Appendix B

Assessment of Noise Effects – Hegley Acoustics

HEGLEY ACOUSTIC CONSULTANTS

PROPOSED WEL WIND PARK

TE UKU

ASSESSMENT OF NOISE EFFECTS

Report No 7599

Prepared for:
WEL Networks Ltd
HAMILTON
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Prepared by:.....
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CONTENTS

EXECUTIVE SUMMARY

It is proposed to develop a Wind Farm with a nominal 84MW capacity. The turbines will be a maximum height of 137m to the tip of the blade at site located on the Wharauroa Plateau about 3km from State highway 23 at Te Uku. This report considers the noise at the houses around the proposed wind farm based on the requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators.

When close to the turbines (within approximately 50m) the characteristic beat as the turbine blades turn is audible. However, at distances of more than 300 - 400m, the noise becomes steady and the beat reduces significantly. With more than one turbine operating, the cumulative noise is a steady sound with the only variation to the noise being due to the changing meteorological effect on sound transmission. It is noted that the noise from the wind turbine generators does not have any significant directivity characteristics so the direction that the wind turbine generators (WTGs) face is not critical in the analysis of the noise effects.

Noise from the proposed wind farm has been predicted using the sound spectrum of the individual wind turbines as provided by a typical wind turbine manufacturer. Based on this information and a three dimensional ground contour model, a computer model has been used that takes into account effects such as distance to the receiver, topographical screening, atmospheric absorption and meteorological effects (such as wind direction) to predict the noise level at each of the closer house to the proposed wind turbine farm. A cross check on the accuracy of the noise predictions was made based on information collected at existing wind farms, such as in the Tararua Ranges (near Palmerston North). This information shows that the levels from a wind farm using the computer model is expected to be within ±2dBA. This is within the degree of accuracy expected when predicting noise levels.

Based on the predicted noise levels and field measurements of the existing noise environment the requirements of NZS6808:1998, Acoustics – The Assessment and

Measurement of Sound from Wind Turbine Generators will be complied with at the notional boundary of all of the dwellings near the proposed wind farm with a significant factor of safety.

When taking into account that the requirements of both NZS 6803:1999 Acoustics – Construction Noise and NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators, which will be complied with by a good factor of safety, the overall effects of the construction and operation of the proposed wind farm will be no more than minor.

1 INTRODUCTION

WEL Networks (WEL) is seeking resource consent for a wind farm that will provide for a range of possible development scenarios. There will be up to 28 3MW turbines on the site. For the purposes of this assessment, the following assumptions have been made:

- The maximum turbine height (inclusive of rotor blades) to be installed on the site will be 137 metres;
- Design hub height 80m;
- The maximum number of turbines to be installed on the site will be 28;
- The maximum power rating of the turbines will not exceed 3MW

The exact make of Wind Turbine Generator (WTG) has not yet been selected so the characteristics of typical 3MW wind turbines representing the development scenario set out above has been used for the purposes of this assessment to determine the potential effects of the proposed wind farm development.

This report considers the noise that will be generated from the proposed WTGs and the potential noise effects for the nearest neighbours. The general site location for the proposed wind farm is shown on Figure 1.

To assist with the understanding of the technical terms used in this report, Appendix A sets out a glossary of terms.

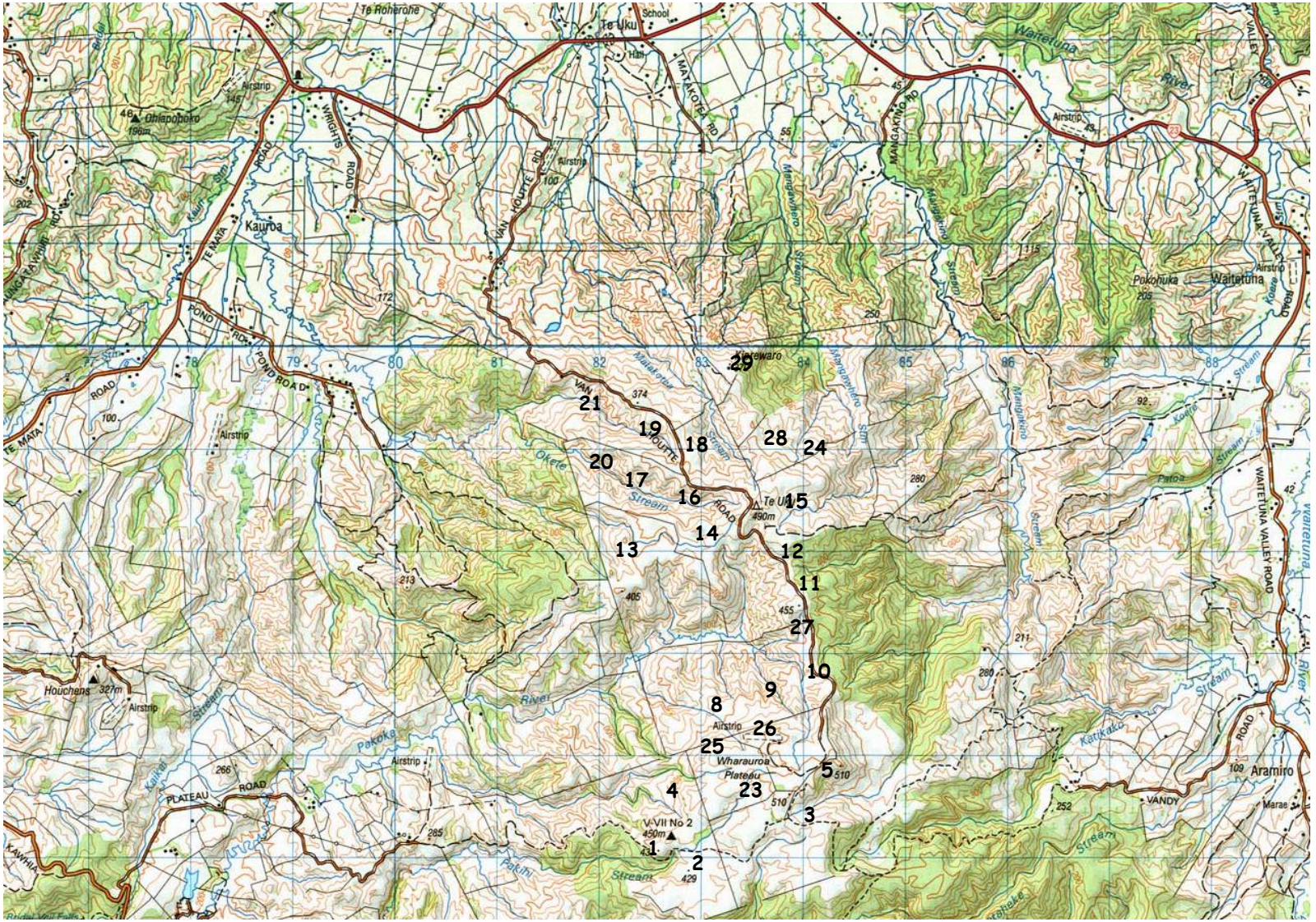


Figure 1. Wind Generator Turbine Locations

2 DESIGN CRITERIA

The site is located on the Wharauroa Plateau about 3km from State highway 23 at Te Uku in the Waikato District Council area. There is no reference to wind farms in the Operative Waikato District Plan. The Proposed District Plan does refer to the NZ Standard for assessment of wind farm noise, but the way it does this is under appeal. For that reason, the requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators has been adopted in the assessment of the proposed wind farm.

Paragraph 1.1 of NZS6808 states:

> *This Standard covers the prediction of sound from wind turbine generators (WTGs), the measurement of sound from WTGs, and the assessment of the received sound. It is designed to provide a level of investigation and reporting that may be specified by land use planning procedures under any relevant legislation (e.g. an act of Government/bylaw of Territorial Government), particularly the assessment of environmental sound. For the purposes of this Standard, sound is defined as being airborne vibration within the audible frequency range.*

The Standard goes on to say in paragraph 1.3

> *This Standard deals specifically with the measurement of sound from WTGs in the presence of wind, a situation which has high potential for fluctuations and errors due to both increased background sound levels and wind effects at the microphone. The measurement of sound in the outdoor environment can produce reasonably accurate and repeatable results if the recommended procedure is followed. Measurements conducted in accordance with other more general Standards (e.g. NZS 6801) should not be used for the measurement of sound arising from WTGs themselves. However NZS 6801 needs to be referenced for measuring background sound and other matters as described in 4.5 of this Standard.*

The normal technique of specifying maximum environmental sound levels (as set out in NZS 6802:1991 Assessment of Environmental Sound) uses methods to quantify sound that rely on the L_{10} criteria. NZS6808 states that it is not appropriate to assess wind turbine sound on this basis. This is because it is not possible to exclude wind effects when measuring low level wind turbine sound in a windy environment, as sound from wind turbines is similar to continuous background effects. The Standard recommends the use of L_{95} to measure and assess wind turbine noise.

