EPURON

APPENDIX I

Noise and Vibration

BOWMANS CREEK
WIND FARM

environmental impact statement

Bowmans Creek Wind Farm

Noise and Vibration Assessment

February 2021

S6150C9

sonus.

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GLOSSARY

A-weighting	Frequency adjustment applied to measured noise levels to replicate the frequency response of the human ear.
AGL	Above Ground Level.
Ambient noise level	The noise level of all existing noise sources in the environment (in the absence of the wind farm).
Associated Residence	Owners and occupiers of land proposed to host wind turbines or related infrastructure, owners and occupiers of land required for access during construction and/or maintenance, or landowners who have reached a financial or in-kind agreement in relation to the Project.
Background noise level	The ambient noise level which excludes intermittent noise sources.
CONCAWE	The oil companies' international study group for conservation of clean air and water - Europe, *The propagation of noise from petrochemical complexes to neighbouring communities* (May 1981).
dB(A)	A-weighted noise in decibels.
DEC 2006	New South Wales Department of Environment and Conservation *Assessing Vibration: a technical guideline* (2006).
DECC 2009	New South Wales Department of Environment and Climate Change *Interim Construction Noise Guideline* (2009).
DECCW 2011	Department of Environment, Climate Change and Water *NSW Road Noise Policy* (2011).
EPA	Environment Protection Authority.
Equivalent noise level	Energy averaged noise level over a period of time.
Intermittent noise sources	Occasional and transient events such as aircraft flyover, dogs barking, mobile farm machinery and vehicle movements.
$L_{A90, \text{ time period}}$	A-weighted noise level exceeded for 90% of defined time period. Represents the background noise level for the defined time period.
$L_{Aeq, \text{ time period}}$	A-weighted equivalent noise level over a defined time period.
RBL	Rating Background Level. Represents the lowest noise levels during an extended assessment period (day/evening/night) as referenced in the Policy.
SA 2009	South Australian Environment Protection Authority *Wind Farms Environmental Noise Guidelines* (2009).
SEARs	Secretary's Environmental Assessment Requirements.
Sound power level	A measure of the sound energy emitted from a source of noise.
The Policy	New South Wales Environment Protection Authority *Noise Policy for Industry* (2017).
The Project	Bowmans Creek Wind Farm.
The Bulletin	New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (2016).
Non-Associated Residence	Not an associated residence.
Weather category 6	The CONCAWE weather conditions which is most conducive for the propagation of noise, resulting in highest predicted noise levels.
WHO Guidelines	*World Health Organisation Guidelines for Community Noise.*
Worst-case	Operational and weather conditions which result in the highest noise level at a residence or assessment location.
WTG	Wind turbine generator.

1 INTRODUCTION

Sonus has conducted a noise and vibration assessment of the construction and operation of the Bowmans Creek Wind Farm (the **Project**).

The Project is located at Bowmans Creek, approximately 10 km east of Muswellbrook and 120 km from the Port of Newcastle in NSW.

The Project seeks State Significant Development (SSD) Development Consent approval *under Division 4.7 of Part 4 of the Environmental Planning & Assessment Act 1979* (EPA Act) (SSD 10315) as supported by the *'Bowmans Creek Wind Farm Environmental Impact Statement', Hansen Bailey, 2020* (the **EIS**). This noise and vibration assessment supports the EIS.

The Project extends predominantly across two Local Government Areas (LGAs), being the Muswellbrook and Singleton Council LGAs. A small number of turbines are additionally proposed in the Upper Hunter Shire LGA. The Project will generally involve:

- Up to 60 WTG sites consisting of:
    - A three-blade rotor mounted onto a tubular tower;
    - Crane hardstand area; and
    - Turbine laydown area;
- Electricity infrastructure:
    - Up to two substations;
    - A 330 kv transmission line to transmit the generated electricity into the existing Transgrid network;
    - Connections between the WTGs and the substations, which will include a combination of underground reticulation cables and overhead powerlines;
- Ancillary infrastructure:
    - Operation and Maintenance Facility (O&M Facility);
    - Construction compound and storage facilities;
    - Unsealed access tracks within the Project Boundary;
    - Ongoing use of existing and additional monitoring masts and other monitoring;
    - Temporary construction facilities (including concrete batching plant, laydown areas and rock crushing facilities);

- Minor upgrades to the road network to facilitate delivery of oversized loads (such as wind turbine components) to the Project; and
- Administrative activities (including boundary adjustments and subdivisions).

The conceptual project layout is shown in Appendix A.

The noise and vibration assessment addresses the "Secretary's Environmental Assessment Requirements" (**SEARs**) issued for the Project (SSD 10315) dated 23 July 2019.

This report assesses environmental impacts during construction and operation of the Project by comparing predicted noise levels at surrounding residences with criteria provided by the SEARs.

2 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The noise related SEARs for the Project specify that the following must be considered:

- *assess wind turbine noise in accordance with the NSW Wind Energy: Noise Assessment Bulletin (EPA/DPE, 2016);*
- *assess noise generated by ancillary infrastructure in accordance with the NSW Noise Policy for Industry (EPA, 2017);*
- *assess construction noise under the Interim Construction Noise Guideline (DECC, 2009);*
- *assess traffic noise under the NSW Road Noise Policy (DECCW, 2011); and*
- *assess vibration under the Assessing Vibration: A Technical Guideline (DEC, 2006);*

Each of the above is described below with respect to the relevant Project components.

2.1 Wind Turbines

The SEARs reference the New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (**the Bulletin**) for the assessment of operational noise from the WTGs.

The Bulletin adopts the South Australian Environment Protection Authority *Wind Farms – Environmental Noise Guidelines* (**SA 2009**) as the basis of the regulatory noise standard and assessment methodology in NSW.

SA 2009 was developed with the "*core objective……to balance the advantage of developing wind energy projects ... with protecting the amenity of the surrounding community from adverse noise impacts"*.

The Bulletin states that the *"NSW Government recognises that rural land use zones in NSW are often more densely settled than those of South Australia and that there is a relatively high density of rural residential living in parts of regional NSW with reliable wind resources.*

Therefore only the lower base noise criteria in SA 2009 will be applied in NSW, these Criteria are defined as:

> *The predicted equivalent noise level ($L_{Aeq,10\ minute}$), adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed 35 dB(A) or the background noise ($L_{A90,10\ minute}$) by more than 5 dB(A), whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between."*

2.2 Ancillary Infrastructure

The SEARs reference the New South Wales Environment Protection Authority's *Noise Policy for Industry* (**the Policy**) for the assessment of noise from ancillary infrastructure such as substations.

The Policy establishes *noise trigger levels* based on the existing background noise environment (intrusiveness) and the amenity for particular land uses (amenity). The *noise trigger levels* are the lower values provided by the two methods, which in a rural environment will generally be the *intrusiveness noise levels.*

In accordance with the Policy, the Rating Background Level (**RBL**) is used to characterise the *intrusiveness noise levels* for each of the day, evening and night periods. The RBL is determined from the lower tenth percentile of the measured background noise level ($L_{A90,\ 15\ minute}$) in the environment, effectively representing the quietest periods of the noise monitoring over an extended period of time.

2.3 Construction

The SEARs reference the New South Wales Department of Environment & Climate Change *Interim Construction Noise Guideline* (**DECC 2009**) for the assessment of construction noise.

The construction of a wind farm comprises activities such as road construction, civil works, excavation, foundation construction, electrical infrastructure works and turbine erection. These construction activities require processes such as heavy vehicle movements, crushing and screening, concrete batching, and the use of mobile plant and equipment (such as loaders, excavators, generators, cranes).

