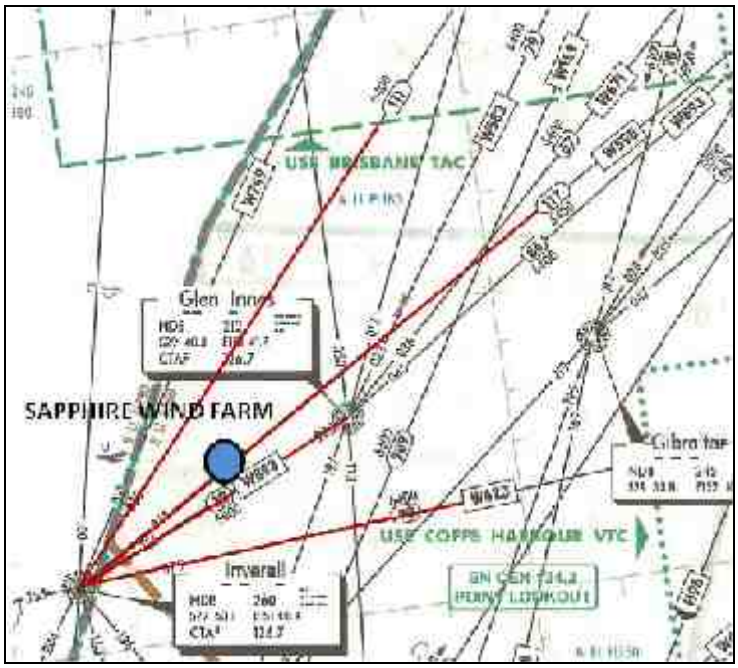

Fig 5-1: Air Routes in the vicinity of Sapphire Wind Farm

5.5 Other Aerodromes

There are no other aerodromes in close proximity that have OLS or PANS OPS surfaces.

5.6 Contingency Procedures – Engine Inoperative Flight Paths

Aerodromes in the vicinity of the proposed Sapphire wind farm are far enough away, and in a favourable direction from these airfields, to not have an impact on the performance of an aircraft that may suffer an engine failure requiring use of contingency procedures to either return to the aerodrome of departure or fly to a suitable alternative.

In the context of the operations in the area of the proposed wind farm development and the physical environment, the proposed Sapphire Wind Farm is considered as not having an impact on contingency procedures in the area.

5.7 Other Issues

- **Radar Interference and Shadowing**

  Radar interference and shadowing was assessed in accordance with CASR Part 139 Manual of Standards.

  The Sapphire Wind Farm proposed development is located outside the clearance zones associated with the nearest ATC Radar Facilities at Mt Sommerville, on the Gold Coast. Airservices Australia advised SWF on 21 September 2009 that the proposed wind farm will not impact on the ATC radar. A copy of this advice is at Appendix E.

- **Potential Impact on Airport Navigation Aids**

  Potential impact on airport navigational aids was assessed in accordance with CASR Part 139 Manual of Standards. The Sapphire Wind Farm development is located outside the clearance zones associated with the NDB navigation aids at Inverell and Glen Innes. Airservices Australia advised SWF on 21 September 2009 that the proposed wind farm will not impact on Airservices navigation aids. A copy of this advice is at Appendix E.

- **Future Developments**

  It is unlikely that any future developments of the PANS OPS surfaces at Inverell and Glen Innes will be affected by this wind farm due to the north-south runway configurations at both aerodromes and the location of the wind farm to the east and west respectively.

  Any future development of Instrument Approach Procedures at airfields within 55.6km (30nm) of the wind farm will be required to take the wind farm characteristics into account during the design process.

- **Department of Defence and Reporting of Tall Structures**

  As the proposed wind farm contains wind turbines which will exceed 110m AGL, the developer is required to inform CASA and the Department of Defence (DoD) of the development in accordance with AC 139-08(0). DoD advised SWF on 7 July 2009 that the proposed wind farm will not have an impact on Defence operations, but that they require to be informed of the Tall Structure. A copy of the Department's advice is at Appendix F.

6. QUALITATIVE RISK ASSESSMENT

Ambidji undertook a Qualitative Risk Assessment based on stakeholder consultations, site visits and its experience in undertaking aviation risk assessments.

A site visit was made to both the wind farm region and the proposed Sapphire Wind Farm site to review the aviation activity and consider the topography and proposed location of the turbines.

Face to face consultations were conducted with:

- Mr Brennan Smith Expenditure Controller (airport manager) and Mr Brad Hilton (Manager Corporate Development), Inverell Shire Council;
- Mr John Newby, Chief Flying Instructor and Chief Pilot, Inverell Aviation;
- Mr Russell Lucas, Chief Pilot, Country Capital Aviation, Tamworth;
- Mr Paul Mitrega, Owner/Managing Director, North West Aviation, Inverell;
- Mr Steve Hicks, Chief Flying Instructor, Highland Flight Training, Glen Innes; and
- Mr Malcolm Donnelly, Manager Asset Services, Glen Innes Severn Council.

Phone consultations and desk top research was conducted for other stakeholders in the region, including:

- Aircraft Owners and Pilots Association;
- Recreation Aviation Australia;
- Australian Parachute Federation;
- Gliding Federation of Australia;
- Hang Gliding Federation;
- NSW Rural Fire Service Aviation Unit;
- NSW Police Air Support Unit;
- NSW Ambulance Service Aviation Unit;
- Country Capital Aviation;
- Aerial Agricultural Association of Australia;
- Superair, Armidale (Mr David Boundy, Manager);
- Tablelands Top Dressing Pty Ltd, Armidale; and
- G and G Agricultural.

These consultations are detailed in Appendix G.

6.1 Impacts on the Operation of Aerodromes and Aircraft Landing Areas in the Region of the Proposed Wind Farm

The approximate distance and direction to aerodromes and Aircraft Landing Areas and airstrips, either in close proximity, or as a sample of those that could be operationally linked to the proposed Sapphire Wind Farm area are tabulated in Table 6-1.

Aerodromes/Aicraft Landing Areas (ALA)	Approximate Distance to Wind Farm	Direction from Wind Farm
Inverell (registered)	30km	South West
Inverell North (unlicensed)	18.5km	West South West
Ashford (unlicensed)	42.6km	North West
Glen Innes (registered)	15km	East
Numerous private airstrips	Located within general area of proposed development	

Table 6-1: Approximate Distances and Directions of Aerodromes and Aircraft Landing Areas to the proposed Sapphire Wind Farm (Relative to Sapphire Location).

The nature of aviation flying activity at the aerodromes and Aeroplane Landing Areas is summarised in Table 6-2 below.

Aerodromes/ALA/Airstrips	Nature of Aviation Flying Activity
Inverell	Private and Recreational Airwork (including agricultural aviation and emergency services, etc.) Flying Training (including RA Aus) Charter
Inverell North	Private and Recreational
Ashford	Private and Recreational
Glen Innes	Private and Recreational Airwork (including agricultural aviation and emergency services, etc.) Flying Training (including RA Aus) Charter
Private Airstrips (unlicensed)	Private and Recreational Airwork (including agricultural aviation and emergency services, etc.)

Table 6-2: Nature of Flying Activity at Aerodromes and Aircraft Landing Areas in the Region

Inverell, Inverell North, Ashford and Glen Innes are all located sufficiently away from the proposed wind farm development. As demonstrated in the OLS and PANS-OPS assessments, operations into and from these aerodromes would not be impacted upon by the development.

Information supplied by the Glen Innes Severn Council indicated that there are numerous private airstrips located in the general area of the proposed development. Feedback from an agricultural aviation stakeholder indicated that there were up to 600 agricultural airstrips within a 250km radius of Glen Innes. Another aerial agricultural operator provided information and contact details of seven properties, in the vicinity of the proposed wind farm development, which have airstrips. Ambidji has been able to make contact with five of the property owners. The prevailing view was that the development would not impact them personally but they recognised the wind farm development would have an impact upon aerial agricultural activities. Their comments and views are précised in Appendix G.

Pilots operating at ALAs/private airstrips are responsible for ensuring that they are aware of the conditions on and surrounding unpublished landing sites.