Paragraph 4.4.2 and 4.4.3 of NZS6808 states:

> ***4.4.2*** *Acceptable limit*
> *As a guide to the limits of acceptability, the sound level from the WTG (or wind farm) should not exceed, at any residential site, and at any of the nominated wind speeds, the background sound level (L_{95}) by more than 5dBA, or a level of 40dBA L_{95}, whichever is the greater.*
>
> *NOTE -*
>
> *(1) The level predicted (LR) is based on the L_{eq} source level of the turbines under consideration and hence the predicted level is also a L_{eq} level. This predicted level needs to be assessed against a recommended acceptable level and possibly a measured background level; both determined using a L_{95} descriptor.*
>
> *(2) Overseas studies on wind farm sound (refer ETSU-R-97), have shown that L_{95} is typically 1.5dB - 2.5dB lower than L_{eq} measured over the same period. Similarly L_{eq} is typically 1.5dB - 2.5dB lower than L_{10} assuming a normal distribution of sound levels. Hence L_{95} is typically 5dB lower than L_{10}. For this reason, a 5dB only margin should be applied above the L_{95} results, rather than the "background plus 10" approach which, subject to specified reservations, is taken in NZS 6802.*
>
> ***4.4.3*** *Special audible characteristics*
> *These limits of acceptability are specified without any adjustment applied for special audible characteristics. Predicted or measured LR levels from WTGs with known special audible characteristics shall be adjusted by adding +5 to the level. This adjustment is a penalty to account for the adverse subjective response likely to be aroused by sounds containing such characteristics (see section 5.3 for compliance assessment for sounds containing special audible characteristics).*

These criteria directly reflect the requirements of the Proposed District Plan with the exception of the assessment point being the ‘site boundary’ rather than the ‘notional boundary’ of any rural dwelling. The Proposed Plan’s use of ‘site boundary’ in this context makes it difficult to determine where the assessment needs to be undertaken in order to demonstrate if the WTGs will comply with the higher of 40dBA or the background sound plus 5dBA. This difficulty arises because to clearly demonstrate full compliance, it would be necessary to assess the background sound at every point along the site boundary to determine the background sound plus 5dBA.

For WEL's proposed wind farm, the noise level has been predicted at the site boundary based on the predicted noise contours for the wind farm. The only field measurements undertaken to determine the background sound plus 5dBA have been done at the closer houses in each direction around the proposed wind farm.

Item 25.18.1 of the Proposed District Plan states:

Any activity is a permitted activity if:

(a) it is designed and conducted so that construction noise from the activity complies with Appendix N (Construction Noise)

Appendix N states:

N2.1 All construction work, including maintenance and demolition work, on any site shall be designed and conducted to ensure that noise from the site does not exceed the noise limits in table 1. Sound levels shall be measured and assessed outside buildings affected by construction noise in accordance with the provisions of NZS6803:1999 Acoustics – Construction Noise.

Time Period	Weekdays (dBA)		Saturdays (dBA)		Sundays and Public Holidays (dBA)	
	L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
06:30 – 07:30	60*	75	45	75	45	75
07:30 – 18:00	75*	90*	75*	90*	55	85
18:00 – 06:30	45	75	45	75	45	75

N2.2 * Where a site is exposed to construction work for a duration exceeding 20 weeks then 5dBA shall be subtracted from the noise limits marked.

N2.3 The air-blast noise limit from the use of explosives shall not exceed a peak sound level of 120dBC measured and assessed outside affected buildings in accordance with the provisions of NZS6803:1999 Acoustics – Construction Noise. Blasting practices shall conform to the provisions of AS2187:Part 2.

N2.4 Construction noise shall be managed using the methods set out in section 8 of NZS6803:1999 Acoustics – Construction Noise.

3 EXISTING NOISE ENVIRONMENT

The area is rural and well clear of any major roads or industrial noise. The main effects on the existing noise environment are any farm activities that may take place and wind generated noise. When determining the location to undertake measurement of the existing noise environment account has been taken of Clause 4.5.1 of NZS6808, which states:

> *This Standard recommends that background sound level measurements be carried out where predicted sound levels of 35dBA or higher are calculated for the relevant locations. It is recommended that measurement positions be selected to include locations at or within the nearest affected residential property boundary, (the notional boundary - if a rural property), and near the location of representative positions for any other residential locations within the vicinity of a WTG or windfarm.*

Based on this criterion, field measurements were undertaken at the houses expected to be the potentially most affected in each direction from the proposed wind farm. The measurements were made over a ten day period to obtain representative noise levels. The location of these houses is shown on Figure 2.

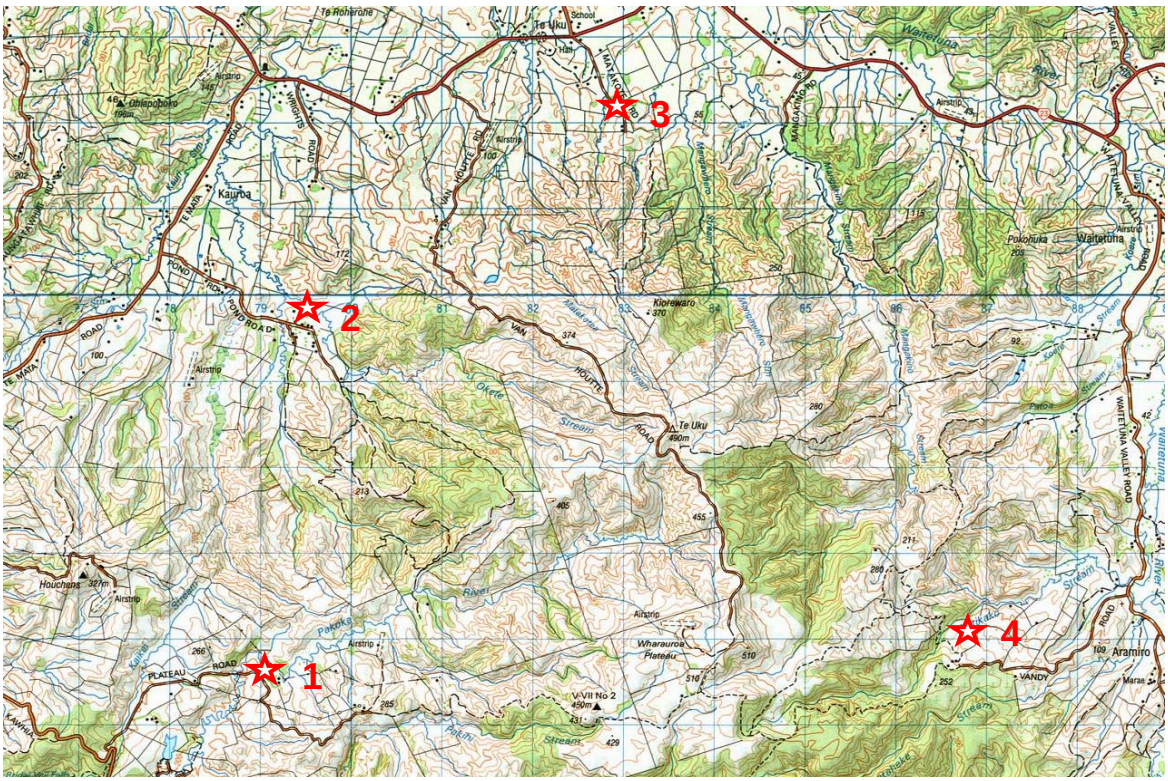


Figure 2. Background Noise Measurement Sites

The weather during the measurement period was generally fine and warm and the wind varied between nearly calm to windy conditions. Figures 3 - 6 show the results of the measured background sound (L_{95}) at house locations as shown on Figure 2 and wind speed measurements at the monitoring station on the proposed wind farm site.

