MARSHALL DAY Acoustics

RIVERBANK ROAD WIND MACHINE REVERSE SENSITIVITY ANALYSIS

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EXECUTIVE SUMMARY

This report provides recommended minimum sound insulation standards for new dwellings constructed on a proposed subdivision near an existing wind machine on Riverbank Road, Wanaka. The minimum sound insulation standards have been developed to adequately protect residents from sleep disturbance when the nearby wind machine is operating with bedroom windows closed.

Predicted noise levels from the wind machine have been provided in the form of noise contours which dictate the minimum sound insulation standards that bedrooms should be designed to achieve. Where bedrooms are positioned on the opposite side of the dwelling to the wind machine, so that no façade of the bedroom has line of sight to the wind machine, the minimum sound insulation standard can be reduced. The construction of dwellings within approximately 150 metres of the wind machine should generally be avoided, unless all bedrooms can be positioned on the opposite side of the dwelling to the wind machine.

Example constructions that achieve the recommended minimum sound insulation standards are provided in this report. Alternative constructions that also achieve these standards are possible but would need to be verified by a suitably qualified and experienced acoustic specialist.

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1.0 INTRODUCTION

Marshall Day Acoustics has been engaged to develop minimum sound insulation standards for new dwellings constructed on the subdivision proposed on the corner of Orchard and Riverbank Road, Wanaka, in order to adequately protect residents from sleep disturbance from a nearby wind machine.

The wind machine is located on a vineyard at 246 Riverbank Road, which is part of the proposed subdivision. We understand that the intention is to eventually decommission the wind machine and replace the vineyard with residential sections as part of the development. However, until this time, minimum sound insulation standards must be developed to ensure that residents of any new dwellings constructed close to the wind machine are adequately protected from wind machine noise.

This report provides:

- A description of the wind machine at 246 Riverbank Road;
- Predicted noise levels from the wind machine;
- Relevant internal noise criteria for the protection of sleep disturbance;
- Minimum sound insulation standards for new dwellings built near the wind machine; and
- Example constructions that would achieve the proposed minimum sound insulation standards.

A glossary of the acoustical terminology used in this report is provided in Appendix A.

2.0 WIND MACHINE

Marshall Day Acoustics were involved with the consent of the wind machine at 246 Riverbank Road in 2010. The wind machine is a Defender Mk II model and located approximately 160 metres back from Riverbank Road, as indicated in Figure 1. The proposed subdivision area is also shown in this figure.

Figure 1: Wind machine location and proposed subdivision area

3.0 PREDICTED NOISE LEVELS

3.1 Prediction Methodology

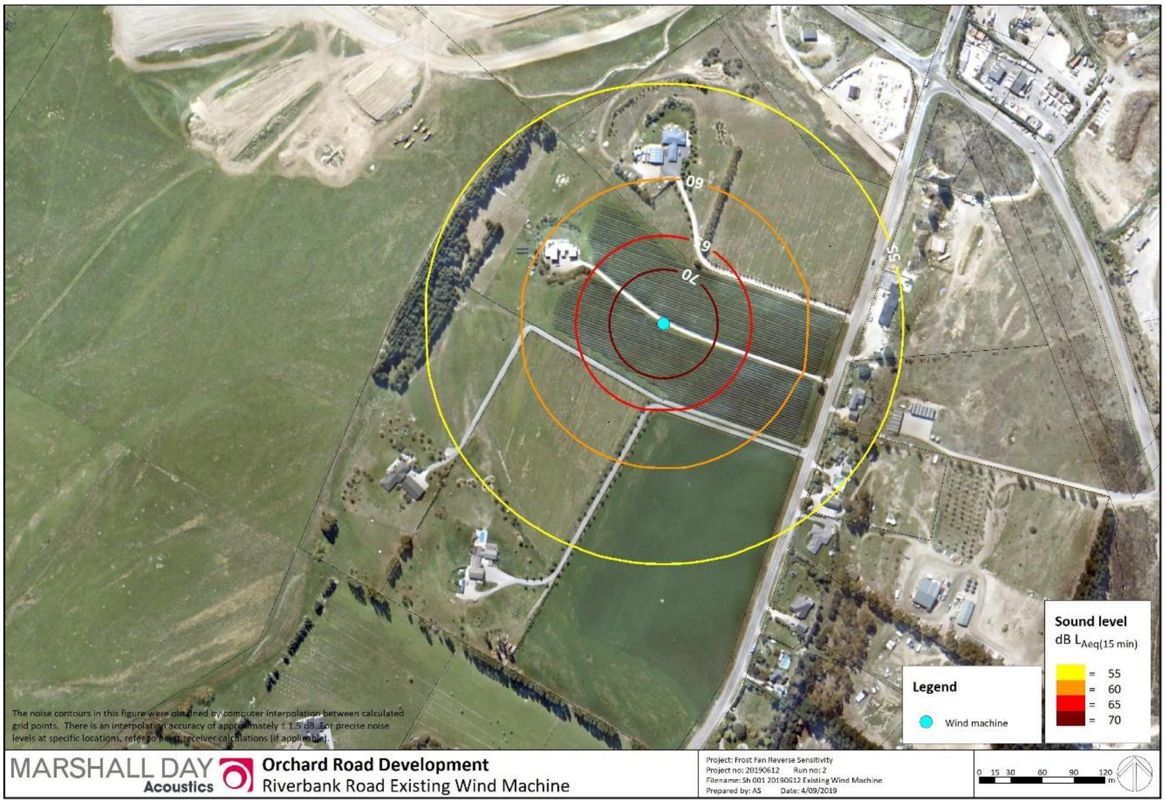
To accurately predict noise levels from the wind machine, the noise modelling package SoundPLAN has been used. Calculations in SoundPLAN are based on ISO 9613-2:1996 "*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*". The effect of meteorological conditions is significantly simplified in this Standard by calculating the average downwind sound pressure level. The Standard adopts the conservative approach of assuming that wind is always blowing from the noise sources to the receiver locations. The equations and calculations also hold for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights.