DECC 2009 provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria all within the framework of a quantitative approach, whereby "management levels" are defined based on the existing RBL. The approach of concentrating on noise reduction measures as distinct to meeting objective standards is in recognition of the transient nature of construction activity and the practical limitations in incorporating engineered noise reduction solutions to activities such as front-end loaders moving and cranes operating.

2.4 Traffic

The SEARs reference the New South Wales Department of Environment, Climate Change and Water *NSW Road Noise Policy* (**DECCW 2011**) for the assessment of traffic noise.

DECCW 2011 applies traffic noise criteria to particular types of project, road category and land use. The most appropriate classification for the traffic associated with the wind farm is considered to be "*Local Roads - Existing residences affected by additional traffic on existing local roads generated by land use developments*".

The traffic associated with the wind farm will predominantly occur during construction. However, it should be noted that the DECCW 2011 criterion applies to an ongoing operation, as distinct to a temporary process and as such provides a conservative assessment approach.

2.5 Vibration

The SEARs reference the New South Wales Department of Environment and Conservation *Assessing Vibration: a technical guideline* (**DEC 2006**) for the assessment of vibration.

DEC 2006 provides an emphasis on construction activity implementing feasible and practicable vibration reduction measures and establishes goal vibration levels based on human response to continuous, intermittent and impulsive vibration.

For construction activity the DEC 2006 can be interpreted to provide goal vibration levels criteria at the dwellings based on the British Standard *BS 6472-1992 "Evaluation of human exposure to vibration in buildings (1-80Hz)".*

There is negligible ground borne vibration associated with the ongoing operation of WTGs even when considered at the base of the towers.

3 NOISE PROPAGATION MODEL

The predictions of environmental noise from the Project utilise the CONCAWE noise propagation model and SoundPLAN noise modelling software. The sound propagation model considers the following influences:

- sound power levels of each individual noise source;
- the locations of noise sources;
- separation distances between noise sources and residences;
- local topography;
- influence of the ground;
- air absorption; and,
- meteorological conditions.

The CONCAWE system divides meteorological conditions into six separate “weather categories”, depending on wind speed, wind direction, time of day and level of cloud cover. Weather Category 1 provides the weather conditions associated with the “lowest” propagation of noise, whilst Weather Category 6 provides “worst-case” (i.e. highest noise level) conditions. Weather Category 4 provides “neutral” weather conditions for noise propagation (that is, conditions which do not account for the effects of temperature inversion or wind on propagation).

The assessment has been based on the following input conditions:

- weather category 6 (representing weather conditions conducive to the propagation of noise);
- atmospheric conditions at 10°C and 80% relative humidity (representing atmospheric conditions with low acoustic absorption rates being conducive to the propagation of noise);
- wind direction from all noise sources to the particular residence under consideration, even in circumstances where sources are located in opposite directions from the residence (representing wind conditions which result in higher noise levels than can occur in practice); and,
- maximum barrier attenuation from topography of 2 dB(A) (representing a conservative assessment of any shielding provided by topography – much higher barrier attenuation can occur for WTGs which do not have line of sight to residences).

In addition to the above, SA 2009 provides a default prediction method which incorporates hard ground in the noise propagation model unless justification is provided for using another input. The CONCAWE propagation model separates ground attenuation into the categories of hard ground and ground with finite acoustic impedance. CONCAWE states that hard ground should be used for surfaces such as concrete or water and all other surfaces including grass or soil should be considered as finite acoustic impedance. The ground between the WTGs and the nearest residences is not concrete or water, and therefore a finite acoustic impedance (corresponding to grass or rough pasture within the CONCAWE model) has been used.

4 MONITORING

To determine background noise levels at various wind speeds, background noise monitoring was conducted at 4 locations in the vicinity of the wind farm between 28 October 2019 and 16 January 2020. The monitoring was conducted in accordance with SA 2009 and the Bulletin.

Monitoring Locations

The monitoring locations are summarised in Table 1 and identified on the aerial image (which includes noise contours) in Appendix G.

Table 1: *Noise monitoring locations*

Monitoring Location ID	Co-ordinates (UTM WGS84 56H)		Monitoring Period
	Easting	Southing	
G15-3	313871	6429662	28/10/2019 to 30/10/2019 and 9/12/2019 to 16/01/2020
G17-1	313824	6427553	28/10/2019 to 9/12/2019
P22-1	323078	6422792	29/10/2019 to 9/12/2019
S17-2	325797	6428209	29/10/2019 to 9/12/2019

The noise monitoring equipment was located in accordance with SA 2009. That is, conducted within 30 metres of the dwelling in the direction of the wind farm. The background noise measurement locations were selected to represent the acoustic environment experienced in the immediate vicinity of the dwelling whilst also being removed from extraneous noise sources, such as pumps and air conditioning units. Photographs of the monitoring equipment at each location are provided in Appendix B.

Equipment

The background noise was measured using a combination of *Rion* "NL-52" and *Rion* "NL-21" sound level meters, all of which have a noise floor of less than 20 dB(A). The sound level meters had all been laboratory (NATA) calibrated and were also tested on site at the beginning and end of the measurement period using a *Rion* "NC74" calibrated reference sound source.

The local wind speed was measured at a height of 1.5m above ground level at G15-3 and P22-1 using *Rainwise* "WindLog" anemometers to identify any periods where wind directly on the microphone may have influenced the measured background noise levels.

Additionally, rainfall was also measured at a height of 1.5m above ground level at P22-1 using a *Rainwise* "Rainlog" sensor to identify any periods where rain on the microphone may have influenced the measured background noise levels.

Collected Data

The background noise level ($L_{A90,\ 10\ minute}$) was measured continuously (in 10-minute intervals) at each monitoring location during monitoring periods of at least 6 weeks.

During the background noise monitoring period, *Epuron* measured the average wind speeds at 120m in 10-minute intervals which were extrapolated to the hub height (140m AGL). The locations of the masts are provided in Table 2 along with the background noise monitoring locations where the data provides representative hub height wind speed at WTGs in the vicinity.

Table 2: *SODAR Location*

Bowmans Creek Mast (SODAR)	**Co-ordinates (UTM WGS84 Z56)**		**Representative of the Hub Height Wind Speed at WTGs in the Vicinity of Monitoring Locations:**
	Easting	**Southing**	
1	317788	6431221	G15-3 and G17-1
2	326092	6425190	P22-1 and S17-2

Data Analysis

Prior to correlation (refer to Appendix C for the graphs of background noise level versus hub height wind speed), the wind and rain data measured at 1.5m were utilised to identify and remove:

- periods where the wind speed exceeded 5 m/s based on the data collected at the *Rainwise* "WindLog" anemometers at the closest of either G15-3 and P22-1; and
- periods of rainfall, including the 10-minute periods before and after any rainfall events, measured using the *Rainwise* "Rainlog" sensor at P22-1.

Additionally, hub height wind speeds below the cut-in (3 m/s) and above the rated power (13 m/s) were removed from the analysis.

Table 3 summarises the number of data points at each monitoring location following the data removal detailed above.

Table 3: *Data Points.*

Monitoring Location ID	Number of Data Points
G15-3	4587
G17-1	4118
P22-1	4417
S17-2	4409

The noise data was collected over a period of 6 weeks at each location and the number of data points collected exceeds the 2,000 measurement intervals required by the Bulletin.

The resultant background noise data for each monitoring location were correlated with the hub height wind speed data to produce a least squares regression analysis and line of best fit, in accordance with SA 2009 and the Bulletin. The data and the regression curves[1] are shown in Appendix C.

Based on the regression analysis, the background noise levels ($L_{A90,\ 10\ minute}$) at integer wind speeds from cut-in to rated power are provided in Table 4.

