

Expert Witness Statement of Christophe Frederic Delaire

(Expert retained by Union Fenosa Wind Australia Pty Ltd)

1 Name and address

CHRISTOPHE FREDERIC DELAIRE

Senior Acoustic Consultant

Marshall Day Acoustics Pty Ltd

6 Gipps Street, Collingwood.

Victoria 3066

2 Area of expertise

- (a) For over 7 years I have worked in the field of acoustics and noise control. I have a special interest in environmental noise.
- (b) My qualifications and experience are detailed in Annexure A.
- (c) I am sufficiently expert to make this statement because I have been involved in environmental noise impact assessments for major environmental projects such as power stations, wind farms and other industrial plants.

3 Scope

3.1 Instructions

My company, Marshall Day Acoustics Pty Ltd (MDA), was commissioned by Union Fenosa Wind Australia Pty Ltd (Union Fenosa) to prepare a noise impact assessment of the proposed Berrybank Wind Farm to be located near the township of Berrybank, Victoria. This assessment was contained within the planning permit application report. I have reviewed that assessment.

I have been engaged by Union Fenosa to provide expert evidence on noise issues associated with the operation of the Berrybank Wind Farm.

3.2 Process and methodology

I have undertaken my assessment in accordance with the *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria 2003* (Victorian Wind Energy Guidelines).

These guidelines require the noise impact assessment to be undertaken in accordance with the New Zealand Standard NZS6808:1998 – *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZ Standard).

The Victorian Wind Energy Guidelines document was recently updated. Section 4.9.1.3.a of the revised Guidelines dated September 2009 state the following:

Evaluation by the responsible authority

A wind energy facility should comply with the noise levels recommended for dwellings in the New Zealand standard NZ6808:1998 Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators.

During the assessment phase of the noise impact, particular attention to the following matters within the Standard is required:

- Separate correlation of background sound levels with the wind speed for different wind directions and/or the time of day (Clause 4.5.5 of the Standard), and*
- Wind speed measurements at the hub height of the proposed turbines as - recommended in the Note to Clause 4.5.6.*

I consider that the noise impact assessment for the Berrybank Wind Farm complies with the revised 2009 Victorian Wind Energy Guidelines. In particular, wind speeds have been referenced to hub height (80m) and noise limits have been determined for the night-time period in addition to the 24 hour period.

The NZ Standard states that the noise level from a wind turbine or wind farm at a residential site should not exceed the background noise level (L_{A95}) by more than 5dBA or a level of 40dBA L_{A95} , whichever is greater. The NZ Standard also requires a minimum of 10 days continuous background noise monitoring at selected affected sites.

In addition, my assessment considers the European Working Group on Noise from Wind Turbines (ETSU-R-97) document which recommends, where the occupier of the property has some financial involvement in the wind farm, that both daytime and night-time lower fixed limits can be increased to 45dBA and that consideration should be given to increasing the permissible margin above background noise level.

Noise levels due to the presence of the wind turbines have been calculated using the method described in the NZ Standard and compared with the NZ Standard noise limits to assess compliance. This method for predicting noise levels is generally accepted as being slightly conservative (i.e. over-prediction of the sound levels).

The Berrybank Wind Farm is proposed to consist of a total of one hundred (100) wind turbines. The proposed turbine layout is presented in Annexure B. Six (6) different wind turbine models have been considered by Union Fenosa for this assessment. These are presented in Table 1.

Table 1
Selected wind turbine models

Model	Power output	Hub height	Rotor diameter
Vestas V90	2.0MW	80m	90m
Vestas V100	1.8MW	80m	100m
Nordex N100	2.5MW	80m	100m
Siemens SWT-101	2.3MW	80m	101m
Repower MM92	2.0MW	80m	92.5m
Mitsubishi MWT-95	2.4MW	80m	95m

The sound power level data for the selected wind turbines has been provided to Union Fenosa by the respective manufacturer.

The following work was undertaken by Marshall Day Acoustics Pty Ltd:

- Calculation of preliminary noise predictions at the surrounding residential properties using the NZ Standard simple prediction method
- Identification of sites within the 35dBA contour for noise assessment and background noise monitoring
- Background noise level measurements at eleven (11) of the thirty-five (35) residential properties which were determined as potentially sensitive to noise impact
- Calculation of appropriate night time and 24 hour noise limits at the monitored residential sites, using the method outlined in the NZ Standard
- Calculation of the predicted noise levels at each selected residential site based upon each of the six (6) selected wind turbines, using the method described in the NZ Standard

Property details are presented Table 2.