The model results have been calibrated with noise measurements undertaken by Marshall Day Acoustics of the same wind machine model (Defender Mk II) during frost conditions (-2.5°C to -4.5°C) with light winds (generally 0-1 m/s).

3.2 Predicted Noise Levels

Predicted noise levels from the wind machine are presented as noise contours in Figure 2. A larger version of this figure is provided in Appendix B.

Figure 2: Predicted noise levels from wind machine



3.3 Wind Machine Blade Replacement

As requested, replacing the existing wind machine blades with a five-bladed unit such as a *Frost Boss C59* has been considered. Whilst a five-bladed unit would produce slightly lower noise levels at mid to high frequencies (500-2000 Hz) than the existing wind machine, the noise levels produced at low frequencies (63-250 Hz) are essentially the same. As the low frequency noise dictates the minimum sound insulation standards, replacing the existing wind machine blades with a five-bladed unit would not result in reduced sound insulation standards.

4.0 INTERNAL NOISE CRITERIA

The World Health Organisation (WHO) Guidelines for Community Noise (Berglund, Lindvall and Schwela, 1999) provide guidelines for environmental noise exposure.

As the wind machine generally only operates during frosts in the early hours of the morning, sleep disturbance is the relevant critical health effect for this assessment. The WHO recommends 30 dB L_{Aeq} and 45 dB L_{AFmax} inside bedrooms to minimise the onset of sleep disturbance.

On balance, we consider an internal noise level of **30 dB $L_{Aeq(15\ min)}$** within bedrooms to be appropriate for wind machine noise. This noise level accounts for Special Audible Characteristics (as defined in New Zealand Standard NZS 6802:2008 *"Acoustics - Environmental Noise"*), which is often present with wind machine noise, particularly inside dwellings, and that the machine only operates for a limited number of nights per year. Our previous measurements of wind machines suggest that provided 30 dB $L_{Aeq(15\ min)}$ is achieved, the 45 dB L_{AFmax} WHO guideline value would also be achieved.

5.0 PROPOSED MINIMUM SOUND INSULATION STANDARDS

In order to achieve the internal noise criteria above, we propose the following minimum sound insulation standards provided in Table 1. Bedroom windows must be closed in order to achieve the minimum sound insulation standards. Where bedrooms are constructed on the opposite side of the dwelling to the wind machine so that no bedroom façade has line of sight to the wind machine, the minimum sound insulation standard can be reduced, as shown in Table 1.

Table 1: Proposed minimum sound insulation standards

External wind machine noise level, dB $L_{Aeq(15\ min)}$	Minimum sound insulation standard, dB $D_{nT,w} + C_{tr}$	
	Bedrooms where a façade has line of sight to the wind machine	Bedrooms where no façade has line of sight to the wind machine
< 55	No minimum requirement*	No minimum requirement*
55 to < 60	35	No minimum requirement*
60 to < 65	40 (dwellings not recommended)	35
65 to < 70	No dwellings permitted until wind machine is decommissioned	40 (dwellings not recommended)

* We still recommend that residents are notified of the wind machine prior to purchasing a section as wind machine noise will still be clearly audible at these properties.

Example constructions to achieve the minimum sound insulation standards are provided in the following section. Please note that 40 dB $D_{nT,w} + C_{tr}$ is very challenging to achieve and we therefore recommend that the construction of dwellings within the 60 dB L_{Aeq} contour (approximately 150 metres from the wind machine) should generally be avoided, unless all bedrooms can be positioned on the opposite side of the dwelling to the wind machine.

