Forest Wind Holdings Pty Ltd

Forest Wind Noise Assessment

September 2019

Executive summary

Forest Wind Holdings Pty Ltd (FWH) has proposed to develop a wind farm, referred to as Forest Wind in Queensland. GHD Pty Ltd was commissioned by FWH to undertake a noise assessment in 2017. Since completion of the noise assessment, placement of the wind turbine generators (WTG) has changed and as such an update to the noise assessment is required. This document summarises the results of the operational noise impact assessment of the proposed updated wind turbine configuration.

Queensland's Department of State Development, Manufacturing, Infrastructure and Planning has issued information detailing the required inputs for noise assessments specific to wind farms. Assessment for noise impacts is to be undertaken in accordance with *State code 23: Wind farm development* (the Code) and *State code 23 Wind farm development – Planning guidelines* (the Guidelines).

Criteria are provided for predicted noise levels at sensitive land uses located on both host and non-host lots. Host lots are parcels of land that accommodates any part of a wind farm development. Non-host lots are classified as a parcel of land that does not accommodate any part of a wind farm development. Sensitive land uses (herein referred to as sensitive receptors) are defined as areas including childcare centres, residential dwellings, caretaker's accommodation, educational establishments, healthcare services, short-term accommodation and tourist parks.

Predicted outdoor (free-field) A-weighted equivalent acoustic level (L_{Aeq}) noise levels assessed at all noise affected existing or approved sensitive land use(s) are required to not exceed:

- 45 dBA during the night at host lots.
- 37 dBA during the day (6:00 am – 10:00 pm) and 35 dBA during the night (10:00 pm to 6:00 am) at non-host lots.

The acoustic modelling assessment was based on a wind farm layout that includes 226 Siemens SG 6.0-170, Rev. 0 WTGs with a hub height of 160 m and 180 m. The technical specifications for this model have a maximum sound power level (LwA) of 106 dBA, however to be conservative, FWH requested this model be assessed assuming a worst case of LwA 109 dBA, or 3 dB above standard technical specifications.

Worst case noise for WTGs operating at 12 m/s are predicted to comply with the required criteria at all host and non-host lots during both day and night periods.

The most stringent noise criterion has been used in this assessment, which is the baseline criterion rather than the background L_{A90} noise level add 5 dBA criterion. As the assessment has been conducted with the most stringent criterion, the requirement for adjustment based on measured background noise levels was not required, and as such background noise monitoring was not necessary for the Project.

The results of this noise assessment demonstrate that the Forest Wind project will comply with the acoustic amenity criteria provided in Performance Outcomes 11 and 12 of the Code, when assessed in line with requirements of the Guidelines.

It is not anticipated that any noise mitigation or management measures are required for the Project. However, should the turbine technology or site design change, measures to mitigate impacts include removing turbine locations, or for turbines causing the impact, operate turbines on a low noise setting as low as 97 dBA in order to ensure ongoing compliance with the conditions of development approval.

The ultimate location of the WTGs may change within the study area prior to construction, in accordance with the development application. If the turbines remain within the study area and maintain similar separation distances from each other and the separation distances from sensitive receptors remains unchanged, then the results are not expected to be materially different. However, an updated noise assessment should be completed once the final turbine models have been selected and final turbine locations are resolved in order to determine compliance with the Code and anticipated conditions of the development approval.

Table of contents

Table index

Figure index

Appendices

Glossary of terms

Term	Description
FWH	Forest Wind Holdings Pty Ltd
dB	Decibel, which is 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound.
dBA	Unit used to measure 'A-weighted' sound pressure levels.
EP Act	Environmental Protection Act 1994
EPP (Noise)	Environmental Protection (Noise) Policy 2008
GHD	GHD Pty Ltd
Host lots	Parcels of land that accommodates any part of a wind farm development.
Non-host lots	Parcels of land that do not accommodate any part of a wind farm development.
IEC 61400-11	IEC 61400-11: Part 11- Acoustic noise measurement techniques, International Standard published by the International Electrotechnical Commission regarding wind turbines.
$L_{Aeq,10\text{-}min}$	The predicted equivalent noise level adjusted for tonality over a 10 minute period.
$L_{A90,10\text{-}min}$	Measured ambient background noise in the absence of the noise under investigation that is equalled or exceeded for 90% of the measurement time interval.
$L_{Aeq\ (time)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
LwA	Sound power level – represents the total noise output of the plant or equipment.
Mitigation	Reduction in severity.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for assessment purposes.
Sensitive receptor	A noise modelling term used to describe a map reference point where noise is predicted. A sensitive receiver would be a home, work place, church, school or other place where people spend time.
Tonal noise	Noise with perceptible and definite pitch or tone.
WTG	Wind turbine generator

1. Introduction

Forest Wind Holdings Pty Ltd (FWH) proposes to develop a wind farm, referred to as Forest Wind (the Project) in Queensland, approximately 165 km north of Brisbane. GHD Pty Ltd (GHD) was commissioned by FWH to undertake a noise assessment. Since completion of the noise assessment, placement of the wind turbine generators (WTGs) has changed and as such an update to the noise assessment is required.

1.1 Purpose of report

This report summarises the results of the updated operational noise impact assessment of the proposed upgraded wind turbine configuration against the *State code 23: Wind farm development*[1] (the Code) and State code 23 *Wind farm development – Planning guidelines*[2] (the Guidelines). Recommended noise mitigation and management measures to reduce noise impact at sensitive receptors (where required) are also included.

1.2 Scope of work

GHD completed the following scope of work:

- Operational noise modelling of the proposed updated wind turbine configuration, as supplied by FWH, taking a range of wind speeds into consideration.
- Assess predicted noise impact results against the Code and the Guidelines.
- Recommend operational noise mitigation and management measures to reduce noise impacts at sensitive receptors (where required).
- Provide a report detailing the findings of the noise impact assessment for inclusion in applications for the Project.

This noise assessment has been prepared by a suitably qualified acoustic consultant who is eligible for membership of the Australian Acoustical Society.

