Chapter 10:

Noise

10.1 Introduction

10.1.1 Overview

This Chapter of the EIS assesses the potential noise impacts generated by the proposed wind farm development on the noise-sensitive locations in the vicinity of the site. GES Ltd. in association with Mr. Mike Simms, Acoustic Consultant, conducted an assessment into the likely noise impact associated with this proposed development during both the construction and operational phases.

During the operation of the wind farm, the principal source of noise will be generated from the blades rotating in the air (aerodynamic noise) and from internal machinery, to a lesser extent, and the generator (mechanical noise). Calculations in this assessment are based on an 11 no. turbine layout with each turbine modelled with an 85m hub height and a 103.0m rotor diameter. All receptors within 1,030m (10 rotor diameters) of a proposed turbine are assessed for noise impact. As the prevailing wind direction in Ireland is south-westerly, it is considered that receptors located north-west of the wind farm are potentially more sensitive to noise.

In assessing the noise impact of a wind development on the existing environment, information from the turbine manufacturer on operating noise sound levels is required. In addition, the existing baseline noise levels in the receiving environs of the subject lands must be established. In undertaking a baseline noise survey, acoustic data must be correlated with wind speed in order to provide a comprehensive assessment.

10.1.2 Purpose of the Noise Impact Assessment

The purpose of the noise impact assessment is to quantify the generated noise levels at nearby noise-sensitive locations resulting from the construction and operational phases of the wind farm to ensure compliance with the recommended guidance set out in the Wind Energy Development Guidelines for Planning Authorities, DoEHLG[1].

Predictions of 'worst-case' noise levels were carried out based on the proposed site layout and the manufacturer's guaranteed noise levels for turbines for the site. 'Worst-case' noise levels in this instance means that all receptors are considered to be downwind of all wind turbines, which clearly cannot happen in practice at all houses simultaneously.

10.1.3 Noise Criteria & Guidance

10.1.3.1 Noise in the Environment

Wind farms are generally situated in rural environments where there are few sources of noise. When wind speeds are high, noise tends not to be a problem since any noise generated is masked by wind induced noise effects, particularly that of the trees and vegetation being blown. However, at lower wind speeds or in particular sheltered locations, the wind induced background noise may not be sufficient to mask any noise generated by wind turbines. At these low speeds, the generated noise levels may be so low as to generate very little impact. The prevailing wind direction in Ireland is south-westerly, therefore receptors located to the north-west of a wind farm development are potentially sensitive, in that exposure to wind farm noise may be more prevalent.

Noise levels are normally expressed in decibels. Noise in the environment is measured using the dB(A) scale which includes a correction for the response of the human ear to noises with different frequency content. As a general rule, for noises of the same nature, a change of 3dB(A) is the minimum perceptible under normal conditions, and a change of 10dB(A) corresponds roughly to halving or doubling the loudness level of a sound[1].

All measurements are based on L_{A90} levels rather than L_{Aeq}. L_{A90} is the 90^{th} percentile noise level which is exceeded for 90% of the time. As wind turbines will be operating continuously throughout its particular range the L_{A90} level is more useful in identifying noise which may be attributed directly to the wind farm rather than L_{Aeq} which will be affected by short term influences such as a passing car or localised agricultural activities.

10.1.3.2 Construction Phase

There is no statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Planning authorities normally control construction activities by imposing noise limits and restrictions on the hours of operation.

In the absence of statutory noise limits, appropriate criteria relating to permissible construction noise levels for a development proposal of this scale may be found in the National Roads authority (NRA) publication '*Guidelines for the Treatment of Noise and Vibration in National Road Schemes*'[1]. **Table 10.1** sets out the maximum permissible noise levels at the facade of dwellings during construction as recommended in the NRA guidelines. The majority of the construction activity in this instance is expected to occur during the normal working hours.

Days and Times	*Noise Levels (dB re. 2x10^{-5} Pa)*	
	$L_{Aeq(1hr)}$	L_{Amax}
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 22:00hrs	60*	65*
Saturdays 08:00 to 16:30hrs	65	75*
Sundays & Bank Holidays 08:00 to 16:30hrs	60*	65*

Table 10.1: Maximum Permissible Noise Levels at the Facade of Dwellings during Construction
Source: National Roads Authority

Note: Construction activity outside of these times, other than that required for emergency works, will normally require the explicit permission of the relevant local authority.

10.1.3.3 Operational Phase

Noise is generated by wind turbines as they rotate to generate power. This only occurs above the 'cut-in' wind speed and below the 'cut-out' wind speed. Below the cut-in wind speed there is insufficient strength in the wind to generate efficiently and above the cut-out wind speed the turbine is automatically shut down to prevent any malfunctions from occurring. The cut-in speed at turbine hub height is normally 3m/sec and the cut out wind speed is normally around 25 m/sec at hub height (85m) on the GE 3.2-103 turbine model, which is anticipated to be installed on-site. The principal sources of noise resulting from wind turbines are aerodynamic noise and mechanical noise.

10.1.3.4 Aerodynamic Noise

Aerodynamic noise is caused by blades passing through the air and it is generally broadband in nature which can have a swishing character. This noise is a function of many factors including blade design, rotational speed, and wind speed and inflow turbulence. Aerodynamic noise has been substantially reduced over time due to improvements in turbine design.

As a result, aerodynamic noise is wind speed dependant, and the sound power output from a turbine must be measured and quoted relative to wind speed. The reference sound power output from a turbine is typically provided by the manufacturer over a range of wind speeds.

Careful design of the rotor blades ensures that aerodynamic noise is minimised. Special consideration is given to the blade tips which, due to their relatively high velocities, generate the most noise. Nevertheless, it should be noted that aerodynamic noise is an unavoidable by-product of wind generated electricity. The use of sufficient separation distances is therefore the fundamental design option available to wind farm developers for the control of noise at residential properties.

10.1.3.5 Mechanical Noise

Mechanical noise is generated by components inside the turbine nacelle (usually the gearbox and generator) and can be radiated by the shell of the nacelle, blades and the tower structure.

Unlike aerodynamic noise, mechanical noise tends to be tonal in nature, i.e. it is concentrated at a few discrete frequencies. Mechanical noise can be successfully controlled at the design stage of the turbine, using advanced gearbox design and anti-vibration techniques. As mentioned above technological developments in engineering practices have in general limited mechanical noise output.

10.1.3.6 Wind Energy Planning Guidelines for Local Authorities, (DoEHLG), 2006

The noise impact guidance for wind energy development is set out in the Wind Energy Development Guidelines for Planning Authorities (2006)[2]. The recommendations put forward in the Guidelines state:

> *"In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours. However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the $L_{A90,\ 10min}$ of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A)."*

The guidelines explain *'A-weighted decibel'* as:

> *"a measure of the overall noise level of sound across the audible frequency range (20Hz-20 kHz) with A- frequency weighting to compensate for the varying sensitivity of the human ear to sound at different frequencies. The decibel scale is logarithmic. A 10 dB(A) increase in sound level represents a doubling of loudness. A change of 3 dB (A) is the minimum perceptible under normal circumstances"*

The Guidelines further recommend that:

> *"Separate noise limits should apply for day-time and for night-time. During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43dB(A) will protect sleep inside properties during the night.*

The Guidelines consider that *noise is considered unlikely to be a significant problem where the distance from the nearest turbine to any noise sensitive property is more than 500 metres. Planning authorities may seek evidence that the type(s) of turbines proposed will use best current engineering practice in terms of noise creation and suppression"*

10.1.3.7 "The Assessment and Rating of Noise from Wind Farms" – ETSU-R-97 September 1996, published by the UK Department of Trade and Industry[3]

The Irish guidelines discussed in the previous section are broadly based on ETSU-R-97 document, which also comments, in respect of houses where the occupant has an interest in the development:

> *"… that both day- and night-time lower fixed limits can be increased to 45dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has come financial involvement in the wind farm."*

The suggested noise limits take into account the fact that all wind turbines exhibit the character of noise described as blade swish to a certain extent. ETSU-R-97 recommends that a penalty should be added, however, to the predicted noise levels, where any tonal component is present. The level of this penalty is related to the level by which any tonal components exceed audibility.

10.1.3.8 Decommissioning Phase

There is no statutory Irish guidance relating to the maximum permissible noise level that may be generated during the decommissioning phase of a project. Planning authorities normally control construction and decommissioning activities by imposing noise limits and restrictions on the hours of operation.