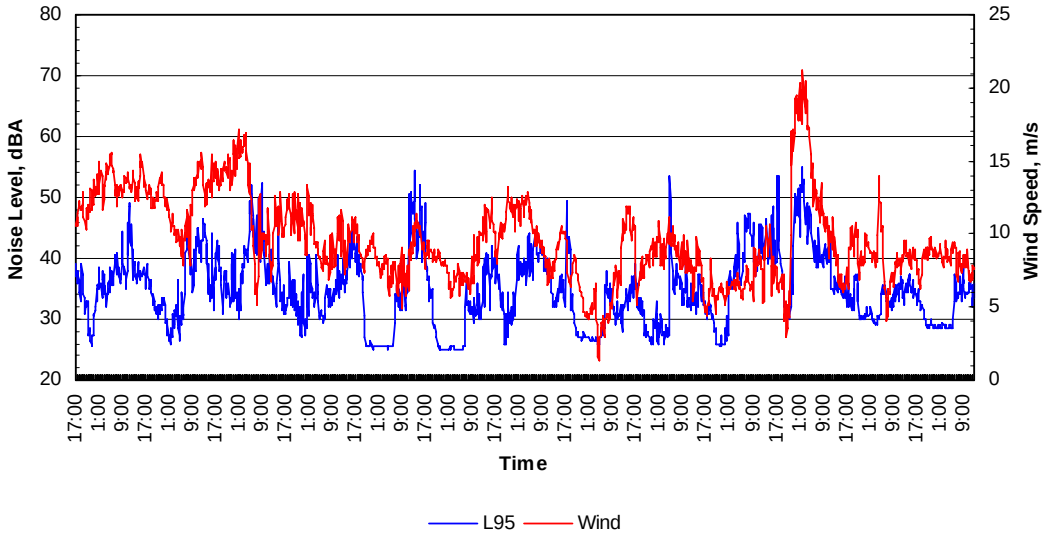


Figure 3. Noise and Wind Monitoring at Site 1

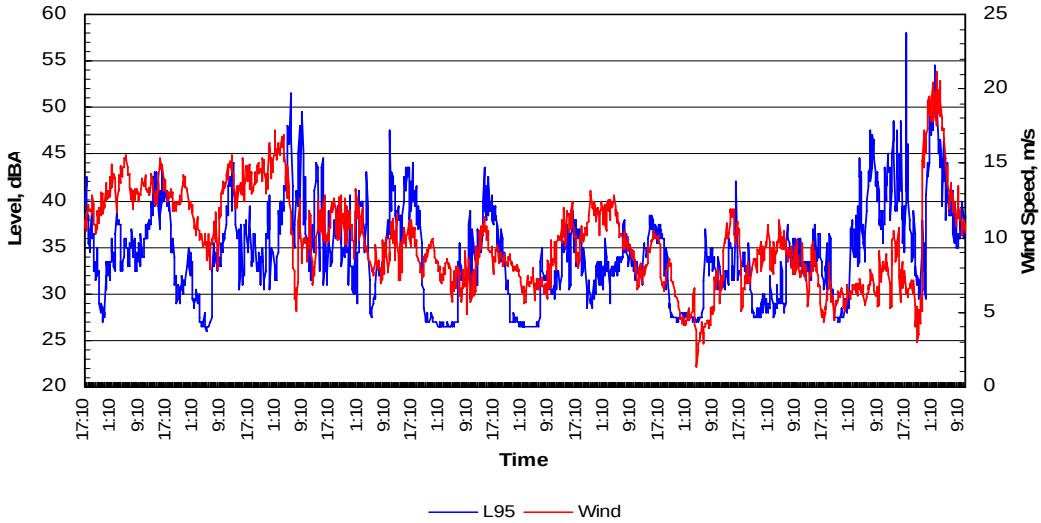


Figure 4. Noise and Wind Monitoring at Site 2

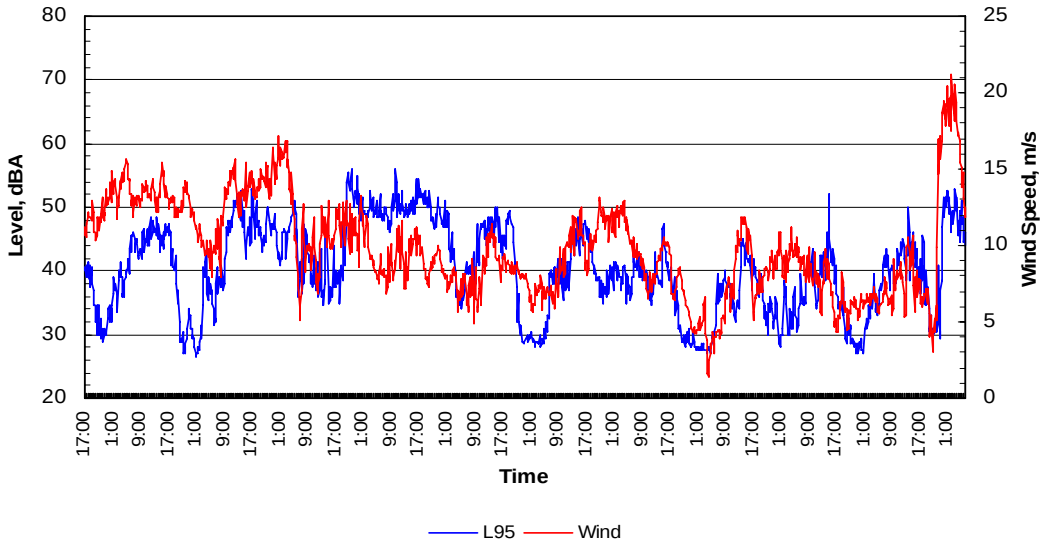


Figure 5. Noise and Wind Monitoring at Site 3

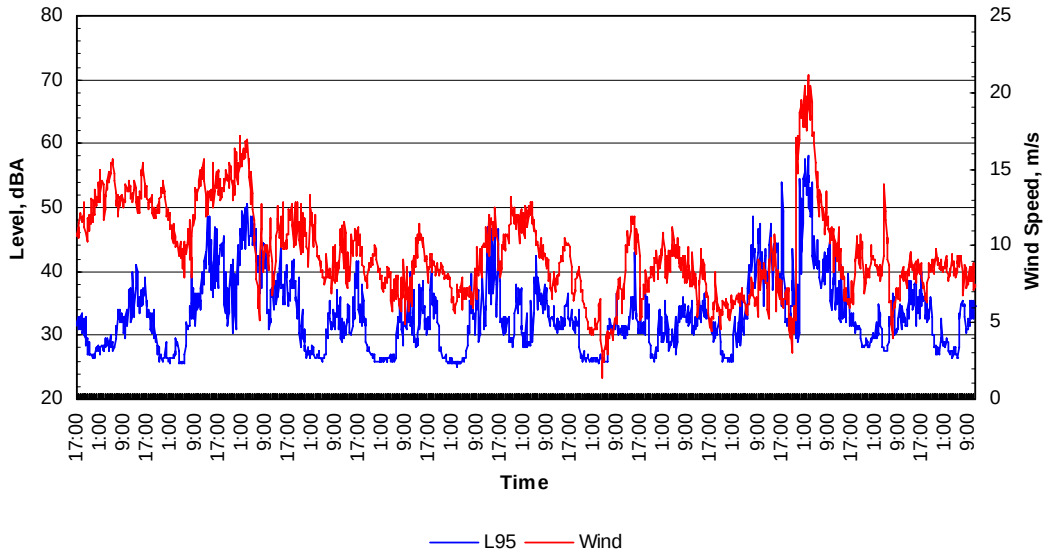


Figure 6. Noise and Wind Monitoring at Site 4

It is noted that all noise monitoring equipment has current calibration certificates and the field surveys were undertaken using an approved wind screen.

As shown above, there is generally a good relationship between the wind as measured at the meteorological station on the wind farm and the noise level as measured at the potentially most affected houses.

To determine an acceptable noise level for the proposed wind farm in accordance with the requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators, the measured background sound (L_{95}) at the potentially most affected houses in each direction has been plotted against the wind speed at the wind farm site. The results are shown on Figures 7 – 10.

