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Technical Report

Ref Number **C/12327/R16/TJH**

Date **1 December 2009**

Project

**Barnsley BSF
Wind Turbine Noise Assessment
Shafton School**

Prepared for

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Summary

Surveys have been done to help assess the impact of noise from the proposed wind turbine installation at Shafton School on neighbouring dwellings. Two possible sites for the wind turbines have been considered. Surveys are reported of the measurement of background noise levels at different times of day and of the measurement of the variation of background noise with wind speed. The measurements have been assessed following the method recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

We conclude that at the closest dwellings, the ETSU criteria are likely to be met at all wind speeds for turbines located in the western boundary.

For turbines located on the southern boundary we have a high degree of confidence that the criteria will be met.



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Contents

1. Introduction
2. Proposed Wind Turbine Installation
3. Assessment Methodology
4. Wind Turbine Noise Levels
5. Background Noise Measurement
6. Assessment
7. Conclusions

Appendix 1

Plan Showing Measurement Locations

Appendix 2

Survey Details

Appendix 3

Survey Results

Appendix 4

Assessment Results

Appendix 5

Noise Measurement Parameter Definitions

1. Introduction

As part of the second phase of the BSF development for Barnsley, it is proposed to erect one or more wind turbines at each of the schools in the scheme. In seeking planning approval for this, it is necessary to have assessed the acceptability of noise from the wind turbines affecting the nearby residents. This report considers the noise impact from the operation of three or four wind turbines at Shafton School.

2. Proposed Wind Turbine Installation

As part of the redevelopment of Shafton School it is proposed to erect three wind turbines on the school playing fields. They would be located close to either the southern or western site boundary, as indicated on the plan in Appendix 1. To the south and east of the turbine sites are small groups of dwellings on or just off Engine Lane, at distances between 180 and 300m. To the west are dwellings along Lindrick Close, Sunningdale Drive and a few properties at the end of George Street. These are at distances from the turbine sites ranging from 200 to 280m from the nearest turbine. To the north of the sites will be the school itself with dwellings beyond it on the far side of the main Collier Road 250m or more away.

The type of wind turbine proposed is the Proven Energy WT 15000, with the turbine hub installed at 25 metres above ground level. The specifications for this turbine shows that it cuts in at a hub wind speed of 3m/s and starts overspeed control at 13m/s.

3. Assessment Methodology

The method of assessing noise impact on-site follows that recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

The wind turbine noise level, expressed as L_{A90} , is predicted at the most affected dwelling(s). If appropriate a tonal correction is made. These predictions are based on measurements done by an independent test organisation of noise output as a function of wind speed. In this case the measurements were done by TUV NEL to an industry protocol, the Small Wind Turbine Performance and Safety Standard (29 February 2008) published by BWEA (British Wind Energy Association).

The background noise level, also expressed as $L_{A90-10min}$, is measured at the dwelling(s). This must be done at different times and at wind speeds over the range at which the wind turbine is expected to operate, because the background noise level will vary with wind speed. The wind speed as a 10 minute average is measured simultaneously, at the recommended reference height of 10 metres above ground level, at a location representative of the proposed wind turbine siting. The corresponding wind speed at hub height of the proposed turbine is calculated by adjusting the measured speeds according to the equation given in the ETSU report.

The predicted wind turbine noise level is then compared with both

- fixed noise level criteria
- the background noise level as a function of wind speed

The corrected wind turbine noise is considered acceptable outside dwellings if it is no greater than:

- 35dB $L_{A90-10min}$ during the daytime
- 43dB $L_{A90-10min}$ during the night-time

or

- the background $L_{A90-10min}$ +5dB at any time

whichever is the higher.

4. Wind Turbine Noise Levels

The measured and declared sound power levels at 8m/s for the Proven Energy WT 1500 are 94.3 and 97 dBA (L_{WA}) with no tonal correction needed.

This is based on the measured noise levels which show a scatter of results at any given wind speed. Linear regression is done to derive the trend (equation of noise level versus wind speed) and standard deviation to measure the degree of scatter. The declared level is the calculated level at 8m/s plus 1.645 x the standard deviation.

The trend line is significantly different above and below an average speed of 9m/s, due to the way the turbine operates and interacts with the wind. The trend line is given by

$$L_{Aeq} = 1.94u + 46.64 \quad 3 \leq u \leq 9 \text{ m/s}$$

$$L_{Aeq} = 0.66u + 64.11 \quad 9 < u < 15 \text{ m/s}$$

where u is the wind speed at hub height.

The Working Party guidelines use the L_{A90} of the turbine noise as the index for assessment, using the relationship $L_{A90} = L_{Aeq} - 2\text{dB}$. They recommend assessment is done up to an average wind speed of 12m/s (at 10m height). They also recommend that the wind speed at the hub height (u_h) is calculated from the averaged wind speed at the reference height (u_{10}) of 10 metres using the relationship:

$$u_h/u_{10} = \ln\left(\frac{h}{z_0}\right)/\ln\left(\frac{10}{z_0}\right) \text{ where } z_0 \text{ is the roughness factor of the local ground cover.}$$

Examples of roughness factor that they give indicate a suitable value for this area to be of the order of $z_0 = 0.01$.

5. Background Noise Measurement

Ambient noise levels (L_{A90} and L_{Aeq}) were measured at different times of day and under different conditions as follows:

- i) During the middle of the night-time with no or low wind (below the speed at which the turbines would operate)
- ii) During the late evening, as being representative of the quietest time of day, with no or low wind
- iii) On at least two different days under different wind conditions. Measurements were done on different days in order to monitor a spread of wind speed within the range 3 to 12m/s
- iv) During the middle of the day under no or low wind conditions.

The measurements were located close to residential properties that were thought most likely to be affected by wind turbine noise. These were :

- Dwellings off Engine Lane to the south of the site
- The farmhouse on Engine Lane to the east of the site
- The rear of dwellings in Sunningdale Drive and the end of George Street. As there was no access directly to the rear of these dwellings, measurements were taken at the western boundary of the site.

These locations are shown on the plan in Appendix 1. Also shown is the location of the wind monitor, which was on a mast at 10 metres above ground level. During the surveys during windy conditions ((iii) above), average wind speed measurements were made every 10 minutes to correspond with the 10 minute background noise level (L_{A90}) measurements.

The equipment used to make the measurements and other survey details are given in Appendix 2. The large spherical B&K windshield was used to prevent noise generated at the windshield invalidating the results. It is less affected than other commercially available windshields.

The results are tabulated in Appendix 3. Measurements of L_{Aeq} are included for information although not used in this assessment.