1.3 Limitations

This report has been prepared by GHD for Forest Wind Holdings Pty Ltd and may only be used and relied on by Forest Wind Holdings Pty Ltd for the purpose agreed between GHD and the Forest Wind Holdings Pty Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Forest Wind Holdings Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

[1] Department of State Development, Manufacturing, Infrastructure and Planning (2019), *State code 23: Wind farm development.*
[2] Department of State Development, Manufacturing, Infrastructure and Planning (2018), *State code 23: Wind Farm development - Planning Guidelines,* June 2018.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Forest Wind Holdings Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Assessment criteria

2.1 State regulation and legislation

2.1.1 State policy

Queensland's Department of State Development, Manufacturing, Infrastructure and Planning has issued information detailing the required inputs for noise assessments specific to wind farms. Assessment for noise impacts is to be undertaken in accordance with *State code 23: Wind farm development* (the Code) and *State code 23 Wind farm development – Planning guidelines* (the Guidelines).

The Code and Guidelines have been developed to be consistent with the *Environmental Protection (Noise) Policy 2008* (EPP (Noise)) acoustic criteria.

2.1.2 State legislation

Environmental Protection Act 1994 Division 3 – Default Noise Standards of the Environmental Protection Act 1994 (EP Act) has been referred to for the determination of noise limits to specific noise sources where required. The EP Act provides noise limits for noise sources of steady state nature and can be applied to establish a noise criterion for any steady-state noise emission of infrastructure related to the Project that is not classified as a wind turbine, such as ancillary equipment located within the wind farm. Acoustic assessment of such equipment has been included in this report (refer to Section 5.3).

2.2 Noise objectives

Acoustic criteria for the predicted acoustic level at sensitive land uses located on host and non-host lots are listed in Table 2-1.

The Guidelines classify host lots as *parcel of land that accommodates any part of a wind farm development.* The Guidelines classify non-host lots as *a parcel of land that does not accommodate any part of a wind farm development.* Sensitive land uses (herein referred to as sensitive receptors) are defined as areas including childcare centre, residential dwellings, educational establishments, healthcare services, short-term accommodation and tourist parks.

The Code establishes performance outcomes (PO) and acceptable outcomes, as listed in Table 23.2.1 of the Code.

PO11 establishes acoustic criteria for the amenity of host lots: *The predicted acoustic level at all noise affected existing or approved sensitive land uses does not exceed the criteria stated in Table 23.3.1* (reproduced in Table 2-1 as host lots).

PO12 establishes acoustic criteria for the amenity of non-host lots: *The predicted acoustic level at all noise affected existing or approved sensitive land uses:*

- *Does not exceed the criteria stated in Table 23.3.2 (reproduced in Table 2-1 as non-host lots).*
- *Where the acoustic levels stated in Table 23.3.2 cannot be achieved at noise affected existing or approved sensitive land uses:*
  - Individual written agreements (deeds of release) from non-host lot owners are provided.
  - The predicted acoustic level at all noise affected existing or approved sensitive land uses does not exceed the criteria stated in Table 23.3.1 (reproduced in Table 2-1 as host lots).

The Guidelines establish the following required supporting actions to demonstrate compliance with each of the performance outcomes:

PO11: A noise impact assessment undertaken by a suitably qualified acoustic consultant with suitable acoustic experience demonstrating compliance with the prescribed acoustic level in Table 1 of the Code.

PO12: A noise impact assessment undertaken by a suitably qualified acoustic consultant with suitable acoustic experience demonstrating compliance with the prescribed acoustic level in Table 2 of the code.

Where necessary, provide deed of releases from all non-host lot owners where the acoustic level stated in Table 2 of the code cannot be achieved at their respective sensitive land use(s).

This noise assessment meets the requirements as a supporting action required under the Code.

Table 2-1 Acoustic criteria for host and non-host lots

Noise characteristic	Time of day	Acoustic level does not exceed
Host lots		
Predicted[1] outdoor (free-field) A-weighted equivalent acoustic level (L_{Aeq}) assessed at all noise affected existing or approved sensitive land use(s).	Night (10:00 pm – 6:00 am)	1. 45 dBA, or 2. The background noise (L_{A90}) by more than 5 dBA whichever is the greater for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in-between referenced to hub height.
Non-hot lots		
Predicted[1] outdoor (free-field) A-weighted equivalent acoustic level (L_{Aeq}) assessed at all noise affected existing or approved sensitive land use(s).	Night 10:00 pm – 6:00 am)	1. 35 dBA, or 2. Background noise (L_{A90}) by more than 5 dBA whichever is the greater for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in-between referenced to hub height.
	Day (6:00 am – 10:00 pm)	1. 37 dBA, or 2. Background noise (L_{A90}) by more than 5 dBA whichever is the greater for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in-between referenced to hub height.

1 Predicted by noise modelling carried out using the sound power levels of the proposed turbines in accordance with the methodology contained in Appendix 4 of the Guidelines.

For this assessment, the most stringent criterion has been used, that is the baseline criterion rather than the background L_{A90} noise level add 5 dBA criterion. As the assessment has been conducted with the most stringent criterion, the requirement for adjustment based on measured background noise levels was not required, and as such background noise monitoring was not necessary for this project.

3. Project overview

FWH proposes to construct a wind farm called Forest Wind (the Project) located within exotic pine plantations in Queensland Government owned Toolara, Tuan and Neerdie State Forests, situated between Gympie and Maryborough in the Wide Bay Region of Queensland. Specifically, the Project comprises a wind farm with up to 226 wind turbines and ancillary infrastructure (herein referred to as the Wind Turbine Area (WTA)) and an Overhead Line Corridor in which a high voltage transmission line (the Transmission Line) will be located to transfer the generated electricity to an existing Powerlink Queensland substation located at Woolooga to the west of Gympie. The Project will be located within the Gympie Regional Council and Fraser Coast Regional Council Local Government Areas.

The location of Forest Wind is shown in Figure 3-1.

