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Stockyard Hill Wind Farm

Background Noise Monitoring Plan

Prepared for

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Level 10, 1 King William Street, ADELAIDE SA 5000

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INTRODUCTION

Origin Energy has been granted Planning Permit Number PL-SP/05/0548 (the Permit) by the Minister of Planning for the Stockyard Hill Wind Farm development. The Permit provides conditions for the development and operation of a wind energy facility comprising a maximum of 157 wind turbines and associated buildings and works.

The Permit includes a requirement for the preparation of a background noise monitoring plan, prior to the start of the development. This document has been prepared in response to that requirement.

The background noise monitoring plan includes the following information:

- Background noise monitoring locations
  - the dwellings at which background noise monitoring will occur, and;
  - the methodology and rationale used in the selection of the dwellings.
- Background noise monitoring methodology
  - the equipment for background noise monitoring;
  - the equipment arrangement and positioning, and;
  - the data to be collected and the format and methodology in which it will be collected.
- Background noise monitoring data analysis
  - the wind speed data, and;
  - the methodology used to analyse the data and to develop the background noise curves and acceptable noise limit curves that will be used for operational noise compliance assessment.

PLANNING PERMIT CONDITIONS

Condition 19 of the Permit specifies the requirement for the preparation of a background noise monitoring plan which includes information on the background noise monitoring locations, the noise monitoring methodology and the data analysis methodology for the development of the background noise and acceptable noise limit curves. Condition 20 specifies the requirements for the key actions in the background noise monitoring plan.

This document has been prepared based on Conditions 19, 20, 21 and 22, which state:

19. *Before the development starts, background noise monitoring must be undertaken to the satisfaction of the Minister for Planning complying with the following requirements:*

    a) *a background noise monitoring plan, or plans, must be prepared by a suitably qualified and experienced acoustics expert;*

    b) *if the wind energy facility is to be constructed in stages, the background noise monitoring plan may be prepared for each stage before the development of that stage begins and those plans may be submitted successively to the Minister for Planning for approval, provided that where a dwelling might be affected by noise from more than one stage that is accounted for;*

    c) *the plan, or plans, must include the number and location of background noise monitoring sites and the justification for the selection of those sites, the methodology to be used for the noise monitoring and the development of the background noise curves, and a statement of how the uncertainty of those results will be estimated;*

    d) *the plan must include background noise monitoring at a minimum of 20 representative non-stakeholder dwellings for the whole wind energy facility, subject to access being granted, or a lesser number per stage if the wind energy facility is to be so constructed, as approved by the Minister for Planning. These monitoring sites must be within the modelled 35dBA L95 noise contour for noise from the wind energy facility only, as determined in Condition 19 c);*

e) the plan must include background noise monitoring at a minimum of 10 representative stakeholder dwellings, other than dwellings under option to the permit holder, for the whole wind energy facility, or a lesser number per stage if the wind energy facility is to be so constructed, as approved by the Minister for Planning. These monitoring sites shall be within the modelled 40dBA L95 noise contour for noise from the wind energy facility only as determined in Condition 19 c); and

f) when approved by the Minister for Planning the noise monitoring plan, or each plan (if the wind energy facility is to be developed in stage), must be made publicly available.

20. After the noise monitoring plan is approved, the background noise testing at each dwelling must be carried out in accordance with that plan and in accordance with NZS 6808:1998 Acoustics — 'The assessment and measurement of sound from wind turbine generators' subject to the following:

a) unless with the consent of the Minister for Planning, the equipment used for measuring noise, wind speed and wind direction must be calibrated by a NATA accredited testing organisation and the background noise measurement and assessment carried out by a NATA approved signatory[1];

b) unless with the consent of the Minister for Planning, the noise monitor used at each site must be a Type 1 noise logger calibrated with a Type 1 calibrator;

c) the anemometer used for the correlation of background noise against wind speed must:

- *be situated at hub height on the nearest meteorological mast to the noise monitoring site;*
- *remain in place after commissioning of the wind energy facility or that stage of it, and*
- *be unaffected by wind turbine turbulence.*

d) a minimum of 4000 ten minute data pairs are to be collected for each site;

[1] The field measurement and noise assessment are not covered by a NATA Certification, which is restricted to laboratory testing.

e) the data pairs must be correlated by 24 hour and night (10 pm to 7 am) time periods and for each time sector for wind directions of ± 45° of 0°, 90°, 180°, and 270° using the regression technique of NZS 6808:1998 or 'bin analysis', as appropriate

f) for each noise monitoring site, the same correlation technique must be used for this pre construction background noise monitoring as this will be used for the post construction compliance monitoring, including the same order regression equation; and

g) an estimate must be made of the uncertainty of the background noise curves.