In the absence of statutory noise limits, appropriate criteria relating to permissible noise levels for a development of this scale may be found in the National Roads authority (NRA) publication '*Guidelines for the Treatment of Noise and Vibration in National Road Schemes*'[4]. **Table 10.1** above sets out the maximum permissible noise levels at the facade of dwellings during construction as recommended in the NRA publication. The majority of the decommissioning activity in this instance is expected to occur during the normal working hours.

10.1.4 Methodology

10.1.4.1 Survey Instruments and Personnel

Mr. Mike Simms (Acoustic Consultant) directed the background noise surveys and the meteorological survey.

Wind data was obtained from the 80m high meteorological mast which has been erected for wind energy evaluation purposes. This mast has anemometers at three heights, 80m, 65m, and 50m. From this, standardised wind speeds at 10 m height have been calculated.

The equipment used in the noise survey was two Svantek 955 Sound Level Meters, each equipped with an outdoor microphone kit, mounted at a height of 1.2 m. Each unit was calibrated before and after the surveys. The meters were configured to measure L_{A90} values over 10-minute intervals, synchronised with the meteorological mast.

10.1.4.2 Receptor Survey

A receptor survey was conducted in order to quantify the number of properties within 1,030 m (10 rotor diameters) of the proposed turbines. In total, 33 receptors were found.

In addition to the on-site survey, a planning history search was carried out in the environs of the subject site using the on-line planning database of Laois County Council and Kilkenny County Council to identify any lands within 1,030 m of a proposed turbine that had received planning permission for development or had applied for planning permission. No additional properties were found.

On this basis, a set of noise-sensitive locations was selected based both on the proximity to the proposed development site and on the variation in ambient noise environments that is expected in the surroundings of the proposed development site. 4 no. houses in the vicinity of the subject site were selected to carry out a survey of background noise.

A noise level meter was installed at each location, taking into account a number of considerations, from ETSU-R-97, which are in turn based on BS4142[4]:

- the microphone should be at least than 10m from a building facade, in order to correlate the results to a free-field noise level;
- where possible, the location selected should represent that used by the residents for outdoor amenity;
- the microphone should be no less than 1.2m above the ground, so that a representative level can be measured, but yet the microphone itself is not overly exposed to the wind.

Measurements were carried out in terms of the $L_{A90,\ 10min}$ parameter, which is the 'A'-weighted, background noise level measured over consecutive 10-minute periods.

10.1.4.3 Meteorological Survey

The wind survey consists of measuring the wind speed at a representative location on the wind farm site, to run concurrently with the noise surveys. The meteorological mast currently in place for the evaluation of wind resource was used.

As rainfall can also affect measured background noise level, rain data was also analysed, so that data during periods of significant rainfall could be removed at a later stage.

The location chosen for the meteorological survey was at the following coordinates:

Description	*National Grid Coordinates*	
	Easting	*Northing*
80m Met Mast	250886	181921

Table 10.2: Location of Meteorological Masts

Due to the nature of the wind farm site and surrounding area, it is considered that wind speed behaviour at this location is representative of the general conditions on the wind farm site, thus data obtained is valid for comparison with any of the locations selected for noise surveys.

10.1.4.4 Noise Survey Locations and Dates

The noise survey locations are presented in **Table 10.3** below and are also shown in **Figure 10.1.**

House ID	*Locality*	*National Grid Coordinates*		*Dates*
		Easting	*Northing*	
H03	Graiguenahown	251992	183032	25/2 to 10/3/2011
H11	Graiguenahown	252557	182147	10/3 to 23/3/2011
H13	Knockardagur	251492	181109	28/1 to 23/2/2011
H27	Boleybawn	249788	180473	25/2 to 10/3/2011

Table 10.3: Noise Survey Locations

- House 03 is along a local road to the northeast of the site. The meter was located in a lawn area to the side of the house;
- House 11 is along a local road to the northeast of the site. The meter was located in an open area to the front of the house;
- House 13 is at the end of a lane off a local road to the east and south of the site. The meter was located in a open lawn area to the front of the house;
- House 27 is along a local road to the west. The meter in an open field to the rear of the house.

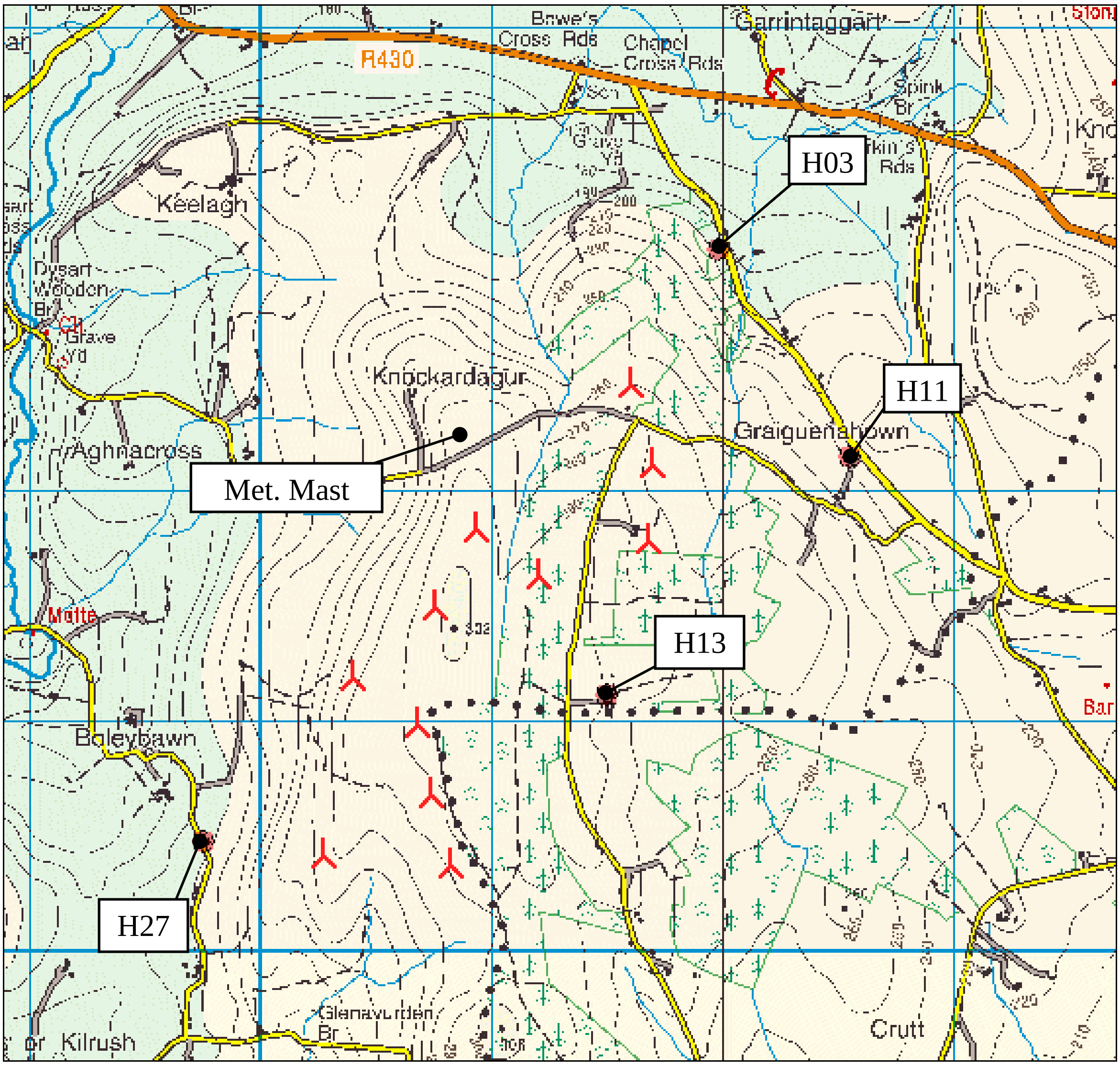

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Figure 10.1: Noise Survey Locations

10.2 Description of the Existing Environment

10.2.1 Survey Results and Discussion

The noise levels at the survey locations over a range of wind speeds are presented in **Table 10.4** and **Table 10.5** below, for daytime and night-time respectively. These are the noise levels which result by averaging the wind and noise samples by fitting a curve to the measured data, as best allowed by the data captured during the survey. Please refer to **Appendix 10.1** for a graphical representation of the data.