6.0 EXAMPLE CONSTRUCTIONS

Table 2 contains example bedroom constructions that achieve the proposed sound insulation standards. Please note that other constructions may also achieve the sound insulation standards, but these would need to be verified by a suitably qualified and experienced acoustic specialist.

Table 2: Example bedroom constructions

Building element	Minimum bedroom construction requirement
35 dB $D_{nT,w} + C_{tr}$	
External walls	
Cladding	Minimum 70 mm thick brick (or equivalent mass)
Insulation	Minimum 75 mm thick fibrous insulation
Internal lining	Single layer of minimum 10 mm thick plasterboard
Windows/glazed doors	Double glazed aluminium joinery consisting of one minimum 6 mm thick glass pane and one minimum 6.38 mm thick laminated glass pane separated by a 12 mm air gap, e.g. 6/12/6.38L. No more than 40% of external wall area
Roof/ceiling	
Cladding	Minimum 0.55 mm thick profiled steel
Insulation	Minimum 75 mm thick fibrous insulation
Ceiling	Two layers of minimum 13 mm thick high-density plasterboard (≥12 kg/m^2) linings (e.g. 2x13 mm GIB Noiseline)
External doors	Solid core door (minimum 24 kg/m^2) with full perimeter seals
40 dB $D_{nT,w} + C_{tr}$	
External walls	
Cladding	Minimum 70 mm thick brick (or equivalent mass)
Insulation	Minimum 75 mm thick fibrous insulation
Internal lining	Single layer of minimum 10 mm thick plasterboard
Windows	Double glazed aluminium joinery consisting of one minimum 6 mm thick glass pane and one minimum 10.76 mm thick laminated glass pane separated by a 12 mm air gap, e.g. 6/12/10.76L. No more than 20% of external wall area. No doors permitted
Roof/ceiling	
Cladding	Minimum 0.55 mm thick profiled steel
Sarking	Minimum 9 mm thick fibre cement board sarking (≥12 kg/m^2) to entire dwelling roof, e.g. 9 mm RAB board sarking
Insulation	Minimum 75 mm thick fibrous insulation
Ceiling	Two layers of minimum 13 mm thick high-density plasterboard (≥12 kg/m^2) linings (e.g. 2x13 mm GIB Noiseline)
External doors	Not permitted

Note that while bedrooms windows must be closed in order to achieve the minimum sound insulation standards, we have not specified an alternative means of ventilation as a requirement given that the wind machine generally only operates during frost conditions on a limited number of nights and early mornings each year.

7.0 CONCLUSIONS

Marshall Day Acoustics has predicted noise levels from the wind machine on the proposed subdivision located on the corner of Orchard and Riverbank Road, Wanaka. Based on the predicted noise levels, minimum sound insulation standards are proposed for new dwellings constructed near the wind machine. The minimum sound insulation standards have been developed to adequately protect residents from sleep disturbance when the nearby wind machine is operating with bedroom windows closed.

Example constructions that achieve the recommended minimum sound insulation standards are provided in this report. Alternative constructions that also achieve these standards are possible but would need to be verified by a suitably qualified and experienced acoustic specialist.

APPENDIX A GLOSSARY OF TERMINOLOGY

Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
Octave Band	A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.
Noise	A sound that is unwanted by, or distracting to, the receiver.
Special Audible Characteristics	Distinctive characteristics of a sound which are likely to subjectively cause adverse community response at lower levels than a sound without such characteristics. Examples are tonality (e.g. a hum or a whine) and impulsiveness (e.g. bangs or thumps).
SPL or L_P	Sound Pressure Level A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 µPa RMS) and expressed in decibels.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 µPa i.e. dB = 20 x log(P/Pr)
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{AFmax}	The A-weighted maximum noise level measured using fast time response (hence 'F'). The highest noise level which occurs during the measurement period.
Sound Insulation	When sound hits a surface, some of the sound energy travels through the material. 'Sound insulation' refers to ability of a material to stop sound travelling through it.
$D_{nT,w}$	Weighted Standardised Level Difference A single number rating of the sound level difference between two rooms. $D_{nT,w}$ is typically used to measure the on-site sound insulation performance of a building element such as a wall, floor or ceiling
C_{tr}	A sound insulation adjustment, commonly used with Rw and $D_{nT,w}$. C_{tr} adjusts for low frequency noise, like noise from trucks and subwoofers. C_{tr} values typically range from about -4 to about -12. This term is used to provide information about the acoustic performance at different frequencies, as part of a single number rating system.
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *"Acoustics – Environmental Noise"*

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APPENDIX B WIND MACHINE NOISE CONTOURS