Table 4: background noise levels

Residence ID	Background Noise Level, $L_{A90,10\ minute}$, for integer wind speeds at Hub Height, 140m AGL (dB(A))										
	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s	13m/s
G15-3	25	26	26	27	27	28	29	30	31	33	36
G17-1	25	25	25	26	27	28	29	30	31	32	32
P22-1	24	24	24	25	26	27	29	31	33	35	38
S17-2	24	24	25	26	26	27	28	30	32	34	37

[1] The correlation coefficient for each regression curve indicates the relationship between the background noise at the dwelling and the wind speed at the wind farm site. A low correlation coefficient indicates a limited relationship, as will naturally occur in many circumstances including locations that are shielded from the winds across the wind farm site, rather than indicating any deficiency in the data or its analysis.

5 WIND TURBINES

5.1 Criteria

The noise criteria for the WTG component of the Project are separated into two categories, being those which apply to a *non-associated residence* and those which apply to an *associated residence.*

Non-Associated Residence

More stringent requirements (lower allowable noise levels) apply to non-associated residences. Based on the Bulletin, noise from the wind farm at non-associated residences should not exceed an external noise level of 35 dB(A) or the background noise ($L_{A90,\ 10\ minute}$) by more than 5 dB(A), whichever is the greater.

The resultant noise criteria for the Project are provided in Table 5 utilising the background noise level results from Table 4

Table 5: Noise Criteria

Residence ID	Noise Criteria, $L_{Aeq,10\ minute}$, for integer wind speeds at Hub Height, 140m AGL (dB(A))										
	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s	13m/s
G15-3	35	35	35	35	35	35	35	35	36	38	41
G17-1	35	35	35	35	35	35	35	35	36	37	37
P22-1	35	35	35	35	35	35	35	36	38	40	43
S17-2	35	35	35	35	35	35	35	35	37	39	42

The above criteria are applied to all other non-associated residences based on their proximity to the residences in Table 5.

Associated Residence

The Bulletin enables a less onerous baseline noise criterion to be applied at an associated residence.

Utilising SA 2009, a suitable criterion is based on the World Health Organisation (**WHO**) *Guidelines for Community Noise* (**WHO Guidelines**) which provide recommendations to protect against:

- sleep disturbance within habitable rooms of residences, and;
- annoyance during the daytime for outdoor areas.

The recommendations of the WHO Guidelines are repeated below:

> *"For a good night's sleep, the equivalent sound level should not exceed 30 dB(A)* (inside the bedroom) *for continuous background noise"*
>
> and
>
> *"To protect the majority of people from being……. moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB* L_{Aeq}*."*

An outdoor level of 45 dB(A) at the *associated residences* will satisfy the WHO Guidelines, including inside a bedroom with the windows to the residence open.

The co-ordinates of the residences, the residence status (associated or non-associated) and the resultant noise criteria determined from SA 2009 and the Bulletin are provided in Appendix D.

5.2 Assessment

Noise Sources

The proposed wind farm layout comprises up to 60 WTGs. The co-ordinates of the WTGs are provided in Appendix E. The closest WTG from each residence and the separation distance and angle between them is provided in Appendix F.

The assessment of WTG noise has been made based on the following:

- the *Vestas V162-5.6* with serrated trailing edge blades and a hub height of 140m being a representative example of the type, generation, and size of WTG proposed for the Project;
- Sound Power Levels as provided in Table 6 for the *Vestas V162-5.6* standard "Mode 0" operation.

Table 6: *WTG Sound Power Level at integer wind speeds for "Mode 0" operation.*

Hub Height Wind Speed (m/s)	Sound Power Level (dB(A) re 1 pW)
3	93.5
4	93.7
5	94.3
6	97.3
7	100.2
8	102.9
9 and above	104

The Bulletin requires that the WTG noise level be adjusted where excessive levels of tonality is identified to a maximum adjustment of 5 dB(A).

The 1/3 octave band data for the representative WTG does not result in an adjustment for the characteristic of tonality in accordance with *ISO 1996.2: 2007 Acoustics - Description, measurement and assessment of environmental noise – Determination of environmental noise levels (Annex D – Objective method for assessing the audibility of tones in noise – Simplified method).*

Based on the above, no adjustments have been made to the predicted noise levels. It is recommended that the procurement process includes a guarantee from the WTG manufacturer that the final WTG selection is free of excessive levels of tonality.

Noise Predictions

The external noise level at residences has been predicted and compared with the relevant criterion at each residence. The predictions at each non-associated residence are provided in Table 7 and the predictions at associated residences are provided in Table 8. Predicted exceedances are shown in **bold**.

Table 7: *Wind Farm Noise Predictions at non-associated residences.*

Residence ID	Predicted Noise Level for integer wind speeds at Hub Height, 140m, AGL (dB(A))									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
D13-1	7	7	8	11	14	16	17	17	18	18
D16-1	11	12	12	15	18	21	22	22	22	22
D17-2	12	12	13	16	19	21	22	22	23	23
D17-3	12	12	12	15	18	21	22	22	22	22
D18-1	12	12	13	16	19	21	22	22	22	22
D18-2	12	12	13	16	18	21	22	22	22	22
D18-3	12	12	13	16	19	21	22	22	23	23
D18-4	11	11	11	14	17	20	21	21	21	21
D18-5	10	10	11	14	17	19	20	20	21	21
D18-6	11	11	12	15	18	20	21	21	21	21
D18-7	11	11	12	15	18	20	21	21	21	21
D21-2	9	9	10	13	16	18	20	20	20	20
D21-4	9	9	10	13	15	18	19	19	19	19
E11-7	8	9	9	12	15	18	19	19	19	19
E12-2	8	8	8	11	14	17	18	18	18	18
E12-5	9	9	10	13	16	18	20	20	20	20
E17-1	13	13	14	17	20	22	23	23	24	24
E17-2	12	13	13	16	19	22	23	23	23	23
E17-3	14	14	15	18	20	23	24	24	24	24
E17-4	12	13	13	16	19	22	23	23	23	23
E17-5	14	14	15	18	20	23	24	24	24	24
E17-6	12	13	13	16	19	22	23	23	23	23
E18-1	13	13	14	17	19	22	23	23	23	23
E18-2	14	14	15	18	21	23	24	24	25	25
E19-1	15	16	16	19	22	25	26	26	26	26
F11-1	9	9	10	13	16	18	19	19	19	19
F11-2	9	10	10	13	16	19	20	20	20	20
F12-1	10	10	11	14	17	19	21	21	21	21
F12-2	11	11	12	14	17	20	21	21	21	21
F16-1	19	19	20	23	26	28	30	30	30	30
F16-2	16	17	17	20	23	26	27	27	27	27
F17-1	19	19	20	23	26	29	30	30	30	30
F18-1	20	21	21	24	27	30	31	31	31	31
F19-1	18	18	19	22	25	27	28	28	28	28
G11-1	13	13	14	17	20	22	23	23	23	23