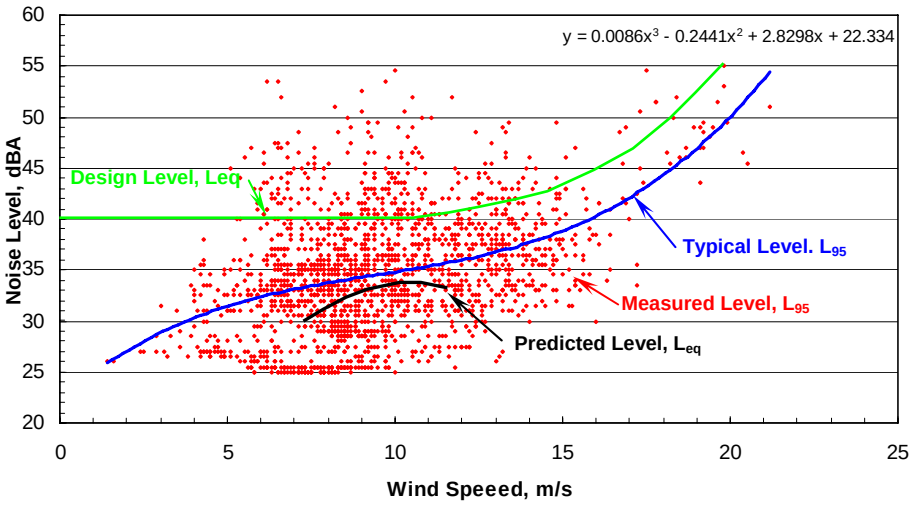


Figure 7. Wind Farm Design Limits at Site 1

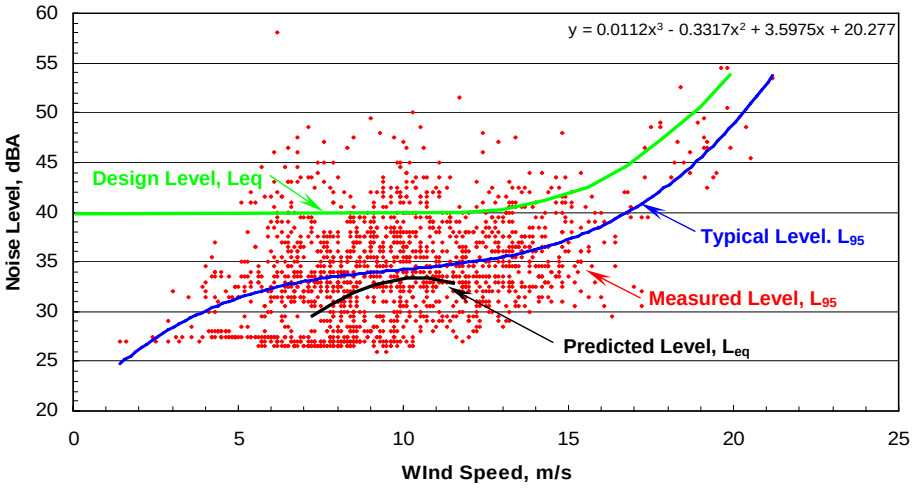


Figure 8. Wind Farm Design Limits at Site 2

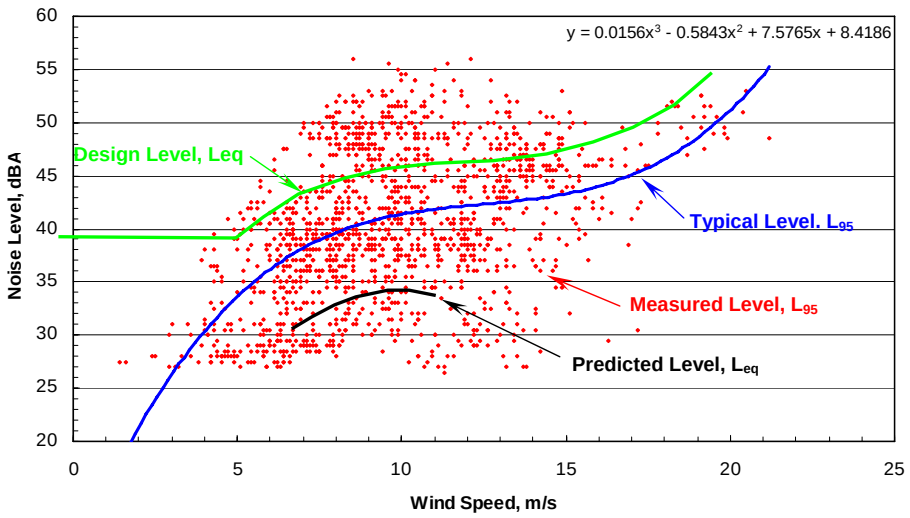


Figure 9. Wind Farm Design Limits at Site 3

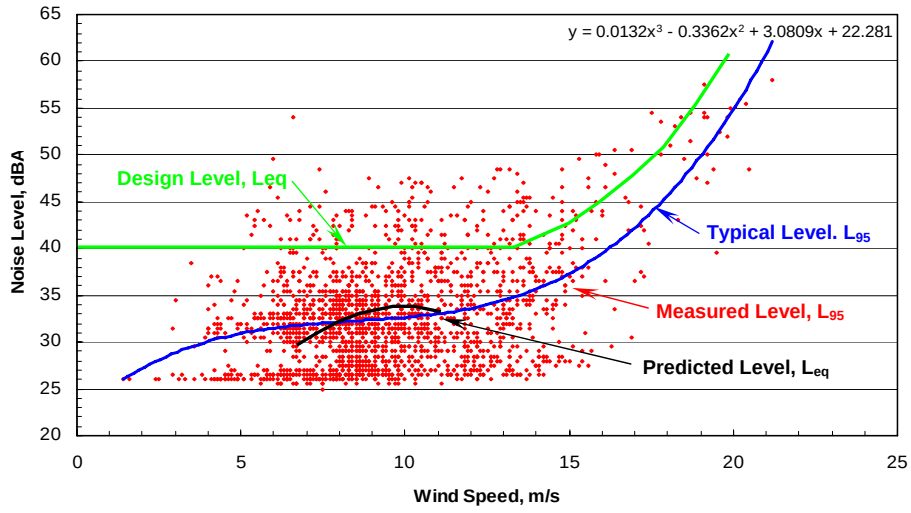


Figure 10. Wind Farm Design Limits at Site 4

In Figures 7 - 10 the background noise levels (on the y-axis) as measured at 10 minute intervals throughout a ten day period were plotted (the red points) against wind speed (on the x-axis). The typical background sound (L_{95}) for the measured points were then calculated as shown by the blue line and related formula given in the top right corner of graph. The typical background line becomes the basis of

acoustic design in accordance with the requirements of NZS 6808 with the design level for the wind farm noise being equal to the higher of 40dBA or the background sound +5dBA as shown by the green line. Finally, the predicted noise level at the house position, where these noise levels have been measured, is shown by the black line.

In each of the above cases, the wind farm noise is well within the design requirements of NZS6808. Inspection of the graphs (Figures 7 – 10) show the noise from the proposed wind farm does not exceed the design requirement of 40dBA at ay time. The background +5dBA is not relied on at any house location for the design limit.

Inspection of the noise against the wind plots shows a significant scatter of the noise level when including all wind directions, particularly for site 3. This can lead to conditions where the noise level at the house may be low when there is wind at the wind farm. Under these conditions the background sound may be low at the house, yet the wind farm may be generating noise. In thi circumstance, assuming the wind is blowing toward the house, the maximum noise will be heard above the background sound. However, in all cases the predicted noise level is below the minimum design level of 40dBA so it is not necessary to separate the various wind directions in order to determine the periods when the background sound is low compared to the wind speed at the wind farm.

It is acknowledged there may be periods when the background sound is relatively low at the houses and the residents will hear noise from the WTGs. However, audibility is not the design criteria at this site. This is no different to the criteria adopted for any other development, including typical industrial sites. Based on complying with the design requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators as proposed, the noise effects from the proposed wind farm will be no more than minor, even in a low background sound environment.

At a design level of 40dBA, the noise from wind farms is still within a limit that will allow undisturbed sleep for the majority of people, which is the design criterion. This is confirmed in Clause 4.4.1 of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators where it is stated:

> *In order to provide a satisfactory level of protection against the potential adverse effects of WTG sounds, this Standard recommends an upper limit of acceptable WTG sound levels outdoors at the residential locations of 40dBA L_{95} (refer to 4.4.2). This has been based on an internationally accepted indoor sound level of 30 to 35dBA L_{eq} commonly used as a design level to protect against sleep disturbance (refer Berglund & Lindvall). See 4.4.2, Notes (1) and (2) for the relationship between L_{eq} and L_{95}. A reduction from outdoors to indoors of typically 10dB with open windows has been assumed.*

As set out above, the scatter of the noise levels for a given wind speed is only of potential concern where the predicted noise level exceeds 40dBA, which is the minimum design level adopted in the Standard. For the proposed wind farm, the predicted noise levels do not exceed 34dBA at any notional boundary.

Keeping in mind that the compliance level (in terms of NZS6808) is predicted to be a minimum of 5dBA, and generally much more, below the design criteria for the proposed WTGs, the effects of scatter on the noise/wind graphs is not considered to be significant. The potential noise exposure under the most critical weather conditions will be within a reasonable limit at all times.

4 PREDICTED NOISE LEVELS

4.1 Construction Noise

During the construction of the internal roading system, plant on site will include earthmoving equipment to prepare the foundations for the WTGs, a crusher, concrete batching plant, trucks delivering concrete and cranes to erect the wind turbines.

During the formation of the internal roads the noise at the most affected houses is predicted to be no more than 30dBA (L_{eq}) and generally 10 – 12dBA lower. Based on measurements taken of excavators operating, the noise level at the closest houses, which is generally on the northern side of the proposed wind farm, will not exceed 27dBA L_{eq} when preparing the foundations for the closest WTG during calm conditions.

The crushing of the concrete aggregate will be with a Nordberg 1213S track mounted Impact crusher fed by an excavator. The noise from this unit has been based on field measurement of a similar size unit that generated 86dBA at 20m. Based on this level the 70dBA L_{eq} design limit will be achieved at 120m from the crusher. The crusher will be located significantly further from the closest dwelling, the noise at the closest notional boundary of any dwelling will be at an upper limit of 34dBA (L_{10}) when assuming minimal screening by the topography.

The batching plant noise has been based on a similar size plant at an existing site. The main noise is from conveyors, the loader loading the hoppers and the concrete truck receiving the concrete and mixing the concrete in the truck. The typical cumulative noise level from this plant is up to 77dBA (L_{eq}) when measured at 15m. based on the distance to the closest house and including some relatively minor screening effects from the topography, the noise level will be up to 34dBA L_{eq}, or less than 30dBA (L_{eq}) if there is good screening by the topography.

Concrete trucks operating on their own are typically 69dBA at 12m, which gives a level of less than 25dBA at the notional boundary of the closest dwelling in the area.

The placing of concrete and the erection of the WTGs will be quieter than the development of the foundations as set out above. These levels will be well within the requirements of the Construction Standard. The levels are below the existing background sound (L_{95}) in the area so the noise is unlikely to be heard at any of the house sites in the area.

4.2 Operation Noise

The two main noise sources from the proposed wind turbines are mechanical noise and aerodynamic noise. All mechanical noise sources will be located within the WTG nacelle on the top of the tower as shown in Figure 11. The noise from the gearbox and drive motors will be controlled by the manufacturer's design, making any mechanical noise secondary to the aerodynamic noise from the wind turbine blades rotating.

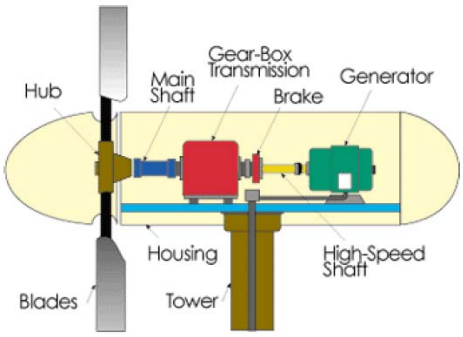


Figure 11. Typical Nacelle Noise Sources

The noise specifications for the WTG are available from the manufacturer. An example of the test data available is set out below for the indicative 3MW WTGs being considered for this site (Vestas V90). Based on the manufacturer's data, the sound power level for a 3MW turbine, which is dependent on the wind speed, is:

Wind speed at 10m height (m/s)	6	7	8	9	9.2*
Sound power level (dB)	105.3	108	109.3	110.1	109.9

* Wind speed corresponding to 95% of rated power

Table 1. Sound Power Levels

The sound power of the wind turbines is at the nominal maximum at 9.2m/s. Once the wind speed reaches 25m/s the turbine is temporarily shut down to prevent any possible damage to the equipment.

Figure 12 shows an example of a 3MW turbine with the sound power of this wind turbine given over a 4 – 10m/s wind speed.

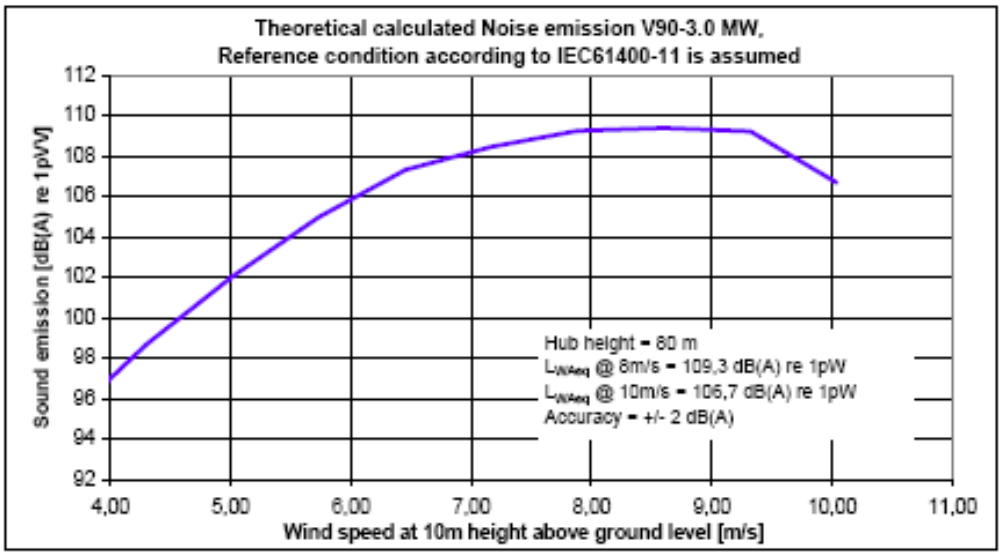


Figure 12. Typical Noise Curve

In a Windtest *Report of acoustical emissions of a wind turbine generator system of the type V90-3MW*, dated May 2005 it is stated:

> Measurements of this turbine carried out at a distance of 500m from the turbine confirmed a reduction in the tonal audibility of tones at around 900Hz of more than 10dB. Therefore in this case, there is no need for any tonality penalty to be applied at the surrounding points of noise impact.