Wind Speed, m/s at 10m height	Noise Level L_{A90}, dB(A) re $2x10^{-5}$Pa, at House			
	H03	H11	H13	H27
4	30.6	23.9	22.2	20.8
5	31.4	25.8	22.9	22.2
6	32.2	27.8	24.2	24.2
7	33.1	29.6	26.1	26.6
8	34.1	31.4	28.4	29.2
9	35.0	32.9	31.0	31.8
10	35.7	34.1	33.8	34.4
11	36.4	35.0	36.7	36.8
12	36.7	35.5	39.6	39.2

Table 10.4: Daytime prevailing noise levels at the survey locations at various wind speeds

Wind Speed, m/s at 10m height	Noise Level L_{A90}, dB(A) re $2x10^{-5}$Pa, at House			
	H03	H11	H13	H27
4	27.3	19.5	18.1	18.7
5	27.3	19.5	18.2	18.8
6	28.2	19.7	20.7	20.5
7	29.0	20.5	23.0	22.1
8	30.1	21.8	25.7	24.1
9	31.3	23.9	28.8	26.4
10	32.6	26.8	32.1	28.9
11	33.9	30.6	35.4	31.5
12	35.3	35.4	38.8	34.2

Table 10.5: Night-time prevailing noise levels at the survey locations at various wind speeds

10.3 Description of Likely Impacts

10.3.1 Noise Prediction Model

10.3.1.1 Overview

There are 33 no. properties located within 1,030m of a proposed turbine (10 rotor diameters). To predict the noise generated at these properties, noise modelling was conducted using WindPRO software, Version 2.8.579. Please refer to **Appendix 10.2** for the results of the prediction model.

The noise prediction model was run from 4 to 12 m/s at 1 m/s intervals. All criteria are based on L_{A90} levels rather than $L_{Aeq:}$ L_{A90} is the 90th percentile noise level which is exceeded for 90% of the time. As wind turbines will be operating continuously throughout its particular operating range the L_{A90} level is much more useful in identifying noise which may be attributed directly to the proposed development rather than L_{Aeq} which will be affected by short term influences such as a passing car or plane or short-term noise from external influences including wildlife or man-made sources.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the frequency characteristics of human hearing. All sound pressure levels are expressed in terms of decibels (dB) relative to $2x10^{-5}$ Pa.

The Noise prediction model implements the International Standard ISO 9613-2, Acoustics – Attenuation of Sound during Propagation Outdoors[5]. The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on conditions favourable to noise propagation.

The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

Predicted Octave Band Noise Level =

$$L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

These factors are discussed in detail below. The predicted octave band levels from each of the turbines are summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together.

10.3.1.2 L_W - Source Sound Power Level

The proposed development consists of 11 no. GE 3.2-103 turbines. The parameters of this turbine type are as follows:

Turbine Elements	*GE 3.2-103*
Rotor diameter	103.0m
Hub height	85m
Cut-in wind speed (at hub height)	3m/s
Cut-out wind speed (at hub height)	25m/s

Table 10.6: Wind Turbine Parameters of the GE 3.2-103 Turbine Model

**Note: The final turbine modem to be installed on site maybe subject to minor immaterial deviations*

The sound power level of a noise source is normally expressed in dB re:1pW. Noise predictions for this site have been based on sound power levels of the GE 3.2-103 turbine, at a hub height of 85m, using the values in **Table 10.7** below.

Wind Speed at 10m Height (m/s)	*Sound Power Level , dB(A) re 10^{-12}W*
4	98.0
5	101.7
6	104.9
7	106.7
8	107.0
9	107.0
10	107.0
11	107.0

Wind Speed at 10m Height (m/s)	*Sound Power Level , dB(A) re 10^{-12}W*
12	107.0

Table 10.7: Wind Turbine Sound Power Levels

10.3.1.3 Directivity Factor

The directivity factor allows for an adjustment to be made where the level of sound radiates from the source in a non-uniform manner. In this case the sound power level is measured in a down wind direction, corresponding to the worst case propagation conditions considered and needs no further adjustment.

10.3.1.4 A_{geo} – Geometrical Divergence

The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in attenuation depending on distance according to:

$$A_{geo} = 20 \times \log (d) + 11$$

where d = distance from the turbine

Each of the wind turbines may be considered as a point source beyond distances corresponding to one rotor diameter.

10.3.1.5 A_{atm} – Atmospheric Absorption

Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation depends on distance according to:

$$A_{atm} = d \times \alpha$$

where d = distance from the turbine and

α = atmospheric absorption coefficient in dB/m

Values of 'α' from ISO 9613 Part 1, corresponding to a temperature of 15ºC and a relative humidity of 70% have been used for these predictions, which give relatively low levels of atmospheric attenuation and correspondingly worst case noise predictions, as given below.

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.0011	0.0023	0.0041	0.0087	0.0264	0.0937

Table 10.8: Assumed Octave Band Atmospheric Attenuation Coefficients

10.3.1.6 A_{gr} – Ground Effect

Ground effect is the interference of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable G, which varies between 0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The predictions have been carried out using a source height corresponding to the proposed height of the turbine nacelle, a receiver height of 4 m and an assumed ground factor G = 0.5.

10.3.1.7 A_{bar} – Barrier Attenuation

The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under down wind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU concludes that an attenuation of just 2 dB (A) should be allowed where the direct line of sight between the source and receiver is just interrupted and that 10 dB (A) should be allowed where a barrier lies within 5m of a receiver and provides a significant interruption to the line of sight. It should be noted that no barrier attenuation has been used in any of the noise predictions for this site.

10.1.3.8 A_{misc} – Miscellaneous Other Effects

ISO 9613 includes effects of propagation through foliage, industrial plant and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

10.3.2 Prediction of likely Noise Impacts

When considering a development of this nature, the potential noise impact on the surroundings must be considered for each of two distinct stages: (i) the short term impact of the construction phase; (ii) the longer term impact of the operational phase; and (iii) the short term duration of the decommissioning phase. Given the nature of the proposed development, it is unlikely that there will be any significant overlap of these phases.

10.3.2.1 Construction Phase

A variety of items of plant will be in use, such as excavators, lifting equipment, dumper trucks, compressors, and generators. There will be vehicular movements to and from the site that will make use of existing roads.

Due to the nature of the activities undertaken on a large construction site, there is potential for generation of significant levels of noise. The flow of vehicular traffic to and from a construction site is also a potential source of noise levels. The potential for vibration at neighbouring sensitive locations during construction is typically limited to excavation works and lorry movements on uneven road surfaces. Due to the proximity of sensitive locations to the site access point, the more significant of these is likely to be uneven road surfaces.

Typical sound levels at 10m from construction equipment are found in 'BS5228:2009 *Code of practice for noise and vibration control on construction and open site's*, values from which are presented in **Table 10.9** below. Due to the fact that the construction program has been established in outline form only, set out in **Chapter 2** of the EIS, it is difficult to calculate precisely the actual magnitude of noise emissions to the local environment. However, the nearest noise-sensitive location to the proposed construction works is House H03, at a distance of approximately 100m from the proposed entrance at the north end of the site. The construction noise levels at this location have been predicted by applying a correction for the additional distance to the house also shown in the table.

Noise Source	*BS5228 Ref.*	*dB(A) $L_{Aeq,10m}$*	*dB(A) L_{Aeq} at house H03*
Excavator (22t)	C2.3	78	58
Dozer	C2.12	81	61
Dump Truck (tipping fill)	C2.30	79	59
Roller (rolling fill)	C2.37	79	59

Noise Source	*BS5228 Ref.*	*dB(A) $L_{Aeq,10m}$*	*dB(A) L_{Aeq} at house H03*
Concrete Mixer Truck	C4.20	80	60
Mobile Telescopic Crane	C4.39	77	57
Mini Tracked Excavator (5t)	C4.68	74	54

Table 10.9: Typical Sound Levels from Construction Equipment

**Source: BS5228:2009 Code of practice for noise and vibration control on construction and open sites*

As can be seen, the expected noise levels are below the criteria in **Table 10.1** for weekdays and Saturdays. It should also be noted that most houses are considerably further away from any part of the proposed works and as such the scenario described above is very much a worst case. Additionally, the construction works will progress around the site, thus any construction noise impact on any particular house will be transitory and temporary

10.3.2.2 Operational Phase

The noise levels due to the proposed operation of the wind farm over a range of wind speeds, are presented in **Table 10.10** below.