3.1 Wind turbines

3.1.1 Noise sources

There are two main noise sources originating from a wind turbine – mechanical and aerodynamic. Sources of mechanical noise include the following:

- Gearbox
- Generator
- Yaw drives
- Cooling fans
- Auxiliary equipment
- Application of brakes

Sources of mechanical noise tend to be both tonal and broadband in nature since the emitted sound is associated with the rotation of mechanical and electrical equipment. However, in modern turbines, mechanical noise is not usually audible above aerodynamic noise. Mechanical noise can be effectively reduced through standard noise control practices such as vibration isolation, damping and noise enclosures.

Aerodynamic noise is associated with the passage of air over the turbine blades and is considered the most dominant source of wind turbine noise emissions. Aerodynamic noise levels typically increase with rotor speed.

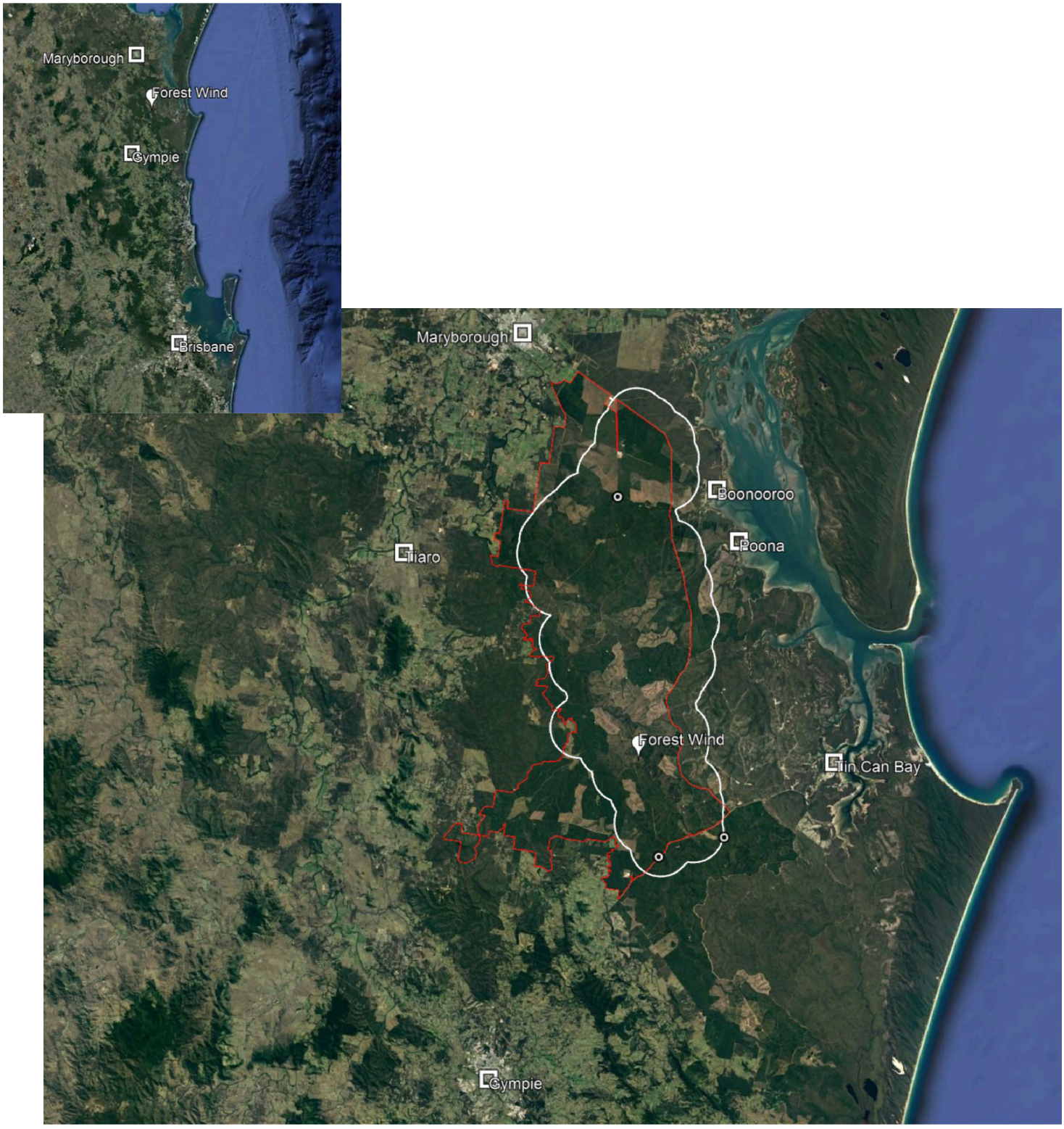
3.1.2 Sound power levels

The turbine make and model will be determined through a procurement process prior to commencement of construction. Typically, wind turbines have a relatively similar noise profile between models. To offer a typical wind turbine for the purpose of this assessment, a Siemens SG 6.0-170, Rev. 0 has been used, with a hub height of 160 m and 180 m included in the assessment.

Given the significant distances to sensitive receptors, the Siemens SG 6.0-170 noise specifications have been increased to a maximum LwA of 109 dBA (from LwA 106 dBA standard maximum level), to be conservative and to provide flexibility in selection of turbine models.

The sound power levels (SWL) for standard noise and worst case noise operations are presented in Figure 3-2 with reference to the *International Electrotechnical Commission (IEC)*

Wind Energy Standard 61400-11 (IEC 61400-11)). The LwAs presented are valid for the corresponding wind speeds referenced to the hub height.