When close to the operating turbines (within approximately 50m) the characteristic beat of the blades is apparent as they turn. However, at distances of more than approximately 300m, the noise becomes steady and the beat reduces significantly. With more than one turbine operating, the cumulative noise is a steady sound. It is noted that the noise from the wind turbine generators does not have any significant directivity characteristics so the direction that the WTGs face is not critical in the analysis of the noise effects.

During calm weather conditions (<≈2.5m/s) the wind turbines will be either stationary or will idle without generating any power. Under these conditions, there will not be any noise from the turbines. This is also the condition for the minimum noise in the environment.

In a gentle to moderate breeze (≈8m/s) the wind turbines will generate close to their maximum noise level. Based on wind speeds of 9m/s, which is the noisiest operating conditions, the resulting noise level at the notional boundary of the dwellings around the site have been predicted. The closer dwellings to the proposed wind farm are shown in Appendix B.

Based on the above, the predicted level at the notional boundary of the houses in each direction is shown in Appendix C. These predictions are based on the standard reduction of noise at the rate of 6dBA for each doubling of distance between the source and receiver position (geometrical spreading) and the effects of atmospheric absorption. The screening effects of the topography has also been included with a reduction of these screening effects as the distance between the WTG and receiver increased due to the 'bending' of the sound waves over barriers at large distances (>≈1km). As the WTGs are relatively high, no sound reduction due to ground effects has been included in the calculations.

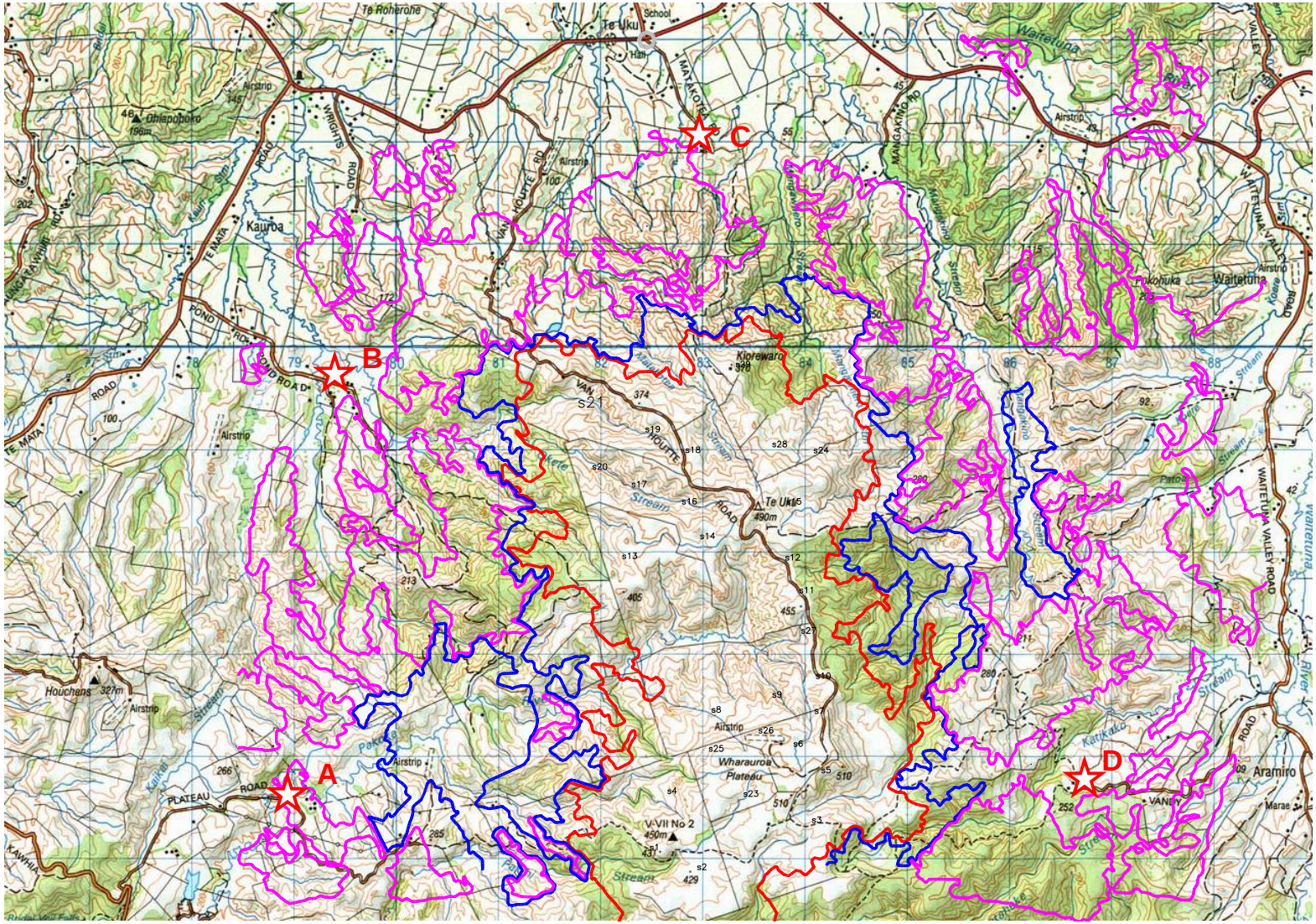
The effect of sound transmission is influenced by wind direction with higher noise levels being received downwind than upwind. As monitoring of the wind farm once it is built would be undertaken downwind (which is representative of the noise level that

would be experienced by residents at times), these effects have been included in the analysis of the predicted noise level. This raises the predicted noise by typically 5dBA at 1km when compared to no wind effects. Similarly, if upwind, the noise level is reduced by typically 8dBA at 1km. In both cases, the difference increases as the distance increases.

As a more general design, Figure 13 shows the noise contours as predicted for downwind conditions. These contours (L_{eq}) are based on 28 WTGs as located in the visual assessment report (with the coordinates as given in Appendix D) and each turbine has the noise output of an indicative 3MW machine.

While the design hub height has been based on 80m above ground height it is noted that the application of for a hub height of up to 90m. Analysis of the 10m variation to the hub height shows there is less than 0.5dBA difference in the noise level as received at any given receiver position. While the small variations are show in the spot noise levels (assuming no rounding to the whole dBA) there will be no perceivable difference to the noise contours, or the sound receiver at any location around the wind farm.

The noise levels have been predicted based on the existing ground contours over an area of approximately 10km x 9km. It should be noted that the noise contours shown on Figure 13 have been based on a downwind condition in all directions, which represents the worst case scenario for each house in all directions at the same time. This means that the assessment is carried out on the basis that the wind is blowing from the WTGs toward the receiver position. While this is not a situation that would occur in practice, this technique of modelling allows the worst noise effects in each direction to be calculated and shown on a single figure. These predicted noise levels will never occur at the same time, they will only be experienced when the receiver is downwind of the wind farm.



30dBA L_{eq}

35dBA L_{eq}

40dBA L_{eq}

☆ Noise Measurement

Figure 13. Predicted Downwind Contours

When the wind is not blowing toward the house being considered, the noise levels would be below those shown as downwind conditions in Appendix B. As for the downwind conditions, these levels will not occur in all directions at the same time.

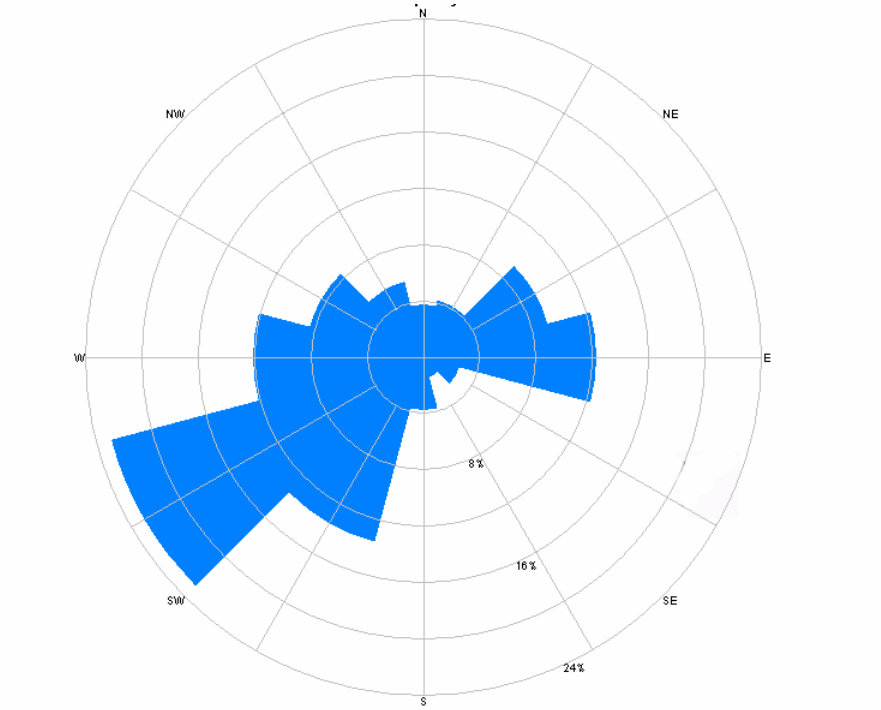


Figure 14. Wind Rose for the Area.

When considering the downwind predicted noise level, the noise levels at the houses shown in Appendix B (which are representative of the houses around the proposed wind farm) are well within the requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators. That is, the noise will be below 40dBA L_{eq} or the background sound level (L_{95}) plus 5dBA at all times.

Houses further away than those listed in Appendix B would experience noise levels lower than those given. The levels for those houses would be well below the requirements specified in NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators.

The noise level from WTGs measured at any other site boundary, as set out in Propsoed Waikato District Plan, has been evaluated based on the noise contours shown in Figure 15. From this figure it can be seen the 40dBA L_{eq} noise contour goes onto land beyond the properties that comprise the project area. However, as shown on Figure 15, there are no houses within approximately 1,300m of the 40dBA L_{eq} noise contour were it is located outside the land with WTGs on it. Thus, the noise effects beyond the wind farm site boundaries will be minimal for any resident in the area.