Wind Speed, m/s at 10m height	*Noise Level LA90, dB(A) re 2x10-5Pa, at House*			
	H03	*H11*	*H13*	*H27*
4	29.6	29.4	34.4	32.2
5	33.3	33.1	38.1	35.9
6	36.6	36.4	41.4	39.2
7	38.6	38.4	43.3	41.2
8	38.7	38.6	43.5	41.4
9	38.7	38.6	43.5	41.4
10	38.7	38.6	43.5	41.4
11	38.7	38.6	43.5	41.4
12	38.7	38.6	43.5	41.4

Table 10.10: Wind turbine noise levels at the survey locations at various wind speeds.

The comparison of the wind turbine noise levels against the prevailing background noise at survey locations is presented in graphical and tabular form in **Appendix 10.1.** The points represented as small circles are individual samples of background noise versus wind speed, with day and night presented on separate graphs for each of the 4 no. locations. In order to average these samples, a curve fit using a polynomial regression is shown. The dotted line on each graph illustrates a planning criterion based on guidance in the Wind Energy Development Guidelines for Planning Authorities 2006.

Each survey location is now discussed in turn:

- *House H03:* At this location, the noise levels at all wind speeds are within both the daytime lower limit of 45dB L_{A90} and the night-time lower limit of 43dB L_{A90}, and therefore comply with the adopted criteria;

- *House H11:* At this location, the noise levels at all wind speeds are within both the daytime lower limit of 45dB L_{A90} and the night-time lower limit of 43dB L_{A90}, and therefore comply with the adopted criteria;
- *House H13:* At this location, the noise levels at all wind speeds are within both the daytime lower limit of 45dB L_{A90} and the night-time lower limit of 45dB L_{A90}, which applies for houses with financial involvement in the project and therefore comply with the adopted criteria;
- *House H27:* At this location, the noise levels at all wind speeds are within both the daytime lower limit of 45dB L_{A90} and the night-time lower limit of 43dB L_{A90}, and therefore comply with the adopted criteria.

The above deals with the properties included in the set of noise survey locations. As it is not practicable to survey noise levels at all houses, a method is required to assess the impact at the remaining houses in the study area.

Noise levels for 29 no. additional houses in the vicinity of the site have been predicted for the wind speed of 12 m/s at 10m height. The results for all houses are re-produced in **Table 10.11** below. It should be noted that these predictions represent downwind propagation in all directions, which clearly cannot happen at all locations simultaneously.

ID	*Predicted Noise Level L_{A90}*	*Applicable lower fixed noise limit, L_{A90}, see text.*	*Complies with Limit?*
H01	36.5	43.0	Yes
H02	37.9	43.0	Yes
H03	38.7	43.0	Yes
H04	40.5	43.0	Yes
H05	38.7	43.0	Yes
H06	39.8	43.0	Yes
H07	39.2	43.0	Yes
H08	39.2	43.0	Yes
H09	39.0	43.0	Yes
H10	40.0	43.0	Yes
H11	38.6	43.0	Yes
H12	39.1	43.0	Yes
H13	43.5	45.0	Yes
H14	43.3	45.0	Yes
H15	39.9	43.0	Yes
H16	39.9	43.0	Yes
H17	38.7	43.0	Yes
H18	38.5	43.0	Yes
H19	37.6	43.0	Yes
H20	36.8	43.0	Yes

ID	Predicted Noise Level L_{A90}	Applicable lower fixed noise limit, L_{A90}, see text.	Complies with Limit?
H21	37.2	43.0	Yes
H22	40.8	43.0	Yes
H23	37.9	43.0	Yes
H24	36.6	43.0	Yes
H25	38.0	45.0	Yes
H26	40.2	45.0	Yes
H27	41.4	45.0	Yes
H28	39.4	43.0	Yes
H29	38.7	43.0	Yes
H30	40.6	43.0	Yes
H31	41.2	43.0	Yes
H32	37.9	43.0	Yes
H33	38.6	43.0	Yes

Table 10.11: Predicted Noise generated at all properties located within 1,030m of a proposed turbine

The lower fixed noise level limit is 43dB L_{A90} for non-involved houses (based on the night-time criteria in the DoEHLG guidelines), and the lower fixed noise level limit for involved houses is 45dB L_{A90}. The predicted noise level therefore lie within the adopted criteria in all cases. The noise impact of the wind farm is considered acceptable.

10.3.2.3 Decommissioning Phase

The decommissioning phase will involve similar operations to those outlined for the construction phase. It is logical therefore that a similar noise impact is predicted for the decommissioning phase. In reality, however, it is likely that the noise impact from decommissioning will have a lesser noise impact than that of the construction phase. This is due to the fact that some of materials which were imported to the site will not be removed.

10.4 Mitigation & Measures

10.4.1 Construction Phase

Construction activities will give rise to noise on site from the increased traffic as well as the construction activity.

To ensure that construction noise remains below 'nuisance' levels, reference will be made to BS 5228: Part 1: 1997 (Noise Control on Construction and Open Sites – Part 1. Codes of Practice for Basic Information and Procedures for Noise Control) which offers detailed guidance on the control of noise from demolition and construction activities.

Accordingly all construction traffic to be used on site should:

- Have effective well-maintained silencers;
- Operators of all mobile equipment will be instructed to avoid unnecessary revving of machinery;

- Where possible the contractor will be instructed to use the least noisy equipment;
- With efficient use of well-maintained mobile equipment considerably lower noise levels than those predicted can be attained;
- The construction phase on-site project engineer will closely supervise all construction activity;
- Construction activity due to its nature is a temporary activity and thus any impacts will be short term typically 12-18 months.

The following mitigation measures for control of construction noise will be implemented, as recommended in BS 5228: Part 1:1997 and as part of the Construction Management Plan:

- The hours of construction activity will be limited to between 08.00 hours and 20.00 hours Monday to Friday and 08.00 hours and 18.00 hours on Saturdays. It should be noted that it may be necessary to commence turbine base concrete pours from 06.00 due to time constraints incurred by the concrete curing process. Additional emergency works may also be required outside of normal working hours as quoted above;
- Communication links will be established and maintained between the developer, contractor, Local Authority and local residents;
- Equipment and technology with generation of low noise levels will be selected where possible;
- Noise generating equipment will be located as far as possible away from local noise sensitive areas identified;
- In the unlikely event that irregularities or complaints arise, the source of the problem will be sought and dealt with;
- Temporary barriers or screens can be erected if necessary around noisy equipment such as generators and compressors.

10.4.2 Operational Phase

Mitigation of noise from the proposed development consists of the following measures:

- Site layout design to ensure minimal disruption to sensitive receptors;
- It is recommended that, additional post development noise monitoring in accordance with international noise standards and in particular ISO 1996: "Description and measurement of environmental noise" be carried out to monitor accurately the acoustic impact of development according to site atmospheric conditions and corrected for background speeds at any potentially sensitive locations.

Mitigation by design measures have already been put in place by siting the wind turbines in an appropriate position in order to have the minimum impact at the nearest noise sensitive location and also by choosing a turbine size that is appropriate to the demands of power generation and noise impact.

A warranty agreement will be drawn up with the manufacturer of the turbines for this site to ensure that the noise output will not contain any significant audible tones.

10.4.3 Decommissioning Phase

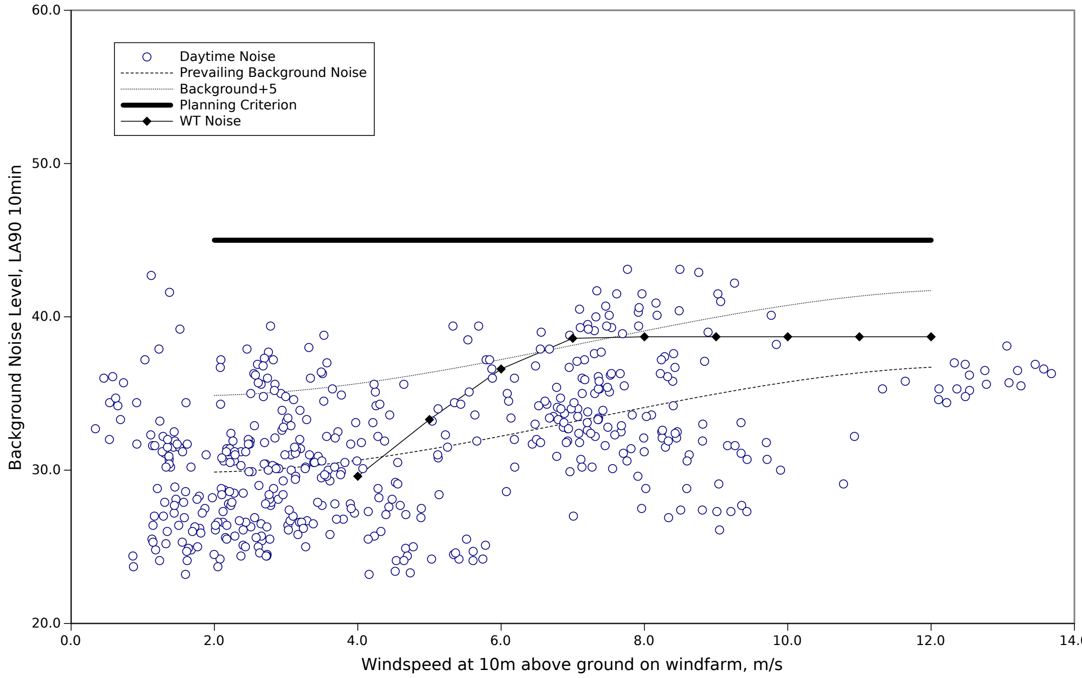
The mitigation measured outlined above for the construction phase are also proposed to reduce the impact of noise from the decommissioning phase.