Table 2
Assessed residential sites

House	Easting	Northing	Maximum predicted preliminary noise levels, dBA
9 (S)	724123	5799807	40
10 (U)	718587	5797888	39
18	719391	5803724	37
27	716501	5793929	37
28	715923	5793021	36
54 (S)	720176	5800321	45
55 (S)	719613	5799970	42
56 (U)	719602	5799532	41
57	719459	5799651	41
58	717818	5801367	38
60	717667	5797118	35
61 (S)	719390	5796269	43
62 (S)	721670	5796577	43
63	722798	5796160	40
64	724012	5796148	37
65 (SU)	723797	5798337	47
66 (S)	722414	5798736	44
67 (S)	718431	5793106	39
68 (SU)	718429	5793061	39
69	718535	5793693	40
70	718346	5793752	40
71 (S)	718590	5793405	39
72	718520	5793406	39
73	718619	5792068	37
74	718006	5791092	35
76 (SU)	722703	5792293	48

House	Easting	Northing	Maximum predicted preliminary noise levels, dBA
78 (S)	720663	5793064	43
79	719983	5793140	41
80	719684	5793375	41
81 (SU)	719130	5793548	40
83	721502	5791385	39
84	723128	5790975	35
102	725109	5796692	37
103	723431	5793860	41
109 (U)	718502	5793373	39

Note: (S) stakeholder property - (SU) uninhabitable stakeholder property
(U) uninhabitable non-stakeholder property

Twelve (12) of the thirty-five (35) assessable residential properties were selected for background noise monitoring. These sites were selected as representative of the other properties in the vicinity of the proposed site. Residents at two (2) of the properties, Houses 57 and 60 which are located to the west of the proposed site, did not allow us to monitor background noise levels at their properties. Background noise monitoring was however undertaken at an uninhabitable property, House 10, which is nearby to House 57 and 60.

Table 3 lists the eleven (11) sites where background noise monitoring was carried out, as well as twenty (20) indicative sites that will share common limits. Houses 9, 65, 66 and 76, are stakeholders in the project and were therefore not considered for background noise monitoring. The minimum possible ETSU-R-97 noise limit of 45dBA has been applied at these houses at all wind speeds.

Table 3
Background monitoring sites

House	Indicative of	Monitoring period
10 (U)	60, 61 (S)	12.03.09 to 25.03.09
18	-	12.03.09 to 25.03.09
27	28	12.03.09 to 27.03.09
58	54 (S), 55 (S), 56 (U), 57	12.03.09 to 26.03.09
63	62 (S), 64, 103	02.04.09 to 15.04.09*
70	67 (S), 68 (SU), 69, 71 (S), 72, 109 (U)	12.03.09 to 26.03.09
73	-	12.03.09 to 27.03.09
74	-	12.03.09 to 26.03.09
80	78 (S), 79, 81 (SU)	12.03.09 to 24.03.09
83	84	12.03.09 to 26.03.09
102	-	12.03.09 to 26.03.09

Note: (S) stakeholder property - (SU) uninhabitable stakeholder property
(U) uninhabitable non-stakeholder property

* measurement repeated due to equipment failure during the 1st monitoring period

Marshall Day Acoustics' report - *Berrybank Wind Farm Noise Assessment* 001 R01 2007398 dated 28 May 2009 was prepared with the assistance of the following staff member:

Staff member	Title	Tasks
Mr Dan Griffin	Senior Consultant	Assistance with background noise monitoring Review of report

3.3 Documents reviewed

I have taken into account the following reports and materials:

- *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria*, 2003
- *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria*, September 2009
- New Zealand Standard NZS6808:1998 – *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZ Standard)
- ISO Standard ISO9613–2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method for calculation* (ISO Standard)
- Final report by The European Working Group on Noise from Wind Turbines (ETSU-R-97, item 24, p(viii))
- Wind turbine manufacturer sound power level data:
 - Vestas General Specification 950019.R5 dated 07/09/05
 - Vestas preliminary specification from Product Presentation dated 11/03/09
 - Nordex document F008_228_A03_EN dated 01/01/09
 - Siemens document E R WP-EN431-10-0000-0172-00 dated 31/03/09
 - Wintest report WT 4993/06 (extract from WT 4992/06) dated 03/03/06
 - Wintest draft report WT 6756/08
- van den Berg G.P., *Effects of the wind profile at night on wind turbine sound*, 2003

4 Findings

4.1 Noise assessment using six (6) selected wind turbine models

Six different wind turbine models are presently being considered by Union Fenosa for the project and all six (6) turbine models have been considered in this noise impact assessment.

It was found that using Vestas V90 wind turbines, both the 24 hour and night-time NZS6808:1998 noise limits are achieved at all assessed non-stakeholder's residential properties and are only exceeded at two (2) uninhabitable stakeholder properties.

NZS6808:1998 24 hour and night-time noise limits are likely to be achieved using the remaining five (5) selected wind turbine models at all properties in the vicinity of the Berrybank Wind Farm if an appropriate noise management plan is implemented.

Modern turbines can be operated in noise management modes for different wind conditions (direction, speed) or time of day. Once sound power level data is available from the respective manufacturer for noise management operation, the noise impact of the Berrybank Wind Farm can be reassessed to demonstrate compliance with both the 24 hour and night-time NZS6808:1998 noise limits.

If necessary, the noise management plan can be refined during the post-construction noise assessment of the wind farm.

4.2 Effects of stable air ("Van den Berg effect")

The 2003 study on the effect of stable air on wind farm noise emissions undertaken by Dr van den Berg in Germany was discussed in Section 4.9 of the noise assessment exhibited with the permit application. The noise impact assessment for the Berrybank Wind Farm was undertaken with wind speeds referenced at hub height (80m) in order to reduce the potential effects of air stability on predicted noise levels.