Pilots undertaking low level flight operations require special endorsement and are required to fully familiarise themselves with all obstacles in the vicinity of their operations. Aerial application pilots are required to survey and plan each operation to take into account terrain and obstacles - including all the various wind farm obstacles. Given this planning requirement, it is important that the location and height of obstacles, including wind turbine generators, meteorological masts and above ground transmission lines, be made available in relevant aeronautical charts and publications.

6.2 Impacts on General Aviation Training (Day Visual Flight Rules)

Visual Flight Rules (VFR) are rules governing flight generally in good visibility and clear of clouds. Aircraft flying under VFR are not normally required to be in contact with air traffic controllers and are responsible for their own separation from other aircraft and obstacles.

Flying training is carried out at both Inverell (GA and RA) and Glen Innes (RA) and training activities take place in the vicinity of the proposed development. These activities include low level flying (e.g. practice engine failures/forced landings).

However, feedback from stakeholders would indicate that the level of training activity is low. Furthermore, the flying training organisation at Glen Innes indicated that they would consider relocating their training area should the development proceed.

Notwithstanding the above, stakeholder feedback indicated that the proposed development has the potential to impact upon VFR operations by day.

6.3 Impacts on General Recreational or Commercial Aircraft Activity

Recreational general aviation fixed wing flying normally covers private pleasure and local sightseeing or cross country flying and the activity is generally under VFR.

Comment received from Recreation Aviation Australia (RA Aus, the peak body representing owners and operators of home-built, ultra-light and non-CASA registered aircraft) revealed that in normal operating circumstances wind farms were not an issue for the organisation and/or its members.

Commercial general aviation fixed wing flying is mostly charter operations originating from airports in the region or otherwise transiting the region. Stakeholder comment

indicated that a number of charter organisations operate into and from Inverell and Glen Innes aerodromes. The majority of charter operations would be undertaken using Instrument Flight Rules (IFR)[23] where lowest safe altitudes apply. However some pilots file IFR and then downgrade to VFR.

VFR operations must be flown in accordance with Civil Aviation Regulations (CAR) 157 which states (in part) that an aircraft must not fly lower than 152m (500ft) over a non-populated area being terrain or obstacles on that terrain and not within, for aircraft other than a helicopter, 600m horizontally, and in the case of a helicopter, 300m horizontally to the same, unless it is engaged in approved low private flying or aerial work.

Additional stakeholder comment revealed that there is one regular commercial operation (courier service) which operates twice daily between Tamworth, Armidale, Inverell and Glen Innes and return. It was also commented that on occasions when VMC conditions were marginal that IFR pilots elect to fly VFR at 500ft AGL between Inverell and Glen Innes and vice versa. When pilots fly IMC and carry out an instrument approach and landing procedures there is not always a guarantee that the pilot makes visual contact with the ground prior to or at the minimum decision altitude. By flying VFR at 500ft AGL the pilot can remain in visual contact with the ground at all times and can be assured of landing.

Mindful of this requirement, a pilot undertaking a VFR flight should only flight plan to transit the area where the wind farm is located if the prescribed vertical and horizontal distances can be maintained. Otherwise the pilot should avoid flying over this area. Again, this reinforces the requirement for the location and height of the wind turbines, meteorological masts and above ground transmission lines to be included on relevant aeronautical charts and publications.

Clearly the 156 metre high wind turbine proposal will impact upon this type of low level operation.

6.4 Light Aircraft Night Flying (IFR and VFR)

Both IFR and VFR aircraft flying at night are protected from obstacles and terrain by published or calculated Lowest Safe Altitudes (LSALT) and descent below them is restricted to within approximately 10km of the airport environs. There are no aerodromes or aircraft landing areas equipped for night operations within 10km of the wind farm and accordingly, all aircraft should be at, or above, LSALT over the proposed wind farm.

Night operations are undertaken by both single and multi-engine aircraft operating under Night Visual Meteorological Conditions (VMC) or IFR rules. For these operations, a minimum clearance[24] of 1000ft (305m) above the turbine tip height or other higher obstacles is required.

[23] Instrument flight rules (IFR) are regulations and procedures for flying aircraft by referring only to the aircraft instrument panel for navigation. Even if nothing can be seen outside the cockpit windows, an IFR-rated pilot can fly while looking only at the instrument panel. IFR-rated pilots are authorised to fly through clouds. Air Traffic Control procedures and airspace rules are designed to maintain separation from other aircraft.

[24] This is a minimum as the LSALT is calculated on the highest man-made or natural obstacles within an area envelope around a particular planned track.

In the event of an engine failure, multi (usually twin) engine aircraft pilots are required to plan their operations such that they are able to maintain operations at or above the lowest safe altitude above the wind farm site. Multiple engine failures are extremely rare and, therefore, there is little likelihood of a twin engine aircraft being unable to maintain LSALT in the case of a single engine failure. The probability of a multiple engine failure over or near the proposed Sapphire Wind Farm at night is very low.

Feedback from stakeholders would indicate that there is minimal night flying activity and this is generally carried out by commercial aviation operators.

6.5 Any known VFR Highly Trafficked Air Routes

Feedback from stakeholders indicated that the Inverell to Glen Innes track is a regularly used air route. Under normal operations and in good weather (e.g. VMC) the proposed development should not impact upon VFR operations.

However, in deteriorating and marginal weather (e.g. IMC) the development (particularly the 156 metre high proposal) may have an impact upon VFR operations.

6.6 Impacts on NSW Emergency Services (Ambulance and Police) Aerial Operations

Air Ambulance

Discussions were conducted with the Base Managers/Chief Pilot of CHC Helicopters in Sydney and Canberra. The discussions revealed that careful pre-planning is conducted prior to commencing an emergency rescue operation. A complete study of topography, including known obstacles (e.g. power lines, wind turbines, communications towers, etc.) is always carried out. CHC operations manuals and safety management systems provide clear guidance to pilots with regard to the planning and conduct of flight in the vicinity of obstructions. It is considered that risks could be mitigated to a low value.

The Chief Pilots indicated that wind farms are treated no differently from other man-made obstacles (towers, etc.) and they posed no greater threat to aviation. CHC's view is that the proposed development would have minimal impact upon its aerial operations.

The Chief Pilots also offered the opinion that the stakeholders at greatest risk would be low time pilots of VFR aircraft operating in poor weather and not having the advantage of IFR skills and training.

NSW Police Aviation Support Branch (ASB)

Several requests were made to the ASB for information regarding their operations and wind farm developments. However, previous advice provided by them in relation to a development to the north of Canberra revealed the following.

"The development in question did not pose any additional potential dangers or risks to their operations. They noted that there are already power lines in the vicinity of the wind farm, which because of the lack of "cultural" lighting in the area, restrict VFR operations to day light tasking only. The ASB consider that in Visual Meteorological Conditions (VMC) the wind farm would be highly conspicuous.

The ASB commented further that the wind farm posed a low risk to their operations for the following reasons:

- Minimal operational tasking conducted in the area;
- Nil Instrument Flight Rules (IFR) operations conducted by ASB;
- VFR preclude night operations without lighting and discernible horizon; and
- Heightened awareness of flight crews of surrounding area and other obstacles in existence (i.e. power lines)".

In the light of ASB's previous comment Ambidji considers the propose development would have a low impact upon their aerial operations.

6.7 Impacts on NSW Rural Fire Service - Aerial Operations

Comment from the NSW RFS Director Aviation indicated that the RFS often uses aerial fire fighting aircraft, both fixed and rotary wing, to assist ground crews in suppressing bush fires. Aircraft are regularly used in both initial attack and in ongoing fire operations in the New England area.

The Director commented that localities that have wind turbines across the landscape would limit an aerial fire fighting capability. Fire fighting aircraft operate at low levels and often with limited visibility due to smoke. If a bush fire was in or around a wind farm then the Service would not be able to undertake an aerial attack of the fire and would have to wait until the fire was clear of the turbines. This would limit RFS's initial attack capabilities and may, dependent on the ground based attack, increase the size of the fire.

Other considerations to aerial fire-fighting capabilities include any impacts to aerodromes and airstrips that may restrict access and accordingly impact on to the general aerial fire fighting capability to a much greater area than the immediate wind farm.

