Ref: 20100623-turbines
Date: 23 June 2010

Dear Mr Hawker,

WIND TURBINE WAKE PLUME
VELOCITY DEFICIT AND TURBULENCE

As per our latest telephone conversation I agreed to write a letter that you can present to the Victorian Review Panel handling the Stockyard Hill Wind Farm Application Number PL-SP/05/0548.

To assist with my analysis you provided me with a map detailing your ALA which included the location of the closest 20 turbines and distance arcs from your runway thresholds – which I will call the operational area map (Ref 8). This map is marked as Beaufort (Hawkwood) YBFT. I also sourced data from the Stockyard Hill Wind Farm Pty Limited website http://www/stockyardhillwindfarm.com.au, and it was determined that the proponent's submission involves turbines with a blade tip diameter of 104 metres.

With the information supplied from you that the strongest prevailing winds are typically from the North West, West and South West directions, and then surveying the turbine proposed locations on your operational area map, I can see two clusters of turbines that will directly affect your ALA operational area to varying degrees of extent, namely the clusters : T40, T52, T59, T37, T46, T55, T53, T39, T41, T50, T64 and T62 for direct take-off and landing, and clusters: T75, T76, T78, T81, T82, T74, T79 and T86 which will affect crosswind operations.

Before I present my arguments I wish to draw your attention to the statements from the proponent's own submissions, namely:

- from Part 1 Section 81 (Ref 1) "that greater capacity turbines may be chosen", and
- from Part 2 Section 5 and ongoing sections entitled CASA (Ref 2), where they indicate that CASA is currently investigating the danger of Wind Turbines to air traffic, and wants notification when a wind-farm is within 30 km of an airport.

Studies have been published demonstrating the presence of wake turbulence and velocity deficits associated with airflow around wind turbines (see Ref 3 for a summary).

By its very design a wind turbine is extracting a significant amount of energy from the free flow airstream. The extraction of this energy results in a velocity deficit in the wind behind the turbine that extends for a considerable distance downstream; the extent is in proportion to the diameter

subscribed by the blade tips, where the bigger the blades the further this deficit extends. The deficit is also largely contained behind the turbine for considerable distances; picture the disturbance as a horizontal plume captured between the blade tips and subsequently contained by the ground further downstream – this is a classic vortex, one end of which always terminates on the ground.

Also contained within the plume are large turbulence components that also extend downstream.

The turbulence is particularly bad immediately behind the turbine, and is still quite severe 5 blade-diameters downstream. This turbulence mixes in with the velocity deficit to make a wake-field that contributes further to the danger of the velocity deficit.

The extent of the deficit has been observed more than 15 km downstream in the case of the Horne Revs offshore wind farm running the relatively small Siemens SWT-2.3-93 turbines (2.3 MW, 93 m diameter blades) – that represents 161 blade diameters down-stream (Ref 3 & 4).

Wind tunnel studies show deficits at more than 16 blade diameters downstream - which would possibly be outside the extent of most wind-tunnels, and by extrapolation of the rate of change of the velocity data, the deficit may extend more than 50 blade diameters (Ref 3). For the proponent's proposed turbines that is 5,200 metres.

This velocity deficit represents a void to flight, and the associated turbulence in the close field behind a turbine would be particularly troublesome to the passage of an aircraft. The magnitude of the velocity deficit is severe, at times representing a wind-speed less than one third of the speed of the surrounding air. See the images on pages: 7, 8, 9 and 11 of Section 1 of the Wind Turbine submission to the NSW Environment Court (Ref 3).

Consider that a reduction of this relative magnitude can reduce the airflow around the wing of an aeroplane to such an extent that the wing stalls. This affect is particularly troublesome for the approach, descent and take-off associated with aircraft landing areas because this is when aircraft are operating at considerable reduced air speed making the safety margin to stall nominal. A deficit such as illustrated, and as supported by anecdotal evidence (Ref 5), represents a serious collapse in performance parameters that may lead to an aircraft suffering a dangerous incident or even crashing.

The proponent's statement in reference 2 acknowledges that CASA is concerned, that CASA intends to develop policy governing turbines – which I would like to add is a direct result of me lobbying them through correspondence, and indirectly through the presentations I made to the NSW Environment Court.