4.3 Summary of opinions

The report prepared by Marshall Day Acoustics was exhibited as part of the planning permit application, and I have used the findings within that report as the basis for my expert witness statement and evidence. A summary of my findings is contained within this statement.

The Berrybank Wind Farm is proposed to consist of a total of one hundred (100) wind turbines. Six (6) different wind turbine models have been considered by Union Fenosa for this assessment. Sound power data used to predict the noise impact of this turbine was provided to us by Union Fenosa.

The method described in the NZ Standard has been used to calculate the predicted noise level at each assessed residential site for the six (6) selected wind turbine models. Comparison of the predicted noise levels, using Vestas V90 turbines, and the noise limits indicates that all twenty-two (22) assessed non-stakeholders' residential properties will comply with both the 24 hour and night-time NZS6808:1998 noise limits.

Using Vestas V90 wind turbines, the NZS6808:1998 noise limits are exceeded at four (4) of the thirteen (13) assessed stakeholders' properties. However, predicted noise levels at two (2) of these four (4) stakeholders' properties will comply with the recommended limit for beneficiaries of such projects as outlined in ETSU-R-97.

The remaining two (2) stakeholders' properties are currently derelict and have been considered uninhabitable.

Using the other five (5) selected wind turbine models, compliance with the 24 hour and night-time noise limits will not be achieved without appropriate noise management settings.

Compliance is likely to be achieved with an appropriate noise management plan specific to each wind turbine model.

Predicted wind farm noise emission at all non-assessed residential properties further from the wind farm are 35dBA or less, well below the lowest possible limit set by the NZ Standard of 40dBA, by at least 5dBA or more.

5 Response to key submissions

I have reviewed key submissions that raise issues relating to noise and make the following responses.

Literature references are presented in Annexure H.

Submitter	Noise issues	Comment
Graham & Catherine Keating (H74)	stated that the current NZS6808:1998 is outdated.	See Annexure C
	stated that no input was requested from them regarding unusual weather activities and seasonal noises of nature during the background noise monitoring at their property	Unattended background noise monitoring was undertaken in accordance with NZS6808:1998. There was good correlation between measured background noise levels and wind speeds. Predicted noise levels at H74 using the V90 wind turbine model comply by at least 4dBA with the minimum possible noise limit of 40dBA which is not dependant on background noise levels.
	stated that both the 24 hour and night-time background regression line of best fit is as high as 52dBA and felt that the background noise levels were very high overall.	House 74 is surrounded by tall pine trees. It would therefore be expected for the noise environment to be high during periods of high wind speeds. This high background noise level is also expected to provide significant masking noise.
stated that several data points exceeding 50dBA should be excluded from the analysis as they incorrectly overstate the line of best fit. It is their view that these points are most likely one off noises not attributable to background noise.	One of the limitations of unattended noise monitoring is the limited control over measured events. However, the descriptor used for the background noise monitoring is LA95 which represents the noise level exceeded for 95% of the time. This means that high transient noise levels (such as bird squawk) will not affect the measurements significantly. High noise level events are part of the background noise at the property and should not be removed.	

Submitter	Noise issues	Comment
Graham & Catherine Keating (H74)	provided comments about the noise impact assessment prepared by Marshall Day Acoustics for the substation proposed to be associated with the Stockyard Wind Farm and to be located in the vicinity of the Berrybank wind Farm site.	Noise from substations is covered by the EPA Interim Guidelines N3/89. These interim guidelines (currently under review) are not applicable to wind farms. The Victorian Wind Energy Guidelines requires the use of NZS6808:1998 to assess noise emissions from wind farms.
	are concerned that the noise of nature is significantly different to turbine noise.	I agree that there is a difference.
	are concerned that one test does not give significant scientific reading of undisputable value.	The background noise monitoring has been undertaken in accordance with NZS6808:1998 which requires one set of measurements for a minimum period of 10 days.
	are concerned that they will be affected by low frequency noise.	See Annexure D
	stated that no decision has been made on the type of turbine to be used for this project.	See Section 4.1
	are concerned about the health effect of noise emissions from wind turbines as presented in the Media in relation to the Waubra Wind Farm	See Annexure D
	are requesting for a minimum 2km setback.	Noise emissions from the Berrybank wind Farm comply with the NZS6808:1998 noise limits at their dwelling (H74). The Victorian Wind Energy Guidelines and NZS6808:1998 do not recommend specific setbacks but compliance with a set of noise limits.
	are concerned about occupational health and safety on their property due to the presence of the wind farm.	See Annexure E