References:

1. National Roads Authority, 2004. *Guidelines for the Treatment of Noise and Vibration in National Road Schemes.*
2. DoEHLG's (2006) *Wind Energy Development Guidelines for Planning Authorities.*
3. ETSU-R-97: UK Department of Trade and Industry, 1996. *The Assessment and Rating of Noise from Wind Farms.*
4. British Standards Institution, 1997. BS 4142:1997 *Method for rating industrial noise affecting mixed residential and industrial areas.* London: BSI
5. International Organization for Standardization, 1996. ISO 9613-2, *Acoustics – Description, Measurement and Assessment of Environmental Noise:* Parts 1 and 2.

Appendix 10.1: Noise Survey Results

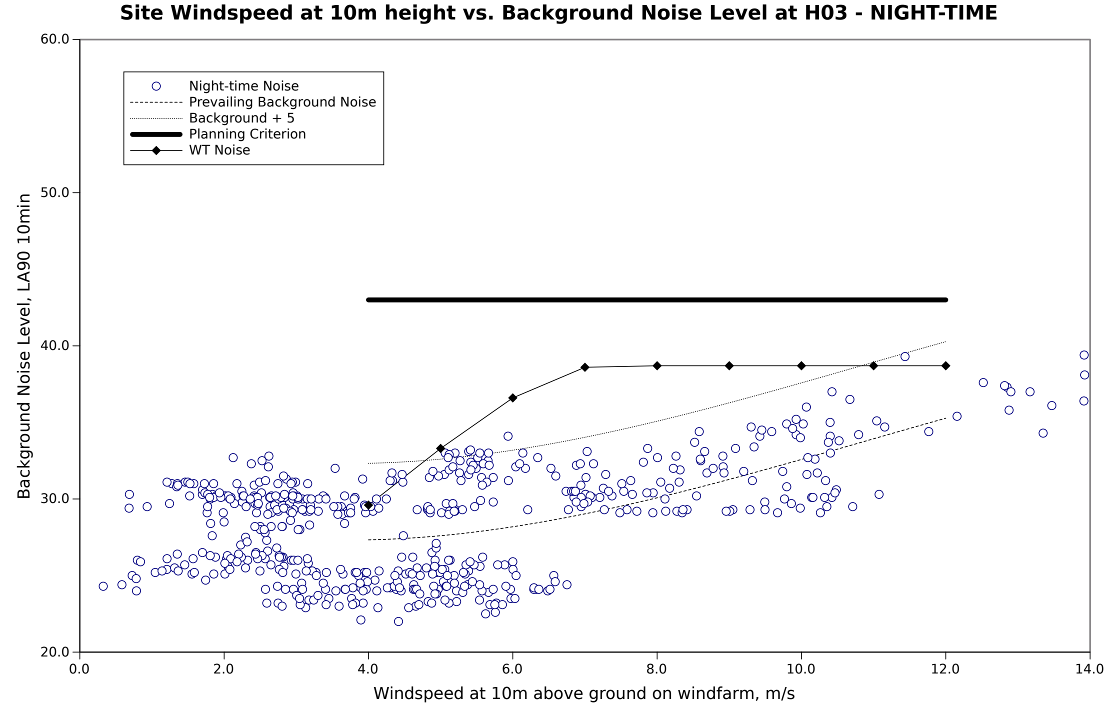
Site Windspeed at 10m height vs. Background Noise Level at H03 - DAYTIME



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E251992, N183032
Date of Noise Survey: 25/02/2011 to 10/03/2011

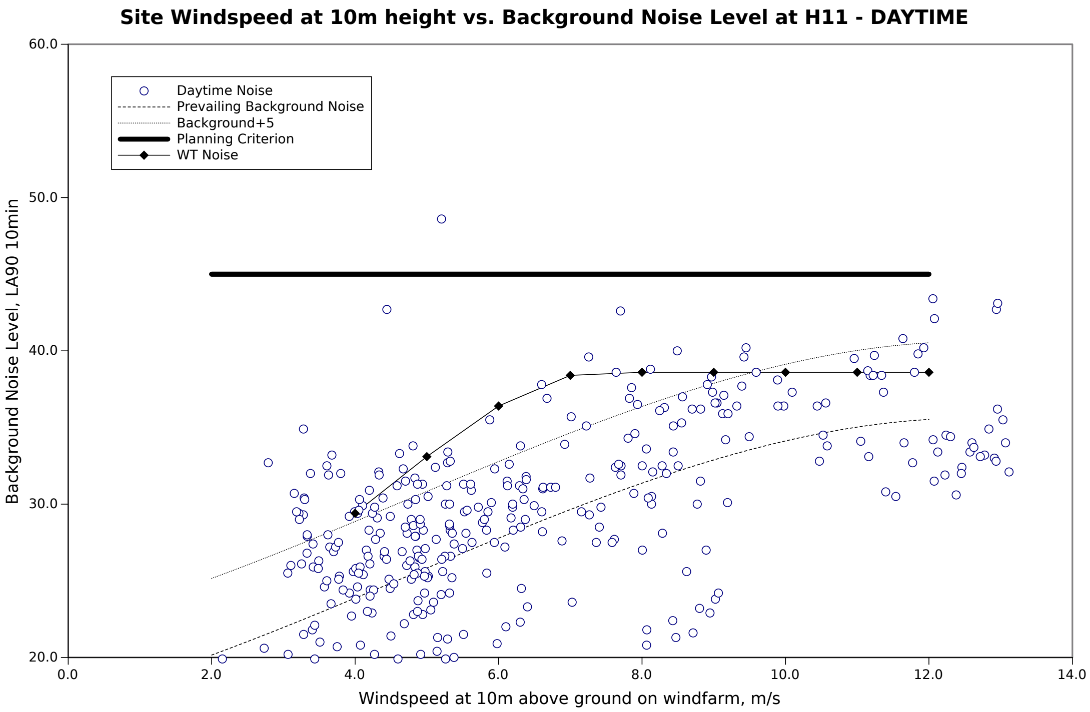
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	30.6	29.6	45.0	−15.4	No
5	31.4	33.3	45.0	−11.7	No
6	32.2	36.6	45.0	−8.4	No
7	33.1	38.6	45.0	−6.4	No
8	34.1	38.7	45.0	−6.3	No
9	35.0	38.7	45.0	−6.3	No
10	35.7	38.7	45.0	−6.3	No
11	36.4	38.7	45.0	−6.3	No
12	36.7	38.7	45.0	−6.3	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E251992, N183032
Date of Noise Survey: 25/02/2011 to 10/03/2011