21. For each of the above background noise curves the derived acceptable noise limit curves for the wind energy facility at each dwelling for the specified time periods and wind direction sectors must then be prepared as described in NZS 6808:1998 Acoustics — 'The assessment and measurement of sound from wind turbine generators'

22. The background noise curves and the derived acceptable noise limit curves for each background noise monitoring site for the specified time periods and wind direction sectors must be provided to the Minister for Planning for approval as having been carried out in accordance with these conditions; and when approved by the Minister for Planning the background noise curves and the acceptable noise limit curves must be made publicly available.

BACKGROUND NOISE MONITORING PLAN

It is noted that all wind turbines will be installed in a single stage and consequently this plan addresses the required background noise monitoring associated with the entire development.

Background Noise Monitoring Locations

To determine appropriate background noise monitoring locations, a conservative noise propagation model was used to model the noise at dwellings in the vicinity of the wind farm.

A detailed noise modeling plan will be undertaken at a later stage in accordance with a noise modeling plan developed and approved by the Minister for Planning as described in Condition 23 of the Permit.

The preliminary noise model takes into account the geometrical spreading of sound and sound attenuation due to air absorption. It is a conservative model as it does not take into account ground absorption, meteorological effects and attenuation from natural barriers. The use of a conservative model ensures that all potentially impacted dwellings will be considered in the development of the monitoring plan.

The noise model has been based on the approved turbine layout comprising 157 turbines, and manufacturer's sound power level data for REpower MM92 turbines with a hub height based on a maximum tower height of 80m.

Using the modelled noise level at dwellings, potential noise monitoring locations have been identified, in accordance with Conditions 19(d) and 19(e).

Based on the identified potential noise monitoring locations, 24 locations representative of non-stakeholder dwellings (Condition 19(d)) and 10 locations representative of stakeholder dwellings (Condition 19 (e)) have been selected. A total of 34 locations will have background noise monitoring.

The coordinates of the selected background noise monitoring locations are provided in the Tables 1 and 2. A map showing these locations and the turbine layout is provided in Appendix A.

Table 1: Background noise monitoring locations representative of non-stakeholder dwellings.

No.	Dwelling	Coordinates (GDA 94 MGA 56)	
		Easting	Northing
1	B37	695651	5853628
2	B40A	699081	5853513
3	B42	698409	5850995
4	C72	705895	5851752
5	C81	706523	5850435
6	D75	712117	5850655
7	D77	712701	5850234
8	H1	703278	5849485
9	H4	704757	5848887
10	H15	707855	5845963
11	H18	703669	5844423
12	H21	706438	5844847
13	H36	708500	5840518
14	I11	711656	5847683
15	I14	711434	5846970
16	I33	710107	5842201
17	L1	696587	5838653
18	L4	697423	5837889
19	M7	702332	5836497
20	M14	709505	5834994
21	N16	712039	5835649
22	N18	714359	5836174
23	N22	716270	5834805
24	N32	715232	5831362

Table 2: Background noise monitoring locations representative of stakeholder dwellings.

No.	Dwelling	Coordinates (GDA 94 MGA 56)	
		Easting	Northing
1	B39	697017	5851896
2	H14	706705	5846346
3	H25	701380	5842799
4	H27	705091	5843052
5	H32	703243	5842092
6	L7	699647	5837851
7	M1	708404	5839745
8	M5	701154	5837552
9	N21	706438	5844847
10	N26	710991	5832179

The proposed background noise logging locations have been selected based on the following rationale:

- **locations representative of non-stakeholder dwellings**
  - at least 20 dwellings (non stakeholder landowner) within 35 dB(A) noise contour;
  - locations which can be represented by monitoring at other locations in close proximity have not been included (e.g. D78 and D80 can be represented by D77);
- **locations representative of stakeholder dwellings**
  - rank potential locations based on the modelled noise levels (all within 40 dB(A) contour), with the highest noise level first;
  - remove potential locations which can be represented by monitoring at other locations in close proximity, including those representative of non-stakeholder dwellings (e.g., L8 can be represented by L7, and M6 can be represented by M7);
  - include potential locations which will not have background noise monitoring conducted in the vicinity (e.g., M1).