In the light of the above comments it is considered that the proposed development would have a significant impact upon aerial fire fighting capabilities in the immediate vicinity of the wind farm.

6.8 Agricultural Aviation Activities

Discussion with the Aerial Agricultural Association of Australia (the peak body) has revealed that the organisation automatically opposes wind farm developments unless the developer has (inter alia):

- consulted in detail with local operators;
- received independent expert advice on safety and economic impacts; and
- considered the impacts on the aerial application industry

Discussions with the three local operators generated mixed opinion.

One operator commented that wind farms and the development in question would not impact upon operations.

The second was of the view that the proposal would propose a challenge but believed that there could be a suitable "work around" i.e. stop the turbines during planned periods of aerial spraying. However, if the turbines were in operation then it would clearly impact upon aerial agricultural activity.

The third operator was clearly opposed to the proposal and cited air safety as the primary reason. The operator also discussed the impact of turbulence created by turbine blade tip vortices and the potential to create in flight instability.

This operator also touched on other issues that were non-safety related but discussed commercial and economic matters. These issues are précised in Appendix G.

Appendix G summarises consultations undertaken with agricultural flying operators.

6.9 Published Air Routes

Several air routes are located or have protection surfaces overhead the proposed Sapphire wind farm site. This aspect has been addressed in Section 5.4 above.

6.10 Topographical and Weather Issues

The area of the proposed development forms part of the New England Tablelands. The locality is characterised by undulating topography of low rolling hillsides set in an elevated tableland. The area contains both forested and agriculturally developed terrain.

Discussion with local stakeholders indicated that the winter months presented the worst weather conditions when low cloud, fog and poor visibility were common. In the summer months inclement weather was usually associated with thunderstorm activity.

During the period of the site visit a range of weather conditions were experienced, which included morning fog patches in and around Glen Innes and general late afternoon cumulo-form cloud development that had the potential to develop into thunderstorms.

These types of weather activity all have the potential to impact upon in-flight safety.

Aircraft operating under Instrument Flight Rules (IFR) can operate in poor weather conditions and in cloud which precludes visual acquisition of obstacles and terrain. These operations are protected from obstacles and terrain by PANS OPS surfaces and LSALT's that are designed to keep the aircraft well above obstacles and terrain.

Otherwise CAR 157 states (in part) that an aircraft operating under VFR must not fly lower than 152m (500ft) over a non-populated area being terrain or obstacles on that terrain and within, for an aircraft other than a helicopter, 600m horizontally and, in the case of a helicopter, 300m horizontally to the same, unless:

- Due stress of weather or any other avoidable cause it is essential that a lower height be maintained; or
- It is engaged in approved low flying private or aerial work; or
- It is engaged in flying training and flies over part of a flying training area in respect of which low flying is authorised by CASA under sub regulation 141 (1); or

- It is undertaking a baulked approach; or
- It is flying in the course of actually taking-off or landing at an aerodrome.

In this regard, the Aeronautical Information Publication (AIP) states that a pilot of a fixed wing aircraft operating under VFR (by day in Class G airspace[25]) must have 5 km forward visibility and remain clear of clouds and in sight of ground or water when operating below 3000ft AMSL. Helicopters are approved in the regulations to operate with 800m visibility if operating at a reduced speed.

In regard to the first bullet point above, it is possible that due to lowering cloud base and if, through poor airmanship the aircraft had pressed on to the point that it was unable to execute a turn and fly away from the weather, that an aircraft could find itself lower than 152m (500ft) above the terrain or obstacles. The probability of this occurrence, given the limited frequency of operations in this area, is considered to be very small and given the conspicuous colour of the turbines and knowledge of the presence of the wind farm (marked in aeronautical charts) the probability of a collision with a turbine is considered as low. The guyed meteorological masts are not as conspicuous as wind turbine generators and aviation marking of these masts is recommended.

Notwithstanding this infrequent event and the conspicuous colour of the turbines, it has been argued in some aviation circles that the presence of lit turbines may be a safety benefit to sight the turbines in reduced light conditions under a low cloud base. However, in consultations with operational staff of operational wind farms, advice provided to date is that it is uncertain whether the lights would be activated in low light conditions associated with cloud cover. Advice on what happens in practice is that, on low cloud days, the lights are activated a little earlier than at dusk.

Irrespective, even if the lights were illuminated, the closest lights to an aircraft approaching the wind farm at low level due the lowering cloud base may actually be in cloud and not visible. This is because not all wind turbines would be lit and the placement of turbines in wind farms tends to be on ridges and other high ground that could be in the cloud.

6.11 Impacts on Australian Defence Force (ADF) Operations

Military low level operations are rigidly controlled and undertaken by specially trained pilots, and military aircraft are fitted with terrain following radar or pilots use night vision goggles to undertake these low flying activities. In accordance with relevant CASA and Defence requirements, the proponent is required to notify the aviation authorities of the existence of the wind farms as a “Tall Structure”[26] to enable the location of the wind farm to be included on relevant civil and defence aeronautical charts and publications.

[25] Class G: IFR and VFR flights are permitted and do not require an airways clearance. IFR flights must communicate with air traffic control and receive traffic information on other IFR flights and a flight information service. VFR flights receive a flight information service on request.

[26] CASA AC 139-08(0) Reporting of Tall Structures.

Apart from the requirement to notify Department of Defence of the "Tall Structure", the Department has advised that the proposed wind farm will not impact on defence operations at this time. A copy of their assessment of the wind farm proposal is at Appendix F.

6.12 Qualitative Risk Assessment Summary

Based on the above discussion, the assessed level of risk is summarised in Table 6-3 below.

Risk Element	Assessed Level of Risk	Comment
Aerodrome operations	LOW	
Aircraft Landing Area operations	LOW	
Agricultural Operations	MEDIUM	In respect of the 156metre turbines this would be HIGH
GA Pilot Training	LOW	
Recreational/Commercial Flying	LOW	In respect of the 156 metre turbines this would be MEDIUM
Known Highly Trafficked Routes	LOW	In marginal weather conditions this would be MEDIUM
Air Ambulance Operations	LOW	
Police Aviation Support Branch	LOW	
Fire Fighting Operations	LOW/MEDIUM	Risk in the immediate vicinity of wind farm is HIGH
ADF Military Operations	LOW	
Published Tracks	LOW	
Night Flying	LOW	
Weather and visibility Issues	LOW	In respect of 156 metre turbines this would be MEDIUM

Table 6-3: Qualitative Risk Assessment Summary

7. CONCLUSIONS

7.1 Obstacle Lighting Review

Ambidji's review of the approach to lighting and consideration of present regulations for wind farms in a number of overseas countries shows that the heights that define them as obstacles and the approach to lighting varies widely.

In Australia, regarding those structures that are outside obstacle limitation surfaces of an aerodrome and are more than 110m above ground level, CASA's Manual of Standards Part 139 - Aerodromes states that in general an obstacle would require obstacle lighting unless an aeronautical study assesses it as being shielded by another object or *that it is of no operational significance.* In addition, CASA previously promulgated an Advisory Circular 139-18 (0) covering the marking and lighting of turbines outside the vicinity of an aerodrome but this has been withdrawn. A review of the potential impact to aircraft operations by wind farms located away from aerodromes is currently being undertaken by DIT. Discussions with DIT have indicated that the recommendations of the withdrawn AC are likely to apply.

Ambidji's survey of the current trends in Australia shows that some wind farm proponents are seeking not to light the farms and some existing operators are seeking to reduce or extinguish their existing lighting.

CASA's current position on obstacle lighting of wind farms that are remote from an aerodrome (as for the proposed Sapphire Wind Farm) is summarised as:

a. CASA cannot mandate obstacle lighting for wind farms that are *"not within the vicinity"* of an aerodrome;

b. Provision of such lighting is a decision for, and the responsibility of, the developer;

c. Any associated requirements placed on developers by planning authorities, insurers or financiers are beyond CASA's scope;

d. A wind farm developer may have a duty of care to the aviation industry and local operators in terms of ensuring obstacles are made conspicuous;

e. Obstacle marking and lighting requirements as specified in the CASA Manual of Standards Part 139, Section 9.4 applies for developers choosing to light a wind farm; and

f. The Advisory Circular information (AC 139-18) is still valid as a recommendation if the proponent wishes to do so as a risk mitigator.[27]

The Sapphire wind farm may have turbines with a maximum height of 156m, which is in excess of an obstacle as defined by ICAO and also in excess of the height of 110m in the CASA withdrawn AC; the wind turbines would, therefore, be assessed as a hazard. Given the state of the current policy situation in Australia regarding obstacle lighting of wind farms, it would seem prudent that the Sapphire wind farm turbines be provided with obstacle lighting.