6. Assessment

The measured relationship between background noise and average wind speed (measured at 10m height) is plotted for turbine site A and locations 1, 2 and 4 on figures 1 to 6 in Appendix 4. Similar plots for turbine site B are shown on figures 7 to 12. See Appendix 1 for locations of turbine sites A and B.

Linear and geometric regression (trend) lines have been calculated and superimposed on figures 1, 3,...11 and 2, 4,...12 respectively, together with the 'goodness' of fit (R^2). At moderate wind speeds the trend line goes below the measured 'no wind' background. In these circumstances the wind generated noise is not affecting the overall background level, so any such data points are not included in the regression analysis.

The predicted turbine noise at the nearest residence is also superimposed on the plots. This calculation is based on the trend line equations, given in section 4, and the wind speed adjusted to a height of 25m.

Under low to moderate wind conditions the wind was considered not to be affecting the background noise levels. The background noise levels during the daytime, at the time of day when wind noise was monitored, generally ranged from 45 to 50 dBL_{A90}. L_{A90} levels measured during high wind noise surveys were all higher than this, which indicates that they were dependent on the wind rather than other noise sources in the locality.

The plot of background noise versus wind speed shows a good correlation at location 1 ($R>0.8$) and very good ($R>0.9$) at location 3 which is midway between locations 2 and 4. There is insignificant difference between the linear and geometric regression curves over the range measured. As the wind speed drops, one would theoretically expect the wind generated noise to fall to nothing ($-\infty$ dBA) at zero wind speed, so a geometric fit would be better. However, other sources will determine the background noise level well before this point is reached.

With no or very low wind the lowest background (L_{A90}) levels measured were as follows:

		Location 1	Location 2
Daytime (evening)	dB L _{A90}	37	40
Nighttime	dB L _{A90}	27	31

At location 4, where we did not gain access, we estimate that the quietest background levels during evening and night-time would be 35 and 25 dBL_{A90} respectively. At these times the L_{A90} at locations 1 and 2 was caused by distant traffic noise, generally from the north, not traffic on the nearby roads, and could be heard all around the site. Location 4 is not sheltered from this direction and would have similar background during evening and night-time.

Taking the turbine sites and residential locations in turn:

Turbine Site A (South)

Location 1 - Daytime

- Lowest background is 37 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 42 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 42 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5 dB) would be 53 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 1 – Night-time

- Lowest background is 27 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 32 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of over 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5dB) would be 53 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the predicted background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Therefore, at location 1 the data show with a high degree of confidence that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the south site (A).

Location 2 – Daytime

- Lowest background is 40 dBL_{A90}
- Criterion for turbine noise is higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 45 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 45 dBL_{A90}, which they would reach at a wind speed of nearly 8m/s at the reference height of 10m above ground level.
- At this wind speed of just under 8m/s (10m), the background noise (+5dB) would be 52 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the background noise is just less than the predicted turbine noise by 0 to 2 dBA. Therefore, the turbine noise would be below the criteria of background level + 5 dB.

Location 2 – Night-time

- Lowest background is 31 dBL_{A90}
- Criterion for turbine noise higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 36 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of just over 7m/s at the reference height of 10m above ground level.
- At this wind speed of >7m/s (10m), the background noise (+5dB) would be 51 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the predicted background noise is just less than the predicted turbine noise by 0 to 3 dB. Therefore, the turbine noise would be below the criterion of background level + 5 dB.

Therefore, at location 2 the data show, with a reasonable degree of confidence, that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the south site (A).

Location 4 - Daytime

- Lowest background is 35 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 40 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 40 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5 dB) would be 52 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 4 – Night-time

- Lowest background is 25 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 30 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5dB) would be 52 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the predicted background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Therefore, at location 4 the data show with a high degree of confidence that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the south site (A).

Turbine Site B (West)

Location 1 - Daytime

- Lowest background is 37 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 42 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 42 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5 dB) would be 53 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 1 – Night-time

- Lowest background is 27 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 32 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of 9m/s at the reference height of 10m above ground level.
- At this wind speed of 9m/s (10m), the background noise (+5dB) would be 54 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the predicted background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Therefore, at location 1 the data show with a high degree of confidence that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the west site (B).

Location 2 – Daytime

- Lowest background is 40 dBL_{A90}
- Criterion for turbine noise is higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 45 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 45 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5dB) would be 52 dBL_{A90}, just above the turbine noise level.
- At higher wind speeds the background noise is similar to the predicted turbine noise (± 1 dB). Therefore, the turbine noise would be below the criteria of background level + 5 dB.

Location 2 – Night-time

- Lowest background is 31 dBL_{A90}
- Criterion for turbine noise higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 36 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of just below 8m/s at the reference height of 10m above ground level.
- At this wind speed of just below 8m/s (10m), the background noise (+5dB) would be 52 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the predicted background noise is similar to the predicted turbine noise (± 1 dB). Therefore, the turbine noise would be below the criterion of background level + 5 dB.

Therefore, at location 2 the data show, with a good degree of confidence, that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the west site (B).

Location 4 - Daytime

- Lowest background is 35 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 40 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 40 dBL_{A90}, which they would reach at a wind speed of just above 6m/s at the reference height of 10m above ground level.
- At this wind speed of just above 6m/s (10m), the background noise (+5 dB) would be 50 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds (>8m/s) the background noise is just less than the predicted turbine noise by 0 to 3 dB. Therefore, the turbine noise would be below the criteria of background level + 5 dB.

Location 4 – Night-time

- Lowest background is 25 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 30 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of 8m/s at the reference height of 10m above ground level.
- At this wind speed of 8m/s (10m), the background noise (+5dB) would be 52 dBL_{A90}, greater than the turbine noise level.
- At higher wind speeds the predicted background noise is just less than the predicted turbine noise by 0 to 3 dB. Therefore, the turbine noise would be below the criteria of background level + 5 dB.