Residence ID	Predicted Noise Level for integer wind speeds at Hub Height, 140m, AGL (dB(A))									
	3	4	5	6	7	8	9	10	11	12
G12-1	13	13	14	17	20	22	23	23	23	23
G15-3	22	22	23	26	28	31	32	32	32	32
G17-1	24	24	24	27	30	33	34	34	34	34
H7-1	8	9	9	12	15	18	19	19	19	19
H8-1	10	10	10	13	16	19	20	20	20	20
H11-1	18	19	19	22	25	28	29	29	29	29
H11-2	15	16	16	19	22	25	26	26	26	26
H12-1	18	19	19	22	25	28	29	29	29	29
H12-2	18	19	19	22	25	28	29	29	29	29
H12-3	19	19	20	23	25	28	29	29	29	29
I24-2	9	9	10	13	16	19	20	20	20	20
K23-1	10	10	11	14	16	19	20	20	20	20
K23-2	10	10	10	13	16	19	20	20	20	20
L23-1	11	12	12	15	18	21	22	22	22	22
L23-2	9	9	10	13	16	19	20	20	20	20
M23-2	12	12	13	16	18	21	22	22	22	22
N21-1	15	15	16	19	22	25	26	26	26	26
N21-2	15	16	16	19	22	25	26	26	26	26
N22-1	13	14	14	17	20	23	24	24	24	24
O22-1	16	16	17	20	23	26	27	27	27	27
P4-1	5	5	6	9	11	14	15	15	15	15
P7-1	14	14	15	18	21	23	25	25	25	25
P22-1	25	25	26	29	32	34	**36**	36	36	36
P22-4	24	24	24	27	30	33	34	34	34	34
Q5-1	7	8	8	11	14	17	18	18	18	18
Q17-1	19	19	20	23	26	28	30	30	30	30
Q17-2	19	19	20	23	26	28	29	29	30	30
Q17-3	19	19	20	23	26	28	29	29	30	30
S4-1	11	11	12	15	18	20	21	21	22	21
S17-2	23	23	24	27	30	33	34	34	34	34
T5-1	13	14	14	17	20	23	24	24	24	24
T6-2	15	16	16	19	22	25	26	26	26	26
T6-9	17	18	18	21	24	27	28	28	28	28
T15-1	18	18	19	22	25	28	29	29	29	29
T15-2	19	19	20	23	26	28	29	29	29	29
V20-1	20	21	21	24	27	30	31	31	31	31
V25-2	9	10	10	13	16	19	20	20	20	20
W8-1	14	14	15	18	21	23	24	24	24	24
W14-1	9	10	10	13	16	19	20	20	20	20
W22-1	11	12	12	15	18	21	22	22	22	22
X21-1	8	8	8	11	14	17	18	18	18	18
X22-1	9	9	10	13	16	18	20	20	20	20
Y15-1	6	7	7	10	13	16	17	17	17	17
Y17-1	7	7	8	11	14	17	18	18	18	18
Y17-2	8	8	9	12	15	17	18	18	19	19
Y18-1	7	8	8	11	14	17	18	18	18	18
Y19-1	7	7	7	10	13	16	17	17	17	17
Y19-2	7	7	7	10	13	16	17	17	17	17

Residence ID	Predicted Noise Level for integer wind speeds at Hub Height, 140m, AGL (dB(A))									
	3	4	5	6	7	8	9	10	11	12
Y19-3	9	9	10	13	15	18	19	19	19	19
Y19-4	9	10	10	13	16	19	20	20	20	20
Y19-5	9	9	10	13	16	19	20	20	20	20
Y20-1	9	9	10	13	16	18	19	19	19	19
Y20-2	8	8	9	12	15	18	19	19	19	19
Y21-3	7	8	8	11	14	17	18	18	18	18

Table 8: *Wind Farm Noise Predictions at associated residences.*

Residence ID	Predicted Noise Level for integer wind speeds at Hub Height, 140m, AGL (dB(A))									
	3	4	5	6	7	8	9	10	11	12
G15-1	23	24	24	27	30	33	34	34	34	34
G15-2	21	21	22	25	28	30	31	31	32	32
H10-1	15	15	16	19	21	24	25	25	25	25
H10-2	15	15	16	19	22	24	25	25	25	25
I23-1	12	12	12	15	18	21	22	22	22	22
M8-1	12	13	13	16	19	22	23	23	23	23
M9-1	14	15	15	18	21	24	25	25	25	25
M9-2	14	15	15	18	21	24	25	25	25	25
M23-1	12	12	13	16	18	21	22	22	22	22
R17-1	22	22	22	25	28	31	32	32	32	32
S5-1	13	13	14	17	19	22	23	23	23	23
S15-1	16	16	16	19	22	25	26	26	26	26
S17-1	21	22	22	25	28	31	32	32	32	32
T6-1	22	22	23	26	28	31	32	32	32	32
U6-1	18	18	19	22	24	27	28	28	28	28
V20-2	21	21	22	25	27	30	31	31	31	31
W20-1	20	20	21	24	27	29	30	30	30	30
X17-1	9	9	9	12	15	18	19	19	19	19
X17-2	10	10	11	14	17	20	21	21	21	21
X17-3	9	10	10	13	16	19	20	20	20	20

Based on the predictions, the equivalent noise levels generated by the WTGs under conditions most conducive to noise propagation will comply with the criteria established under Table 5 with the exception of P22-1 by 1 dB(A) at a hub height wind speed of 9 m/s.

In lieu of P22-1 becoming an Associated Residence, a curtailment strategy (operating turbine(s) in a “sound optimised” (SO) mode at the wind speeds where the predictions indicate that the criteria will be exceeded) to achieve compliance with the Table 5 criteria at P22-1 has been determined.

The curtailment strategy has been determined using the *Sound Optimised Mode S02* for the *Vestas V162-5.6* with serrated trailing edge blades. The sound power levels for *Sound Optimised Mode S02* are provided in Table 9 below.

Table 9: *WTG Sound Power Level at integer wind speeds for "Sound Optimised Mode S02".*

Hub Height Wind Speed (m/s)	Sound Power Level (dB(A) re 1 pW)
3	93.5
4	93.7
5	94.3
6	97.3
7	100.2
8	102
9 and above	102

The noise predictions indicate that the operation of T23 in *Sound Optimised Mode S02* at an integer wind speed of 9m/s is required to ensure the noise criterion is achieved at P22-1. That is, with T23 operating in *Sound Optimised Mode S02* at integer wind speeds of 9m/s, the noise level from the wind farm is predicted to achieve the noise criteria at all residences.

Given that the noise assessment has been made based on a representative WTG and the selection may change during the detailed design of the Project, the need for curtailment and the final operating strategy will be determined during the pre-construction noise assessment. The pre-construction noise assessment will consider the final WTG selection and layout, guaranteed sound power levels for the WTG, and final agreements with landowners.

In addition to the above, the highest predicted low frequency noise level at any residence is 50 dB(C). This occurs at P22-1. A noise level of 50 dB(C) is an order of magnitude lower than the 60 dB(C) level which the Bulletin identifies as an excessive level of low frequency noise at non-associated residences.

The predicted noise level contours at the hub height wind speed corresponding to the WTG maximum sound power levels (wind speed of 10m/s and above) are provided in Appendix G.

Appendix G also shows:

- the locations of *non-associated* and *associated residences*;
- the noise monitoring locations; and,
- the WTG locations.

6 ANCILLARY INFRASTRUCTURE

6.1 Criteria

The Policy establishes *noise trigger levels* based on the existing background noise environment (intrusiveness noise levels) and the amenity for particular land uses (amenity noise levels). The *noise trigger levels* are the lower values provided by the two methods.

The amenity level for a noise source which operates over a 24-hour period in a rural area is 40 dB(A).

The intrusiveness noise level is determined from the background noise environment (refer Section 4 of this report). Based on the measured background noise levels, the effective RBLs were calculated to be less than 30 dB(A) at all monitoring locations, resulting in an intrusiveness level of 35 dB(A) during the night.

The Policy noise trigger level therefore becomes 35 dB(A) for ancillary infrastructure.

If noise assessed under the Policy is found to have a character that has the potential to be annoying, such as tonality, modulation or dominant low-frequency content, a modifying correction factor is to be applied to the predicted noise levels at the residence before comparison with the project *noise trigger level*.

6.2 Assessment

Noise Sources

The Project will comprise up to two substations. This assessment considers three potential substation locations (with co-ordinates provided in Appendix H) to provide flexibility for the western substation location.

The assessment of the substation noise has been made based on high-voltage transformer(s) with an overall capacity of 450MVA at each of the three potential substation locations with a sound power level equivalent to the level derived from the Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers* -

Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD) as summarised in Table 5.