SCALE

0 10 20 30 40

Kilometres (at A4)

N

LEGEND

WTG 3 km buffer area

Project boundary

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS) Zone 56 J

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

Forest Wind Holdings Pty Ltd

Forest Wind - Noise Assessment

FIGURE 3-1

Project location

DRAWING NO.	REVISION	DATE
Fig 3-1.srf	0	5/9/2019

CREATED	CHECKER	APPROVER	FILE PATH
JF	RC	JF	G:\61\38468\Tech\EMI\Noise\WP

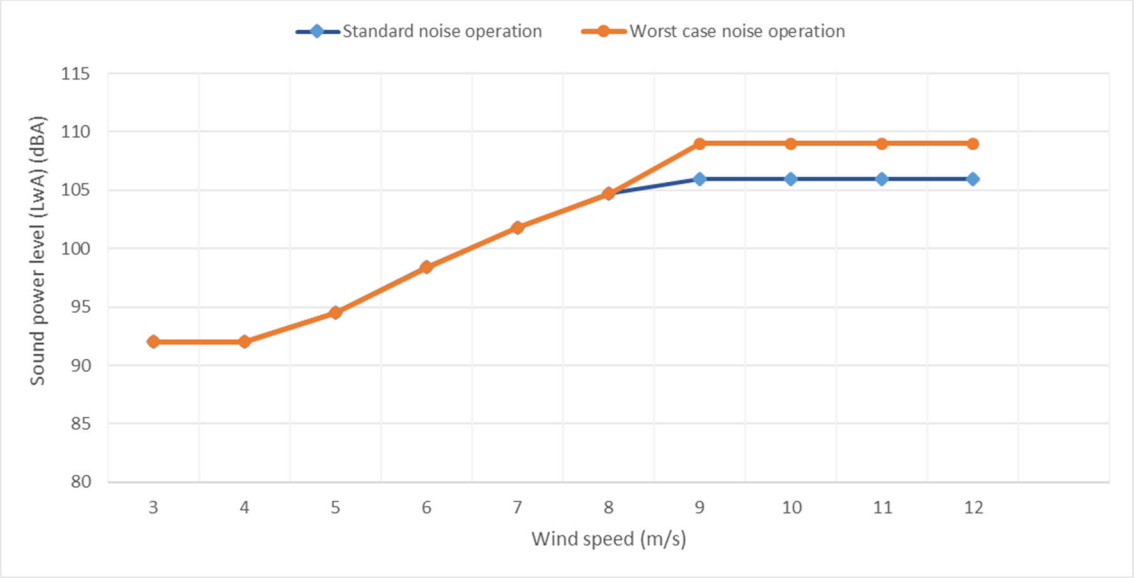


Figure 3-2 Sound power level of Siemens SG 6.0-170, Rev. 0 WTG

Typical spectra for LwA in dBA re 1 pW for the corresponding centre frequencies are shown in Figure 3-3 for 8 m/s wind speeds as an example and referenced to the hub height as per *IEC 61400-11*[3]. Refer to Appendix B for spectra for other wind speeds.

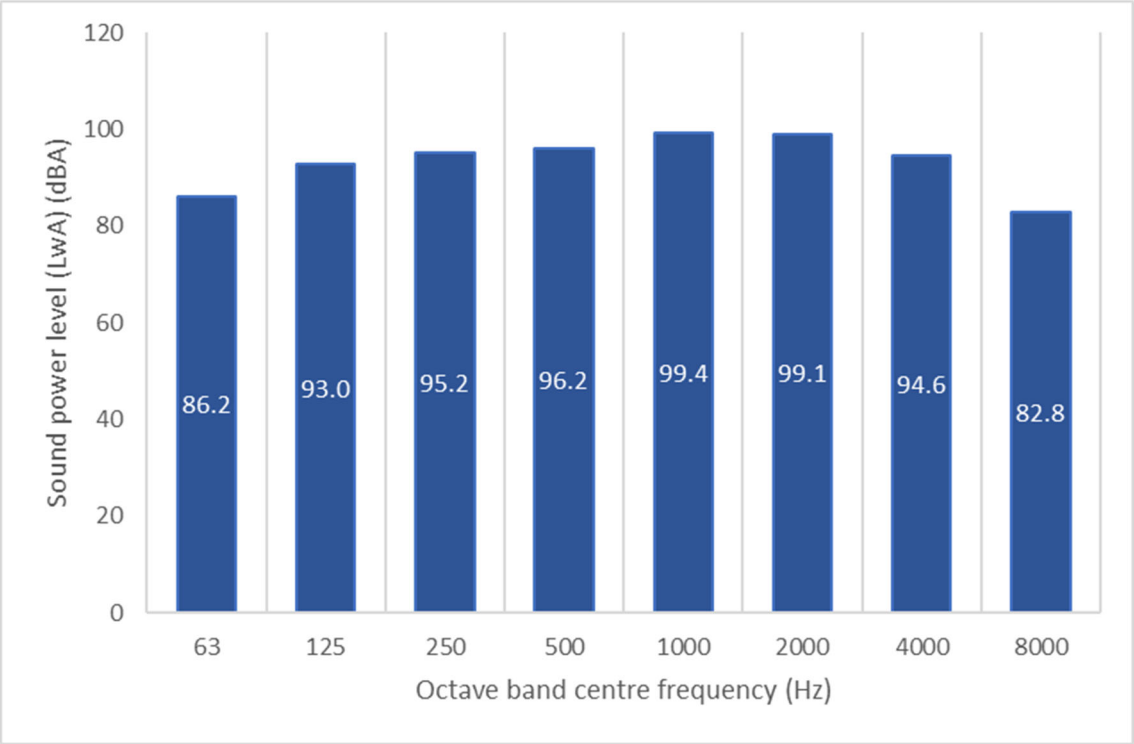


Figure 3-3 Typical 1/1 octave A-weighted band spectrum at 8 m/s

3.1.3 Tonality and infrasound

WTG manufacturers are obliged to conduct independent tests in accordance with IEC 61400-11. According to the Guidelines, an addition of 5 dBA should be made to the measured noise level from a wind farm where tonality is shown to be a characteristic and is audible at the affected receptor.

[3] Standard Acoustic Emission, SG 6.0-170, Rev. 0, Document ID:SGRE ON APAC TE RSAS-40-0000-100000016948-00, 2019.07.04, Restricted (provided at Appendix B).

A correctly operating wind turbine may exhibit sound with tonal characteristics. These characteristics can be minimised or avoided by careful design and/or mitigation measures. GHD understands that FWH will avoid the installation of wind turbines that exhibit sound with tonal characteristics by specifying the supply of wind turbines from a manufacturer which guarantees that the supplied wind turbines will not exhibit tonal characteristics at residences.