Submitter	Noise issues	Comment
Brendan Keating (H75)	concerned about the health effect of noise emissions from wind turbines as presented in the Media in relation to the Waubra Wind Farm	See Annexure D
	states that recent research by the University of Ballarat concluded that noise levels at the Waubra wind Farm are well above the acceptable level.	I am not aware of any report by the University of Ballarat regarding noise emissions from the Waubra Wind Farm.
	concerned about what Union Fenosa would do if he is adversely affected by the wind farm.	NZS6808:1998 requires that post-construction noise monitoring be undertaken once the wind farm is operating. How people are affected by a noise source is highly subjective. The aim of NZS6808:1998 is to provide noise limits to minimise the impact of the wind farm. If it is found that the wind farm noise emissions do not comply with NZS6808:1998 noise management will be required to achieve compliance.
	concerned about occupational health and safety on their property due to the presence of the wind farm.	See Annexure E
Patrick D. Toohey	concerned about occupational health and safety on their property due to the presence of the wind farm.	See Annexure E
	concerned about health issues relating to the Berrybank wind farm in particular for babies and disabled people.	See Annexure D and F

Submitter	Noise issues	Comment
Kathy Russell	stated that the noise assessment report does not address in any significant manner the known effects of audible wind farm noise due to special audible characteristics (modulation effects in particular) on human perception, annoyance and sleep disturbance.	<p>See Annexure F and G</p> <p>NZS6808:1998 requires that predicted noise levels from wind turbine with known special audible characteristics must be adjusted by a 5dB penalty. Although amplitude modulation has been identified at a few sites worldwide.</p> <p>To my knowledge, it hasn't been identified at any Australian site.</p> <p>It cannot be fully predicted and therefore it would not be appropriate to apply the 5dB penalty for amplitude modulation during the planning stage.</p> <p>During the design stage, the only predictable special audible characteristic is tonality. Information about the presence of audible tones is generally provided by wind turbine manufacturers.</p>
	stated that the noise assessment report does not address the effects of infrasound and low frequency sound on human perception, annoyance and sleep disturbance as well as the debated potential for adverse health effects on persons within the locality of the wind farm.	See Annexure D and F
	stated that the noise assessment report contains substantial technical deficiencies.	It is not possible to comment unless more detail is provided to identify the areas where Kathy believes technical deficiencies occur.
	stated that she has specific evidence on the health effects of the Waubra Wind Farm on residents in that local community.	<p>It is not possible to comment unless this specific evidence is provided for review.</p> <p>I am not aware of any published report regarding noise emissions from the Waubra Wind Farm and the alleged health effects.</p>
	states that manufacturers' specification stipulate that sitting turbines too close to each other, near plantations or on gradients greater than 10 degrees could have a detrimental impact in respect to noise and vibration.	It is not possible to comment unless the manufacturers' specifications mentioned are provided for review.

Submitter	Noise issues	Comment
David Hocking (H105)	stated that compliance with the NZS6808:1998 will not result in the turbines being inaudible.	I agree that compliance with NZS6808:1998 will not result in the turbines being inaudible. The aim of NZS6808:1998 is to minimise the impact of the wind farm, not to make it inaudible to surrounding residents. Turbines will be more likely to be audible when a dwelling is located downwind from the wind farm. When the dwelling is located upwind from the wind farm, it will be less likely to be audible.
	concerned about the difficulty and uncertainty associated with predicting wind farm noise emissions.	Noise predictions have been undertaken in accordance with the NZS6808:1998 simple prediction method
	concerned that acceptable emission level of 40dBA will impact on his family's ability to sleep at night.	See Annexure F
	concerned about the health effect of low frequency noise emissions from wind turbines as presented in the Media in relation to the Waubra Wind Farm.	See Annexure D
	stated that recent research shows that computer model used to predict noise levels assumes ideal stable weather conditions, which are very often not the case at Berrybank.	The NZS6808:1998 simple prediction method has been used to predict noise emissions from the Berrybank Wind Farm in accordance with NZS6808:1998. As presented in Section 4.2, the noise impact assessment for the Berrybank Wind Farm was undertaken with wind speeds referenced at hub height (80m) in order to reduce the potential effects of air stability on predicted noise levels.
	stated that Kamperman and James (<i>Why noise criteria are necessary for proper siting of wind turbines</i> , 2008) indicate that the noise level limits of 50-55dBA at the nearest home, recommended by the wind industry, are far too high for the quiet nature of rural communities and pose health risks for the nearest residents.	The noise limits mentioned by Kamperman and James are from the USA and are significantly higher than those provided by NZS6808:1998. See Annexure F
	mentioned a Youtube video presenting the noise impact at a nearby resident of a wind farm in Wisconsin, USA.	The video states that the nearest turbine is located approximately 350m from the subject dwelling. The nearest non-stakeholder property is located approximately 1km from the nearest Berrybank Wind Farm wind turbine.