Table 5: *450 MVA substation transformer sound power levels.*

Octave Band Centre Frequency (Hz)	Sound Power Level (dB(A) re 1 ρW)
63 Hz	82
125 Hz	90
250 Hz	97
500 Hz	100
1,000 Hz	92
2,000 Hz	89
4,000 Hz	82
Total	**103**

Noise Predictions

The noise levels are predicted to be less than 20 dB(A) at all residences from a substation at any of the potential locations.

Transformers will often have audible tonality in close proximity, although the potential for it to be a dominant characteristic is diminished at the separation distances to the residences. At predicted noise levels of less than 20 dB(A) a penalty for a dominant characteristic does not apply.

Based on the predictions, the maximum equivalent noise levels generated by the substations under conditions most conducive to noise propagation (such as temperature inversions) will easily comply with the criteria established by the SEARs at all residences.

7 CONSTRUCTION

7.1 Criteria

DECC 2009 establishes management levels for the following periods:

- Monday to Friday 7am to 6pm and Saturday 8 am to 1 pm
- Sundays and public holidays
- Activity outside of the above periods.

The management levels are used as a trigger to take all feasible and reasonable noise reduction measures for the construction activity. That is, construction can occur at higher levels than the "management levels"; however, must take all *feasible and reasonable noise reduction measures* when doing so. The management levels are linked to a margin above the RBL. Based on the above, the construction noise *Management level* and the requirement for "feasible" and "reasonable" noise reduction measures are detailed in Table 6:

Table 6: DECC 2009 Requirements**.**

Time of Day	**Management level** $L_{Aeq\ (15\ min)}$	**How to apply**
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected **RBL + 10 dB = <u>45dB(A)</u>**	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected **75 dB(A)**	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected **RBL + 5 dB = <u>35dB(A)</u>**	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

7.2 Assessment

Noise Predictions

The equipment and activities on site will vary throughout the project, depending on various stages of construction, required processes and specific equipment used. The predicted noise from construction activity is presented as a typical worst case (highest noise level) scenario for various stages of construction.

The predictions are based on weather conditions that are the most conducive for the propagation of noise. Other weather conditions would result in lower noise levels than those predicted for day-time construction.

The non-associated residences are separated 1,380m or more from the closest proposed WTG, and 2,200m or more from the closest proposed concrete batching plant (with co-ordinates provided in Appendix H).

The predicted noise level from the closest activity at the WTG sites (at a separation distance of 1380m) is provided in Table 6. The required separation distance in order to achieve 45 dB(A) during standard hours is also provided.

The predicted noise level from the closest activity that could occur outside of standard construction hours, such as the operation of the batching plant and concrete pouring at WTG sites early in the morning, is provided in Table 7. The required separation distance in order to achieve 35 dB(A) for activity outside of standard hours is also provided.

Separation distances greater than the distances presented in Tables 6 and 7 will result in lower noise levels.

In accordance with DECC 2009, if the noise is “particularly annoying’ to nearby residents, a modifying correction factor is to be applied to the measured level. The noise associated with construction activity can exhibit annoying characteristics on occasion and therefore a 5 dB(A) correction has been applied to the noise predictions.

Table 6: Predicted construction noise levels during standard hours.

Phase	Main Plant and Equipment	Predicted Noise Level at Closest Residence	Outcome/Action
Site Set-Up and Civil Works	Generator Transport truck Excavator Low loader	43 dB(A) at 1380m	Achieves the standard hours criterion at all non-associated residences.
Road Construction	Mobile crushing and screening plant Dozer Roller Low loader Tipper truck Excavator Scraper Transport truck	49 dB(A) at 1380m	Exceeds Management Level at residences within 1,800m of the construction activity. Implement "feasible and reasonable" noise control strategies to minimise noise during construction in accordance with the recommendations below.
Excavation and foundation construction	Excavator Front end loader Mobile crushing and screening plant Truck-mounted concrete pump Concrete mixer truck Mobile crane Transport truck Tipper truck	48 dB(A) at 1380m	Exceeds Management Level at residences within 1,700m of the construction activity. Implement "feasible and reasonable" noise control strategies to minimise noise during construction in accordance with the recommendations below.
Electrical Installation	Rock trencher Concrete mixer truck Low loader Tipper truck Mobile crane	49 dB(A) at 1380m	Exceeds Management Level at residences within 1,800m of the construction activity. Implement "feasible and reasonable" noise control strategies to minimise noise during construction in accordance with the recommendations below.
Turbine Delivery and Erection	Extendable trailer truck Low loader Mobile crane Support crane Grinder Rattle Gun	43 dB(A) at 1380m	Achieves the standard hours criterion at all non-associated residences.

Table 7: Predicted construction noise levels outside of standard hours.

Phase	Main Plant and Equipment	Predicted Noise Level at Closest Residence	Outcome/Action
Batching	Front end loader Truck	37 dB(A) at 2200m	Exceeds level at residences within 2,400m of the construction activity. Where batching outside of hours is required, there will need to be additional mounding or shielding (which could be provided by natural topography) to all residences within 2400m. This distance can decrease under other weather conditions.
Concrete Pour	Generator Truck Concrete pump	39 dB(A) at 1380m	Exceeds level at residences within 1,900m of the construction activity. Where concrete pouring outside of hours is required, there will need to be additional mounding or shielding (which could be provided by natural topography) to all residences within 1900m. This distance can decrease under other weather conditions.

Recommendations

For construction with noise levels as detailed above, DECC 2009 requires the developer to apply all feasible and reasonable work practices, and to inform the residents of the proposed construction work.

A Construction Management Plan will be developed by the construction team to include "feasible and reasonable" noise control strategies to minimise noise during construction. The Plan will need to include engineering measures such as the construction of temporary acoustic barriers, the use of proprietary enclosures around machines, the use of silencers, the substitution of alternative construction processes and the fitting of broadband reversing signals. It may also include administrative measures such as inspections, scheduling and providing training to establish a noise minimisation culture for the works.

The following mitigation measures are recommended to be implemented for the construction works and provide the framework for the development of a Construction Management Plan by the construction team once the final construction methods, timing, locations and equipment has been determined.

Scheduling

Construction works, including heavy vehicle movements into and out of the site, restricted to the hours between 7am and 6pm Monday to Friday, and between 8am and 1pm on Saturdays. Works carried out outside of the hours will only entail:

- works that do not cause noise emissions above 35 dB(A) at any nearby residences not located on the site; or,
- the delivery of materials as requested by Police or other authorities for safety reasons; or,
- emergency work to avoid the loss of lives, property, and/or to prevent environmental harm; or,
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours

If any other works are required outside of the specified hours, they will only be carried out with the prior consent of the relevant authority.

Location of Fixed Noise Sources

Locate fixed noise sources such as crushing and screening plant, concrete batching plant, generators and compressors at the maximum practicable distance to the nearest dwellings, and where possible, use existing topography to block line of sight between the fixed noise source and the dwelling.

Provide Acoustic Screens around Fixed Noise Sources

Provide acoustic screens or mounding for *fixed* crushing and screening plant and concrete batching plant operating outside of scheduled hours wherever these noise sources are located within 2400m of a non-associated residence and do not have direct line of sight blocked by site topography to that dwelling, in accordance with the following requirements:

- Locate the acoustic screens or mounding as close as practicable to the noise source. Natural topography can be used in such circumstances subject to consideration and assessment;
- Construct from mounding using excavated soil from the site or a material with a minimum surface density of 10 kg/m^2, such as 1.2mm thick sheet steel or 9mm thick compressed fibre cement sheeting, or use proprietary barriers such as the *FlexShield* "Sonic Quilt";
- Construct to a minimum height that blocks direct line of sight between the noise source and any residences within 2400m.
- Construct such that there are no air gaps or openings at joints between sections of the acoustic screens.