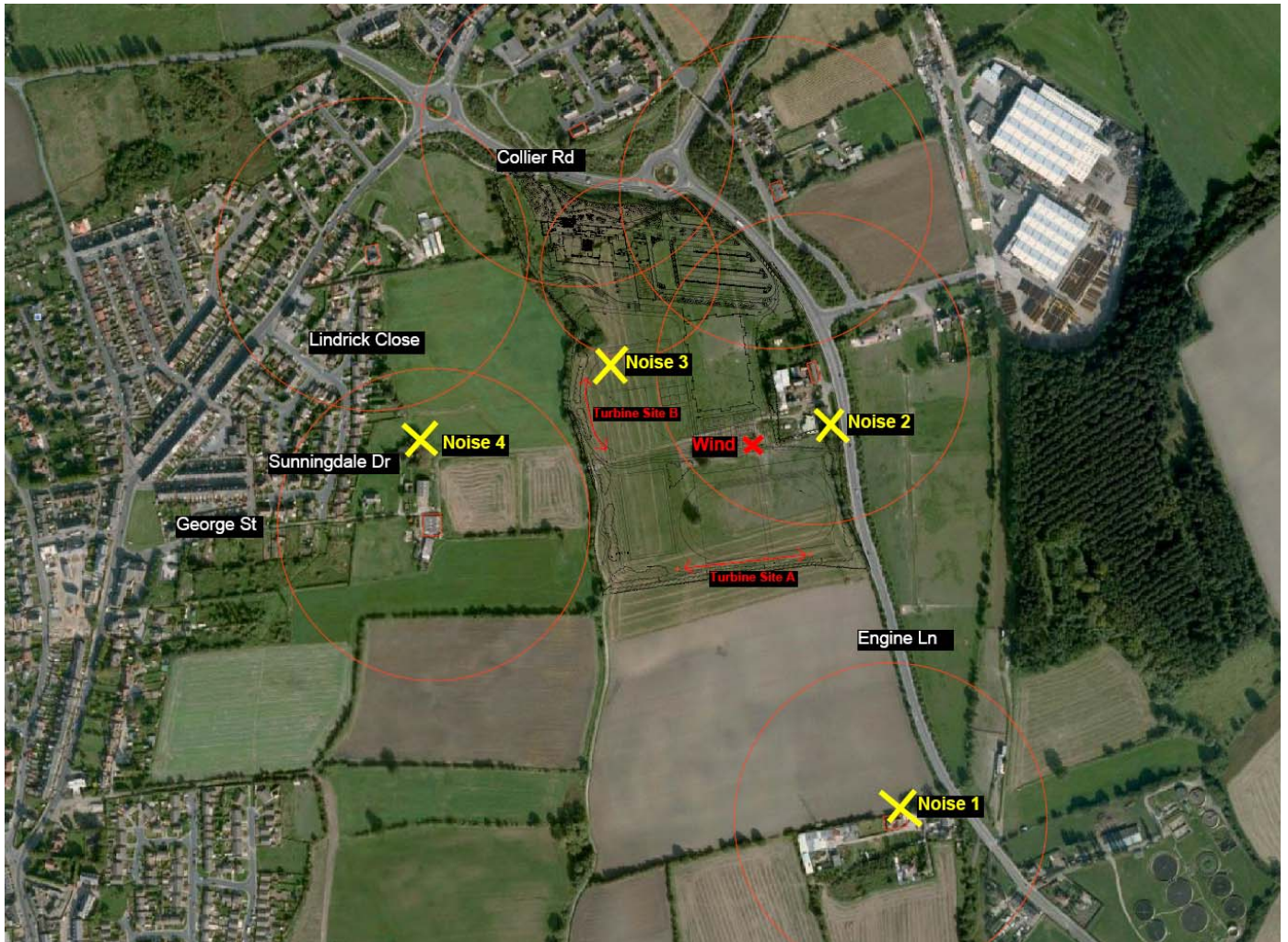
Therefore, at location 4 the data show with a reasonable degree of confidence that the ETSU criteria would be met at all appropriate wind speeds by an installation of three turbines as proposed at the west site (B).

7. Conclusions

The measured data indicate that the ETSU criteria for the acceptability of wind turbine noise are likely to be met at all speeds for both daytime and night-time with three turbines at either of the locations proposed. From the point of view of turbine noise, the southern turbine site (A) has less impact, and, apart from one farmhouse on Engine Lane, we have a very high degree of confidence that the criteria will be met. The western site (B) is relatively close to many houses in Sunningdale Drive and Lindrick Close where the predicted turbine noise is just within the criteria.

Appendix 1

Plan showing Measurement and Predictions



Appendix 2

Survey Details

A1. Location of Surveys

Shafton, Barnsley. For measurement positions see Appendix 1

A2. Dates & Type of Surveys

26 & 27 October 2009 – Day/Evening/Night-time, no/low wind

23 November 2009 – Daytime – low to moderate wind

24 November 2009 – Daytime, moderate to high wind

A3. Personnel Present During Surveys

Mark Hinds- 26 & 27 October, 23 & 24 November

Mark Graham – 23 & 24 November

A4. Instrumentation

Brüel & Kjær

Type 2250 Sound Level Meter, S/N 2559287

Type 4189 Microphone, S/N 2556367

Type 4231 Sound Level Calibrator, S/N 2482655

Type 2270 Sound Level Meter, S/N 2623080

Type 4189 Microphone, S/N 2638475

Type 4231 Sound Level Calibrator, S/N 2665089

Davis

Type Vantage Pro 2 6152UK Weather Station, S/N A90708N037

A5. Calibration Procedure

Before and after the survey the sound level measurement apparatus was checked calibrated to an accuracy of ± 0.3 dB using the type 4231 Sound Level Calibrator.

A.6 Survey Procedure

Ambient noise levels and average wind speed were monitored at various positions around the site as shown in Appendix 1. The measurements are tabulated in Appendix 3, and explanations of the parameters used are listed in Appendix 5.

Appendix 3

Survey Results at Shafton School

Measured Ambient Noise Levels (dB re 2×10^{-5} Pa)

Evening/Night – Low Wind

Date Position	Time	L _{A90}	L _{Aeq}	Comments
26.10.09				
1	21:00	40	52	
2	21:15	49	59	Barking Dog
1	21:27	38	52	
2	21:40	42	60	Barking Dog
1	21:56	37	53	
2	22:10	40	58	
1	22:28	42	53	
2	22:43	44	58	
27.10.09				
1	01:57	28	41	
2	02:11	31	48	
1	02:28	27	42	
2	02:42	32	45	
1	02:59	29	43	
2	03:13	32	46	
1	03:30	28	36	
2	03:44	32	48	

Daytime, Low Wind

Date Position	Time	L _{A90}	L _{Aeq}	Comments
26.10.09				
1	11:41	53	59	Barking Dog – Continually
2	11:58	47	63	
1	12:12	49	58	Barking Dog
2	12:28	55	65	Tractor Nearby
1	12:42	49	58	Barking Dog
2	12:55	48	63	
1	13:08	48	58	
2	13:22	47	62	
1	13:36	47	58	
2	13:49	49	63	
1	14:03	51	59	
2	14:17	54	64	Tractor Nearby
1	14:32	50	58	
2	14:46	48	62	
23.11.09				
3	11:55	46	51	
3	12:10	45	49	
3	12:20	44	49	
3	12:30	44	47	