[27] CASA advice to Ambidji 22 September 2008

7.2 Aeronautical Impact Assessment

A review of the wind farm's potential impacts on aerodrome OLS and PANS-OPS surfaces located in the region was undertaken. It was determined that the Sapphire Wind Farm does not infringe upon any PANS OPS surfaces or OLS for aerodromes in the proposed wind farm's region. Air route published LSALTs are well above the height of the proposed turbines.

In addition, the Sapphire Wind Farm is located at a sufficient distance from all listed aerodromes so as to not affect take-off and landing operations at these aerodromes.

7.3 Qualitative Risk Assessment

The Qualitative Risk Assessment can be summarised as follows:

- With the exception of authorised low flying operations, all aircraft operating in the area are required by aviation regulations to operate at a height that would exceed the maximum height of the wind turbines for the proposed Sapphire Wind Farm site;
- With respect to pilots undertaking emergency services low level flights the organisational operations manuals and safety management systems would provide clear guidance to pilots with regard to the planning and conduct of flight in the vicinity of obstructions. It is considered that risks could be mitigated to a low value;
- The presence of wind turbines significantly limits the aerial fire-fighting capabilities of the NSW RFS in the immediate vicinity of the wind farm;
- With respect to agricultural aviation activities it is considered that the proposed development presents a medium to high level of risk; and
- With regard to all the categories assessed the development poses an overall low to medium level of risk.

7.4 Duty of Care Disclaimer

The obstacle lighting review has determined that there are no regulatory requirements for aviation lighting to be installed for the proposed Sapphire Wind Farm. However, given the current status of the review of obstacle marking and lighting of wind farms, it would seem prudent to allow for obstacle marking and lighting of the turbines and meteorological masts and guy wires in accordance with this report. This would also be consistent with the policy of the Aerial Agricultural Association of Australia

Additionally, as a function of corporate responsibility and duty of care, it is appropriate to formally advise all relevant stakeholders of:

- the locations and heights of the turbines and meteorological masts and when they would be constructed or decommissioned; and
- the developers intentions regarding marking and lighting of the wind farm turbines.

SWF's attention is also drawn to the following determination of the New South Wales Court of Appeal, in the case of *Sheather vs Country Energy*, where, inter-alia, the court determined the following.[28]

> *"Mr Sheather, the owner of the helicopter which crashed into a Country Energy owned spur line while flying well below the mandatory height regulations for aircraft, appealed an earlier decision on the grounds that Country Energy had failed to provide sufficient warning of the spur line. Despite Country Energy observing all legal compliance requirements, the NSW Court of Appeal held that Country Energy owed a duty of care to pilots and aircraft owners and had breached its duty of care".*

Due cognisance of this decision should be taken by SWF and its legal and insurance advisors in considering this qualitative risk report.

[28] Sheather v Country Energy [2007] NSWCA 179

8. RECOMMENDATIONS

Ambidji makes the following recommendations:

- As the highest turbine at 156m AGL is, in ICAO and CASA terminology, an obstacle, it is considered prudent that SWF consider the provision of obstacle marking and lighting as a duty of care obligation;
- Should SWF consider that obstacle lighting is not to be provided, SWF should engage with its legal, insurance and other relevant advisors in regard to its own corporate assessment of risk and duty of care responsibilities in regard to the non-requirement for aviation obstacle lighting;
- That subject to acceptance of this study findings by SWF and its legal, insurance and other relevant advisors, SWF formally advise CASA, Department of Defence and other relevant stakeholders of the study;
- That SWF ensure that the locations and heights of the wind farm turbines, meteorological masts and power lines are provided to the Department of Defence and the Aeronautical Information Service (AIS) to enable their inclusion on relevant aeronautical charts;
- That SWF make contact with the relevant aviation stakeholders as listed in Appendix G, prior to the construction of turbines and meteorological masts in the area; and
- That any meteorological masts in the Sapphire wind farm area be fitted with swing flap reflector markers or other suitable markers acceptable to the Aerial Agricultural Association of Australia. Discussion with a power industry reflective flag manufacturing company (Power Engineers) suggested the mast guy stays be marked as follows:
    - Fitting 3 x 30cm flags per guy stay;
    - In alternating colours yellow, white and orange, to each mast guy;
    - Spaced equidistant along each guy wire; and
    - In addition to using the snap clamp supplied with each marker a proprietary brand construction adhesive such as Sika Flex (http://www.sika.com.au/) be used in conjunction with the clamp.

APPENDIX A

ICAO Recommendations - Classification of Obstacles and Aviation Lighting of Wind Farms

APPENDIX A

ICAO Recommendations - Classification of Obstacles and Aviation Lighting of Wind Farms

4.3 Objects outside the obstacle limitation surfaces

4.3.1 **Recommendation.**— *Arrangements should be made to enable the appropriate authority to be consulted concerning proposed construction beyond the limits of the obstacle limitation surfaces that extend above a height established by that authority, in order to permit an aeronautical study of the effect of such construction on the operation of aeroplanes.*

4.3.2 **Recommendation.**— *In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 150 m or more above ground elevation should be regarded as obstacles, unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes.*

Note.— This study may have regard to the nature of operations concerned and may distinguish between day and night operations.

6.4 Wind turbines

6.4.1 A wind turbine shall be marked and/or lighted if it is determined to be an obstacle.

Note.— See 4.3.1 and 4.3.2.

Markings

6.4.2 **Recommendation.**— *The rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, unless otherwise indicated by an aeronautical study.*

Lighting

6.4.3 **Recommendation.**— *When lighting is deemed necessary, medium-intensity obstacle lights should be used. In the case of a wind farm, i.e. a group of two or more wind turbines, it should be regarded as an extensive object and the lights should be installed:*

a) to identify the perimeter of the wind farm;

b) respecting the maximum spacing, in accordance with 6.3.14, between the lights along the perimeter, unless a dedicated assessment shows that a greater spacing can be used;

c) so that, where flashing lights are used, they flash simultaneously; and

d) so that, within a wind farm, any wind turbines of significantly higher elevation are also identified wherever they are located.

6.4.4 **Recommendation.**— *The obstacle lights should be installed on the nacelle in such a manner as to provide an unobstructed view for aircraft approaching from any direction.*

APPENDIX B

Comparison of International Standards for Obstacle Lighting of Wind Farms

APPENDIX B

Comparison of International Standards for Obstacle Lighting of Wind Farms

Obstacle Marking Requirements

As the Australian Civil Aviation Safety Authority (CASA) has determined that provided the turbines are of a colour that enables them to be readily conspicuous (preferably white), then marking of wind turbines for daytime visibility is not considered necessary in the Australian environment. Consequently, the following table not does make a comparison of marking requirements.

Obstacle Lighting Requirements

The table below has been prepared to indicate the variation between countries as to the obstacle lighting criteria applicable to wind farms. The purpose is to show that these criteria can vary considerably between countries. Only those factors that are pertinent to the proposed Sapphire Wind Farm have been included in this review. This information is general in nature only and the relevant regulations should be read in full to gain a full understanding of the complete requirements.

Country	*Turbine Height Criteria for Lighting*	*Obstacle Lighting Criteria*	*Reference*
Australia	Turbines >110m AGL.	Objective is to define the extent of the wind farm: a. spacing not more than 900m b. define the extremities and perimeter of the wind farm c. identify the highest terrain obstacle	Advisory Circular AC139-18(0) (Note: Although this AC has been withdrawn and the requirements being reviewed by CASA, the technical requirements can be used as a "risk mitigator" by wind farm developers)
		Dependent on a number of factors, ". including direction of air traffic and the nearness of aerodromes..."	Transport Canada. CAR621.19 Advisory Circular 1/06 (Draft).