Infrasound is not tested as an obligatory part of IEC 61400-11. Infrasound (sound below 20 Hz in frequency) was a characteristic attributable to earlier designs of WTGs where turbine blades were downwind of the main tower. This generated an infrasound effect as the blades cut through the turbulence generated around the downwind side of the tower. Modern WTG designs typically have the blades upwind of the main tower and combined with improved blade design, infrasound is found not to be detected with modern wind turbines.

3.1.4 Wind turbine locations

The proposed layout and turbine locations are displayed in Figure 3-4 and the co-ordinates are provided in Appendix A. It is worth noting that the ultimate turbine model and locations will not be determined until prior to construction, however, will remain within the study area.

SCALE

0 5 10 15 20

Kilometres (at A4)

N

LEGEND

WTG 3 km buffer area

Wind turbine generator

Sensitive receptor

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS) Zone 56 J

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

GHD

Forest Wind Holdings Pty Ltd

Forest Wind - Noise Assessment

FIGURE 3-4

Wind turbine and sensitive receptor locations

DRAWING NO.	REVISION	DATE
Fig 3-4.srf	0	5/9/2019

CREATED	CHECKER	APPROVER	FILE PATH
JF	RC	JF	G:\61\38468\Tech\EMI\Noise\WP

4. Existing environment

4.1 Study area

The site is characterised by flat to undulating terrain with elevations of 10 m to 150 m Australian Height Datum (m AHD). The primary land use for the area is growing and extracting exotic pine from a major forestry plantation. Other services the land provides for are public access, recreation and some commercial activities, such as apiary, communications facilities and cattle grazing.

4.2 Sensitive receptors

The noise assessment methodology as specified in the Guidelines requires that all sensitive land use receptors should be identified for a minimum distance of three kilometres from the nearest potential wind turbine location in the area surrounding the proposed wind farm. For the Project, only one sensitive receptor is located within this three kilometre buffer area and this belongs to a host lot. FWH selected the closest sensitive receptors beyond the three kilometre buffer area surrounding the Project for inclusion in the assessment.

The majority of these locations are residential dwellings belonging to non-host lots. Sensitive receptors are shown in Figure 3-4 and coordinates for each receptor are provided in Table 4-1.

Table 4-1 Sensitive receptor locations

Sensitive receptor	Classification	Environment	Easting	Northing	Height (m AHD)
Host lots					
SR09	Caretaker accom.	Forestry yard	483,374	7,124,827	54.0
Non-host lots					
SR01	Caretaker accom.	Demolition yard	478,534	7,169,811	20.3
SR02	Dwelling house	Rural	470,298	7,160,786	44.0
SR03	Dwelling house	Rural	468,335	7,159,198	25.6
SR04	Dwelling house	Rural	466,763	7,155,600	49.5
SR05	Dwelling house	Rural	469,848	7,149,608	49.0
SR06	Dwelling house	Rural	470,800	7,148,861	35.3
SR07	Dwelling house	Rural	470,612	7,139,963	66.0
SR08	Dwelling house	Rural	477,704	7,123,913	74.0
SR10	Dwelling house	Rural	489,701	7,129,760	89.0
SR11	Dwelling house	Rural	484,902	7,158,499	13.2
SR12	Dwelling house	Rural	490,293	7,155,589	12.2
SR13	Dwelling house	Rural	487,291	7,160,004	9.0
SR14	Dwelling house	Rural	487,646	7,161,478	9.0
SR15	Dwelling house	Rural	486,989	7,167,139	11.3

5. Impact assessment

5.1 Noise model

The Guidelines state that a suitable model must be selected to predict the worst case noise level at all relevant receptors; recommending the use of prediction methods in accordance with ISO 9613.2:1996 *Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation* (ISO9613-2).

Noise from the proposed Project has been predicted using the ISO9613-2 propagation model implemented in version 2019 of Datakustik's CadnaA noise prediction software. The ISO9613-2 noise propagation model is used around the world and widely accepted as an appropriate model for the assessment of wind farms. The model has the ability to take into account the distance between the source and receptor, topography, hardness of the ground, atmospheric absorption at different frequencies and meteorological conditions favourable to noise propagation.

The noise levels at the relevant receptor locations were predicted for the maximum wind speed (12 m/s) LwA, representing a worst case scenario. The Guidelines recommend the following inputs to ensure a conservative approach to predicting wind farm noise and have therefore been implemented in the noise model:

- Warranted sound power levels
- Atmospheric conditions at 10°C temperature and 70% relative humidity
- 50% acoustically hard ground and 50% acoustically soft ground
- Barrier attenuation of no greater than 2 dBA
- 4 m receiver height
- Application of a 3 dBA correction where a "concave" ground profile exists.

Topographical ground contours with 5 m resolution have been used in preparation of this noise model, as per the requirements of the Guidelines.

5.1.1 Model scenarios

Two model scenarios were carried out with hub heights of the WTGs specified at 160 m and 180 m. It was found that varying the hub height had a minimal effect on predicted noise levels at the sensitive receptors. Therefore predicted noise levels from the scenario with hub height specified as 160 m only are presented in this report. Where noise levels were higher in the scenario with hub heights specified as 180 m, this has been indicated.

5.2 Noise model results

Noise levels have been presented at the identified sensitive receptors with all WTGs operating at 12 m/s. The 12 m/s operating scenario was chosen as WTG operating at 12 m/s or higher will create maximum noise impacts (i.e. there is no significant increase in noise levels at higher wind speeds) (refer Figure 3-2).

Predicted noise level results are shown in Table 5-1 and graphically in Figure 5-1.