Daytime - Moderate Wind

Date Position	Time	L _{A90}	L _{Aeq}	Wind speed m/s@10m	Comments
23.11.09					
3	12:40	45	48	4.0	
	12:50	47	49	3.6	
1	13:10	49	54	4.9	
	13:20	50	54	4.9	
	13:30	49	53	4.9	
	13:40	48	53	4.9	
3	14:00	48	50	5.4	
	14:10	48	51	5.8	
	14:20	48	50	4.9	
	14:30	48	52	6.3	
	14:40	48	50	5.8	
	14:50	48	62	5.4	Helicopter
1	15:10	51	55	6.3	
	15:20	51	55	6.7	
	15:30	51	54	6.3	
	15:40	50	53	5.8	
	15:50	51	54	6.3	
Note: Under moderate wind conditions distant road traffic noise was at too high a level for the effect of wind speed to be measured. These readings were not used in the analysis.					

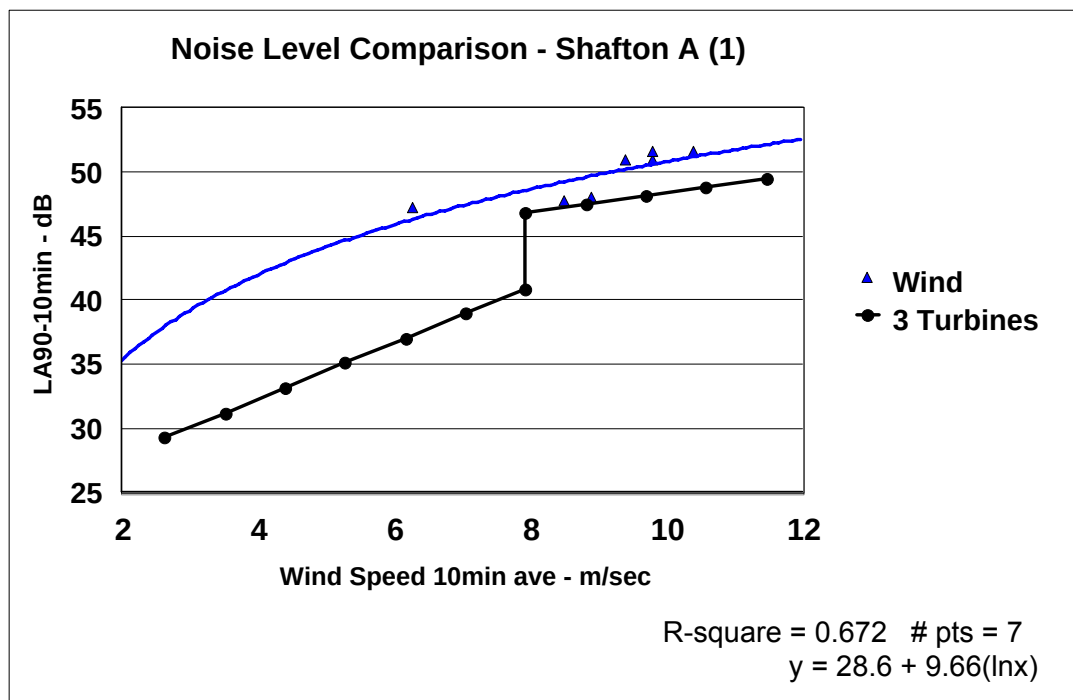
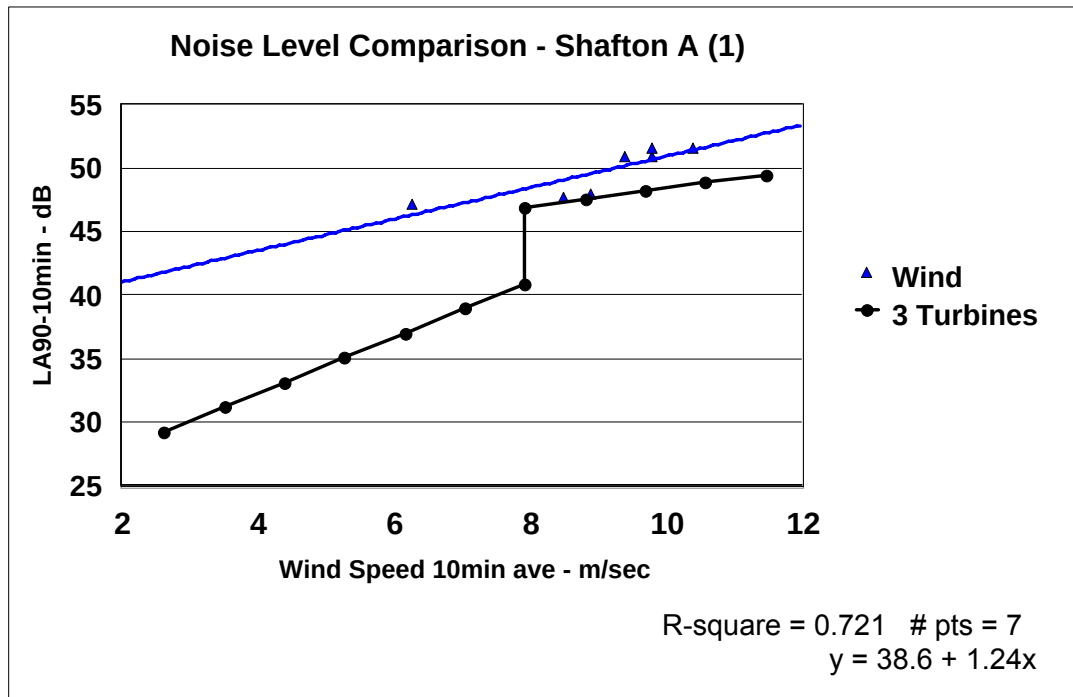
Daytime - High Wind

Date Position	Time	L _{A90}	L _{Aeq}	Wind speed m/s@10m	Comments
24.11.09					
3	13:10	50	57	10.3	
	13:20	50	57	9.8	
	13:30	49	56	8.9	
	14:10	54	63	11.2	
	14:20	50	58	9.4	
	14:30	50	56	9.4	
	14:40	50	57	9.4	
	14:50	49	55	8.9	
	15:00	50	59	9.4	
	15:10	50	55	9.4	
	15:20	50	55	9.4	
1	15:40	51	56	9.8	
	15:50	52	55	9.8	
	16:00	51	55	9.4	
	16:10	52	57	10.4	
	17:40	48	54	8.9	
	17:50	48	54	8.5	
3	18:05	48	51	8.9	
	18:15	47	50	8	
	18:25	46	49	6.7	
	18:35	46	49	6.7	
1	18:50	47	57	6.3	