Canada	Turbines 90m AGL.	Longitudinal spacing "in the order of 900m" Deviation not more than 10%. Nav Canada has recently approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems. OCAS® has been approved for use in Norway, USA and Canada.	NAV CANADA Aeronautical Information Circular 45/08, 20 Nov 08.
Ireland	"potential en route air navigation obstacle" above 45m AGL. Offshore - above 90m AGL.	Onshore - No published regulations, Wind Farms planned away from the vicinity of aerodromes are considered 'case by case', requirement of lighting dependant on size, and vicinity to en-route aircraft.	S.I No. 423 of 1999.
New Zealand	Dependent on whether the structure is a hazard in navigable airspace Turbines of >60m AGL.	Selected turbines to be lit, "the highest turbines, … those at the extremities … and spacing not to exceed 1nm (1850m)" All wind farms must be marked on aeronautical charts.	Civil Aviation Authority of New Zealand, "Lighting and Marking of Wind Farms", May 2006.
Norway	Wind turbine overall height greater than 60m AGL.	Norwegian Civil Aviation Authority has approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems.	Norwegian Civil Aviation Authority.
South Africa	Towers of heights over 45m.	Define periphery, not more than 800m spacing.	Civil Aviation Regulations, 1997.
Taiwan	Wind turbines >=60m AGL. Various criteria: Depends on location, Onshore,	"Objects that are around the airport, airfield, and navigation aids and will affect safety…" Onshore 1. Within vicinity of an aerodrome, obstacle lighting is required if the obstacle is assessed as a hazard to	Article 32, Taiwan Civil Aviation Act.

United Kingdom	Offshore, vicinity of aerodromes and whether it is assessed as a hazard to aviation. Onshore - within vicinity if an aerodrome, if assessed as a hazard - away from immediate vicinity of an aerodrome, 150m AGL.	air navigation. 2. Away from the immediate vicinity of an aerodrome – "In general terms, structures less than 150m high, which are outside the immediate vicinity of an aerodrome are not routinely lit; unless by virtue of its nature or location .. it presents a significant hazard to air navigation".	CAP764 CAA Policy and Guidelines on Wind Turbines (February 2009).
United States	Wind turbine overall height greater than 200ft (approx. 61m).	Need to take into account "proximity to airports, VFR routes, extreme terrain and local flight activity… " Spacing "not more than ½ statute mile" (approx. 805m). FAA has recently approved the use of the Obstacle Collision Avoidance System (OCAS®) as an alternative to obstacle lighting systems.	FAA. AC 70/7460-1K (January 2007).

Many of the reference documents indicate that in determining the requirement for obstacle lighting of a wind farm, an aeronautical assessment should be made to determine whether the wind farm is a hazard to aviation and that, in addition to the height AGL of the wind farm turbines, this will depend on such factors as:

- Number of wind turbines.
- Location and proximity to airports.
- Proximity to aeronautical routes and air operations in the area.
- Nature of terrain in the area.
- Proximity to navigational aids.
- Extent and type of air traffic.
- Environmental restrictions.

Overseas experience appears to be trending towards a more rigorous justification of obstacle lighting of wind farms that are remote from an aerodrome, taking into account *"its nature and location"* as part of the assessment process.

APPENDIX C

CASA Briefing Statements October 2008 and 1 March 2011

APPENDIX C

CASA Briefing Statement - October 2008

"Taking a fresh look at wind farms"

"CASA is reviewing the way in which wind farms located near aerodromes are assessed and regulated. An advisory circular relating to the marking and lighting of wind farms has been withdrawn. CASA CEO Bruce Byron has directed that an appropriate safety study into the risk to aviation posed by wind farms be conducted as a basis for developing a new set of guidelines. The advisory circular was published to provide guidance to wind farm developers on the potential hazards to aviation and to provide advice on the means of marking or lighting wind farms. Under Civil Aviation Safety Regulation Part 139, CASA's jurisdiction only applies to structures within approximately 30 kilometres of an aerodrome. That means CASA cannot currently mandate the lighting or marking of structures outside this distance. However, the advisory circular gave the impression CASA could require the lighting of obstacles not in or near the vicinity of an aerodrome.

In addition, some recent industry complaints considered by CASA's Industry Complaints commissioner identified a number of other issues with the circular. On this basis Bruce Byron directed Advisory Circular 139-18(0) be withdrawn and a safety study be conducted. This will include appropriate consultation with the aviation industry and other stakeholders."

CASA Briefing Statement – 1 March 2011

Project AS06/07. Assessment of obstacles including wind turbines and exhaust plumes.

Project Closure notes – Project closed 1 March 2011

Project overtaken by events. AC139-18(0) Obstacle Marking and Lighting of Wind Farms was withdrawn September 2009 after CASR139 (Aerodromes) was found to be not applicable to areas located away from aerodromes regulated under CASR139. CASA embarked on a review of the risk to aviation by wind farms located away from aerodromes and a consultants report outlining proposed recommendations was finalised in late 2009 but no further action was taken. The Department of Infrastructure and Transport is currently addressing the impact of wind farms on aviation which they raised in the paper "Safeguards for Airports and the Communities around them."

APPENDIX D

Obstacle Lighting of Wind Farms in Australia

APPENDIX D

Lighting Arrangements for Operating or Approved Wind Farms in Australia - February 2011

The following table has been prepared from a review of power generation company web sites and discussions with representatives of power generation companies. The purpose of the table is to identify whether or not wind farms in Australia have or will be provided with obstacle lighting. It is not claimed to be an exhaustive survey. No responsibility is accepted for the accuracy of the information contained herein. These wind farms are either fully operational and/or approved by relevant planning authorities.

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Albany Wind Farm AKA Grasmere	12	100m	WA	Verve Energy	No Lighting
Alinta Wind Farm	54	118m	WA	Infigen Energy	No Lighting
Berrybank Wind Farm	99	131m	VIC	Union Fenosa	A layout for 50% of turbines has been developed however not yet approved.
Blayney Wind Farm	15	67.5m	NSW	Eraring Energy	No Lighting
Bremer Bay Wind Farm	1	69m	WA	Verve Energy	No Lighting
Canunda Wind Farm	23	108m	SA	International Power	No Lighting
Capital Wind Farm AKA Bungendore	67	125m	NSW	Infigen Energy	No Lighting
Capital II Woodlawn Wind Farm	20	124m	NSW	Infigen Energy	Yet to be constructed Possibly No Lighting
Carmody's Hill Wind Farm	70	138m	SA	Pacific Hydro	Approved, yet to be constructed. Pacific Hydro are undecided if turbines are going to be lit.

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Cathedral Rocks Wind Farm	33	100m	SA	Hydro Tasmania / Acciona Energy	No Lighting
Challicum Hills Wind Farm	35	100m	VIC	Pacific Hydro / Origin	No Lighting
Clements Gap Wind Farm	27	123m	SA	Pacific Hydro	Lit – 50% of turbines, they are planning to turn off.
Cocos Island	4	25m	AUS	Power station	No Lighting
Codrington Wind Farm	14	81m	VIC	Pacific Hydro	No Lighting
Collgar Wind Farm	127	135m	WA	Colgar Wind Farm P/L	Yet to be constructed undecided if going to light.
Coober Pedy Wind Farm	1	43.5m	SA	Energy Generation P/L	No Lighting
Coral Bay Wind Farm	3	71m	WA	Verve Energy	No Lighting
Crookwell Wind Farm I	8	67m	NSW	Eraring Energy	No Lighting
Crookwell Wind Farm II	46	128m	NSW	Union Fenosa	Approved however still assessing if going to light turbines.
Crookwell Wind Farm III	25-35	152m	NSW	Union Fenosa	Approved however still assessing if going to light turbines.
Cullerin Range Wind Farm	15	125m	NSW	Origin Energy	Lit – 9 of 15 Turbines are lit. Origin are currently assessing whether lights can be reduced or turned off.
Dandaragan Wind Farms - Yaddi Wind Farm - Wandin Wind Farm	 97 57	 132m 132m	WA	Wind Prospect	Both farms are approved however they are still assessing if they are going to be lit.

