periods at critical windspeeds to satisfy 4.4.2 (e.g. if wind turbine or windfarm sound levels exceed 40 dBA L_{95}). This may be for a limited range of windspeeds and directions, with the WTG(s) non-operational.

5.5 Further monitoring

When sound levels from WTGs have been established as complying with the criteria for acceptability set down in 4.4.2 of this Standard, nothing in this Standard shall prevent further monitoring at any later date as a further check on compliance. All such follow-up testing shall be carried out in accordance with the procedures set down in this Standard. Such testing may, for example, be conducted at a later date when investigating noise complaints, as provided for under procedures set down in relevant legislation.

6 DOCUMENTATION

6.1

Relevant sound measurements and specifications shall be documented as follows:

6.2 Sound level predictions

The following information used in the calculation of the sound pressure levels received from WTG(s) shall be recorded:

(a) L_w WTG sound power level ..... dBA

(b) L_R Predicted far field sound level ..... dBA, calculated

(c) R Distance from the source in metres

(d) α_a dBA/m

(e) The sound attenuation value(s) if used to account for acoustic screening (e.g. as a result of topography) ..... dBA

(f) The source and method used for deriving the value of L_R listed above;

(g) The make and model of the WTG used;

(h) The hub height of the WTG;

(j) A topographical map showing the topography (contour lines) in the vicinity of the windfarm, the position of the WTGs, and the location of residential locations and any other noise sensitive location (optional).

(k) The positions of the locations of interest for which L_R is calculated.

6.3 Background sound level measurement and assessment

The following information on the measurement of the background sound levels in addition to the requirements of 4.5, shall be recorded as follows:

(a) Description of the sound monitoring equipment including ancillary equipment;

(b) Description of the anemometry equipment including the height above ground level of the anemometer;

(c) The location of sound monitoring positions;

(d) Atmospheric conditions. The windspeed and direction at the windfarm or WTG position shall be recorded, and where relevant, record the temperature, humidity, rainfall, cloud conditions etc.

(e) Time and duration of the monitoring period;

(f) Averaging period for both sound and windspeed measurements;

(g) Position of windspeed measurements;

(h) Number of data pairs measured (windspeed in m/s, sound in L_{95} dBA);

(j) Description of the regression analysis;

(k) Graphical plot showing the data scatter and the regression curve;

(m) The background sound level L_{95} relating to a windspeed of 8 m/s at 10 m AGL at the relevant windfarm or WTG position.

6.4 Compliance level testing

In addition to the requirements of 5.4 the following shall be documented:

(a) Description of the sound monitoring equipment including any ancillary equipment;

(b) A statement confirming the use of A frequency-weighting and F time-weighting;

(c) Description of the anemometry equipment including the height above ground level of the anemometer;

(d) The monitoring positions;

(e) Number of operational WTGs;

(f) Sound power level of the turbines (L_w) and source of data;

(g) Make and model of the wind turbines;

(h) Atmospheric conditions. The windspeed and direction at the windfarm or WTG position shall be recorded, and where relevant record the temperature, humidity, rainfall, cloud conditions etc.

(j) Time and duration of monitoring period;

(k) Averaging period for both sound and windspeed measurements;

(m) Position of windspeed measurements;

(n) Number of data pairs measured (windspeed in m/s, sound in L_{95} dBA);

(o) Description of the regression analysis;

(p) Graphical plot showing the data scatter and the regression line;

(q) Graphical plot showing the data scatter and the regression lines for both the background and the windfarm in operation;

(r) The sound level, at a windspeed of 8 m/s at 10 m AGL, at the windfarm or WTG position;

(s) Assessment of special audible characteristics.

APPENDIX A
WORKED EXAMPLE

A1 PREDICTED SOUND PRESSURE LEVEL (refer 4.3)

A1.1
It is proposed that two WTGs are to be installed having the following characteristics:

(a) WTG make, "AURORA";

(b) WTG model, BSH45;

(c) Sound Power Level of each turbine, L_W = 100 dBA at 8 m/s at 10 m AGL;

(d) Increase in WTG sound power level with windspeed = 0.9 dBA per m/s;

(e) WTGs are guaranteed free of any audible tones;

(f) Turbine cut-in windspeed = 3.5 m/s;

(g) Turbine cut-out windspeed = 20 m/s;

(h) Turbine hub height = 40 m.

A1.1.2
Wind data is monitored on the site at 40 m and 10 m AGL. Monitored data shows that a windspeed of 8 m/s at 10 m AGL is equivalent to a 9 m/s windspeed at 40 m AGL.

A1.1.3
The proposed site is at a constant elevation (i.e. flat) and the WTG and residence locations are shown in figure A1. As both WTGs are visible, no attenuation due to acoustic screening has been considered in the calculations below.