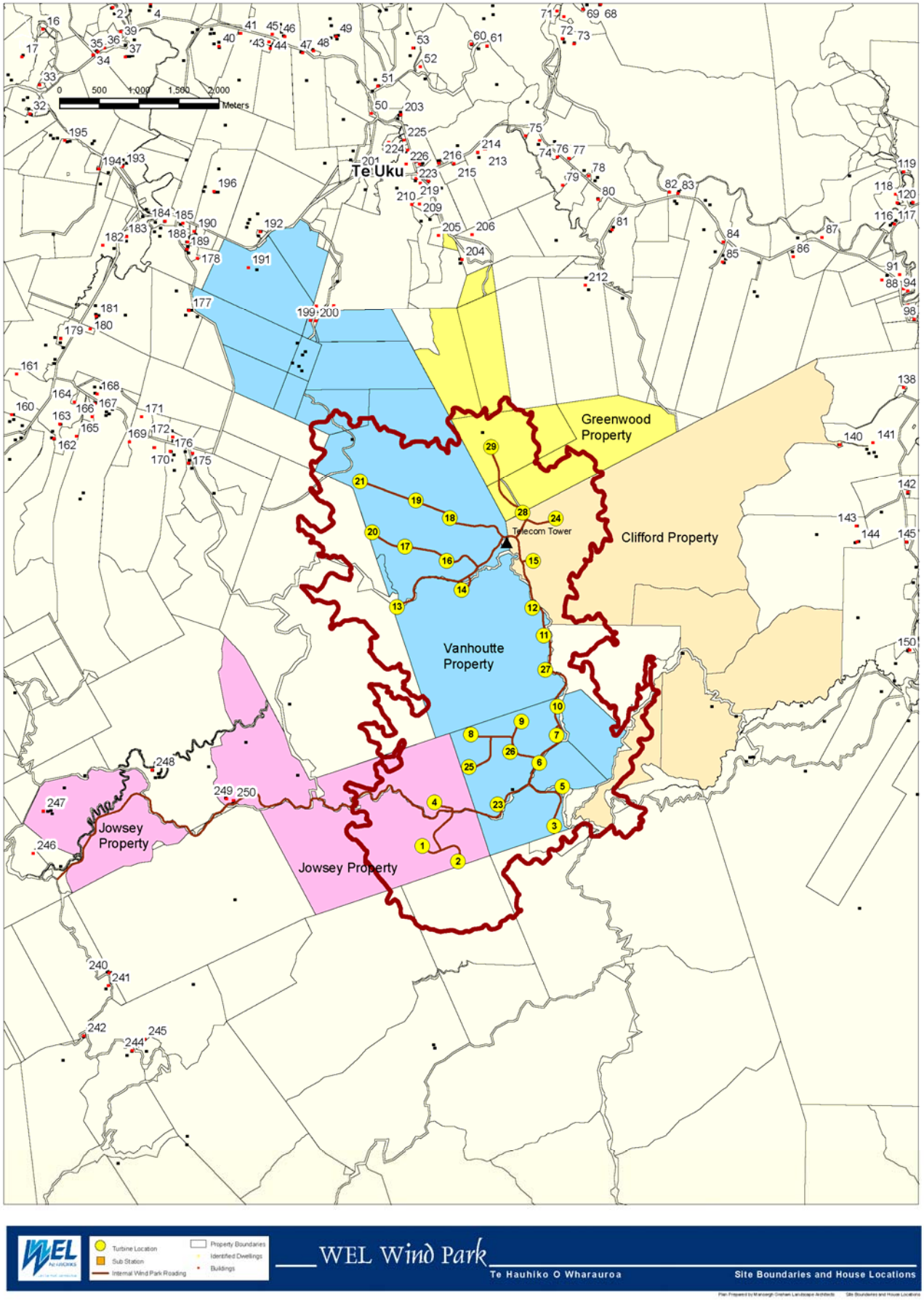


Figure 15. Site Boundaries and Site

5 TRAFFIC NOISE

Very little traffic will be generated during the operation of the wind farm with only the occasional service vehicles arriving on site.

Based on information provided by the project's traffic engineer, it is expected that over the course of the construction phase of the project, the over length truck that transports the WTG blades will travel to the site in the order of 84 times over a six month period. Other external deliveries to site include cement (approximately 2,333 trips), reinforcing steel (56 trips) and other materials (312 trips) and similar all over an extended period. This equates to approximately 10 heavy vehicles trips per day during turbine erection. Workers providing the expertise and labour will generate the largest movements (30 - 40 trips per day). These trips will occur after the road construction phase of the work.

The site access will be via State Highway 23 to Te Mata Road, Kawhia Road and Plateau Road. This access route will be used by all heavy construction vehicles. Emergency and some light vehicle traffic could enter the site via State Highway 23 and Van Houtte Road.

There is no specific control of traffic noise in the District Plan, Resource Management Act or any other current legislation. The only guidelines available are the Transit New Zealand Guidelines for the Management of Road Traffic Noise – State Highway Improvements and the lowest noise level adopted in these guidelines is 55dBA measured as a 24 hour L_{eq}. This is the level adopted for the quietest noise environments. There are no recommended noise limits for the 1 hour L_{eq}, although generally the 1 hour L_{eq} does not exceed the 24 hour L_{eq} by more than 2 – 4dBA.

As given in the traffic engineers report, and set out above, the typical daily traffic will only increase by around 10 heavy commercial vehicles per day and 30 – 40 light vehicles. As there are already some 4,000 vehicles per day on SH23 near Te Uku the increase in total vehicle numbers, and hence the increase in noise level, will be minimal with less than 1dBA increase to the existing 67dBA (24 hour L_{eq}) for houses at 10m from the edge of SH23 in the Te Uku area. Further east on SH23 existing

traffic flows are higher that at Te Uku so the existing noise is also higher and hence the effects of traffic associated with this project will be less than predicted above.

Existing traffic flows on Van Houtte Road are typically 30vpd, which is too low to provide any meaningful predicted traffic noise level. At these low flows the sound of individual vehicles is all that will be heard. With the increased traffic on Van Houtte Road due to the development of the wind farm the traffic noise will still be below a level that can be assessed with a 24 hour L_{eq} and again, it will be the individual events that will be heard.

Should the Te Mata Road, Kawhai Road and Plateau Road access be used the total daily noise effects will again be minimal as flow are typically 400vpd on Te Mata Road and 150vpd on Kawhai Road.

Although the daily noise exposure will remain low and well within a noise level generally considered to be reasonable, it must be kept in mind that the individual truck movements will be clearly audible for anyone living close to the road. As the truck movements are expected to be limited to the daytime rather than at night time (10:00pm – 7:00am), sleep disturbance will not be affected. However, it does need to be kept in mind that that this will be introducing an additional noise source for the neighbours during the construction period although the effect will be no more than minor.

Once operational, it is expected there will be 3 - 4 staff members arriving at the site via Plateau Road. Although the noise from the individual cars passing will be heard, the overall noise effects in terms of even the 1 hour or 24 hour L_{eq} will be insignificant.

6 NOISE MONITORING

In order to verify the noise from the operational wind farm it is proposed to undertake noise monitoring in terms of the requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators. The relevant section of that Standard are set out below.

Clause 5.1.8 states:

> *Once the WTG (or windfarm) is installed and operational, it may be necessary to monitor the sound level in the surrounding area. If so, measurements shall be taken of the sound level, and in addition, consideration needs to be given as to whether there are any special audible characteristics of the sound which may justify analysis and possible application of a penalty which must be taken into account when determining acceptability (see 4.4.3).*

Clause 4.4.3 states:

> *These limits of acceptability are specified without any adjustment applied for special audible characteristics. Predicted or measured LR levels from WTGs with known special audible characteristics shall be adjusted by adding +5 to the level. This adjustment is a penalty to account for the adverse subjective response likely to be aroused by sounds containing such characteristics (see section 5.3 for compliance assessment for sounds containing special audible characteristics).*

In addition, any further monitoring should be undertaken in terms of Clause 5.5 of NZS6808, which states:

> *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.*

One of the design options to check the noise levels is to install permanent noise monitors. However, before any permanent noise monitoring is considered, the reason for such monitoring needs to be established. The only reason would be to demonstrate compliance with the relevant noise Standards. If monitoring is undertaken at the houses (or other representative sites), it would be very difficult to

determine the difference between the noise from WTGs, traffic noise, wind generated noise or some other source of noise from unattended monitoring.

The alternative is to measure relatively near the wind farm. Any such monitoring point would need to be very close (300 – 400m) to a turbine so the turbine noise dominated the measured levels. When this close to a set of turbines the result is unlikely to be representative of another part of the wind farm so the measurements become invalid unless there are a number of monitoring sites. Each site would need to be calibrated for the different house locations with specific wind directions. Even if this were practical, the results could not be used for 'enforcement', as there will always be variations that make it impractical to confirm the results with absolute certainty so the results would be of little actual value.

The important issue is that the noise from any WTG is constant at a given wind speed so the only variable to the received noise level will be directly related to the metrological conditions. The testing procedures set out in NZS6808 have been developed in order to take these variations into account and achieve a representative noise level. Having achieved that level there should not be any variation to the measurements; hence there is no advantage in undertaking continuous noise monitoring.

In addition, the highest WTG noise has been predicted to be 34dBA at six houses (see Appendix C). At this level there will not be any adverse noise effects from the proposed wind farm noise so no extended noise monitoring will be necessary at this site.

7 RECOMMENDATIONS

It is recommended that the proposed wind farm is designed to comply with the following noise conditions.

1. The wind turbines shall be designed and constructed so that within the notional boundary of any rural dwelling existing at *[insert the date of this resource consent]*, the sound level from the generators shall not exceed the background sound level (L_{95}) by more than 5dBA, or a level of 40dBA L_{95}, whichever is the greater, as determined in accordance with NZ Standard NZS6808:1998 Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators.