Enclose Generators and Compressors

Provide proprietary acoustic enclosures for site compressors and generators located within 2400m of a non-associated residence.

Alternative Processes

Investigate and implement alternative processes where feasible and reasonable, such as hydraulic or chemical splitters as an alternative to impact rock breaking, or the use of broadband reversing alarms in lieu of the high-pitched alarms. The fitting of a broadband alarm should be subject to an appropriate risk assessment, with the construction team being responsible for ensuring the alarms are installed and operated in accordance with all relevant legislative requirements.

Site Management

- Select and locate centralised site activities and material stores as far from residences as possible;
- Care should be taken not to excessively drop materials such as rock, to cause peak noise events, including materials from a height into a truck. Site personnel should be directed as part of a training regime to consider such practices;
- Plant known to emit noise strongly in one direction, such as the exhaust outlet of generator set, shall be orientated so that the noise is directed away from noise sensitive areas if practicable;
- Machines that are used intermittently shall be shut down in the intervening periods between works or throttled down to a minimum;
- Implement worksite induction training, educating staff.

Equipment and Vehicle Management

- Ensure equipment has Original Equipment Manufacturer (OEM) mufflers (or better) installed;
- Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the OEM design specifications. This inspection should be part of a monitoring regime;
- Ensure silencers and enclosures are intact, rotating parts are balanced, loose bolts are tightened, frictional noise is reduced through lubrication and cutting noise reduced by keeping equipment sharp. These items should be part of a monitoring regime;

- Use only necessary power to complete the task;
- Inspect, as part of a monitoring regime, plant and equipment to determine if it is noisier than other similar machines, and replace or rectify as required.

Community Consultation

Implement the following noise related elements into the overall community consultation process. The aim of the consultation is to ensure adequate community awareness and notice of expected construction noise.

The minimum elements should include:

- Community Information newsletters, providing details of the construction plan and duration of the construction phases;
- A site notice board in a community location providing copies of the newsletters, updated construction program details, and contact details of relevant project team members;
- A feedback mechanism for the community to submit questions to the construction team, and for the construction team to respond;
- Regular updates on the construction activities to local authorities to assist in complaint management if necessary;
- Contact details of the project manager and/or site "Environmental Representative".

In addition, prior to any construction activity occurring in the vicinity of a non-associated residence where the noise could exceed the DECC 2009 "management levels", or significant construction traffic periods or impacts on local road conditions, the following actions should be taken:

- Contact the local community potentially affected by the proposed works and inform them of the proposed work, the location of the work, the day(s) and date(s) of the work and the hours involved;
- Contact should be made a reasonable time before the proposed commencement of the work; and
- Contact details of the project manager and / or site "Environmental Representative" should be provided.

The above measures should be incorporated and implemented through a Construction Noise Management Plan for the site. The Plan should be developed by the construction team once the actual construction activities have been determined.

8 TRAFFIC

The traffic associated with the winds farm will predominantly occur during construction and will include semi-trailers, low loaders, trucks, mobile cranes, water tankers, four-wheel-drive vehicles and passenger vehicles.

8.1 Criteria

The DECCW 2011 criteria for "*Local Roads - Existing residences affected by additional traffic on existing local roads generated by land use developments*" are equivalent ($L_{Aeq, 1hour}$) noise levels of no greater than 55 dB(A) during the day-time (7am to 10pm) and 50 dB(A) during the night-time (10pm to 7am). This noise level is to be achieved outside, at a distance of 1m from the facade of a residence and at a height of 1.5m.

It should be noted that DECCW 2011 applies to a permanent change to the environment as it is established for the assessment of changes to the permanent road network. Therefore, its application to transient and fixed term construction activity represents a conservative approach. Indeed, higher construction traffic noise levels than DECCW 2011 could be accommodated without adverse impacts subject to traffic movements being governed under an adequate Construction Management Plan (whereby routes, content and times were clearly articulated to the local community).

8.2 Assessment

An assessment has been made against DECCW 2011, which considers the closest residence to any road/track in the vicinity of the wind.

The closest residence is understood to be M23-1 which is set back 20m from the proposed access road. The next closest residences are R17-1, S17-2 and V20-1 which are set back approximately 40m from Bowmans Creek Road. Other residences are set back 60m or more from any road/track, with the closest in the vicinity of the wind farm being I23-1, K23-1, S17-1 and W22-1.

It is predicted that for M23-1 (set back 20m from the road side) the 55 dB(A) day time criterion can be achieved for 20 passenger vehicle movements and six heavy vehicle movements in one hour.

For the other residences located further from the road, the above number of vehicle movements can double for every doubling of the distance between the road and residence.

The exact number of vehicles associated with the wind farm using the roads will be subject to the final construction team's approach; however, the above traffic volumes show that DECCW 2011 can be satisfied with a relatively large number of vehicle movements. When taking into account the application of a policy which is designed for permanent road changes, this indicates high levels of construction traffic will be accommodated without adverse impacts.

It is noted that care should be taken to avoid excessive acceleration of trucks and the use of truck engine brakes in close proximity to dwellings. These practical control measures and others, such as the clear communication of routes, content and times to the local community should be governed under an adequate Construction Management Plan.

Such a Plan should include the following elements to reduce construction traffic noise:

- Communicate with the affected community in accordance with the provisions above;
- Establish and maintain a route into the site so that heavy vehicles do not enter noise sensitive areas for access where practicable;
- Incorporate information regarding the route to all drivers prior to accessing the site and the need to minimise impacts through driver operation at certain locations;
- Schedule construction traffic deliveries such that it is as evenly dispersed as practicable;
- Restrict construction to the day-time operating hours for the construction site, subject to the justifications for activity outside of this time as detailed in the Construction Noise Management Plan;
- Driver education so that excessive acceleration or use of engine brakes adjacent residences is minimised as far as is reasonable and practicable.

9 CONSTRUCTION VIBRATION

9.1 Noise Criteria

For construction activity occurring during the day time, the DEC 2006 can be interpreted to provide the vibration criteria in Table 8 at the dwellings, based on the core document used as the technical basis for the Technical Guideline, the British Standard *BS 6472-1992 "Evaluation of human exposure to vibration in buildings (1-80Hz)".*

Table 8: Vibration Criteria

Continuous Vibration Vertical (rms)		**Impulsive Vibration Vertical (rms)**		**Vibration Dose Value for Intermittent Vibration**	
Preferred	Maximum	Preferred	Maximum	Preferred	Maximum
0.01 m/s^2	0.02 m/s^2	0.3 m/s^2	0.6 m/s^2	0.2 $m/s^{1.75}$	0.4 $m/s^{1.75}$

Continuous vibration is uninterrupted for an extended period of time. Intermittent vibration is an interrupted form of continuous vibration, and impulsive vibration is a sudden event or events.

9.2 Assessment

It is expected that the main sources of construction vibration will be the rock trenching equipment and roller operation during the road and hard stand construction. The level of vibration at a distance will be subject to the input of the equipment and the local ground conditions. Typically, the distances required to achieve the construction vibration criteria provided in DEC 2006 are in the order of 20m. At 100m distance, vibration from these activities is unlikely to be detectable.

Based on the separation distances between the construction activities and the nearest dwellings being well in excess of 100m, vibration levels are predicted to easily achieve the criteria.

If construction activities producing high levels of vibration occur within 100m of a dwelling, it is recommended that a monitoring regime is implemented during these times to ensure compliance with DEC 2006.

10 CONCLUSION

Sonus has conducted a noise and vibration assessment of the construction and operation of the Bowmans Creek Wind Farm (the **Project**) to support the *'Bowmans Creek Wind Farm Environmental Impact Statement', Hansen Bailey, 2020* (the **EIS**)).