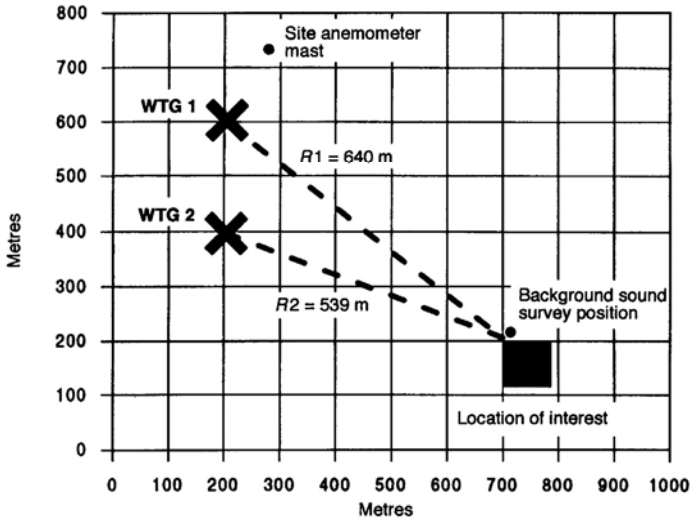

Figure A1 – Proposed site layout

(NOTE – In the example that follows, the distance between each of the WTGs and the location of interest is based on the separation distance in a horizontal plane and not including the effect of the turbine being at 40 m AGL. The effect of this assumption is negligible as the turbine tower height is very small in relation to each of the separation distances.)

A1.1.4
Using equation 1:

The predicted sound pressure level, from WTG 1, at the location of interest is calculated as follows:

$L_{R,1} = L_W - 10 \text{ Log } (2 \pi R1^2) - \Delta L_{a,1}$

(It is assumed that the air absorption coefficient, (α_a = 0.005 dBA/m)

$= 100 - 10 \text{ Log } (2 \pi 640^2) - (0.005 \text{ X } 640)$

$L_{R,1} = 32.7$ dBA.

The predicted sound pressure level, from WTG 2, at the location of interest is calculated as follows:

$L_{R,2} = L_W - 10 \text{ Log } (2 \pi R2^2) - \Delta L_{a,2}$

(It is assumed that the air absorption coefficient, (α_a = 0.005 dBA/m)

$= 100 - 10 \text{ Log } (2 \pi 539^2) - (0.005 \text{ X } 539)$

$L_{R,2} = 34.7$ dBA.

Now summing the two predicted sound pressure levels:

$L_{R,1+2} = 10 \text{ Log } (10^{32.7/10} + 10^{34.7/10})$

$L_{R,1+2} = 36.8$ dBA

i.e. $L_{R,1+2} = 37$ dBA.

The predicted combined contribution of both wind turbines is therefore 37 dBA at a site windspeed of 8 m/s measured at 10 m AGL. For the site under consideration, this is equivalent to a 9 m/s windspeed measured at 40 m AGL.

A1.2 Monitored background levels (refer 4.5)

A1.2.1
Measurements of the L_{95} background sound levels were monitored at the location of interest, at the position shown in figure A1. The sound measurements were averaged over consecutive 10 minute intervals which coincided with 10 minute wind statistics measured at the proposed site at 40 m AGL. The location of the site wind measurement mast is shown in figure A1.

A1.2.2
The details of the monitoring equipment used during the background sound survey are as follows:

(a) Type I sound level meter, make DECIBEL, model 72H ➤

(b) Site anemometers, make DECIBEL, model JU63

(c) Site wind vanes, make COMMA, model 5247T

(d) Anemometry datalogger, make APOSTROPHE, model 678W

Data were monitored during the period 1 April 1997 to 13 April 1997.

A1.2.3
A total of 1931 data pairs (windspeed and L_{95}) were available for analysis which represented 13.5 days of monitoring. The data pairs are plotted in figure A2 and show L_{95} plotted against the 40 m/s windspeed.

A1.2.4
A polynomial least-squares fit was used to describe the data between 3.5 m/s and 20 m/s, these defining the operational windspeed range of the wind turbine. The fitted function is defined as :

$$L_{background} = -0.0056\ V^3 + 0.1550\ V^2 + 0.452\ V + 26.52 \quad \text{(Eq. A1)}$$