Table 5-1 Predicted noise levels from WTGs (hub height 160 m) operating at 12 m/s and LwA 109 dBA

Sensitive receptor	Classification	Environment	Noise level L_{Aeq} (dBA)	
			Day	Night
Hosts				
		Criteria	***-***	***45***
SR09	Caretaker accom.	Forestry yard	38	38
Non-hosts				
		Criteria	***37***	***35***
SR01	Caretaker accom.	Demolition yard	29	29
SR02	Dwelling house	Rural	27	27
SR03	Dwelling house	Rural	25	25
SR04	Dwelling house	Rural	25	25
SR05	Dwelling house	Rural	27	27
SR06	Dwelling house	Rural	28	28
SR07	Dwelling house	Rural	22	22
SR08	Dwelling house	Rural	24	24
SR10	Dwelling house	Rural	25	25
SR11	Dwelling house	Rural	35	35
SR12	Dwelling house	Rural	27	27
SR13	Dwelling house	Rural	31	31
SR14	Dwelling house	Rural	31	31
SR15	Dwelling house	Rural	29	29

1 Noise level at SR10 with hub height set as 180 m was predicted to be 26 dBA. This is below both the day and night time noise criteria.

Based on the noise results presented in Table 5-1, worst case noise for a WTG operating at 12 m/s are predicted to comply with the required criteria at all host and non-host lots during both day and night periods. Noise contours are presented at Figure 5-1.

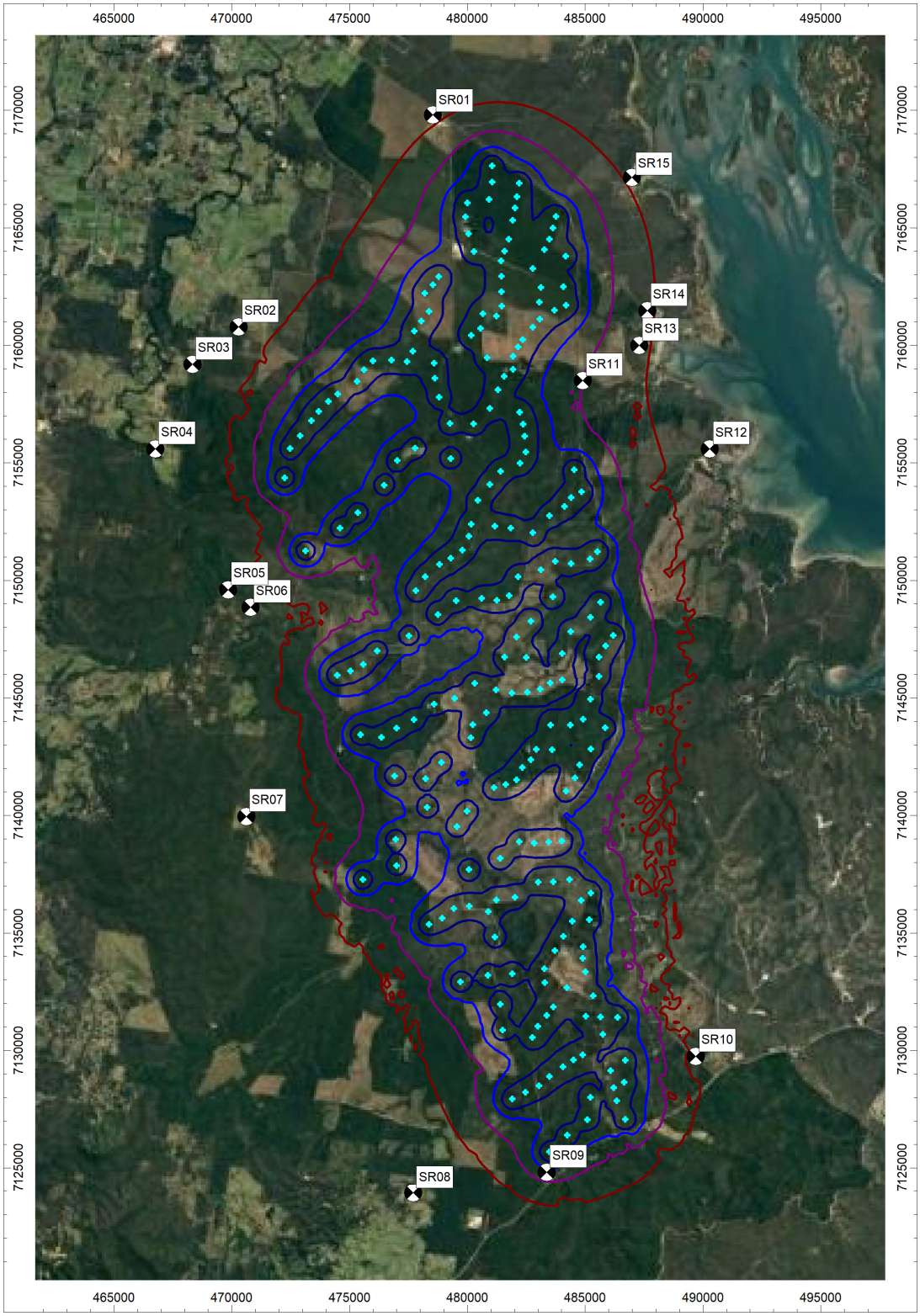
The Guidelines requires an assessment of where concave ground may occur. In such areas, application of a 3 dBA correction is to be made in order to account for potential for predicted noise levels to underestimate the actual measured levels, due to reduced ground effect and the potential for additional reflection paths.

From the results in Table 5-1, only receptor SR11 would potentially exceed the required criteria with the addition of the penalty of 3 dBA for concave topography. An assessment of concave topography was completed as per the Guidelines, with assessment showing concave topography was not present between SR11 and the closest WTGs.

For this assessment, the most stringent criterion has been used, that is the baseline criterion rather than the background L_{A90} noise level add 5 dBA criterion. As the assessment has been conducted with the most stringent criterion, the requirement for adjustment based on measured background noise levels was not required, and as such background noise monitoring was not necessary for this project.

5.3 Ancillary equipment

Ancillary equipment located at Forest Wind will include items such as electrical transformers and switchgear. Noise levels of such equipment have been assessed against EPP (Noise) acoustic criteria, for both day and night time operation. Due to the location of such equipment and the resulting separation distance to the nearest sensitive receptor, compliance is predicted for ancillary equipment.