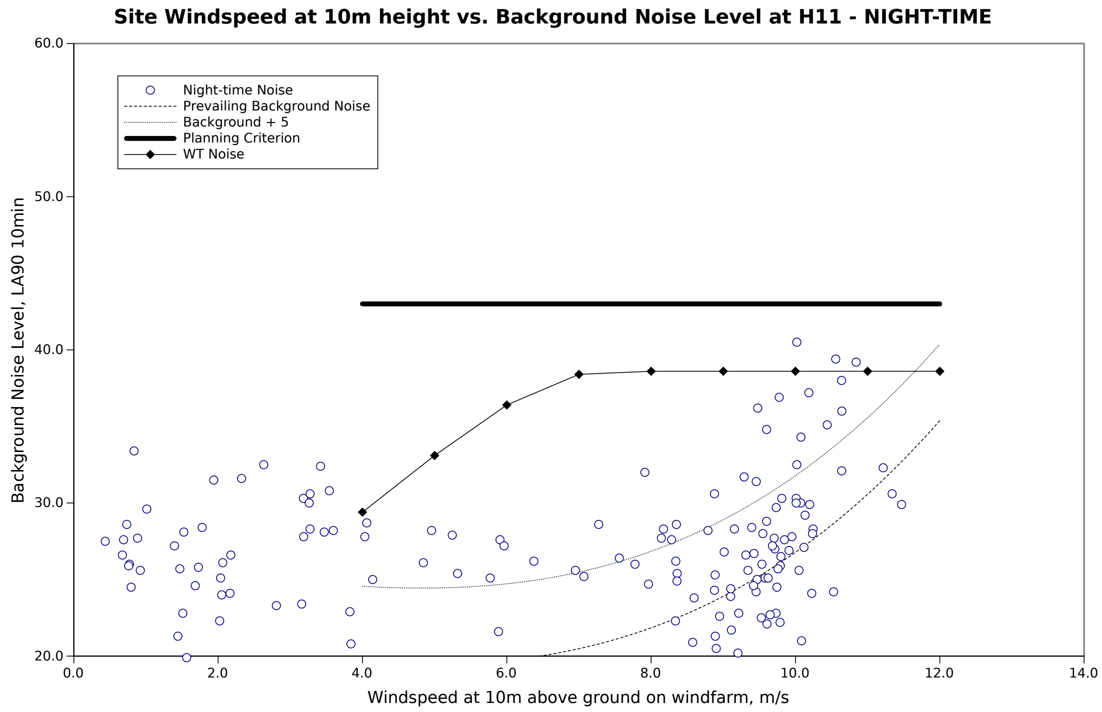
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	27.3	29.6	43.0	−13.4	No
5	27.3	33.3	43.0	−9.7	No
6	28.2	36.6	43.0	−6.4	No
7	29.0	38.6	43.0	−4.4	No
8	30.1	38.7	43.0	−4.3	No
9	31.3	38.7	43.0	−4.3	No
10	32.6	38.7	43.0	−4.3	No
11	33.9	38.7	43.0	−4.3	No
12	35.3	38.7	43.0	−4.3	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E252557, N182147
Date of Noise Survey: 10/03/2011 to 23/03/2011

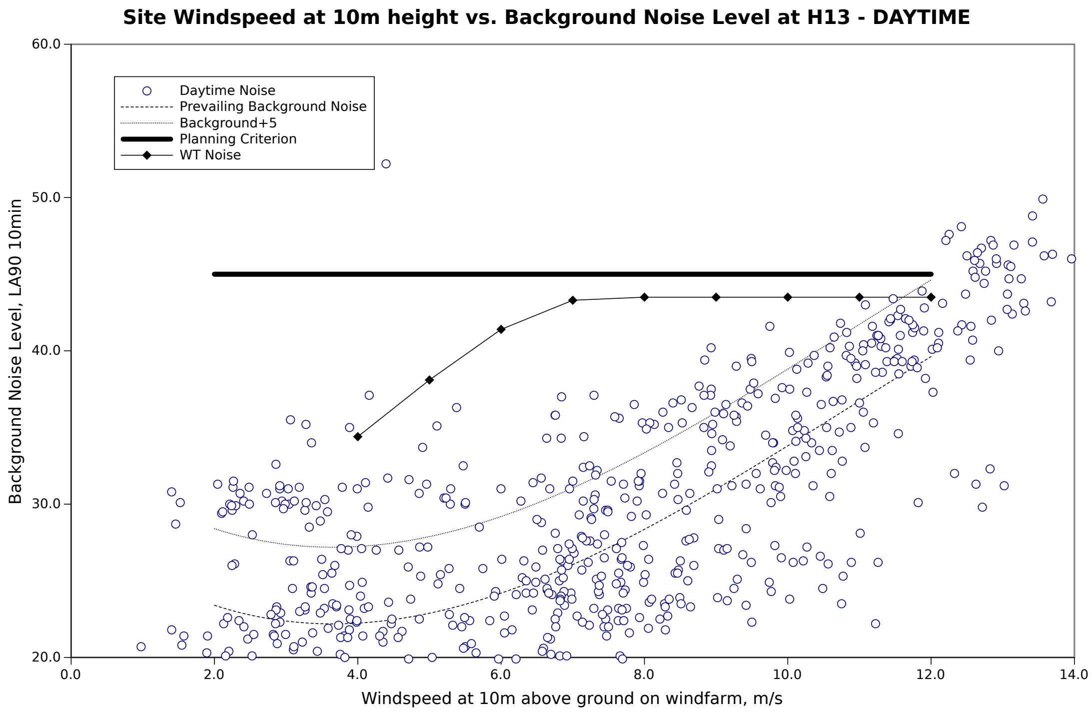
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	23.9	29.4	45.0	−15.6	No
5	25.8	33.1	45.0	−11.9	No
6	27.8	36.4	45.0	−8.6	No
7	29.6	38.4	45.0	−6.6	No
8	31.4	38.6	45.0	−6.4	No
9	32.9	38.6	45.0	−6.4	No
10	34.1	38.6	45.0	−6.4	No
11	35.0	38.6	45.0	−6.4	No
12	35.5	38.6	45.0	−6.4	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E252557, N182147
Date of Noise Survey: 10/03/2011 to 23/03/2011

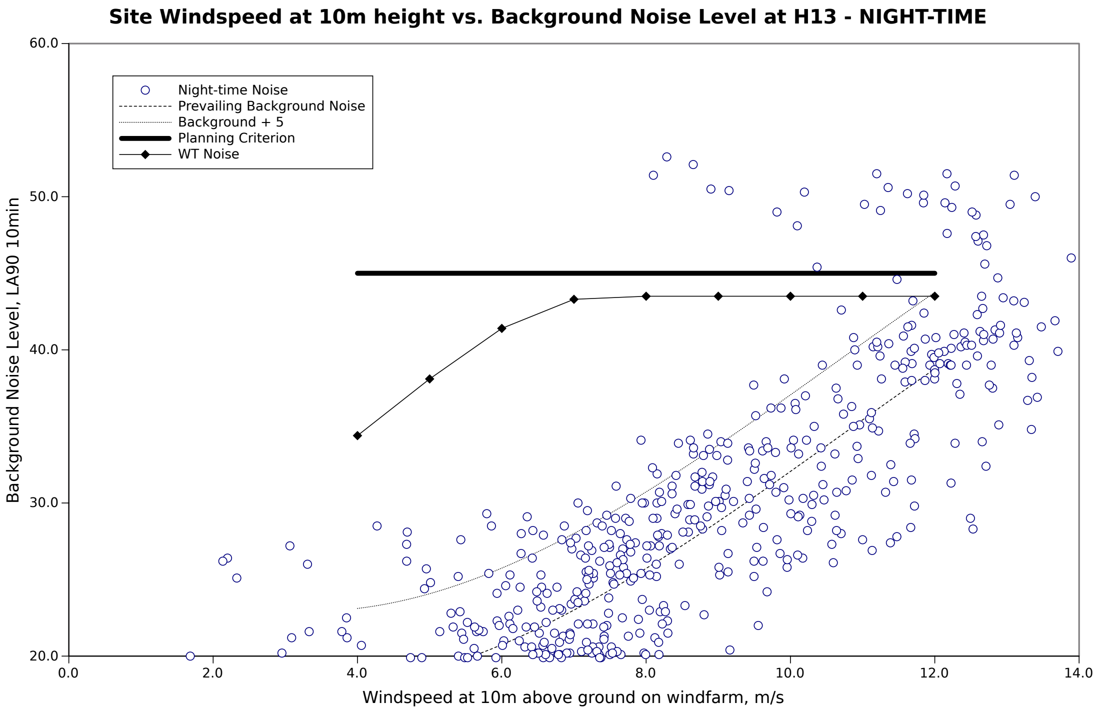
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	19.5	29.4	43.0	−13.6	No
5	19.5	33.1	43.0	−9.9	No
6	19.7	36.4	43.0	−6.6	No
7	20.5	38.4	43.0	−4.6	No
8	21.8	38.6	43.0	−4.4	No
9	23.9	38.6	43.0	−4.4	No
10	26.8	38.6	43.0	−4.4	No
11	30.6	38.6	43.0	−4.4	No
12	35.4	38.6	43.0	−4.4	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E251492, N181109
Date of Noise Survey: 28/01/2011 to 23/02/2011