2. Prior to giving effect to this consent, the consent holder shall provide to the Council a noise assessment prepared by an appropriately qualified person that demonstrates that the intended number, layout and type of turbines to be used will meet the noise standard specified in condition *x* above.

8 CONCLUSIONS

The noise during the construction of the wind turbines will be well within the requirements of NZS 6803:1999 Acoustics – Construction Noise.

The proposed wind farm analysis has been based on an indicative 3MW turbine at 28 sites, to establish the noise limit at all of the houses in the immediate area. The acoustic analysis has considered the noise contribution of each WTG at each of the closer houses.

Once operational, the noise from the wind farm will also be within the noise requirements of NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators of 40dBA or the background sound (L_{95}) +5dBA, whichever is the greater. In addition, where the noise exceeds 40dBA at the site boundary (as set out in the Proposed District Plan) there are no houses within approximately 1,300m so there will not be any adverse effects in those areas where 40dBA is exceeded at the site bouindary.

From the analysis, it has been shown that the proposed wind farm will achieve the design limit with a significant factor of safety. Section 16 of the Resource Management Act requires the best practicable option to be adopted to minimise noise and this requirement would be achieved by installing one of the modern quieter styles of WTG on the market. Locating the turbines to minimize the noise to neighbours is also a technique that has been adopted during design to minimise any potential for adverse noise effects.

When taking the above into account, the noise effects of the proposed wind farm will be no more than minor for the neighbours.

* * *

APPENDIX A
Guide to Noise Terms

The following sets out an explanation of the acoustic terms that will be referred to throughout this report. The aim is not to necessarily provide technical definitions, but to enable a basic understanding of what is meant.

The setting of specific noise levels to control any adverse effects does not necessarily mean that noise will not be heard. Audibility depends on the level of a sound, the loudness of the background sound and any special frequency composition or characteristics that a sound may have.

Research suggests that a small number of people (approximately 10%) will find any noise not of their own making unacceptable. Conversely, there are approximately 25% of the population that are essentially immune to any noise. Neither of these two extremes is normally designed for. In establishing the appropriate noise levels the aim is to try and represent the typical expected community reaction, this will generally be approximately 90% of the people.

In order to reflect community response to noise it is necessary to establish a measure that reflects our attitude to the sounds that we hear. Due to the variability of many sounds (level, tone, duration, intrusiveness above the existing sound, etc) no single descriptor will totally describe the potential community reaction to a sound. For this reason there are a number of terms that need to be understood.

dBA

The basic unit to quantify a sound is the decibel. The A-weighted sound level, or dBA, is a good environmental noise descriptor because of the similarity between A-weighting and the frequency response of the human ear at moderate sound levels. It can also be measured easily. However, it provides no indication of tonal frequency components or unusual frequency distributions of sound that may be the cause of annoyance. Where appropriate, this must be assessed separately.

We can hear a change in sound pressure that varies from 1 (taken as the threshold of hearing) through to 1,000,000,000,000 (taken as the threshold of pain). In order to bring these numbers to a more manageable size a logarithmic scale is normally adopted. This reduces the above values to 0 and 12 respectively. The decibel is then described as 10 times the logarithm of the ratio of the pressure level of interest, to a reference pressure level. Thus the scale becomes 0 to 120dBA.

Some typical subjective changes in noise levels are:

A change of 3dBA is just perceptible
A change of 5dBA is clearly perceptible
A change of 10dBA is twice (or half) as loud

Because we use a logarithmic scale care must be taken when adding sound levels. Two equal noise sources raises the level of one source by 3dBA. It takes 10 equal noise sources to raise the level of one source by 10dBA. ie 60dBA + 60dBA = 63dBA and 60dBA x 10 = 70dBA.

Maximum Sound Level (L_{max})

This unit equates to the highest (maximum) sound level for a defined measurement period. It is adopted in NZS6802:1991 Assessment of Environmental Sound, mainly as a method of protecting sleep.

L_{10}

The sound level which is equaled or exceeded for 10% of the measurement time. This level is adopted in NZS6802:1991 Assessment of Environmental Sound to measure intrusive sound. This level may be considered as the average maximum sound level.

Background Sound L_{95}

The sound level which is equaled or exceeded for 95% of the measurement time. This level is adopted in NZS6802:1991 Assessment of Environmental Sound to measure the background sound. This level may be considered as the average

minimum sound level and is the component of sound that subjectively is perceived as continuously present.

Equivalent Sound Level (L_{eq})

L_{eq} may be considered as the continuous steady noise level that would have the same total A-weighted acoustic energy as a fluctuating noise over the same time period.

Ambient Sound

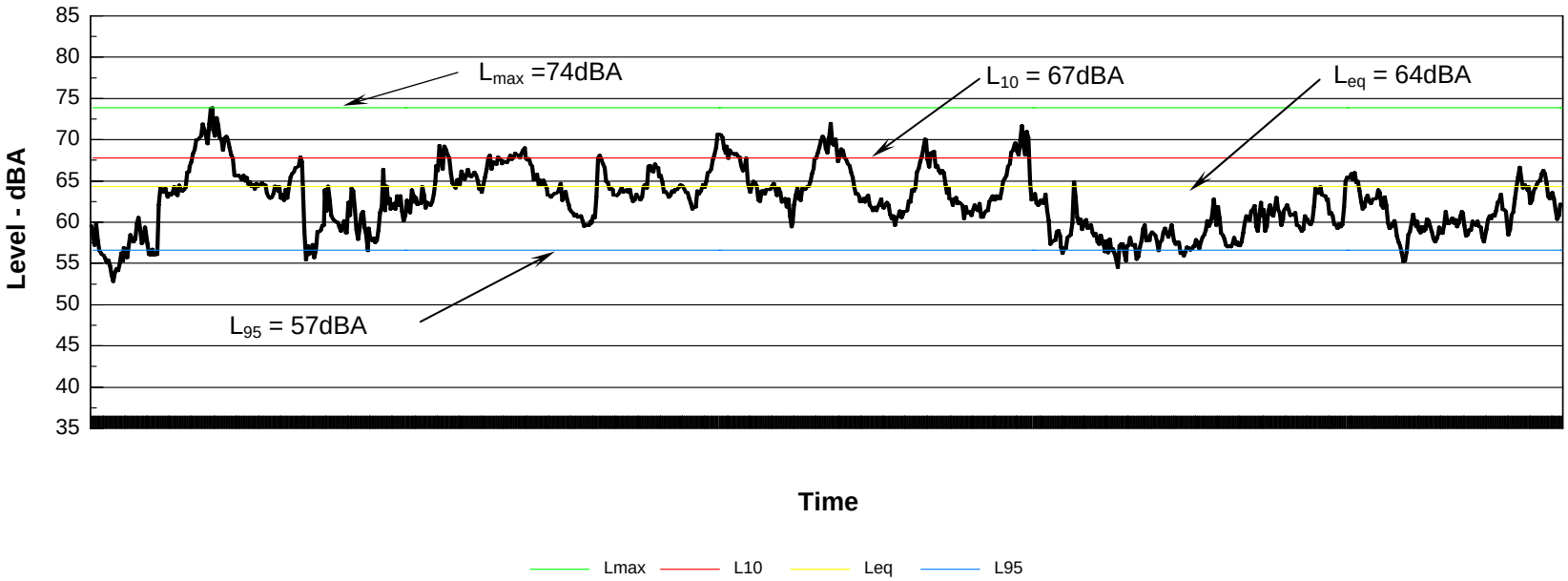
The ambient sound is normally used to describe the total noise environment. The ambient sound is often measured as the 24 hour $L_{eq,}$ which is an average value over the 24 hour period. Shorter times are often used, such as the daytime period

Notional Boundary

The notional boundary is defined as a line 20 metres from the facade of any rural dwelling or the legal boundary where this is closer to the dwelling.

Figure 1 shows a noise trace with the relationship of L_{max}, L_{10}, L_{95} and L_{eq} values when including all events over the 15 minute measurement period and Figure 2 some typical noise levels.

* * *



L_{max} is the maximum noise level
L_{10} is the noise level that is equaled or exceeded for 10% of the measurement period
L_{95} is the noise level that is equaled or exceeded for 95% of the measurement period
L_{eq} is the noise level that contains the same energy as the time varying noise