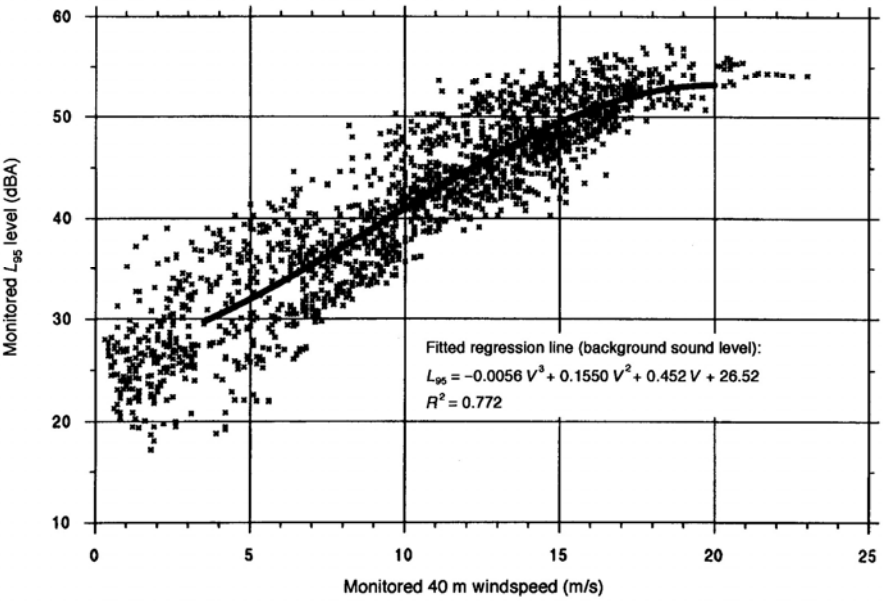

Figure A2 – Data monitored during the background sound survey

A1.2.5
At a windspeed of 9 m/s (at 40 m AGL) the background L_{95} level is 39.1 dBA.

A1.2.6
In order to assess the impact of the wind turbines at other windspeeds, the rate of increase in wind turbine sound power level has been provided by the WTG manufacturer as 0.9 dBA per m/s increase in

windspeed over the operating range of the WTG. It is therefore possible to plot the equation for the variation in sound pressure level with windspeed, for the site of interest. This is based on a straight line, having a gradient of 0.9 dBA/m/s and passing through 36.3 dBA at a windspeed of 9 m/s (at 40 m AGL). The variation of the predicted combined wind turbine sound pressure level has been plotted together with the data monitored during the background noise survey. This equation ($L_{R,1+2} = 0.9\ V + 28.2$) is shown in figure A3.

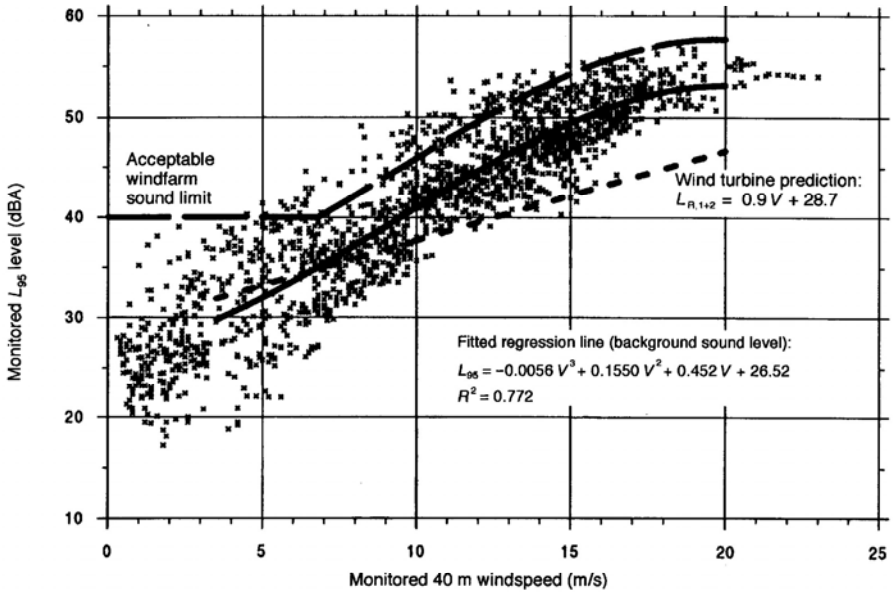

Figure A3 – Predicted total WTG sound and background sound data

Based on the background measurements and the prediction of windfarm sound levels, it is considered that the proposed windfarm installation (two WTGs) will comply with the limits set out in this Standard.

A1.3 Compliance testing (refer section 5)

Once the two WTGs have been installed, a further sound survey will need to be completed (if required) in order to check compliance. If no complaints arise and the sound levels are subjectively considered acceptable, it may not be necessary to undertake measurements. If, however, measurements are required, the analysis shown in A1 of this Appendix should be repeated with the turbines operational.

If operational measurements are undertaken, the results of the 'operational' sound measurements should be compared to the background measurements (non-operational) defined by equation A1, to determine compliance. Since the "operational" measurements will be combined windfarm and background levels, it may be necessary to adjust these measurements to determine the "windfarm only" levels.

The compliance test should include consideration and an assessment (if necessary) of any special audible characteristics.

NOTES

Approved by the Standards Council on 13 April 1998 to be a New Zealand Standard pursuant to the provisions of section 10 of the Standards Act 1988.

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