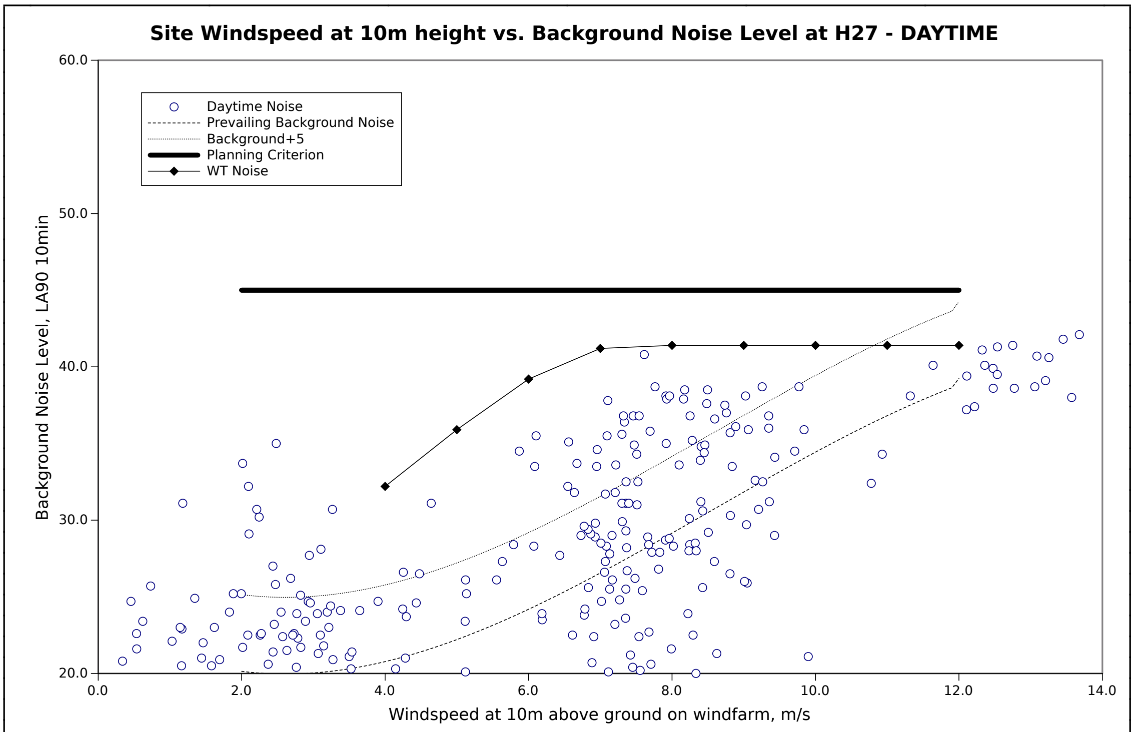
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	22.2	34.4	45.0	−10.6	No
5	22.9	38.1	45.0	−6.9	No
6	24.2	41.4	45.0	−3.6	No
7	26.1	43.3	45.0	−1.7	No
8	28.4	43.5	45.0	−1.5	No
9	31.0	43.5	45.0	−1.5	No
10	33.8	43.5	45.0	−1.5	No
11	36.7	43.5	45.0	−1.5	No
12	39.6	43.5	45.0	−1.5	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E251492, N181109
Date of Noise Survey: 28/01/2011 to 23/02/2011

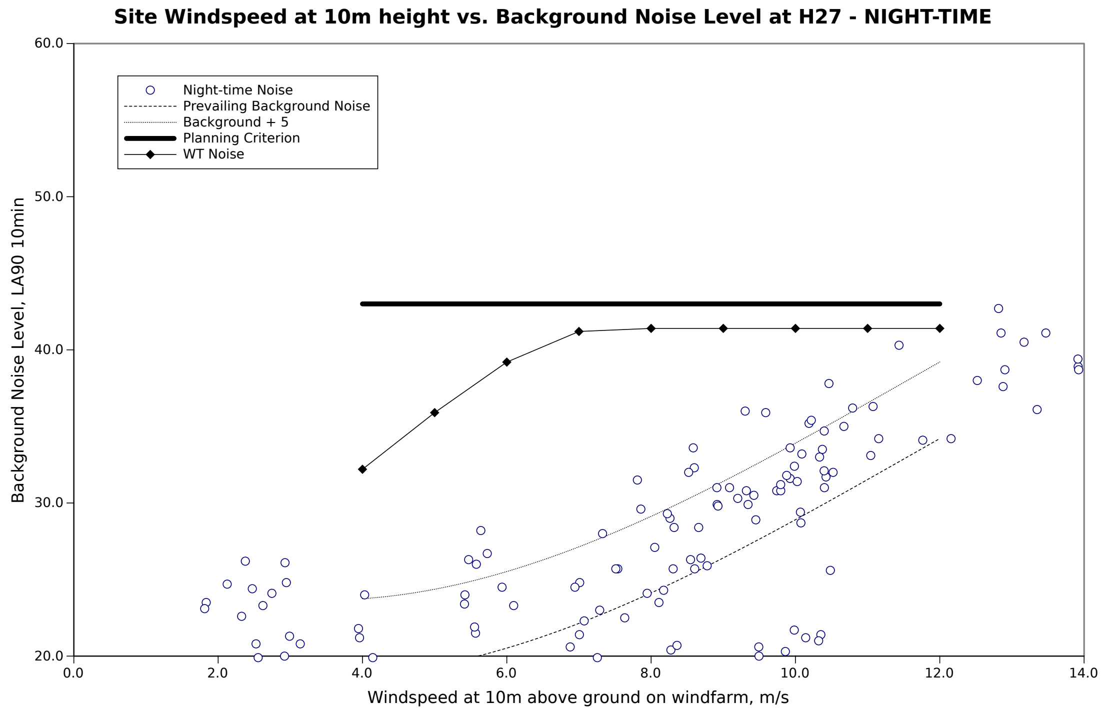
Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	18.1	34.4	45.0	−10.6	No
5	18.2	38.1	45.0	−6.9	No
6	20.7	41.4	45.0	−3.6	No
7	23.0	43.3	45.0	−1.7	No
8	25.7	43.5	45.0	−1.5	No
9	28.8	43.5	45.0	−1.5	No
10	32.1	43.5	45.0	−1.5	No
11	35.4	43.5	45.0	−1.5	No
12	38.8	43.5	45.0	−1.5	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E249788, N180473
Date of Noise Survey: 25/02/2011 to 10/03/2011

Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	20.8	32.2	45.0	−12.8	No
5	22.2	35.9	45.0	−9.1	No
6	24.2	39.2	45.0	−5.8	No
7	26.6	41.2	45.0	−3.8	No
8	29.2	41.4	45.0	−3.6	No
9	31.8	41.4	45.0	−3.6	No
10	34.4	41.4	45.0	−3.6	No
11	36.8	41.4	45.0	−3.6	No
12	39.2	41.4	45.0	−3.6	No



Noise/Windspeed Analysis
Site: Pinewoods

Noise Meter Location: E249788, N180473
Date of Noise Survey: 25/02/2011 to 10/03/2011

Windspeed	Background Noise based on Curve Fit dB, LA90	Wind Turbine Noise at House dB, LA90	Planning Criterion dB	Difference dB	Exceeds?
4	18.7	32.2	43.0	−10.8	No
5	18.8	35.9	43.0	−7.1	No
6	20.5	39.2	43.0	−3.8	No
7	22.1	41.2	43.0	−1.8	No
8	24.1	41.4	43.0	−1.6	No
9	26.4	41.4	43.0	−1.6	No
10	28.9	41.4	43.0	−1.6	No
11	31.5	41.4	43.0	−1.6	No
12	34.2	41.4	43.0	−1.6	No

Appendix 10.2: Noise Modelling Output

Project:
Pinewoods Wind Farm

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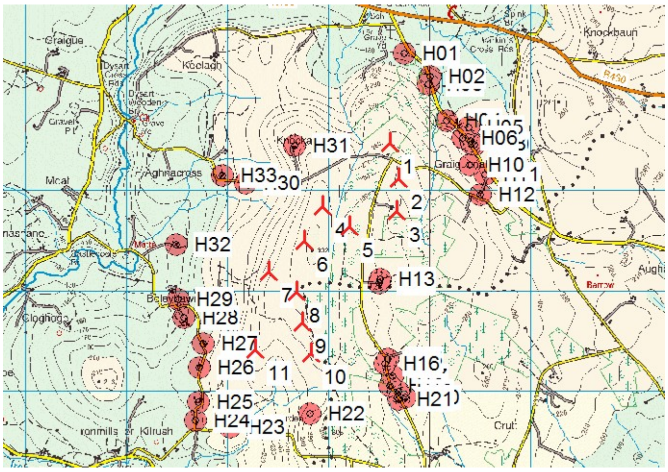
Licensed user:
Galetech Energy Services Limited
Clondargan, Stradone
IE-CO. Cavan