Background Noise Monitoring Methodology

Based on the selected monitoring locations, the background noise monitoring at each location will be conducted as follows:

Equipment for background noise monitoring

The New Zealand Standard NZS6808:1998 (the New Zealand Standard) does not specify the equipment to be used for background noise monitoring. The important feature of a sound level meter used for wind farm background noise monitoring is a low noise floor. To ensure sufficient precision in the noise measurements, Type 2 sound level meters are generally considered acceptable.

Considering the above, Type 2 sound level meters with a low noise floor no greater than 20 dB(A) are proposed. The sound level meters will be calibrated before and after the background noise monitoring regime with a Type 1 calibrator and weatherproof microphone windshields will be fitted.

It is noted that Condition 20(e) of the Permit requires the use of Type 1 sound level meters. This requirement appears to relate to the Planning Panel discussion regarding the need for the meter to represent the true background noise level, for which the important feature is a low noise floor, as noted above.

A Type 1 sound level meter can possess a high noise floor that will not represent the true background noise level, which in turn can falsely relax the project assessment criteria. The Planning Panel discussion noted that the Rion NL-21 and Rion NL-31 Type 2 sound level meters have an excellent (low) noise floor, and was the preferred meter to be used for this reason.

Subject to the Minister's approval of this plan, the background noise monitoring regime will be conducted with only Rion NL-21 and Rion NL-31 low noise floor Type 2 sound level meters.

The Permit conditions and the New Zealand Standard do not specifically require the removal of adverse data from the background noise monitoring data. However, it is good practice to exclude data points where rain has occurred and when wind on the microphone has had an impact on the measured noise levels. The most appropriate way of determining these points is to place a weather logger at an equivalent location to the noise logger.

Therefore, in addition to the noise loggers, two weather loggers will be placed adjacent to selected noise loggers. Over the course of the logging, four noise logger sites will have weather stations at these sites. The weather loggers will record local rainfall, wind speed and wind direction. The weather data will give an indication of the data points which were collected during periods of rain or when wind on the microphone has had an adverse impact on the measured noise levels. This data that has been adversely affected by the local weather conditions will then be removed as part of the background noise monitoring data analysis phase.

Equipment Arrangement and Positioning

The location of the noise logger (comprising a sound level meter and batteries within a weatherproof container connected to a pole mounted microphone) will typically be at least 5m from the building facade to remove the effects of large reflecting surfaces on any future post construction measurements to be taken at the same point, in accordance with Permit Condition 20(f). The location will be required to be representative of background noise levels and this is generally achieved by placing the logger at an equivalent distance to large trees as those trees are to the facade of the dwelling.

The logger will also be placed on the wind farm side of the dwelling to enable any future post construction measurements at dwellings to be taken at the same point, again in accordance with Permit Condition 20(f). The microphone of the noise loggers will be positioned approximately 1.5m above the ground.

Photographs and a GPS grid reference of each noise logging location will be taken to assist in the identification of the noise monitoring locations. A typical noise monitoring equipment arrangement is shown in Figure 1 (located in the centre of the photograph).

Figure 1 – Typical Noise Monitoring Equipment Arrangement.

Noise Measurements

The noise logging will collect both L_{95} and L_{90} data to enable comparison against the 1998 and 2010 versions of the New Zealand Standard, respectively. The measurements will be made continuously over 10 minute intervals.

Although the New Zealand Standard requires only 1440 data points (which can be collected in 10 to 14 days), Condition 20(d) of the Permit requires a minimum of 4000 data points to enable sector wind direction analysis during both day and night time periods.

To collect 4000 valid data points, the noise monitoring equipment will be on site for a period of up to approximately 6 weeks to allow for the typical removal of data affected by adverse wind or rain periods. This monitoring period is more than three times longer than that required to satisfy the New Zealand Standard.