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Denham Wind Farm Turbines - 1,2,3 Turbine - 4	4	 65m 62.5	WA	Verve Energy	Lit – All 4 Turbines Tourist Area
Devon North Wind Farm	7	130m	VIC	Synergy Wind Developments	Approved, yet to be constructed, will be lit 3 of 7.
Emu Downs Wind Farm	48	80m	WA	Griffith Energy	No Lighting
Esperance Wind Farms - Nine Mile Beach Wind Farm - Ten Mile Lagoon	 6 9	 69m 45m	WA	Verve Energy and Horizon Power	No Lighting of either farms
Exmouth Advanced Mini Wind Farm	3	35.2m	WA	Verve Energy Horizon Power	No Lighting
Gunning Wind Farm	31	120m	NSW	Acciona	Under construction No Lighting
Hallett Wind Farm 1 – Brown Hill	45	124m	SA	AGL Energy	Lit - 17 of 35 Turbines NOW TURNED OFF
Hallett Wind Farm 2 – Hallett Hill	34	124m	SA	AGL Energy	Lit - 40% of Turbines NOW TURNED OFF
Hallett Wind Farm 3 – Mount Bryan	38	130m	SA	AGL Energy	No Lighting
Hallett Wind Farm 4 – Nth Brown Hill	63	124m	SA	AGL Energy	No Lighting

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Hallett Wind Farm 5 – Bluff Range	25	124m	SA	AGL Energy	No lighting
Hampton Wind Farm	2	74m	NSW	Hampton Park Wind Farm (Private)	No Lighting
Hepburn Wind Park aka Leonards Hills	2	109m	VIC	Hepburn Wind	No Lighting
Hopetoun Wind Farm	1	69m	WA	Verve Energy	No Lighting
Huxley Hill Wind Farm AKA King Island	5	44m - 86m	TAS	Hydro Tasmania	Lit - 1 of 5 Turbines 5kms from airport
Kalbarri Wind Farm	2	74m	WA	Verve Energy	No Lighting
Kings Creek Hotel	1	>30m	VIC	Victoria Cellars	No Lighting
Kooragang, Newcastle	1	>110m	NSW	Energy Australia Dept Water and Eng NSW	No Information
Lake Bonney – Stage 1	46	106m	SA	Infigen Energy	No Lighting
Lake Bonney – Stage 2	53	125m	SA	Infigen Energy	Turbines lit
Lake Bonney – Stage 3	13	125m	SA	Infigen Energy	Not yet constructed, turbines will be lit
Lal Lal Wind Farm	64	130m	VIC	West Wind Energy	Yet to be constructed, 44 of 64 turbines to be lit

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Lexton Wind Farm	19	126m	VIC	Origin Energy	Yet to be constructed, Aeronautical Impact Assessment has been conducted, proponent deciding if they will be lit.
Longwood Wind Power Station	2	36m	VIC	Elgo Estate Winery	No Lighting
Macarthur Wind Farm	150	135m	VIC	AGL and Merridian (NZ)	To be constructed by 2013 Not to be lit
Mawson – Antarctic	2	49m	AAD	Australian Antarctic Division	No Lighting
Moorooduc Wind Farm	1	>110m	VIC	Atlanta Fruit Sales P/L	No information
Mortlake Wind Farm	96	141m	VIC	Acciona Energy	No decision has been made to light
Mount Gellibrand wind farm	116	141m	VIC	Acciona Energy	No more than 20 turbines are to be lit (condition of consent by Minister of Planning).
Mount Millar Wind Farm	35	120m	SA	Transfield Services now owned by Meridian	Lit – 11 out of 35 Turbines
Musselroe Wind Farm	56	125m	TAS	Roaring 40's	Not yet fully approved undecided if going to be lit.
Newfield Wind Farm	15	>110m	VIC	Acciona Energy	No Lighting

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Portland Project Stage I - Yambuk Stage II - Cape Bridgewater Stage III - Cape Nelson South, Stage IV - Cape Nelson North, Sir William Grant	 20 29 22 11 16	 106m 109.9m 109.9m 126m 110-126m	VIC	Pacific Hydro	Stage IV – Not yet constructed Only section to possibly be lit 16 out of 26 turbines. Still undecided. Have reduced number by one. Since 2008 layout.
Rottnest Island	1	69m	WA	Verve Energy	No Lighting
Snowtown Wind Farm (Barunga Ranges)	47	124m	SA	Trust Power	Lit – 24 of 47 Turbines Up to 83 turbines to be constructed TO BE TURNED OFF
Starfish Hill Wind Farm	23	100m	SA	Transfield Services	No Lighting
Thursday Island	2	>110m	QLD	Ergon Energy	No Information
Toora Wind Farm	12	100m	VIC	Transfield Services Infrastructure Fund	No Lighting
Waterloo wind farm	37	125m	SA	Roaring 40's	Near completion, no aviation lighting
Wattle Point Wind Farm	55	109.5m	SA	AGL Energy	No Lighting

Wind Farm	No. of T's	Height AGL	Location	Operator	Lighting Arrangements
Waubra Wind Farm	128	110m – 120m	VIC	Acciona Energy/ANZ	Lit – 48 of 128 Turbines, Acciona currently assessing ability to reduce or turn off lighting
Windy Hill Wind Farm	20	69m	QLD	Transfield Services Infrastructure Fund	No Lighting
Wonthaggi Wind Farm	6	110m	VIC	Wind Power Pty Ltd / now Origin Energy now Transfield	Lit 2 of 6 turbines are lit Seeking confirmation
Woolnorth Wind Farm Stage 1 – Bluff Point 6 Stage 2 – Bluff Point 31 Stage 3 – Studland Bay 25	62	 110m 110m 125m	TAS	Roaring 40's / Hydro Tasmania	Operational, with no aviation lighting.
Yaloak Wind Farm	14	126.25m	VIC	Pacific Hydro	Yet to be constructed, still undecided on lighting
Yass Valley Wind Farm	200	160m	NSW	Origin/SKM	Assessment taking place in regards to lighting

APPENDIX E

Airservices Australia Advice

From: [redacted]
Sent: Monday, 21 September 2009 4:23 PM
To: Adrian Mackenzie
Subject: WF-241 - Sapphire Wind Farm

Hi Adrian,

Apologies for the late reply on this one.

A maximum turbine blade tip height of [redacted] for the wind farm as proposed will not affect any sector or circling altitude, nor any approach altitudes and Inverell aerodromes. (Deals with 3.3MW turbines).

A maximum turbine blade tip height of 180m AHD the wind farm as proposed will not affect any sector or circling altitude, nor any approach altitudes and Inverell aerodromes. (deals with 2MW turbines).

The wind farm will not impact on Precision/Non-Precision Nav Aids, HF/VHF Comms, A-SMGCS, Radar, PRM or Satellite/Links.

Kind regards,

Carly

Carly Fiumara Personal Assistant - Industry Relations
Corporate & International Affairs
Ph: +61 02 6268 4725
Fax: + 61 02 6268 4233

Airservices Australia
Ph: 1800 SOM 200 (within Australia)
Ph: +61 2 6268 4111 (outside Australia)
[redacted]
www.airservicesaustralia.com

APPENDIX F

Department of Defence Advice

Australian Government
Department of Defence
Defence Support Group

2004/1044160/5
LPSI/OUT/2009/140

Adrian Maddocks
Development Manager
Wind Prospect CWP Pty Ltd
P.O. Box 1708
NEWCASTLE, NSW 2300

Dear Mr Maddocks

RE: SAPPHIRE WIND FARM CONSULATION

Thank you for your letter dated 23 June 2009, and your email of 7 July 2009 inviting comment from the Department of Defence (Defence) on the Preliminary Environmental Assessment for the Sapphire Wind Farm (formerly the Table Top Wind Farm). Defence is familiar with this proposal, and has previously provided advice to the NSW Department of Planning in this regard (see Attachment A).

Defence can advise that, based on the information provided, the proposed Sapphire Wind Farm will not have an impact on Defence operations, and confirm that it has no concerns at this time.