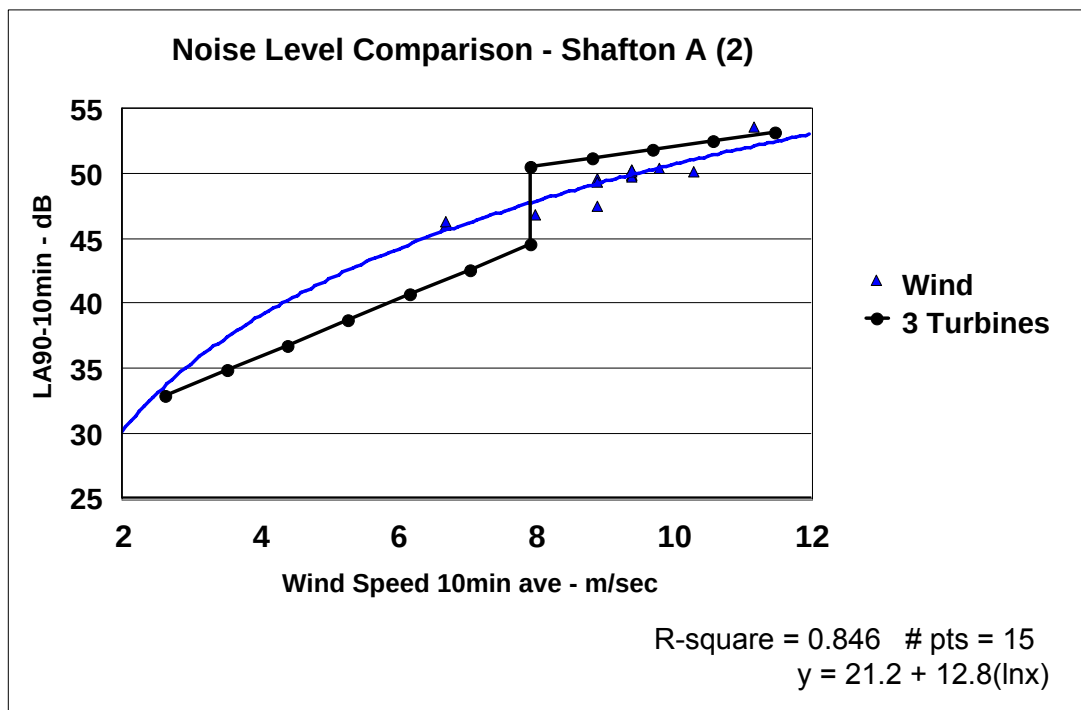
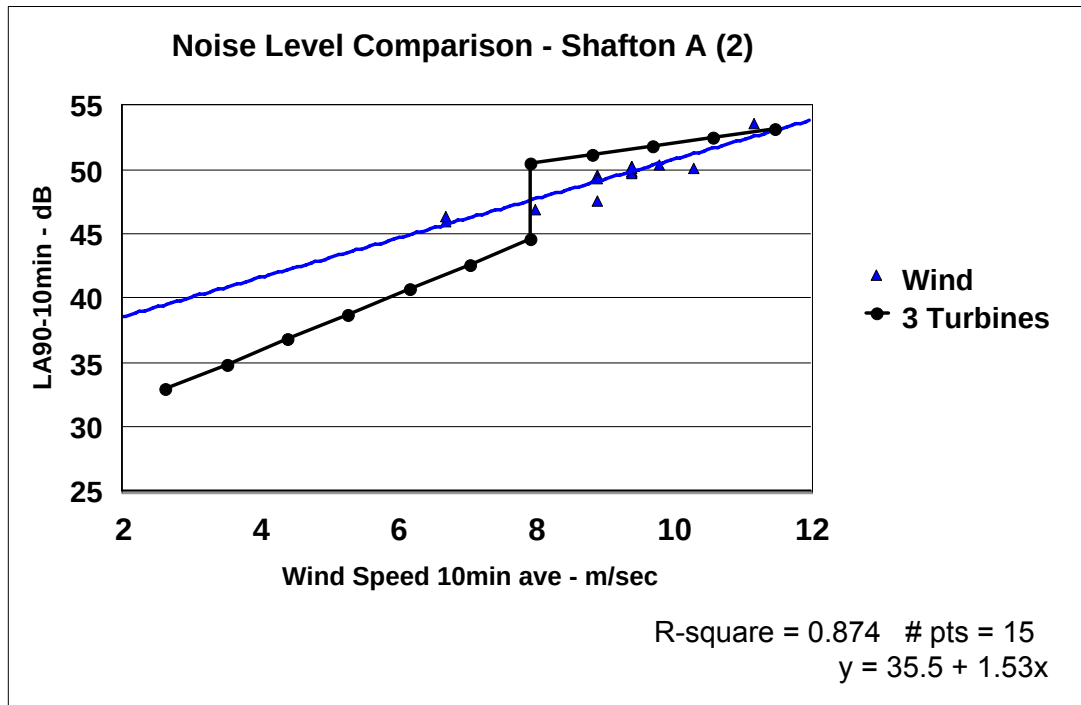
Appendix 4