Submitter	Noise issues	Comment
David Hocking (H105)	concerned about the actions that Union Fenosa would take if the post-construction noise monitoring program indicates that the wind farm noise emissions do not comply with NZS6808:1998. David is also concerned about the potential adverse effects from non compliance.	NZS6808:1998 requires that post-construction noise monitoring be undertaken once the wind farm is operating. How people are affected by a noise source is highly subjective. The aim of NZS6808:1998 is to provide noise limits to minimise the impact of the wind farm. If it is found that the wind farm noise emissions do not comply with NZS6808:1998 noise management will be required to achieve compliance.
Anne and Allan Schafer (H63)	concerned about the noise generated by the wind turbines effecting their health, well-being and ability to reside on their property.	See Annexure D and F
	mentioned a recent Foreign Correspondent programme on ABC television (3/11/09). In this programme a Danish wind farm engineer said that the major reasons for now placing wind turbines offshore was that "they make noise".	I agree. Wind turbines make noise and placing wind turbines offshore is likely to generally reduce levels of noise emission onshore.
	concerned that their ability to sleep may be compromised.	See Annexure F
	concerned that the noise and its effects will be amplified by the intensive placement so close to their home.	I agree that noise levels are higher the closer and the more numerous wind turbines are near a dwelling. Noise emissions from the final selected wind turbine model will need to comply with the NZS6808:1998 noise limits, regardless of whether a noise management plan is required to achieve compliance.
	concerned about the methodology of gathering background noise levels and their interpretation at their property.	Background noise monitoring has been undertaken in accordance with NZS6808:1998.

Submitter	Noise issues	Comment
Anne and Allan Schafer (H63)	<p>stated that they kept a diary of the weather and general activity and noted that there was some 24 hour tractor activity on their western property boundary, approximately 100m from the recorders.</p> <p>They also stated that they were surprised that background noise levels at their property were the highest.</p> <p>They further stated that factors affecting noise levels, such as weather conditions and tractor use, should also be recorded to give an accurate and comprehensive picture.</p>	<p>Review of the data collected during the second survey did not indicate having been affected by a constant noise source over several hours.</p> <p>One of the limitations of unattended noise monitoring is the limited control over measured events.</p> <p>However, the descriptor used for the background noise monitoring is LA95 which represents the noise level exceeded for 95% of the time. This means that high transient noise levels (such as bird squawk) are not affecting the measurements significantly.</p> <p>High noise level events, such as farming activities, are part of the background noise at the property and should not be removed.</p> <p>Background noise levels collected at this property are not the highest measured around the site at all wind speeds.</p>
	<p>stated that in a telephone conversation with me they discussed the background noise monitoring and the request to repeat the noise monitoring</p>	<p>The background noise survey presented in the noise impact assessment has been undertaken in accordance with NZS6808:1998. The data collected during the second survey has been deemed valid and therefore no further survey is required in accordance with NZS6808:1998.</p>
	<p>stated that selecting background noise levels as representative of the background noise levels for other properties to the east of the proposed site is not accurate.</p>	<p>The most critical range of wind speed for assessing compliance with NZS6808:1998 is below 10m/s before rated power. At rated power, sound power levels typically plateau.</p> <p>Background noise levels measured at H63 are the lowest below 10m/s for the properties located to the east of the proposed wind farm and the second lowest for all the monitored properties.</p> <p>Therefore we believe that the use of the noise limits derived from the background noise levels measured at H63 is acceptable and conservative.</p>
	<p>concerned about effect of low frequency noise.</p>	<p>See Annexure D</p>
	<p>are concerned about the fact the recommendation to operate certain wind turbine models in noise managed mode.</p>	<p>See Section 4.2</p>

Submitter	Noise issues	Comment
Darryl J Baxter (H102)	concerned about noise levels and the impact of low frequency noise.	See Annexure D
	concerned about the health effect of low frequency noise emissions from wind turbines as presented in the Media in relation to the Waubra Wind Farm.	See Annexure D
	concerned that the proposed wind farm will affect the amenity of their land and dwelling.	Noise emissions from the final selected wind turbine model will need to comply with the NZS6808:1998 noise limits. Noise management plan may be required if necessary. How people are affected by a noise source is highly subjective. The aim of NZS6808:1998 is to provide noise limits to minimise the impact of the wind farm.
Corangamite shire Council	recommended that Union Fenosa investigate noise impacts that are likely to be experienced by farmer operators carrying out their business in the vicinity of the turbines. The Council also recommended that the proponent provide information on any implications the wind farm has on ability of surrounding farm operators to meet occupational health and safety requirements.	See Annexure E

6 Conclusion

It is planned to install one hundred (100) wind turbines. Six (6) different wind turbine models have been considered by Union Fenosa for this assessment.

Using Vestas V90 wind turbines, the NZS6808:1998 noise limits are exceeded at four (4) of the thirteen (13) assessed stakeholders' properties. However, predicted noise levels at two (2) of these four (4) stakeholders' properties will comply with the recommended limit for beneficiaries of such projects as outlined in ETSU-R-97.

The remaining two (2) stakeholders' properties are currently derelict and have been considered uninhabitable.

Using the other five (5) selected wind turbine models, compliance with the 24 hour and night-time noise limits will not be achieved without appropriate noise management settings. Compliance is likely to be achieved with an appropriate noise management plan specific to each wind turbine model.

Predicted wind farm noise emission at all non-assessed residential properties further from the wind farm are 35dBA or less, well below the lowest possible limit set by the NZ Standard of 40dBA, by at least 5dBA or more.

7 Declaration

I have made all the enquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the panel.