The background noise monitoring at the 34 locations will be conducted over two logging periods. Each period will involve 17 monitoring locations and will occur for 6 weeks. This approach is suggested for logistical reasons, including farm access and the transport of sufficient auxiliary (battery) power for a 6 week noise monitoring regime. Two weather stations will be installed for each of the logging periods. Should any of the sites experience equipment malfunction then the period of logging at the location may need to be extended.

Background Noise Monitoring Data Analysis

Once the background noise monitoring has been completed, the collected noise and weather data will be analysed to establish background noise and acceptable noise limit curves for each monitored location.

Noise data collected during periods of rain or during measured wind speeds of greater than 5m/s (at the equivalent microphone position) will be removed. Following the removal of data adversely affected by local weather conditions, the remaining noise data points will be correlated against wind speed data collected at the same time and for the same period as the background noise levels.

Reference Wind Speed Data

This section has been developed by Origin with noise related considerations provided by Sonus.

The reference wind speed data is used for the correlation with synchronous background noise data. This data will be provided by Origin from met masts located at the wind farm site and from met masts within three kilometers of the nearest turbine. The anemometers providing the wind speed data to be correlated with background noise levels will be situated at hub height on the nearest mast to the noise monitoring location.

The wind mast locations (Table 3) have been selected in accordance with the following rationale:

1. **Wind monitoring external to the wind farm site** – Three met masts will be located at points distant from the turbines, generally clear of wake effects of the turbines. These locations address requirements of the Permit conditions but provide wind speeds that in some cases are lower than on the ridgelines where the turbines will be located. Therefore,

the wind speeds obtained cannot be directly used for the prediction of wind farm noise levels.

To overcome this limitation and enable a robust assessment of potential noise impacts and operational compliance, a second set of wind masts will be located on the ridgelines and obtain wind speed data before and after installation of the turbines. The wind speed data from the ridgeline masts would be used for prediction of turbine noise levels prior to construction.

The remote masts (external to the wind farm array) will be used as the "constant" for both pre and post-construction measurements.

2. **Wind monitoring in proximity to turbine sites** – Three additional met masts (one existing, and two proposed) will be located on the ridgelines close to where the turbines will be located to provide representative wind speeds for the proposed turbine sites. It is noted that one of the remote met mast, Ext 3 will also be located on the ridgeline at similar elevation to the proposed turbines in the northwest of the wind farm site.

   The wind speed for the ridgeline masts will be used as the input to the noise prediction model as the highest wind speed on the site. The highest wind speed is used when predicting noise levels from the wind farm to ensure a conservative assessment. It is noted that a proportion of turbine sites will experience lesser wind speeds and as a consequence will generate lower noise levels than predicted in accordance with a conservative assessment approach.

   If, once operational, the mast locations on the ridgelines are at times subject to the turbine turbulence, then the wind speed recorded may be lower than that measured pre-construction under the same conditions. In such situations, reference to wind speeds for the external masts will provide a more consistent basis for pre and post commissioning relationships with noise measured at neighbouring dwellings.

Based on the proposed methodology for obtaining reference wind speeds at the six wind monitoring masts (three external and three internal to the wind farm site) it is considered that a robust noise assessment will be possible due to:

- the ability to relate noise monitoring (before and after commissioning) to wind speeds at external mast locations that are unaffected by turbine operation
- the ability to correlate wind speeds external to the wind farm site to those within the site and gauge the actual circumstances for turbine operation and noise levels

The proposed locations of the met masts have been selected to, as far as practicable, achieve the objectives of a robust noise assessment program and achieve compliance with requirements of the Permit conditions.

The approximate met masts locations are shown in Table 3. These locations are subject to specialist review and regulatory approvals. It is possible that adjustments may be required to address the outcome of the planning process.

Table 3 – Locations of met masts with hub height anemometers.

Reference	Status	Easting	Northing
Ext 1	Proposed	711003	5846524
Ext 2	Proposed	707974	5836409
Ext 3	Proposed	700817	5851953
WF 1	Existing	701372	5839185
WF 2	Proposed	711444	5848364
WF 3	Proposed	712257	5833098

Note: (1) Ext – External to wind farm array, WF – in proximity to turbine sites.
(2) Ext 3 is an external mast but is at an elevated location that will also have wind speed similar to that for the turbine site.