It should be noted, however, that tall structures such as wind turbines present a potential danger to low-flying aircraft. As such, there is an ongoing need to obtain and maintain accurate information about tall structures so that risks associated with inadvertent collision by low flying aircraft can be reduced. The RAAF Aeronautical Information Service (RAAF AIS) in Melbourne is responsible for recording the location and height of tall structures. The information is held in a central database managed by RAAF AIS and relates to the erection, extension or dismantling of tall structures the top measurement of which is:

a. 30 metres or more above ground level - within 30 kilometres of an aerodrome, or
b. 45 metres or more above ground level elsewhere.

The proposed wind turbines will meet the above definition of tall structures. The Department of Defence therefore requests that you provide RAAF AIS with "as constructed" details so that the mast can be appropriately shown on aviation charts. RAAF AIS has a web site with a Vertical Obstruction Report Form at www.raafais.gov.au/obstr_form.htm which can be used to enter the location and height details of tall structures.

Defending Australia and its National Interests

Thank you for offering Defence the opportunity to provide comment. Should you wish to discuss the content of this advice further, please contact Jim Ponton, Executive Officer Land Use Planning, on (02) 6266 8186 or by email at jim.ponton@defence.gov.au.

Yours sincerely

Judith Bedford
A/g Director Land Planning & Spatial Information
Department of Defence
BP3-1-A052
Brindabella Park
Canberra ACT 2600

1 July 2009

Cc. RD DSO NNSW
RAAF AIS

Defending Australia and its National Interests

ATACHMENT A

Australian Government
Department of Defence
Defence Support Group

2004/1044160/4
LPSI/OUT/2009/99

Dinuka McKenzie
Major Infrastructure Assessments
NSW Department of Planning
GPO Box 39
Sydney, NSW, 2001

Dear Sir/Madam

RE: SAPPHIRE WIND FARM - REVISIONS TO WIND FARM LAYOUT

On 15 May 2009 Defence wrote responding to the proposed modification of the Sapphire Wind Farm. In this letter Defence advised that an assessment of potential radar impacts had not been finalised. Defence has completed its assessment and can advise that the modifications to the Sapphire Wind Farm will not have an impact on Defence operations. Defence confirms that it does not object to the proposed modifications.

Should you wish to discuss the content of this advice further, please contact Brenin Presswell, Executive Officer, Land Planning on (02) 6266 8138 or by email at brenin.presswell@defence.gov.au.

Yours sincerely

Original signed

John Kerwan
Director Land Planning & Spatial Information
Department of Defence
BP3-1-A052
Brindabella Park
Canberra ACT 2600

May 2009

Cc. RD DSO NNSW
RAAF AIS
CASA

Defending Australia and its National Interests

APPENDIX G

Stakeholders Consultations – Sapphire Wind Farm Area

APPENDIX G

Stakeholders Consultations – Sapphire Wind Farm

Generic Stakeholders

Stakeholder	Contact Person	Comment
Aerial Agricultural Association of Australia	Phil Hurst - CEO PO Box 353 MITCHELL ACT 2911 AUSTRALIA Ph: (02) 6241 2100	AAAA has produced a Windfarm policy which is available on the AAAA website. AAAA opposes **all** wind farm developments unless the developer has (inter alia): a. consulted in detail with local operators; b. received independent expert advice on safety and economic impacts; and c. considered the impacts on the aerial application industry. AAAA recommends wind farm developers be made aware of "duty of care" responsibilities established under *Sheather v Country Energy* (NSW Court of Appeals). AAAA recommends that all wind monitoring towers including guy wires should be clearly marked and that wind farm locations and tall structures should be included on aeronautical charts.
G and G Agricultural	Cameron camsuzg@bigpond.com	Wind farms do not present a problem for this company's operations
Superair Armidale	David Boundy Manager 02 6772 5055 superair@iinet.net.au	Mr Boundy is strongly opposed to wind farm developments. They are considered to represent a hazard to aviation safety. Expressed concern with regard to the impact of vortices generated by turbine blades and associated turbulence that may be created.. Mr Boundy also commented on potential economic loss as result of the proposal due the following: • requirement to fly at higher levels to avoid WF • reduce accuracy of application • increased operating costs passed on to customer • potential for customers to seek alternative spray methods to defray cost • lack of compensation provided by WF developer Mr Boundy also provided information about 7 airstrips which he considered may be affected by the proposed developments. Leaweena Mr Greg Gallacher 02 6733 6784 • Airstrip used for agricultural spraying by Superair • Refer Superair's comments Derrra Mr Ben Swan 02 6722 4486 • In negotiation with WF developer • Airstrip in poor condition • Nil impact upon aviation activity Mt Buckley Mr Norm Turner 02 6722 2050 • In negotiaition with Sapphire WF developer • Strip on property used by Superair • Nil impact personally but understands problems faced by Superair operations

		King's Plain Mr Don Hollingworth 02 6733 6802 Warrandah Mr Don Hollingworth 02 6733 6802 • 3 airstrips on the 2 properties • Infrequently used – once in last 3 years • Conducts ground spraying operations • Nil impact personally but understands the problems for the agricultural aviation industry Kia Tami Mr Dale Brown 02 6733 6861 • Nil Response Argyle Geoff Houston 07 4625 9626 • Nil Respone
Tablelands Top Dressing Pty Ltd	Glenn Gilmour Owner/Manager 02 6771 1157 studentpilot@ttd.net.au	Mr Gilmour indicated that he would have no problems operating in the vicinity of a WF – provided the turbines are stopped during spraying operations. He considered WFs to be another hazard/obstacle and there are potential "work-arounds".
Aircraft Owners and Pilots Association (AOPA)	Brian Hannan Former Vice President 03 5968 3311	Ambidji has spoken to Mr Hannan on several occasions in the past with regard to wind farms and meteorological masts and how they impact upon aviation activity. AOPA has no formal policy on wind farms per se but have been critical of the lack of consultation regard some WF developments in the past.
Australian Parachute Federation	Ms Kim Hardwick CEO	Not aware of any parachuting activity occurring in the vicinity of the proposed development. Stringent APF regulations with regard to risk and safety assessment and clearance from obstacles in particular.
Country Capital Aviation Tamworth	Mr Bill Bryant Managing Director Mr Russell Lucas Chief Pilot 02 6760 7169	Country Capital operate throughout NSW and particularly in the NSW New England region. It operates a twice daily freight/courier service between Tamworth, Armidale, Inverell, Glen Innes and return.
Glen Innes Severn Council	Mr Malcolm Donnelly Manager Asset Services 02 6730 2362 mdonnelly@gisc.nsw.gov.au	Mr Donnelly's primary concern related to the OLS and PANS-OPS surfaces at Glen Innes. Mr Donnelly provided Ambidji with a map showing known private airstrips in the Glen Innes region and the proposedWellingrove Cluster in particular.
Gliding Federation of Australia	Dr Bob Hall Safety Advisor 02 6332 2072 00438 675 051 Head Office Melboune 03 9303 7805	Ambidji has spoken with Dr Hall on several occasions in the past. He has indicated that WFs were not a problem for gliders in normal operating circumstances.
Hang Gliding Federation	Mr John Ollis 03 9336 7155 0417 644 633	
Highland Flight Training Glen Innes	Mr Steve Hicks Chief Flying Instructor 02 6732 1684 0429 414 314	Highland Flight Training conducts RA Aus training at Glen Innes. Mr Hicks commented that WFs can be considered as another obstacle/hazard. He compared WFs with other man made obstacles such as the existing communications tower to the SE of the aerodrome and also the HT power lines in the Emmaville/Swan Valley area. The RA training area is in close proximity to the proposed Wellingrove cluster; however, Mr Hicks commented that the traing area could be relocated if the development was to proceed. WFs per se were not an issue for Highland Flight Training.