SCALE

0 2500 5000 7500 10000

Metres (at A4)

N

LEGEND

- Sensitive receptor
- Wind turbine generator

Predicted L_{Aeq} noise level:

- 30 dBA
- 35 dBA
- 40 dBA
- 45 dBA

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 56 J

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

Forest WInd Holdings Pty Ltd

Forest Wind - Noise Assessment

FIGURE 5-1

Predicted noise levels from WTGs (hub height 160 m) operating at 12 m/s

DRAWING NO.	REVISION	DATE
Fig 5-1.srf	0	4/9/2019

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	G:\61\38468\Tech\EMI\Noise\WP

6. Noise mitigation and management measures

Predicted day and night noise levels comply with the noise criteria at all sensitive receptors. It is not anticipated that any noise mitigation or management measures are required for the Project. However, should the turbine technology or site design change, measures to mitigate impacts include removing turbine locations, or for turbines causing the impact, operate turbines on a low noise setting as low as 97 dBA in order to ensure ongoing compliance with the conditions of development approval.

Alternatively, a formal agreement with non-host lot owners could be put in place.

7. Conclusions and recommendations

Worst case noise impacts from the Forest Wind project have been assessed against relevant L_{Aeq} day and night time criteria prescribed by the *State code 23: Wind farm development* (the Code) and *State code 23 Wind farm development – Planning guidelines* (the Guidelines).

Noise levels were predicted using the ISO9613-2 calculation algorithm implemented in version 2019 of Datakustik's CadnaA noise prediction software.

The modelling assessment was based on a wind farm layout that includes 226 Siemens SG 6.0-170, Rev. 0 WTGs with a hub height of 160 m and 180. The technical specifications for this model have a maximum noise output of 106 dBA, however to be conservative, FWH requested this model be assessed assuming a worst case of LwA 109 dBA, or 3 dB above standard technical specifications.

Worst case noise for WTGs operating at 12 m/s are predicted to comply with the required criteria at all host and non-host lots during both day and night periods.

The results of this noise assessment demonstrate that the Forest Wind project will comply with the acoustic amenity criteria provided in Performance Outcomes 11 and 12 of the Code, when assessed in line with requirements of the Guidelines.

The most stringent noise criterion has been used in this assessment, which is the baseline criterion rather than the background L_{A90} noise level add 5 dBA criterion. As the assessment has been conducted with the most stringent criterion, the requirement for adjustment based on measured background noise levels was not required, and as such background noise monitoring was not necessary for this project.

Appendices

Appendix A – Locations of WTGs used in this assessment

Table A-0 WTG coordinates

ID	X (m UTM)	Y (m UTM)	Z (m UTM)	ID	X (m UTM)	Y (m UTM)	Z (m UTM)
1A_1	483768	7165491	187	2_94	481142	7141187	274
1A_2	483625	7164998	187	2_95	479991	7140190	265
1A_3	483479	7164519	189	2_96	479561	7139535	248
1A_4	483264	7164073	190	2_97	482200	7138880	255
1A_5	484180	7163791	190	2_98	484016	7138918	252
1A_6	484076	7162498	190	2_99	483449	7138871	264
1A_7	484189	7161711	187	2_100	481389	7138186	245
1A_8	483696	7161487	190	2_101	480060	7137702	231
1A_9	483070	7161120	190	2_102	485233	7136699	265
1A_10	482780	7160765	191	2_103	483652	7137173	250
1A_11	482346	7160250	195	2_104	484460	7135504	249
1A_12	482146	7159940	195	2_105	485168	7135574	280
1A_13	481935	7159547	195	2_106	483002	7137168	240
1B_1	486211	7128427	273	2_107	481172	7134833	266
1B_2	485233	7128009	251	2_108	484077	7134864	254
1B_3	486343	7127867	280	2_109	484919	7134414	263
1B_4	486706	7127070	265	2_110	483707	7134249	252
1B_5	485088	7127056	254	2_111	484896	7133918	260
1B_6	484246	7126399	237	2_112	480873	7133197	235
1B_7	483489	7125687	238	2_113	483262	7133488	255
2_1	481047	7167641	191	2_114	485017	7133347	265
2_2	482202	7166893	190	2_115	481900	7133272	236
2_3	481047	7166949	192	2_116	483288	7132883	245
2_4	482101	7166324	190	2_117	479710	7132927	235
2_5	480925	7166211	193	2_118	484216	7132670	260
2_6	479998	7166065	195	2_119	485343	7132338	279
2_7	482013	7165844	190	2_120	481395	7131973	245
2_8	479920	7165465	195	2_121	483640	7131859	255
2_9	481920	7165319	190	2_122	485025	7131461	268
2_10	480051	7164748	198	2_123	485657	7131430	290
2_11	481584	7164011	194	2_124	486375	7131417	270
2_12	480278	7163998	199	2_125	482983	7131034	238
2_13	481432	7163590	195	2_126	481494	7130878	250
2_14	481763	7164518	194	2_127	485757	7130694	281
2_15	482776	7163269	191	2_128	482757	7130565	245
2_16	481440	7162932	194	2_129	484902	7129815	254
2_17	483116	7162460	190	2_130	484507	7129606	250
2_18	481448	7162280	194	2_131	486695	7129581	263
2_19	483050	7161835	190	2_132	484058	7129314	259