The noise and vibration assessment addresses the "Secretary's Environmental Assessment Requirements" (**SEARs**) issued for the Project (SSD 10315) dated 23 July 2019.

Noise predictions have been made from the operational WTGs, the potential substations, traffic and construction activities including batching. Vibration predictions have been made for construction activities.

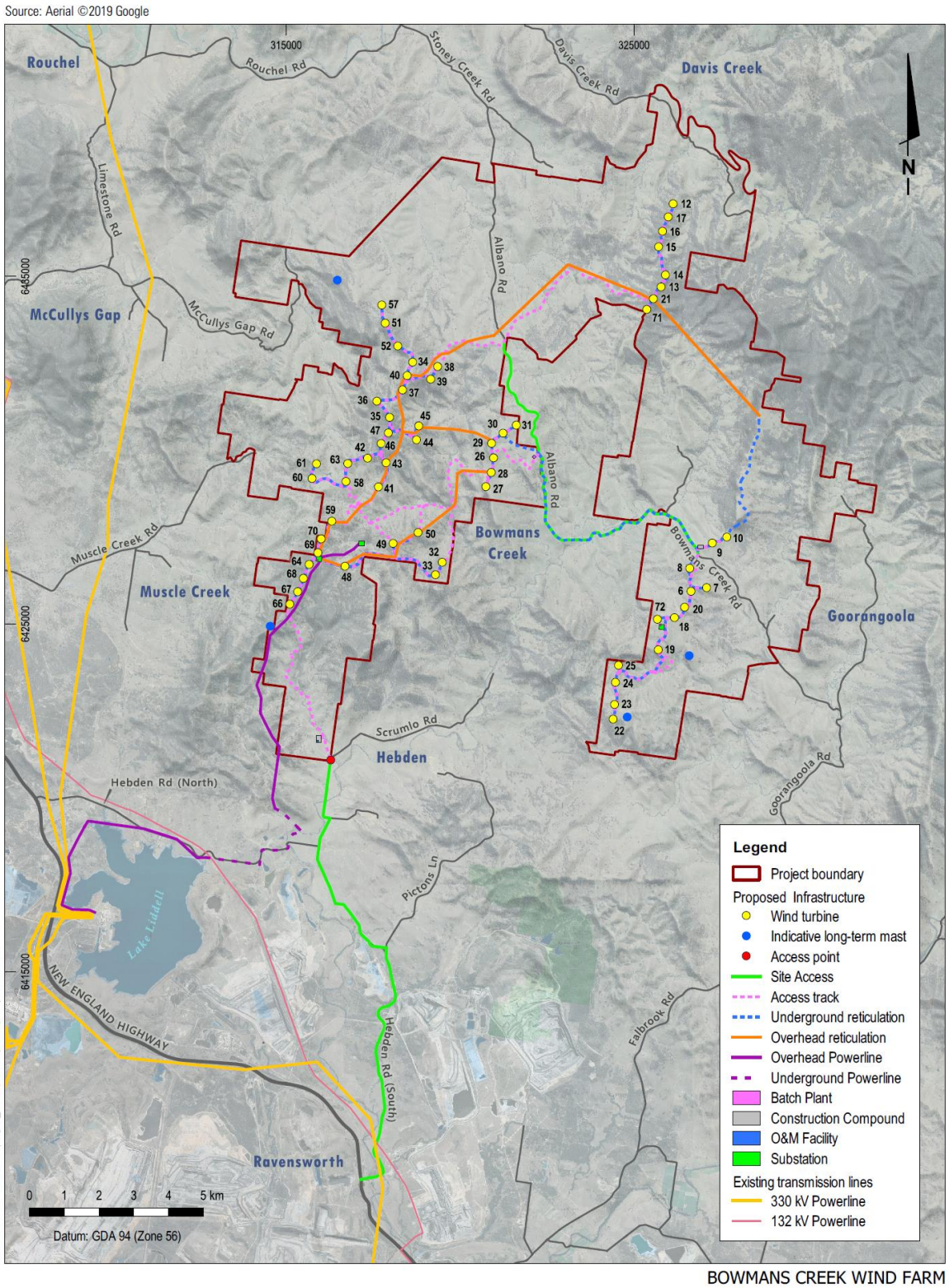
Based on the predictions, the relevant noise and vibration criteria established by the SEARs will be achieved under conditions most conducive to noise propagation at all residences. In the circumstance where P22-1 is not an associated residence, then in order for the criteria to be achieved, WTG T23 would need to be operated in *Sound Optimised Mode S02* at integer wind speeds of 9m/s

The predicted noise level contours at the wind speed corresponding to the WTG maximum sound power levels (wind speed of 10m/s and above) are provided in Appendix G along with the following:

- the locations of *non-associated* and *associated residences*;
- the noise monitoring locations; and,
- the WTG locations.