Figure A1

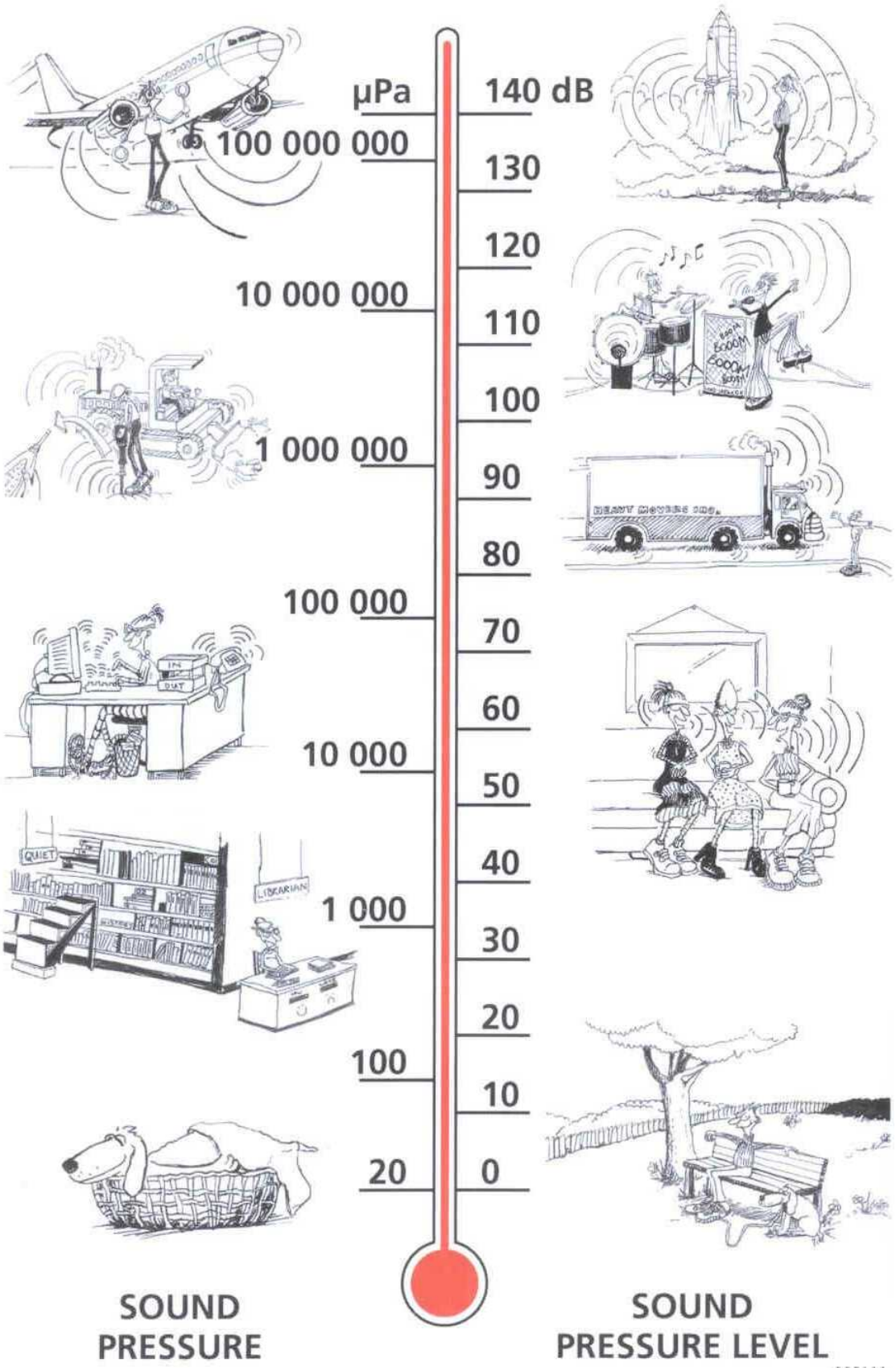
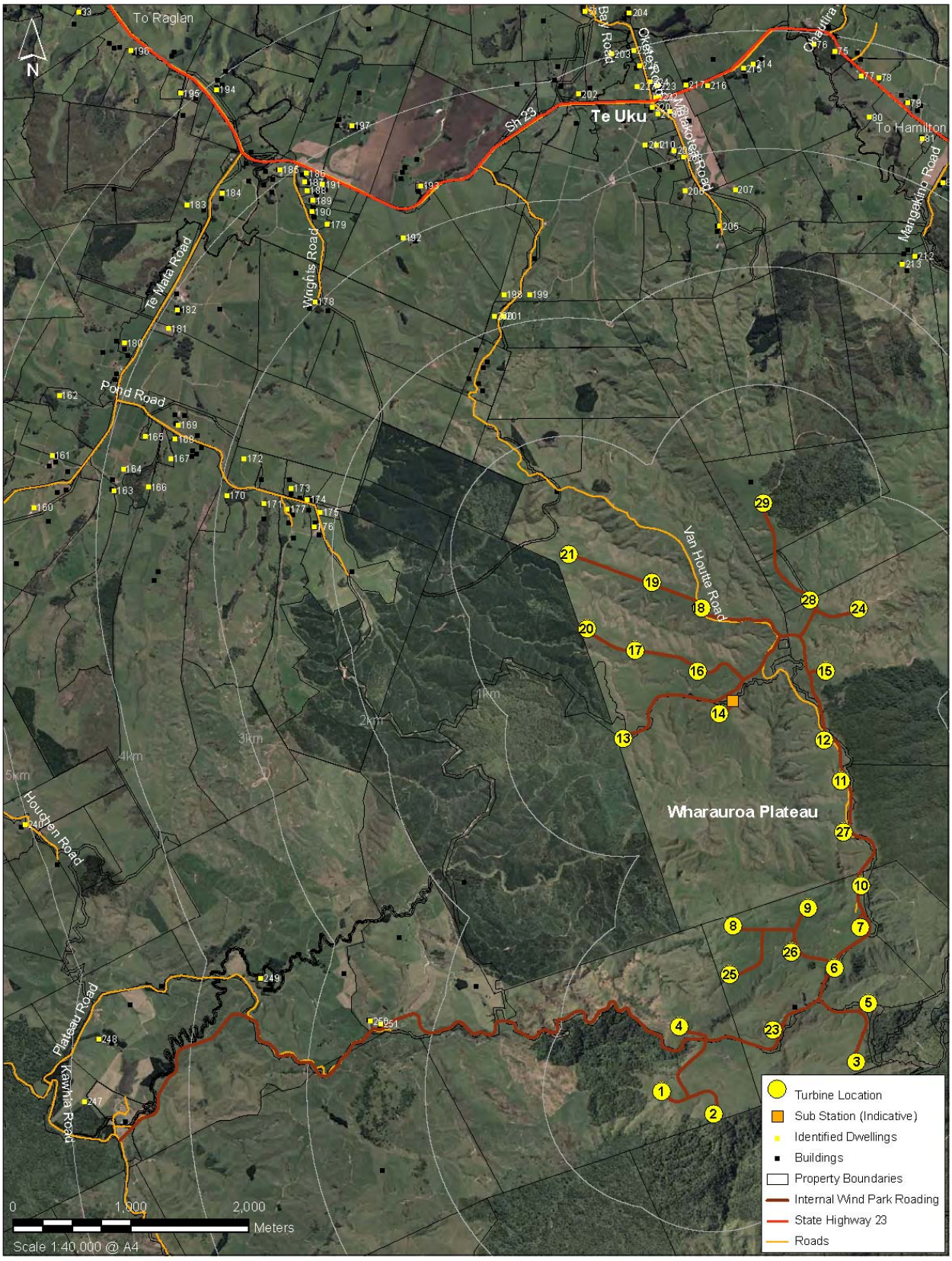

μPa
140 dB
100 000 000
130
120
10 000 000
110
100
1 000 000
90
80
100 000
70
60
10 000
50
40
1 000
30
20
100
10
20
0
QUIET
LIBRARIAN
SOUND PRESSURE
SOUND PRESSURE LEVEL

Figure A2

APPENDIX B - HOUSE LOCATIONS



APPENDIX C – PREDICTED NOISE LEVELS, dBA L_{10}

House	Level	House	Level	House	Level	House	Level	House	Level
1	27	50	30	99	23	148	32	197	32
2	28	51	31	100	26	149	32	198	33
3	28	52	31	101	25	150	32	199	33
4	28	53	31	102	27	151	29	200	28
5	28	54	30	103	28	152	31	201	33
6	26	55	29	104	27	153	32	202	33
7	26	56	29	105	27	154	33	203	32
8	27	57	29	106	27	155	33	204	32
9	27	58	29	107	28	156	32	205	31
10	27	59	29	108	28	157	33	206	32
11	27	60	29	109	28	158	30	207	33
12	27	61	30	110	29	159	31	208	33
13	27	62	30	111	27	160	31	209	33
14	27	63	28	112	28	161	31	210	33
15	26	64	29	113	29	162	31	211	33
16	27	65	29	114	30	163	32	212	29
17	28	66	29	115	29	164	32	213	33
18	28	67	29	116	29	165	32	214	32
19	28	68	29	117	30	166	33	215	32
20	28	69	29	118	26	167	33	216	33
21	28	70	29	119	15	168	33	217	33
22	28	71	30	120	30	169	33	218	33
23	28	72	30	121	29	170	34	219	33
24	28	73	30	122	30	171	34	220	33
25	28	74	30	123	29	172	34	221	33
26	28	75	32	124	29	173	34	222	33
27	28	76	32	125	30	174	34	223	33
28	29	77	32	126	30	175	33	224	33
29	29	78	32	127	30	176	33	225	33
30	29	79	33	128	30	177	34	226	32
31	29	80	33	129	30	178	33	227	33
32	28	81	30	130	30	179	30	228	29
33	28	82	33	131	30	180	32	229	30
34	28	83	30	132	30	181	32	230	29
35	29	84	32	133	30	182	32	231	29
36	29	85	32	134	30	183	31	232	29
37	29	86	29	135	30	184	31	233	29
38	29	87	32	136	31	185	32	234	29
39	29	88	31	137	31	186	32	235	29
40	28	89	28	138	31	187	32	236	29
41	29	90	26	139	28	188	32	237	28
42	29	91	23	140	31	189	32	238	30
43	30	92	28	141	33	190	32	239	29
44	30	93	28	142	33	191	32	240	32
45	30	94	26	143	33	192	33	241	32
46	30	95	26	144	33	193	32	242	32
47	30	96	21	145	33	194	30	243	31
48	30	97	21	146	32	195	30	244	32
49	30	98	23	147	32	196	26	245	32
								246	32

APPENDIX D

Location of Wind Turbine Generators

Turbine	X	Y	Z
1	2682482	6364587	500
2	2682975	6364382	520
3	2684170	6364872	560
4	2682664	6365173	520
5	2684268	6365389	560
6	2683977	6365664	580
7	2684198	6366007	570
8	2683124	6366019	560
9	2683758	6366176	580
10	2684210	6366370	555
11	2684039	6367262	505
12	2683892	6367602	515
13	2682195	6367617	480
14	2683005	6367824	515
15	2683905	6368184	560
16	2682816	6368185	510
17	2682292	6368363	480
18	2682853	6368721	490
19	2682435	6368937	480
20	2681884	6368547	445
21	2681732	6369193	400
23	2683457	6365144	540
24	2684187	6368717	505
25	2683096	6365614	550
26	2683614	6365803	575
27	2684058	6366842	500
28	2683756	6368781	530
29	2683375	6369612	460