At this court the finding was that 11 turbines be removed from the proposal affecting the Crookwell Aerodrome, now these turbines were within 3.6 km from the runway threshold which represents only 38 blade-diameters of setback. Had these research findings been available early on in the submission process there would have been more opportunity to request for a setback of at least 50 blade-diameters.

Note that the wake plume velocity deficit extent depends on the size of the blade-tip diameter, should larger turbines be permitted, as indicated in the proponents submission part 1 (Ref 1), then allowance must be made for even greater distances downstream.

The NSW Environment court upheld the rejection of 11 turbines at Crookwell on the basis of aviation safety, and they stated that should the proponent wish to contest the rejection that they are to commission a thorough analysis to prove that such turbines are not hazardous to aviation under their duty of care, and at their cost.

Allowance must also be made for the operational area that an aircraft requires to circle and land, and to circle and climb when making the determination of a setback.

The operational area depends very much on aircraft performance; the larger the aircraft, the more room it requires. Under the ICAO recommendations a category B aircraft requires a manoeuvring area of 2.66 nautical mile radius (4.92km), and a Category A aircraft requires one of 1.68 nautical mile radius (3.11km) – measured from the runway thresholds (See ref 6.)

I understand that a light twin with an approach speed of 95Kts operates from this ALA, which would mean that the Category B criteria should be allowed. The aircraft typically requires that much operational area for safe manoeuvring - the aircraft performance does not change despite the legislation not applying to an ALA.

A light twin is also particularly susceptible to the change in airspeed that such turbine velocity deficit would represent, and an encounter with such a deficit is more likely to result in the airflow falling below the minimum control speed (Vmc). Under these conditions, if they were sustained for a period, the aircraft would crash, and it would certainly be subjected to loss of altitude (Ref 5).

Thus I would argue for an operational area of 4920 meter radius from the runway threshold for Category B aircraft and a setback of turbines from this operational area of 50 blade diameters. This represents an additional 5200 meters for turbines with the proposed 104 metres blade-tip diameter.

I wish this to be put to the panel, and to the proponent, that a comprehensive study be conducted under duty of care before allowing any turbines within the setback distance of 50 blade-diameters from the Category A or Category B circling area radius as deemed appropriate for the airport use. I recommend that such a study be reviewed by parties independent to the proponent's witness, and to be operated under the Review Panel's instructions.

I also refer you to the video footage of "Windmills In the Mist" for visual evidence of the wake plume effect (Ref 7)
http://www.arising.com.au/aviation/windturbines/WindmillsInTheMist20090904.MOV