Calculated:
12/04/2016 12:24/2.8.579

DECIBEL - Main Result

Calculation: April 2016 GE 3.2 103.0 m RD 85 m HH

Noise calculation model:
ISO 9613-2 General
Wind speed:
4.0 m/s - 12.0 m/s, step 1.0 m/s
Ground attenuation:
General, Ground factor: 0.5
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are 90% exeedance values (L90)
Pure tones:
Pure and Impulse tone penalty are added to WTG source noise
Height above ground level, when no value in NSA object:
4.0 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)



Scale 1:75,000
New WTG
Noise sensitive area

WTGs

	Irish Grid (IG)-IRELAND65 (IE) East	North	Z [m]	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Noise data Creator	Name	First wind speed [m/s]	LwaRef [dB(A)]	Last wind speed [m/s]	LwaRef [dB(A)]	Pure tones
1	251,604	182,460	258.7	T1	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
2	251,693	182,105	267.5	T2	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
3	251,676	181,781	273.2	T3	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
4	250,937	181,833	297.7	T4	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
5	251,205	181,628	299.3	T5	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
6	250,756	181,489	302.7	T6	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
7	250,403	181,186	278.9	T7	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
8	250,682	180,984	292.8	T8	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
9	250,742	180,675	291.0	T9	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
10	250,826	180,372	287.6	T10	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f
11	250,276	180,413	260.8	T11	Yes	GE WIND ENERGY	3.2-3,200	3,200	103.0	85.0	USER	Normal Operation	4.0	98.0	12.0	107.0	0 dB f

f) From other hub height

Calculation Results

Sound Level

Noise sensitive area No.	Name	Irish Grid (IG)-IRELAND65 (IE) East	North	Z [m]	Imission height [m]	Demands Max Noise [dB(A)]	Sound Level Max From WTGs [dB(A)]	Demands fulfilled ? Noise
H01	H01	251,747	183,345	179.5	4.0	43.0	36.5	Yes
H02	H02	252,003	183,118	189.9	4.0	43.0	37.9	Yes
H03	H03	251,985	183,038	196.4	4.0	43.0	38.7	Yes
H04	H04	252,171	182,682	208.9	4.0	43.0	40.5	Yes
H05	H05	252,389	182,614	212.0	4.0	43.0	38.7	Yes
H06	H06	252,334	182,504	217.9	4.0	43.0	39.8	Yes
H07	H07	252,407	182,475	217.6	4.0	43.0	39.2	Yes
H08	H08	252,419	182,452	218.8	4.0	43.0	39.2	Yes
H09	H09	252,443	182,442	219.0	4.0	43.0	39.0	Yes
H10	H10	252,398	182,245	230.0	4.0	43.0	40.0	Yes
H11	H11	252,554	182,144	226.2	4.0	43.0	38.6	Yes
H12	H12	252,505	181,946	240.1	4.0	43.0	39.1	Yes
H13	H13-Landowner	251,509	181,108	286.4	4.0	45.0	43.5	Yes
H14	H14-Landowner	251,504	181,064	286.4	4.0	45.0	43.3	Yes
H15	H15	251,584	180,317	281.7	4.0	43.0	39.9	Yes
H16	H16	251,563	180,264	282.8	4.0	43.0	39.9	Yes
H17	H17	251,638	180,140	276.5	4.0	43.0	38.7	Yes
H18	H18	251,603	180,046	273.4	4.0	43.0	38.5	Yes
H19	H19	251,691	179,992	270.9	4.0	43.0	37.6	Yes
H20	H20	251,763	179,930	266.8	4.0	43.0	36.8	Yes
H21	H21	251,697	179,912	266.9	4.0	43.0	37.2	Yes

To be continued on next page...

Project:
Pinewoods Wind Farm

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Galetech Energy Services Limited
Clondargan, Stradone
IE-CO. Cavan

Calculated:
12/04/2016 12:24/2.8.579

DECIBEL - Main Result

Calculation: April 2016 GE 3.2 103.0 m RD 85 m HH

...continued from previous page

Noise sensitive area		Irish Grid (IG)-IRELAND65 (IE)				Demands	Sound Level	Demands fulfilled ?
No.	Name	East	North	Z	Imission height	Max Noise	Max From WTGs	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	
H22	H22	250,816	179,769	278.8	4.0	43.0	40.8	Yes
H23	H23	250,021	179,640	215.1	4.0	43.0	37.9	Yes
H24	H24	249,684	179,702	193.7	4.0	43.0	36.6	Yes
H25	H25-Landowner	249,712	179,885	196.4	4.0	45.0	38.0	Yes
H26	H26-Landowner	249,723	180,232	200.3	4.0	45.0	40.2	Yes
H27	H27-Landowner	249,755	180,471	197.1	4.0	45.0	41.4	Yes
H28	H28	249,570	180,722	179.3	4.0	43.0	39.4	Yes
H29	H29	249,506	180,906	170.2	4.0	43.0	38.7	Yes
H30	H30	250,173	182,064	215.9	4.0	43.0	40.6	Yes
H31	H31	250,665	182,436	264.8	4.0	43.0	41.2	Yes
H32	H32	249,491	181,450	162.4	4.0	43.0	37.9	Yes
H33	H33	249,951	182,134	198.5	4.0	43.0	38.6	Yes

Distances (m)

	WTG										
NSA	1	2	3	4	5	6	7	8	9	10	11
H01	896	1241	1565	1715	1800	2103	2542	2589	2852	3111	3279
H02	769	1059	1376	1669	1690	2051	2508	2509	2748	2987	3208
H03	692	977	1294	1597	1611	1977	2435	2432	2669	2906	3131
H04	609	749	1028	1497	1429	1850	2315	2258	2463	2672	2955
H05	800	862	1096	1648	1540	1982	2445	2360	2543	2732	3050
H06	731	755	977	1549	1429	1876	2337	2244	2424	2611	2933
H07	803	804	1008	1604	1470	1922	2382	2279	2451	2630	2964
H08	815	804	1001	1606	1467	1921	2380	2274	2443	2619	2957
H09	839	822	1012	1624	1481	1937	2395	2286	2452	2626	2968
H10	822	719	858	1518	1343	1807	2258	2129	2281	2445	2803
H11	1001	862	950	1646	1444	1913	2354	2202	2332	2474	2860
H12	1037	827	845	1572	1338	1807	2235	2061	2173	2301	2704
H13	1355	1014	693	923	602	844	1108	836	881	1004	1415
H14	1399	1058	737	955	638	860	1107	826	855	968	1389
H15	2142	1791	1466	1648	1364	1435	1466	1121	915	760	1311
H16	2196	1845	1521	1689	1410	1466	1481	1137	918	745	1295
H17	2320	1965	1641	1832	1549	1611	1618	1275	1043	844	1389
H18	2413	2060	1736	1907	1631	1673	1655	1314	1066	842	1376
H19	2469	2112	1789	1989	1706	1764	1756	1415	1169	945	1476
H20	2534	2175	1852	2074	1787	1855	1851	1509	1264	1036	1563
H21	2549	2192	1869	2065	1785	1836	1815	1476	1222	985	1506
H22	2803	2494	2187	2067	1899	1721	1476	1222	909	603	840
H23	3233	2978	2705	2376	2313	1989	1592	1497	1261	1088	814
H24	3360	3131	2878	2471	2453	2083	1649	1624	1437	1324	925
H25	3194	2974	2729	2300	2294	1913	1473	1465	1298	1215	772
H26	2915	2717	2492	2009	2035	1627	1171	1218	1111	1112	582
H27	2715	2534	2324	1803	1854	1427	965	1059	1008	1075	524
H28	2675	2533	2357	1761	1869	1412	953	1142	1173	1303	770
H29	2610	2493	2339	1705	1845	1379	939	1178	1257	1423	914
H30	1484	1520	1529	798	1120	819	907	1194	1501	1813	1654
H31	939	1080	1204	661	972	951	1277	1452	1762	2070	2059
H32	2341	2297	2209	1495	1723	1265	949	1279	1471	1715	1300
H33	1684	1742	1760	1031	1352	1031	1050	1362	1659	1967	1751