Stakeholder	Contact Person	Comment
Inverell Shire Council	Mr Brennan Smith Expenditure Controller (Airport Mgr) Mr Brad Hilton Manager Corporate Development 02 6728 8288 Brennan.smith@inverell.nsw.gov.au Bradley.hilton@inverell.nsw.gov.au	Inverell Shire's primary concern was the impact that the development would have on the prescribed aviation surfaces at Inverell aerodrome (No impact). Council also expressed concern with regard low level flying operations such as agricultural aviation and fire fighting particularly during periods of poor weather (e.g. fog, low cloud, reduced visibility). Council did not believe the development would impact upon "normal" aviation activity.
Inverell Aviation	Mr John Newby Chief Pilot and Chief Flying Instructor 02 6723 1344 Inverell.aviation@bigpond.com	Inverell Aviation is an Air Charter and GA/RA - Aus flying training organisation. They operate 8 aircraft ranging from PA31 Chieftain down to C172. Mr Newby's primary concerns related to low level flying operations particularly in the Emmaville, Swan Valley, Wellingrove area (he conducts training activities in this region). He commented that there is regular GA activity between Inverell and Glen Innes and operations are often conducted at 500ft AGL. Mr Newby's opinion is that the proposed development (particularly the 156 metre proposal) would have a significant impact upon aviation activity.
North West Aviation Inverell	Mr Paul Mitrega Owner/Managing Director 02 6723 1236 pam@northwestaviation.com.au	North West Aviation is primarily an aircraft maintenance and repair organisation (MRO). They own and operate an aircraft. Mr Mitrega commented the proposed WF development would not impact upon his company's operations per se. He considered that WFs would not impact aviation activity when flights are being conducted in line with the appropriate aviation regulations. His main concern related to low level flight in poor weather conditions and possibility of aircraft flying below prescribed minimum altitudes (i.e. contravening regulations).
NSW RFS Aviation Section	Chief Superintendent Maryanne Carmichael Director Aviation 02 8741 5263 0439 909 943 Maryanne.carmichael@rfs.nsw.gov.au Chris Waldbridge Fire Control Officer Glen Innes Chris.waldbridge@rfs.nsw.gov.au	The Rural Fire Service often uses aerial firefighting aircraft, both fixed and rotary wing, to assist ground crews in suppressing bush fires. Aircraft are regularly used in both initial attack and in ongoing fire operations in the New England area. Localities that have wind turbines across the landscape would limit an aerial firefighting capability. Firefighting aircraft operate at low levels and often with limited visibility due to smoke. If a bush fire was in or around a wind farm then the Service would not be able to undertake an aerial attack of the fire and would have to wait until the fire was clear of the turbines. This would limit our initial attack capabilities and may, dependent on the ground based attack, increase the size of the fire. The RFS would classify the wind farm area as a "no fly" zone due to the danger to low level operations. Other considerations to aerial firefighting capabilities include any impacts to aerodromes and airstrips that may restrict access and accordingly impact on to the general aerial firefighting capability to a much greater area than the immediate wind farm.

Stakeholder	Contact Person	Comment
NSW Police Aviation Support Branch	Inspector Tim Calman Deputy Chief Pilot 1800 725 631 Calm1tim@police.nsw.gov.au	
Toll Aviation Brisbane	Andre ??? 07 3860 4477	Toll advised that they do not operate into Inverell or Glen Innes. Try Country Capital Aviation.
NSW Ambulance Service	Craig Thomas Chief Pilot/Base Manager Canberra 02 6264 6600 Brendan Kelly Chief Pilot CHC Helicopters Australia 02 9722 1600 Brendan.kelly@chc.ca	CHC has well developed and detailed operations manuals and safety management system which provide clear guidance to pilots with regard to operations in the vicinity of obstacles. WFs pose no greater threat to aviation activity than other known obstacles – i.e. communications towers etc. The proposed development would have minimal impact upon CHC aerial operations.

APPENDIX H

Glossary of Terms and Abbreviations

APPENDIX H

GLOSSARY OF TERMS and ABBREVIATIONS

Abbreviations used in this report, and the meanings assigned to them for the purposes of this report are detailed in the following table:

Abbreviation	Meaning
AC	Advisory Circular (document support CAR 1998)
ACFT	Aircraft
AD	Aerodrome
AHD	Australian Height Datum
AHT	Aircraft height
AIP	Aeronautical Information Publication
AIRPORTS ACT	Airports Act 1996, as amended
AIS	Aeronautical Information Service
ALA	Aeroplane Landing Area
ALT	Altitude
AMSL	Above Minimum Sea Level
A(POFA)R	Airports (Protection of Airspace) Regulations, 1996 as amended
APARs	Airports (Protection of Airspace) Regulations, 1996 as amended
ARP	Aerodrome Reference Point
AsA	Airservices Australia
ATC	Air Traffic Control(ler)
ATM	Air Traffic Management
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
Cat	Category
DAP	Departure and Approach Procedures (charts published by AsA)
DER	Departure End of (the) Runway
DEVELMT	Development
DME	Distance Measuring Equipment
Doc nn	ICAO Document Number nn
DITRDLG	Department of Infrastructure, Transport, Regional Development and Local Government. Also called “Infrastructure”. (Formerly Department of Transport and Regional Services (DoTARS))
DOTARS	See DITRDLG above
ELEV	Elevation (above mean sea level)
ENE	East North East
ERSA	Enroute Supplement Australia
FAF	Final Approach Fix
FAP	Final Approach Point
ft	feet

Abbreviation	Meaning
GA	General Aviation
GNSS	Global Navigation Satellite System
GP	Glide Path
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IHS	Inner Horizontal Surface, an Obstacle Limitation Surface
ILS	Instrument Landing System
ISA	International Standard Atmosphere
km	kilometres
kt	Knot (one nautical mile per hour)
LAT	Latitude
LLZ	Localizer
LONG	Longitude
LSALT	Lowest Safe Altitude
m	metres
MAPt	Missed Approach Point
MDA	Minimum Descent Altitude
MGA94	Map Grid Australia 1994
MOC	Minimum Obstacle Clearance
MOS	Manual of Standards, published by CASA
MSA	Minimum Sector Altitude
MVA	Minimum Vector Altitude
NDB	Non Directional Beacon
NE	North East
NM	Nautical Mile (= 1.852 km)
nnDME	Distance from the DME (in nautical miles)
NNE	North North East
NOTAM	NOtice To AirMen
OAS	Obstacle Assessment Surface
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OHS	Outer Horizontal Surface
OIS	Obstacle Identification Surface
OLS	Obstacle Limitation Surface
PANS-OPS	Procedures for Air Navigation Services – Aircraft Operations, ICAO Doc 8168
PRM	Precision Runway Monitor
PROC	Procedure
QNH	An altimeter setting relative to height above mean sea level
REF	Reference
RL	Relative Level
RNAV	aRea NAVigation
RNP	Required Navigation Performance

Abbreviation	Meaning
RPA	Rules and Practices for Aerodromes — replaced by the MOS Part 139 — Aerodromes
RPT	Regular Public Transport
RWY	Runway
SFC	Surface
SID	Standard Instrument Departure
SOC	Start Of Climb
STAR	Standard ARrival
TAR	Terminal Approach Radar
TAS	True Air Speed
THR	Threshold (Runway)
TNA	Turn Altitude
TODA	Take-Off Distance Available
VFR	Visual Flight Rules
V_n	aircraft critical Velocity reference
VOR	Very high frequency Omni directional Range

AMBIDJI

Our Ref: J0353

Mr. A. Maddocks
Senior Development Manager
Wind Prospect CWP Pty Ltd
PO Box 1708
NEWCASTLE NSW 2300

Dear Sir:

Sapphire Wind Farm – Aeronautical Impact Assessment
Increase in tip height

Wind Prospect has advised that the tip height of the wind turbines for the Sapphire Wind Farm will now be 157m AGL, comprising a 93m tower and 83m blade. The aeronautical studies undertaken earlier this year by Ambidji for this project were based on a tip height of "approximately 158m AGL".

This increase in tip height, although marginally decreasing the clearance from prescribed airspace, will not have any further significant impact on the aviation risk from the project. The maximum elevation of wind turbines will now be 1314m AHD, which is still below the lowest protection surface over the wind farm site; i.e. the Glen Innes airport 25NM Minimum Sector Altitude of 1315m AHD.

All findings and recommendations of the Ambidji Final Report "Proposed Sapphire Wind Farm – Aeronautical Impact Assessment, Qualitative Risk Assessment and Obstacle Lighting Review" dated 27 May 2011 still apply.

Yours faithfully
The Ambidji Group Pty Ltd

(Barrie Slingo)
Senior Associate

4 November 2011

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