Approval is required for the mast sites in respect of conditions for the Planning Permit and EPBC approval.

Background Noise Curves

The correlation between the measured background noise levels and the wind speed (from external masts) will be conducted for the 24 hour and night (10pm to 7am) time periods, and for each time sector for wind directions of within ± 45° of 0°, 90°, 180° and 270° using the regression technique in accordance with the New Zealand Standard, as required by Permit Condition 20(e). The resultant regression line will form the background noise curve for each monitored location.

An example of a regression line plot produced from background noise measurements is shown in Figure 2. The regression line (black line in Figure 2) represents the background noise curve.

It is important to note that the wind speeds (external masts) will not be the same as those that are representative of the turbine sites. In most cases, wind speeds at external mast sites will be lower than for the turbine sites. It may therefore be necessary to establish a relationship between the wind speeds used to develop the background noise curves and the concurrent wind speeds that would apply at the locations of the turbines to which the background sites relate.

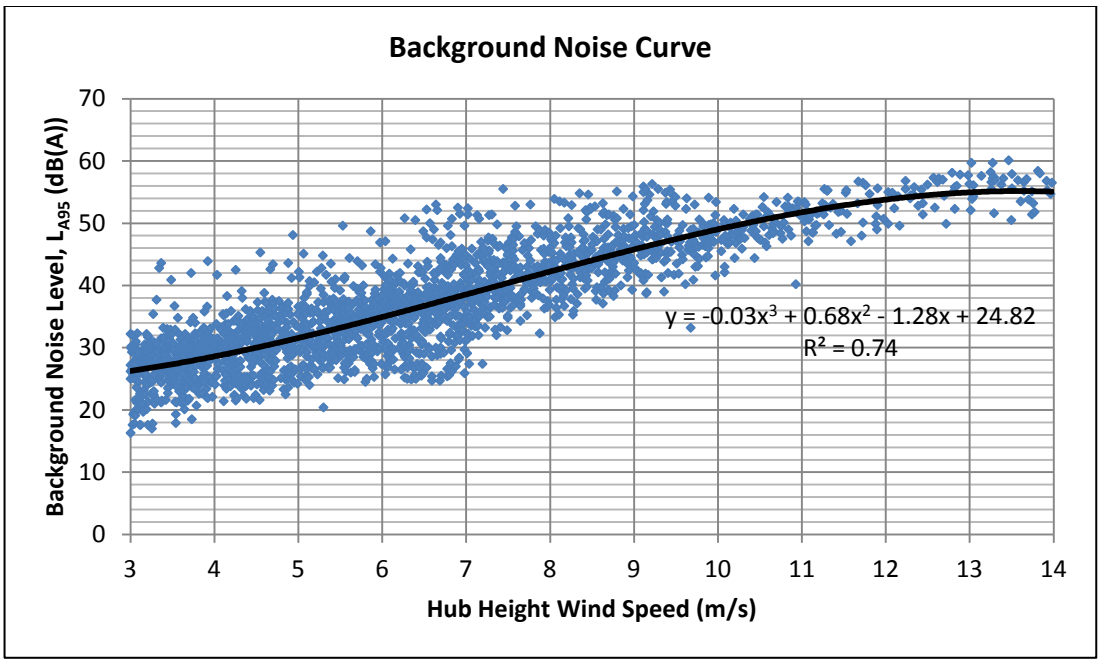
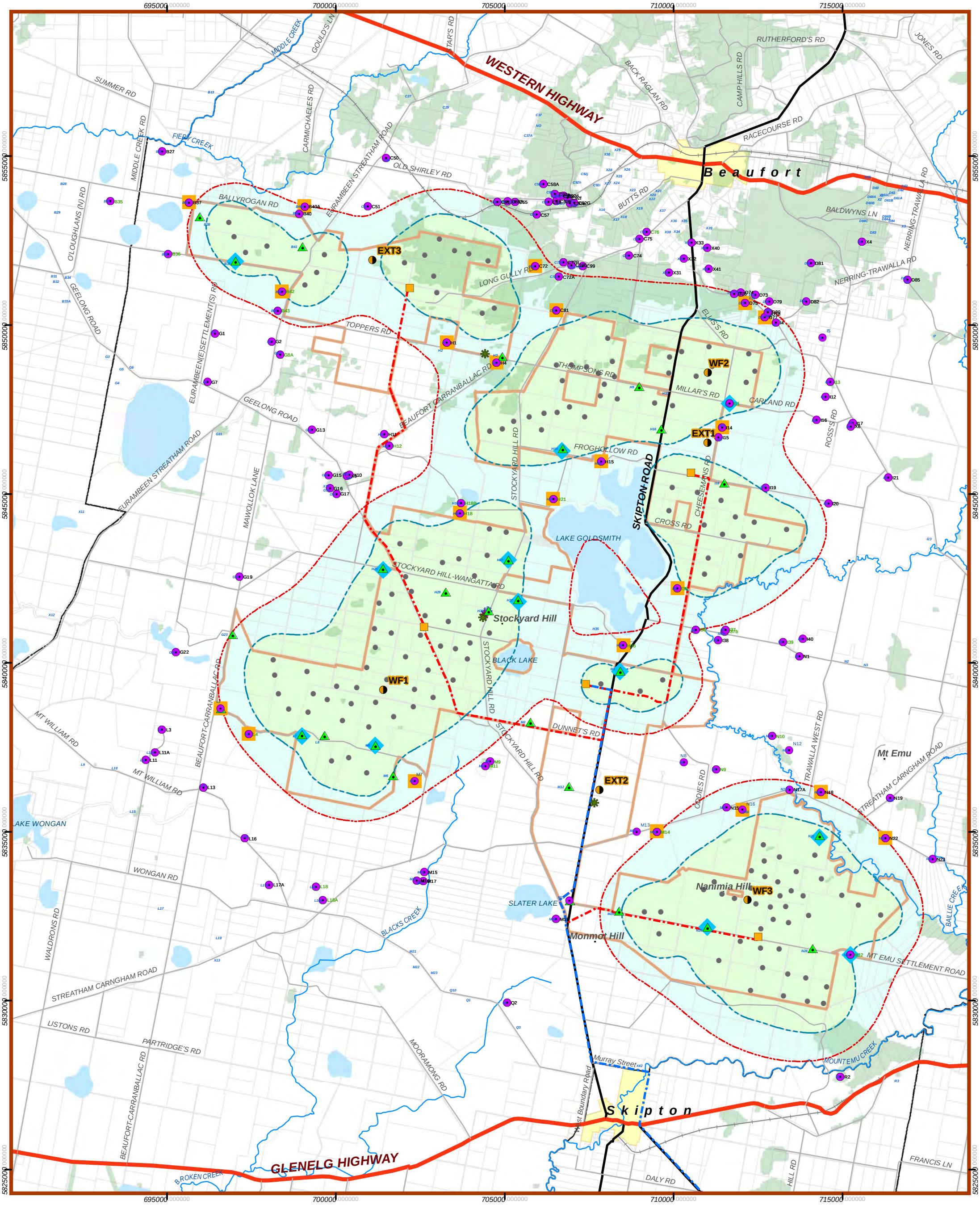