Christophe Frederic Delaire

4 February 2010

Annexure A – Qualifications

Qualifications

- Dipl.Ing. (France) Diploma of Engineering
from Ecole Supérieure d'Ingénieurs de Poitiers (France)

Employment history

- 2002 – Present

Senior Consultant, Marshall Day Acoustics Pty Ltd, Melbourne, Australia
Consultants in acoustics and noise control.

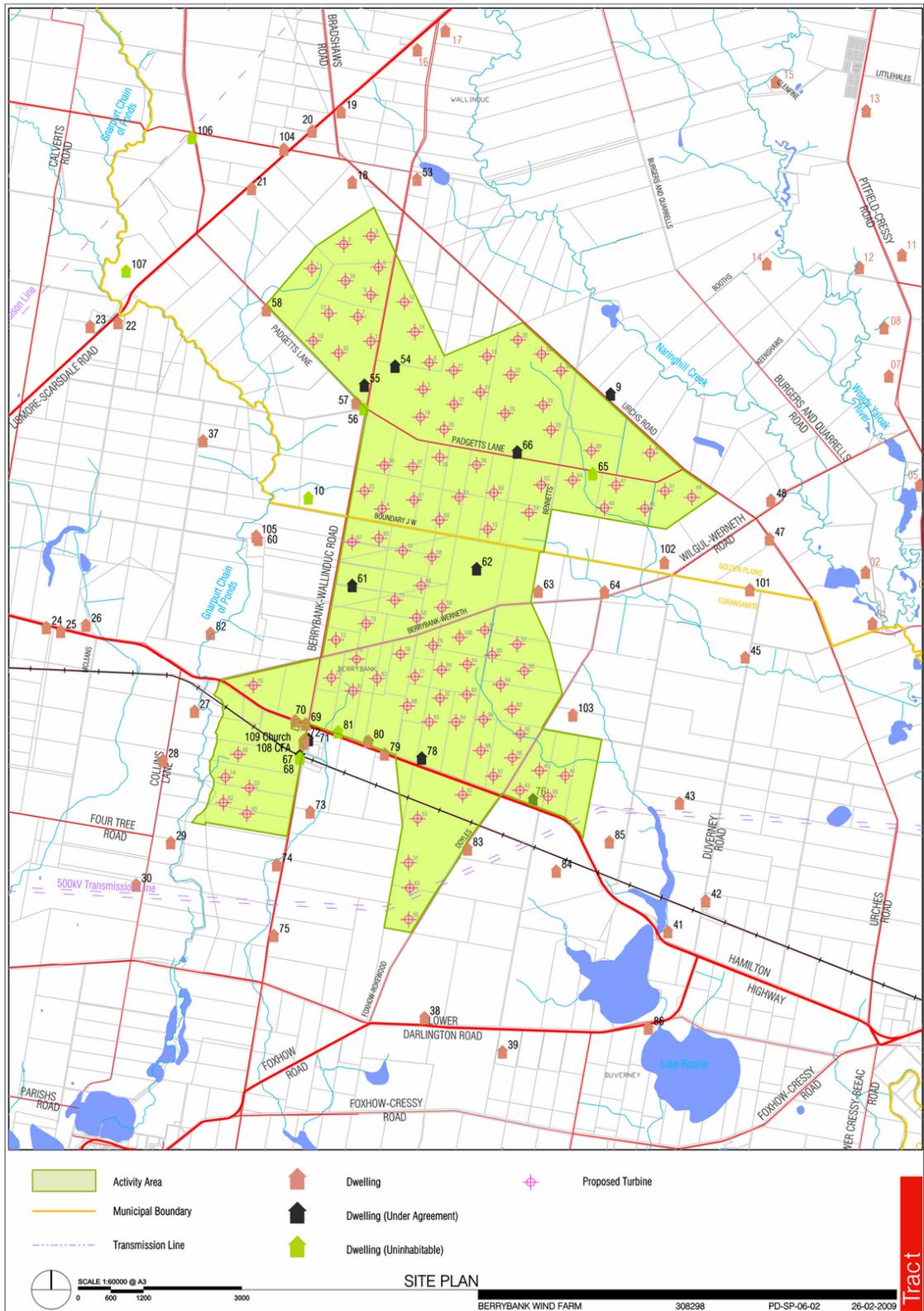
Responsibilities include consulting work in environmental noise impact (including wind farms), industrial noise control, building services noise control, and architectural sound insulation

Noise impact assessments of Victorian wind farm developments at Bald Hills, Wonthaggi, Chalicum Hills, Portland, Waubra, Ryan Corner, Hawkesdale, Mt Gellibrand, Mt Mercer, Hepburn, Yarram, Newfield, Oaklands Hill, Winchelsea, Crowlands, Mortlake, Lal Lal, Berrybank, Sidonia Hill, Stockyard Hill, Moorabool and Yaloak South.

- 2001

Vacation Employment, Marshall Day Acoustics Pty Ltd, Melbourne, Australia
Consultants in acoustics and noise control.