ID	X (m UTM)	Y (m UTM)	Z (m UTM)	ID	X (m UTM)	Y (m UTM)	Z (m UTM)
2_20	480844	7159474	200	2_133	486656	7128647	260
2_21	481931	7158983	190	2_134	486076	7129137	276
2_22	481560	7158681	194	2_135	483489	7128905	255
2_23	481294	7158116	195	2_136	483036	7128504	245
2_24	480960	7157328	200	2_137	482457	7128229	240
2_25	482223	7157149	206	2_138	481903	7127953	232
2_26	480265	7156658	208	3_1	479254	7156683	220
2_27	482364	7156654	210	3_2	477788	7155629	222
2_28	482428	7156134	207	3_3	479290	7155188	220
2_29	482475	7155462	215	3_4	477027	7155103	220
2_30	482242	7154987	215	3_5	476472	7154051	221
2_31	481409	7154650	215	3_6	475359	7152878	231
2_32	484542	7154702	199	3_7	474603	7152223	237
2_33	483484	7152750	211	3_8	473130	7151255	248
2_34	480958	7154090	219	3_9	478206	7150165	255
2_35	484847	7153773	205	3_10	477821	7149567	247
2_36	484411	7153527	202	3_11	483628	7149304	213
2_37	480451	7153415	230	3_12	478744	7148554	253
2_38	484120	7153140	205	3_13	482689	7148265	222
2_39	484400	7150722	214	3_14	477514	7147649	275
2_40	480172	7152397	235	3_15	482087	7147596	234
2_41	482769	7152027	208	3_16	476164	7146997	230
2_42	479298	7150947	250	3_17	482494	7146717	235
2_43	481162	7152302	225	3_18	481577	7146740	243
2_44	481839	7152228	219	3_19	475047	7146157	232
2_45	479787	7151295	243	3_20	475573	7146431	232
2_46	485524	7151223	205	3_21	474475	7145973	212
2_47	480072	7151886	230	3_22	479465	7144982	262
2_48	485211	7150914	206	3_23	478592	7144744	263
2_49	483735	7150813	215	3_24	477733	7144082	232
2_50	478816	7150677	250	3_25	477000	7143716	235
2_51	484838	7136386	257	3_26	475458	7143434	225
2_52	483127	7150461	215	3_27	476351	7143327	230
2_53	482080	7141517	244	3_28	478892	7142255	270
2_54	482153	7150163	225	3_29	476914	7141688	231
2_55	482328	7142050	253	3_30	478221	7141559	255
2_56	481772	7149352	229	3_31	478300	7140344	245
2_57	481245	7149164	235	3_32	476960	7138982	235
2_58	485648	7149075	203	3_33	477002	7137876	240
2_59	480609	7149235	228	3_34	475559	7137275	225
2_60	479525	7149140	240	3_35	482026	7136529	231
2_61	482850	7138829	247	3_36	481235	7136412	246
2_62	485221	7148439	215	3_37	480074	7136141	247

ID	X (m UTM)	Y (m UTM)	Z (m UTM)	ID	X (m UTM)	Y (m UTM)	Z (m UTM)
2_63	484345	7137273	250	3_38	480889	7135922	260
2_64	483368	7131489	248	3_39	479426	7136050	245
2_65	486191	7147664	210	3_40	478939	7135633	232
2_66	484382	7147828	220	3_41	478374	7135365	221
2_67	485873	7147225	215	4_1	478792	7162926	200
2_68	484021	7146890	215	4_2	478542	7162577	200
2_69	485583	7146744	215	4_3	481454	7161680	195
2_70	485586	7145914	230	4_4	478198	7162213	200
2_71	484019	7145776	225	4_5	481232	7161245	196
2_72	480313	7145620	248	4_6	478376	7161439	204
2_73	481212	7145351	265	4_7	478050	7161032	205
2_74	483510	7145642	230	4_8	480653	7161339	198
2_75	481896	7145219	243	4_9	480551	7160720	200
2_76	482928	7142808	240	4_10	477743	7160608	207
2_77	485217	7144955	223	4_11	480172	7160431	202
2_78	483083	7145376	237	4_12	477685	7159749	210
2_79	482550	7145246	240	4_13	476775	7159378	220
2_80	483528	7143846	230	4_14	475996	7159349	224
2_81	480799	7144375	240	4_15	477438	7159316	211
2_82	484916	7144101	234	4_16	478581	7159245	204
2_83	480230	7143873	255	4_17	475607	7158969	238
2_84	484369	7143845	225	4_18	478626	7158597	202
2_85	485853	7143726	224	4_19	475320	7158475	237
2_86	480149	7143313	263	4_20	474494	7157923	240
2_87	485242	7142829	235	4_21	478804	7157794	215
2_88	483595	7142792	238	4_22	474101	7157613	235
2_89	484771	7142154	235	4_23	473684	7157187	230
2_90	482699	7142373	240	4_24	473379	7156791	225
2_91	484573	7141592	229	4_25	472902	7156161	226
2_92	481633	7141314	276	4_26	472479	7155608	235
2_93	484189	7141043	244	4_27	472240	7154371	220

Appendix B – WTG sound power levels

1/1 octave band centre frequency	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Hub height wind speed								
3 m/s	73.5	80.3	82.5	83.5	86.7	86.4	81.9	70.1
4 m/s	73.5	80.3	82.5	83.5	86.7	86.4	81.9	70.1
5 m/s	76.0	82.8	85.0	86.0	89.2	88.9	84.4	72.6
6 m/s	79.9	86.7	88.9	89.9	93.1	92.8	88.3	76.5
7 m/s	83.3	90.1	92.3	93.3	96.5	96.2	91.7	79.9
8 m/s	86.2	93.0	95.2	96.2	99.4	99.1	94.6	82.8
9 m/s	86.8	94.7	97.1	96.6	100.0	100.8	96.0	84.8
10 m/s	86.8	94.7	97.1	96.6	100.0	100.8	96.0	84.8
11 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
12 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
13 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
14 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
15 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
16 m/s	85.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0

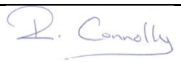
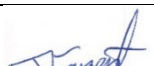
Data from *Standard Acoustic Emission, SG 6.0-170, Rev. 0*, Document ID:SGRE ON APAC TE RSAS-40-0000-100000016948-00, 2019.07.04, Restricted.

GHD

Level 10
999 Hay Street
T: 61 8 6222 8222 F: 61 8 9463 6012 E: permail@ghd.com

6138468-78052/https://projects.ghd.com/oc/WesternAustralia2/forestwindupdatedemi/Delivery/Documents/6138468-REP_Noise assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft A	A Sala Tenna G Formentin	R Connolly				23/7/19
Draft B	J Forrest	R Connolly				20/8/2019
Draft C	J Forrest	R Connolly				30/8/2019
Rev 0	J Forrest	R Connolly		J Forrest		4/9/2019

www.ghd.com