Figure 2 – Example Regression Analysis Plot

The above figure is typical of that expected at a dwelling in the vicinity of wind farm, where the background noise level increases with an increasing wind speed at the wind farm.

Appendix A: Background Noise Monitoring Locations



Legend

- Anemometers
- Potential Wind Turbine Sites
- Proposed substations
- Residence (Off Lease)
- Participating Residence (On Lease)
- Noise monitoring site >40dB
- Noise monitoring site >35dB

Noise contours from Sonus preliminary noise model

- 35 dB(A)
- 40 dB(A)
- Proposed site boundary

** - EXT (Setback from Turbine Sites)
** - WF (Within Turbine Sites)

Proposed 132kV Overhead power line

- Internal
- External

Roads

- Highway
- Major Roads
- Minor Roads
- Watercourses
- Rail
- Wetlands or waterbodies
- Major vegetation areas
- Local government areas

*Subject to verification

Stockyard Hill Wind Farm

Background Noise Monitoring Plan
- Location of Monitoring Sites

Scale: 1:100,000 (Printed A3)
Scale: 1:50,000 (Printed A1)

0 0.5 1 2 3 4 5
Kilometers

Date	*04/10/2011*		
Map no	*WF 132*	*Drawn*	*JC*
Revision	*06*	*Checked*	*JB*