Annexure B – Proposed Site Plan



Annexure C - Revised NZS6808, Draft Australian Standard and National Guidelines

(a) *DZ6808v2.5 Acoustics – Wind farm noise*

NZS6808:1998 has been revised and a Public Comment Draft was made available by Standards New Zealand in February 2009 with closing date for comments on 30 April 2009. It is my understanding that the standard has now been finalised and is expected to be released in February 2010.

The methodologies employed in DZ6808v2.5 are very similar to those proposed in NZS6808:1998. The key differences are not of methodology but of general refinement and clarification of technical detail.

Considering the similarities between the methodology presented in DZ6808v2.5 and the methodology used in the Berrybank Wind Farm noise impact assessment, it is my opinion that the Berrybank Wind Farm would comply with DZ6808v2.5. However, no formal assessment against the draft standard has been carried out.

(b) *DR AS 4959 CP Acoustics—Measurement, prediction and assessment of noise from wind turbine generators*

A draft Australian Standard for measurement, prediction and assessment of wind farm noise emissions was available in 2002 and then in 2007 and referenced DR 07153 CP.

In November 2009, a Public Comment Draft with a new designation as noted above was made available by Standards Australia with closing date for comment on 14 December 2009. It is my understanding that the finalised standard is expected to be released in early 2010.

The fundamental approach and methodologies for assessment of wind farm noise emission proposed by DR AS 4959 are broadly consistent with those described in NZS6808:1998. The most significant difference is that, by definition of its scope, DR AS4959 provides only general guidance on acceptable levels of wind farm noise emission and does not provide specific noise limits. DR AS4959 leaves to setting of noise limits for the relevant regulatory authority.

(c) *EPHC National Wind Farm Development Guidelines*

In 2009, National Wind Farm Development Guidelines were developed by a working group including Commonwealth and State representatives of the Environmental Protection and Heritage Council (EPHC) and the Local Government and Planning Minister's Council.

A team of expert consultants, including Marshall Day Acoustics, was commissioned to develop the National guidelines. I was the internal reviewer for the Noise section of the Guidelines.

In October 2009, a Public Comment Draft (version 2.1) was made available with closing date for comment on 16 December 2009. It is my understanding that the finalised National Guidelines is expected to be released in 2010.

The current draft of the Guidelines endorses the draft Australian standard with a view to the final version of the Guidelines endorsing a finalised version of that standard. The methodologies recommended in the Guidelines are therefore broadly consistent with draft standard. However, some additional guidance has been provided where it was considered that the methods of the standard require some elaboration. In particular the Guidelines include additional discussion of post-construction noise measurement methods and special audible characteristics which include amplitude modulation, infrasound, low frequency noise, impulsivity and tonality.

The draft Guidelines do not attempt to set or recommend appropriate noise limits.

Annexure D - Low Frequency and Infrasound

(a) Definition

Although there can be variations between individuals, it is generally accepted that frequencies between 20Hz and 20kHz are audible by humans. Sound in the frequency range between 20Hz and 100Hz is typically considered as Low frequency noise. Sound in the frequency range below 20Hz is commonly referred to as infrasound.

(b) Sources of Infrasound and low frequency noise

Infrasound is created by a wide range of different sources including sources which are naturally occurring in the environment (such as wind, ocean waves and thunderstorms) and are also created by a wide range of man made sources including heavy industrial equipment and motor vehicles.

(c) Infrasound, perception and annoyance

Human perception of sound energy in the infrasound frequency range is much less acute than other frequency bands. Significant energy is required to produce levels of infrasound which are high enough to be perceived by humans.

Berglund (*Community Noise*, 1995) states:

[...] the main sensitive organ for sound at frequencies below 20Hz is within the ear and not in the breast or stomach. There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects. Infrasounds slightly above detection threshold may cause perceptual effects but these are of the same character as for "normal" sounds.

The Berglund report (*Community Noise*, 1995) was commissioned by the World Health Organization (WHO) and formed the basis for the globally applicable *Guidelines for Community Noise* dated 1999. Berglund was the editor of these 1999 guidelines.

(d) Wind turbine infrasound levels

The available literature indicates that wind turbines only produce low levels of low frequency noise and infrasound.

Section 5.5.1 of the draft revised NZS6808 (DZ6808v2.5) states:

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

Furthermore, the South Australian EPA (*Wind farms environmental noise guideline*, July 2009) notes:

The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site.

Annexure E - Occupational Health and Safety

The Victorian Occupational Health and Safety (OH&S) Regulations 2007, *Statutory Rule No.54/2007*, took effect from the 19 June 2007. The rule requires that noise exposure should not exceed $L_{Aeq,8h}$ 85dBA, or peak levels of L_{Cpeak} 140dBC.

These limits are significantly higher than the NZS6808:1998 noise limits and predicted noise emissions from the Berrybank Wind Farm do not exceed 50dBA outside the site boundary. Typical noise levels a 100m from a wind turbine do not generally exceed 60-65dBA.

Therefore compliance with NZS6808:1998 will ensure that the OH&S noise limits are achieved in the vicinity of the wind farm site.