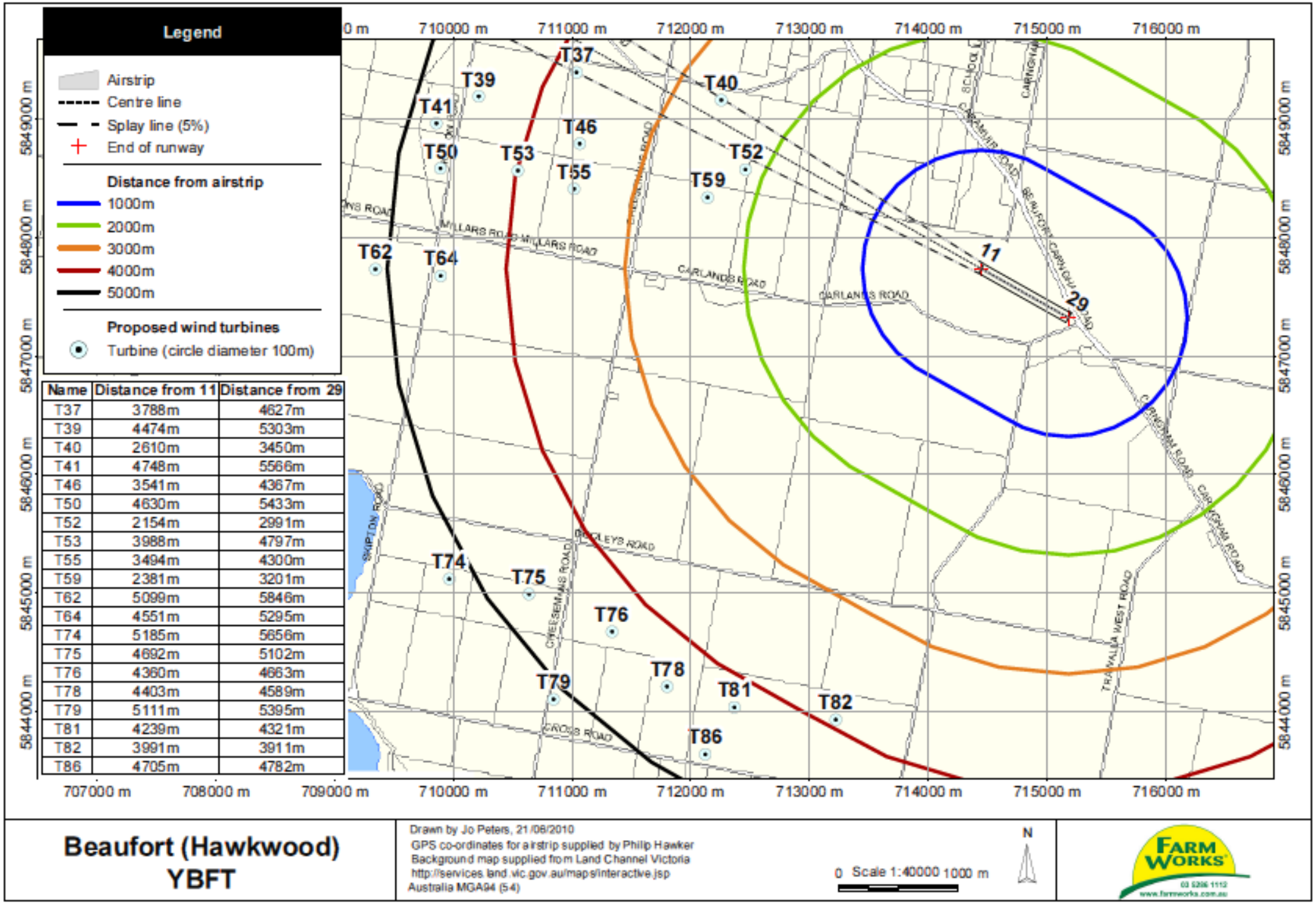
Yours sincerely,

Ralph B. Holland
B Sc., Dip Ed, Dip Com Sc.

References:

1. Stockyard Hill Wind Farm Application
   http://www.stockyardhillwindfarm.com.au/pdf/EWPP/SubBehalfofProponent_part1.pdf
2. Stockyard Hill Wind Farm Application
   http://www.stockyardhillwindfarm.com.au/pdf/EWPP/SubBehalfofProponent_part2.pdf
3. Submission to NSW Environment Court regarding MP 070118 Gullen-Range Wind Farm development http://www.arising.com.au/aviation/windturbines/WindTurbines-2.pdf
4. Siemens SWT-2.3-93 turbine http://www.thewindpower.net/wind-turbine-datasheet-22-siemens-swt-2.3-93.php
5. Flying behind a wind turbine – don't do it
   http://www.arising.com.au/aviation/windturbines/RichardThompson.pdf
6. Hard Landing, Flight Safety Australia, September-October 2002, A CASA Safety magazine
   http://www.casa.gov.au/wcmswr/_assets/main/fsa/2001/sep/34-39.pdf
7. Video: Wind Turbines in the Mist
   http://www.arising.com.au/aviation/windturbines/WindmillsInTheMist20090904.MOV
8. Your operational Area Map attached.

All references have been confirmed active at the time of writing, if you are unable to access these then relevant material is available on request.



Name	Distance from 11	Distance from 29
T37	3788m	4627m
T39	4474m	5303m
T40	2610m	3450m
T41	4748m	5566m
T46	3541m	4367m
T50	4630m	5433m
T52	2154m	2991m
T53	3988m	4797m
T55	3494m	4300m
T59	2381m	3201m
T62	5099m	5846m
T64	4551m	5295m
T74	5185m	5656m
T75	4692m	5102m
T76	4360m	4663m
T78	4403m	4589m
T79	5111m	5395m
T81	4239m	4321m
T82	3991m	3911m
T86	4705m	4782m

Beaufort (Hawkwood)
YBFT

Drawn by Jo Peters, 21/08/2010
GPS co-ordinates for airstrip supplied by Philip Hawker
Background map supplied from Land Channel Victoria
http://services.land.vic.gov.au/maps/interactive.jsp
Australia MGA94 (54)

0 Scale 1:40000 1000 m

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