Assessment Results

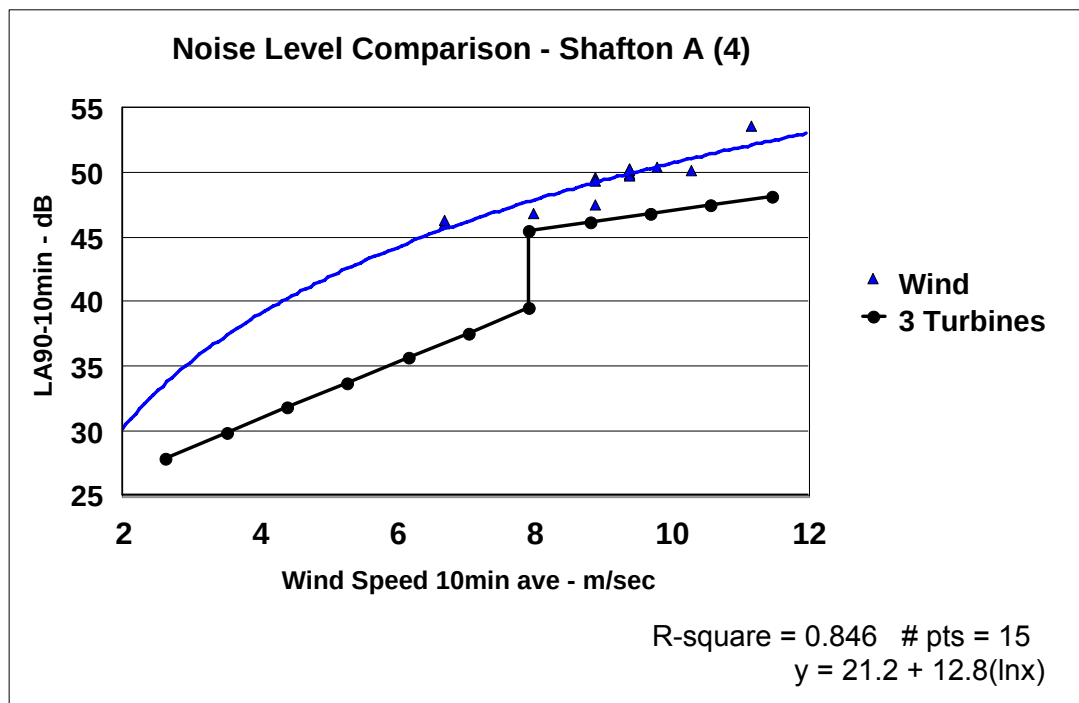
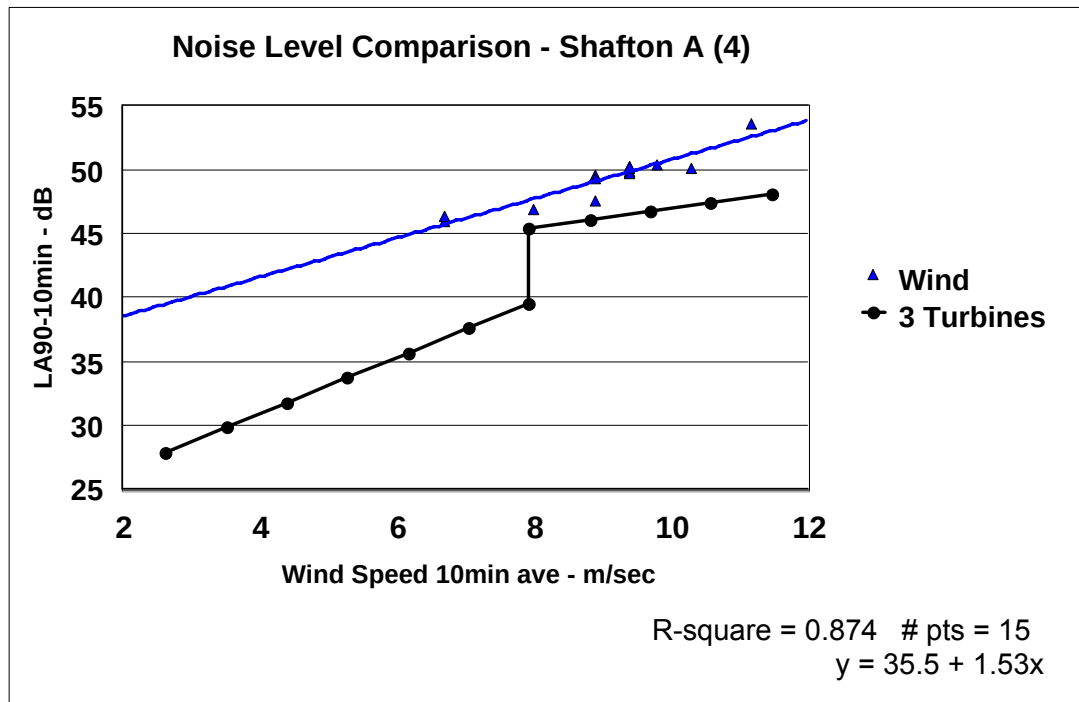
Figures 1 & 2 – Turbine Site A – Location 1



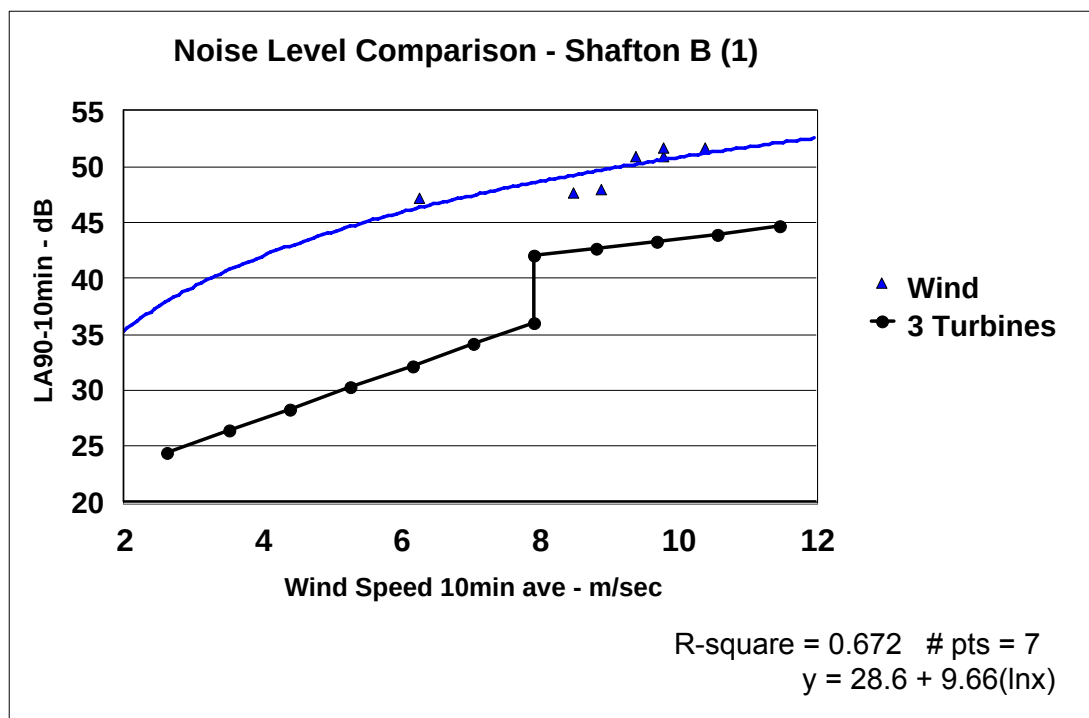
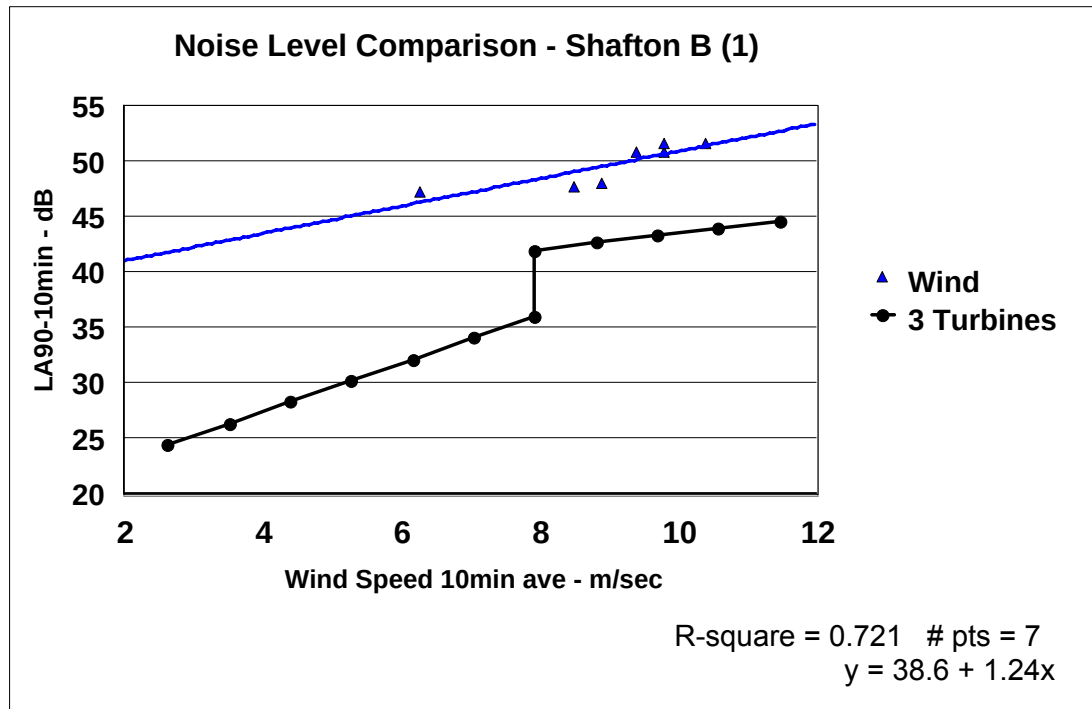
Figures 3 & 4 – Turbine Site A - Location 2