Annexure F – Sleep disturbance and vibration

(a) Sleep disturbance

I am aware of studies indicating that wind farm noise can potentially cause sleep disturbance. According to the World Health Organisation (WHO) Guidelines for Community Noise, an indoor noise level of 30dBA should not be exceeded for continuous noise if negative effects on sleep are to be minimised.

It is internationally accepted that noise reduction from outside to inside through an open window is 10dBA. Therefore in accordance with the WHO guidelines, outdoor noise levels should not exceed 40dBA to avoid sleep disturbance. This is consistent with the 2009 WHO Night Noise Guidelines for Europe which states:

For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40dB of $L_{night, outside}$ during the part of the night when most people are in bed. The LOAEL [Lowest Observed Adverse Effect Level] of night noise, 40dB $L_{night, outside}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise.

Section 7 of the Marshall Day report exhibited as part of the permit application includes graphs showing the background noise levels against different wind speeds. Wind farm noise levels are permitted above 40dBA at non-landholders' residences only when wind induced background noise levels are likely to mask wind farm noise.

The WHO Guidelines would therefore suggest that compliance with the NZ Standard noise limits will mean that the Berrybank Wind Farm is not likely to cause sleep disturbance for most people.

(b) Vibration

The Eskdalemuir study (*Microseismic and infrasound monitoring of low frequency noise and vibration from wind farms*, 2005) provided evidence that wind turbines generate measurable vibrations in the ground at predictable frequencies. However, this study was designed to measure the effects of extremely low levels of vibration at a very quiet site, using some of the most sensitive equipment available.

Annexure G - Amplitude modulation

An HGC Engineering report (*Wind turbines and sound: Review and best practice guidelines*, 2007) defines amplitude modulated sound as “a sound which noticeably fluctuates in loudness over time.” The report also comments that:

There appears to be some confusion between this low speed temporal modulation of sound and low-frequency or low-pitched sounds. To avoid misunderstanding, it should be realised that any sound, with predominantly low, middle or high-pitched frequency content can be modulated in time, without changing the pitch of the sound.

In January 2007, the UK Department for Business, Enterprise and Regulatory Reform (BERR, formerly DTI) and the UK Department for Environment, Food and Rural Affairs (DEFRA) commissioned a study to investigate Aerodynamic Modulation (AM) of sound from wind turbines. Their report (*Research into aerodynamic modulation of wind turbine noise: Final report*, 2007) concluded the following:

Results indicate that 27 out of the 133 windfarms operational at the time of the survey had received formal complaints about noise at some point in their history.

[...]

[...] investigation of the four sites identified by the Local Authority with AM has shown that the conditions associated with AM might occur between about 7% and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system.

[...]

There is little published information on AM, only two peer-reviewed publications are available. The causes of AM are still open to debate, and the theories put forward to date do not apply to some UK sites where the phenomenon has occurred. We conclude that the causes of AM are not fully understood and that AM cannot be fully predicted at current state of the art.

Section 5.3.1 of the current NZS6808:1998 does not provide guidance on a method for assessing special audible characteristic, except for tonality.

Section 5.4.4 of the draft revised NZS6808 (DZ6808v2.5) states:

No appropriate objective test for audible modulation has been standardised. If a wind farm is deemed subjectively to create sound with a clearly audible modulation an adjustment of +5 dB shall be applied to the wind farm sound level for the wind conditions under which the modulation occurs.

C5.4.4

Modulation special audible characteristics occur when there is significant amplitude modulation of the aerodynamic sound from a wind turbine such that there is a greater than normal degree of fluctuation at about once per second.

It is envisaged that appropriate objective tests for modulation special audible characteristics will be developed in future.

Older styles of wind turbine used ‘stall regulation’, which can give rise to amplitude modulation noise effects under certain wind conditions. This effect is characterised by a ‘beating’ or ‘thumping’ sound and is significantly lower in modern ‘pitch regulated’ wind turbines.

The proposed wind turbines are not ‘stall regulated’ but ‘pitch regulated’.

Annexure H – Further literature references

- EPA Guidelines EPA publication N3/89 *Interim guidelines for control of noise from industry in country Victoria*
- Kamperman and James, *Why noise criteria are necessary for proper sighting of wind turbines*, November 2008
- DZ6808v2.5 *Acoustics – Wind farm noise*, February 2009
- DR AS 4959 CP *Acoustics—Measurement, prediction and assessment of noise from wind turbine generators*, November 2009
- EPHC *National Wind Farm Development Guidelines, Public Comment Draft (version 2.1)*, October 2009
- Berglund et al., *Community Noise*, 1995
- South Australian EPA, *Wind farms environmental noise guideline*, July 2009
- Victorian Occupational Health and Safety (OH&S) Regulations 2007, *Statutory Rule No.54/2007*, June 2007
- World Health Organization, *Night Noise Guidelines for Europe*, 2009
- Styles et al., *Microseismic and infrasound monitoring of low frequency noise and vibration from wind farms*, July 2005
- HGC Engineering, *Wind turbines and sound: Review and best practice guidelines*, February 2007, Prepared for the Canadian Wind Energy Association
- Moorhouse et al., *Research into aerodynamic modulation of wind turbine noise: Final report*, July 2007