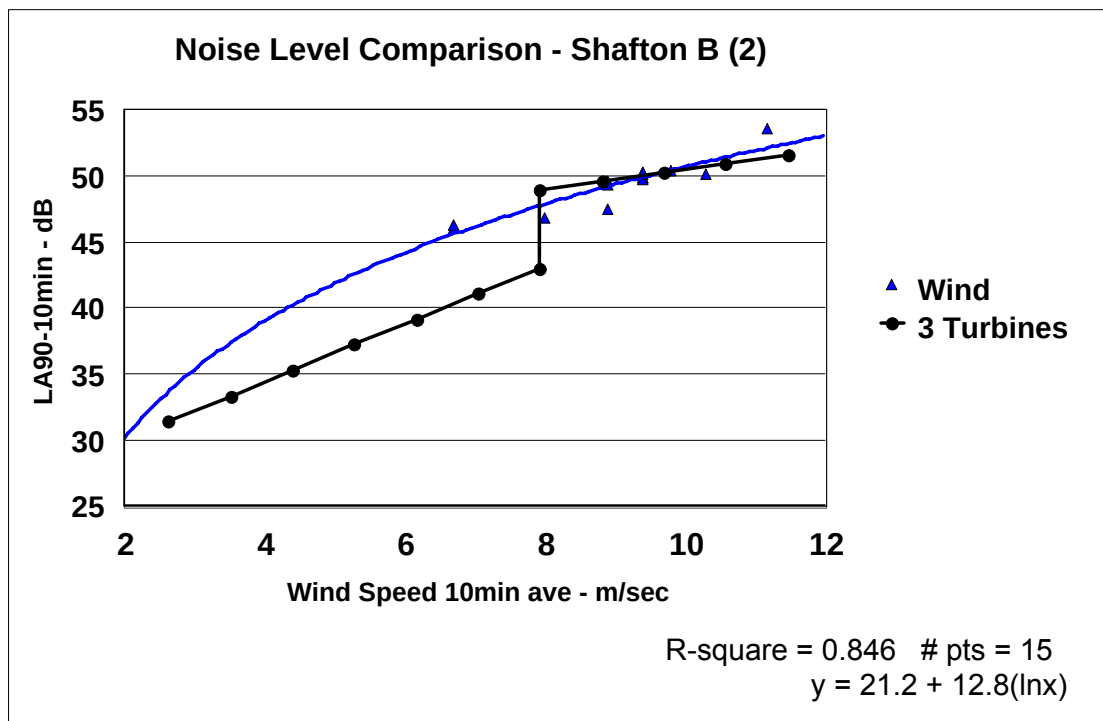
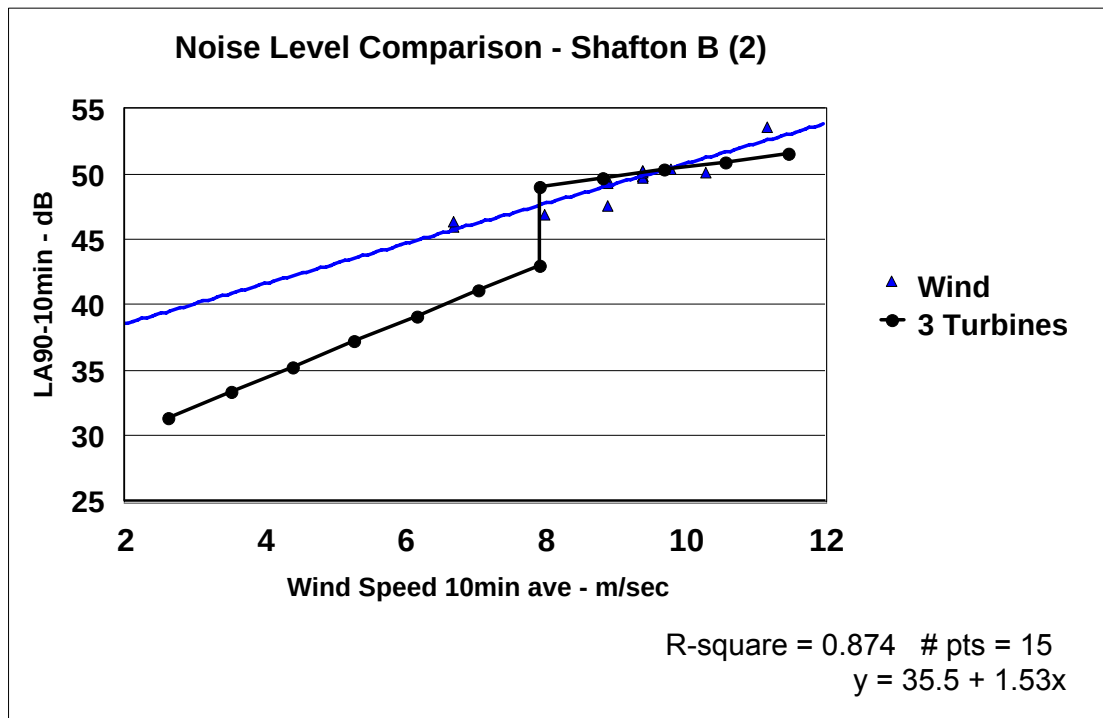
Figures 5 & 6 – Turbine Site A - Location 4



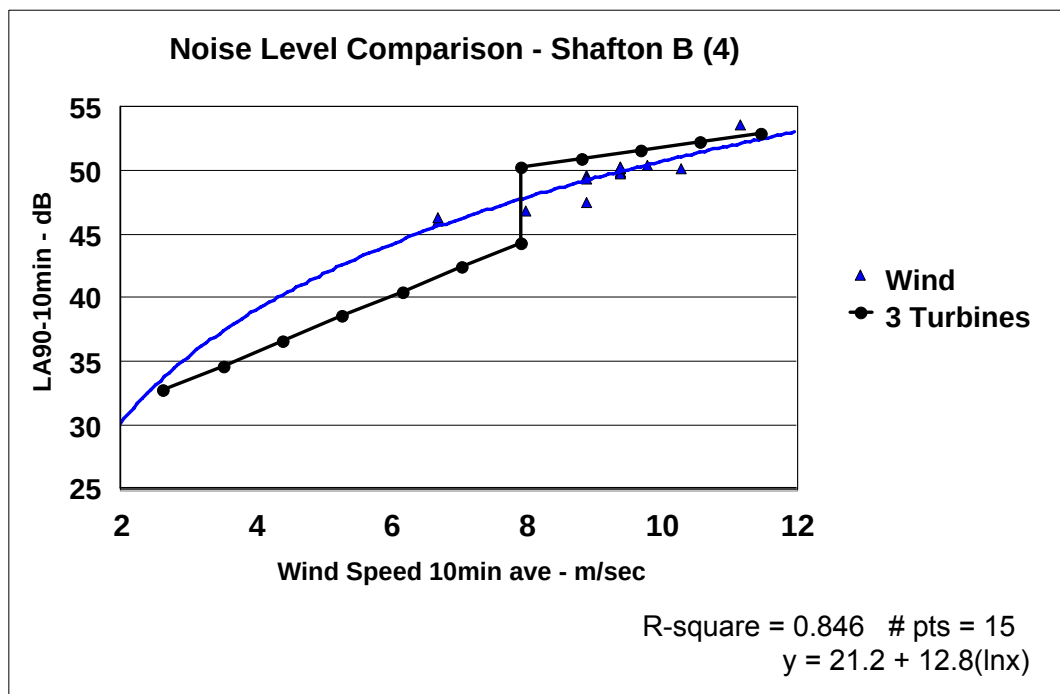
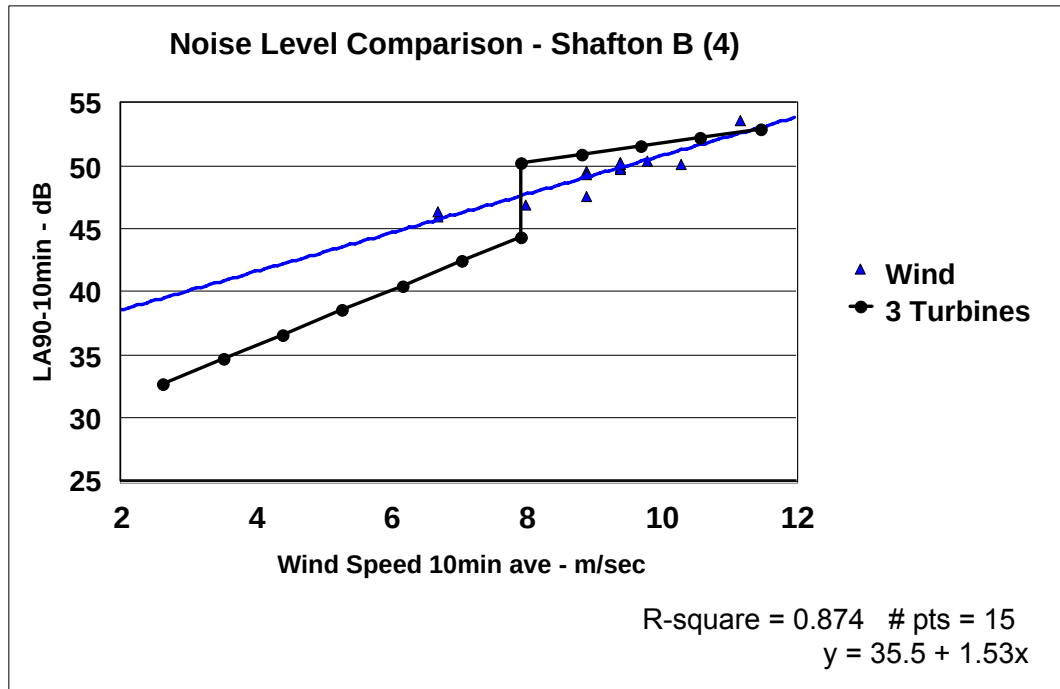
Figures 7 & 8 – Turbine Site B - Location 1



Figures 9 & 10 – Turbine Site B - Location 2



Figures 11 & 12 – Turbine Site B - Location 4





Appendix 5

Noise Measurement Parameter Definitions

L_{A90} - The "A" weighted sound pressure level that is exceeded for 90% of the measurement period. It is commonly used as the "Background Noise Level".

L_{Aeq} - The "A" weighted equivalent continuous sound pressure level. A representation of a continuous sound level containing the same amount of sound energy as the measured varying noise, over the measurement period. It can be considered as the "average" noise level.



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