APPENDIX A: Development Layout

Figure A1: *Development Layout.*



BOWMANS CREEK WIND FARM

Hansen Bailey ENVIRONMENTAL CONSULTANTS | EPURON

Conceptual Project Layout

APPENDIX B: Monitoring Equipment

Figure B1: *G15-3 Monitoring Equipment.*

Figure B2: *G17-1 Monitoring Equipment.*

Figure B3: *P22-1 Monitoring Equipment.*

Figure B4: *S17-2 Monitoring Equipment.*

APPENDIX C: Background Noise Regression Curves

Figure C1: *G15-3 Background Noise Regression Curve.*

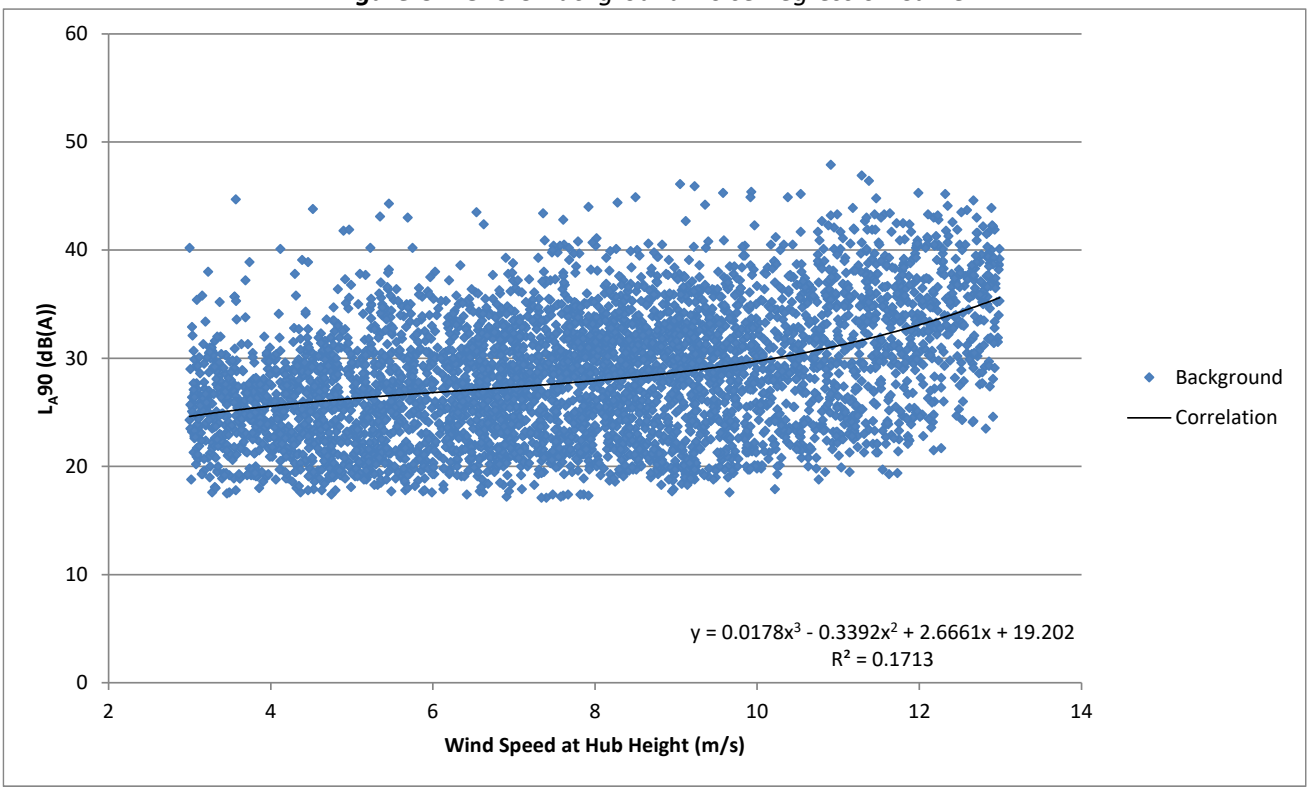


Figure C2: *G17-1 Background Noise Regression Curve.*

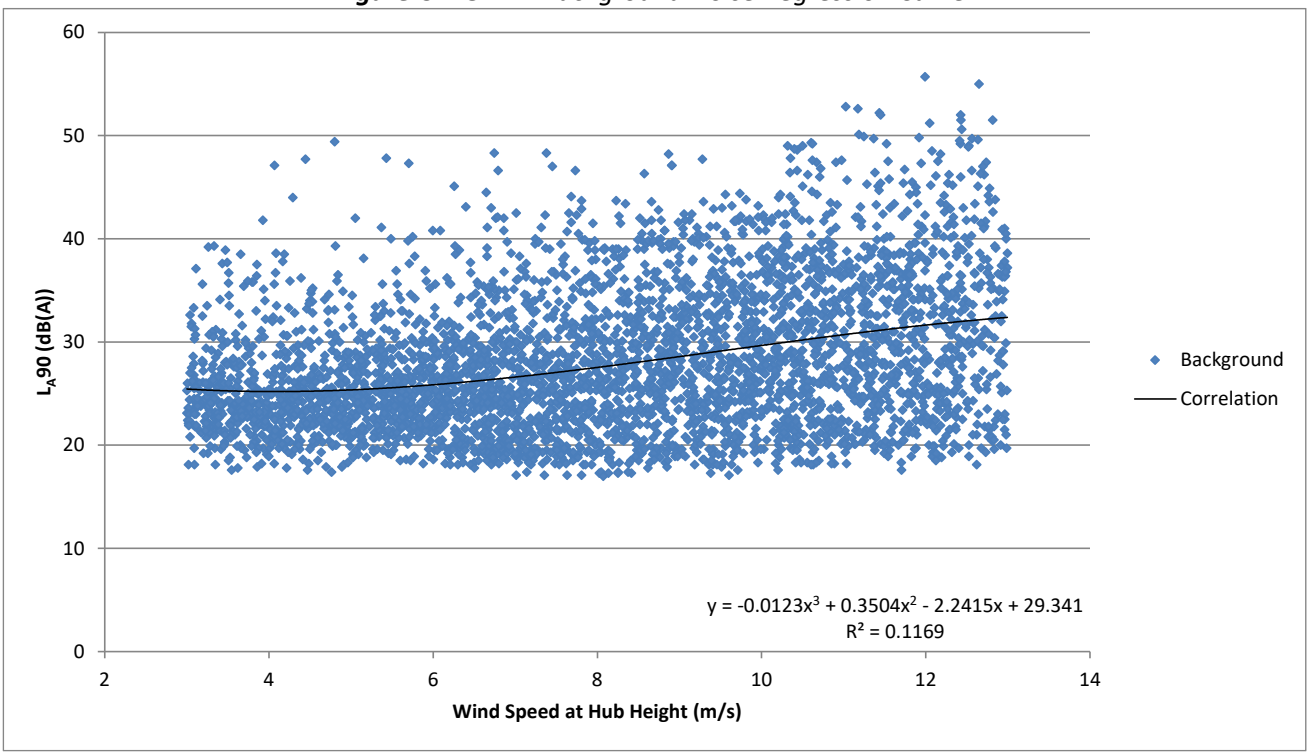


Figure C3: *P22-1 Background Noise Regression Curve.*

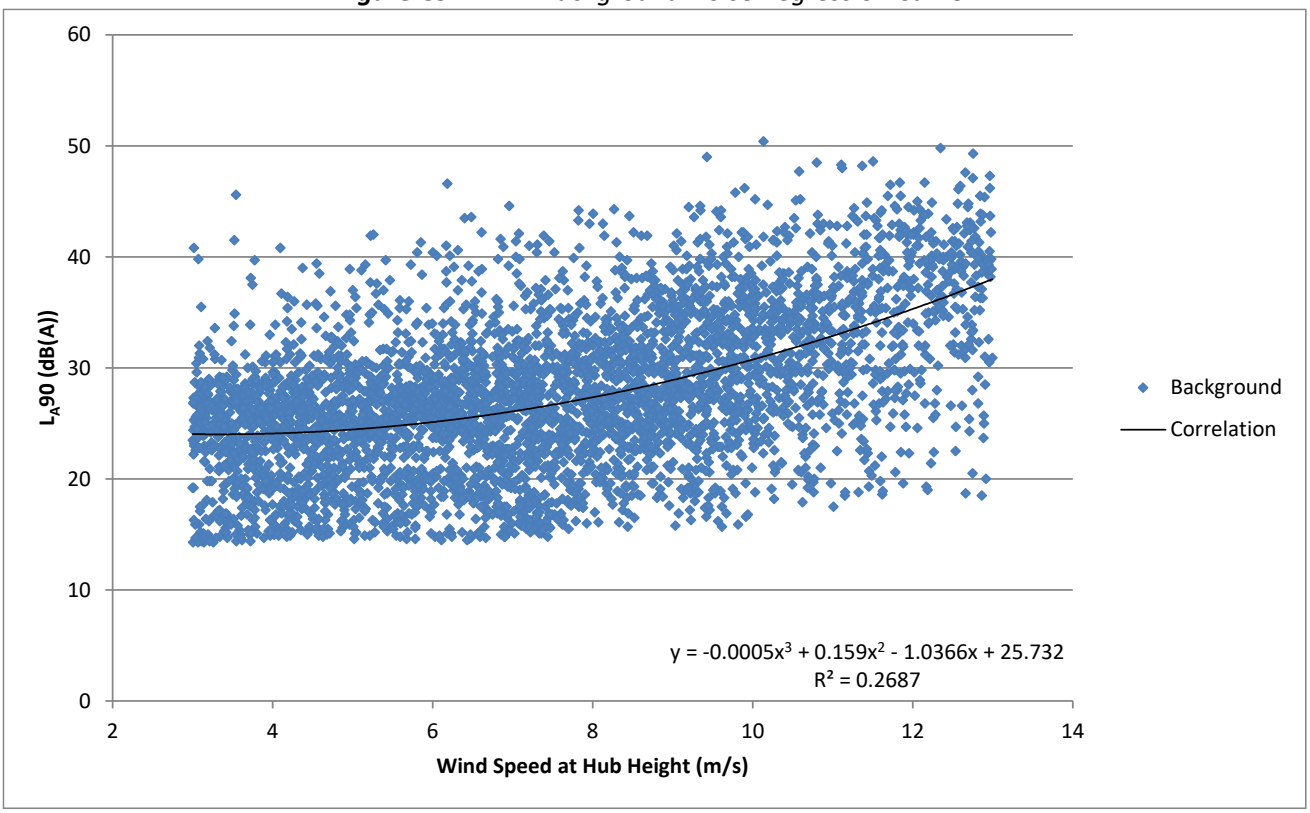
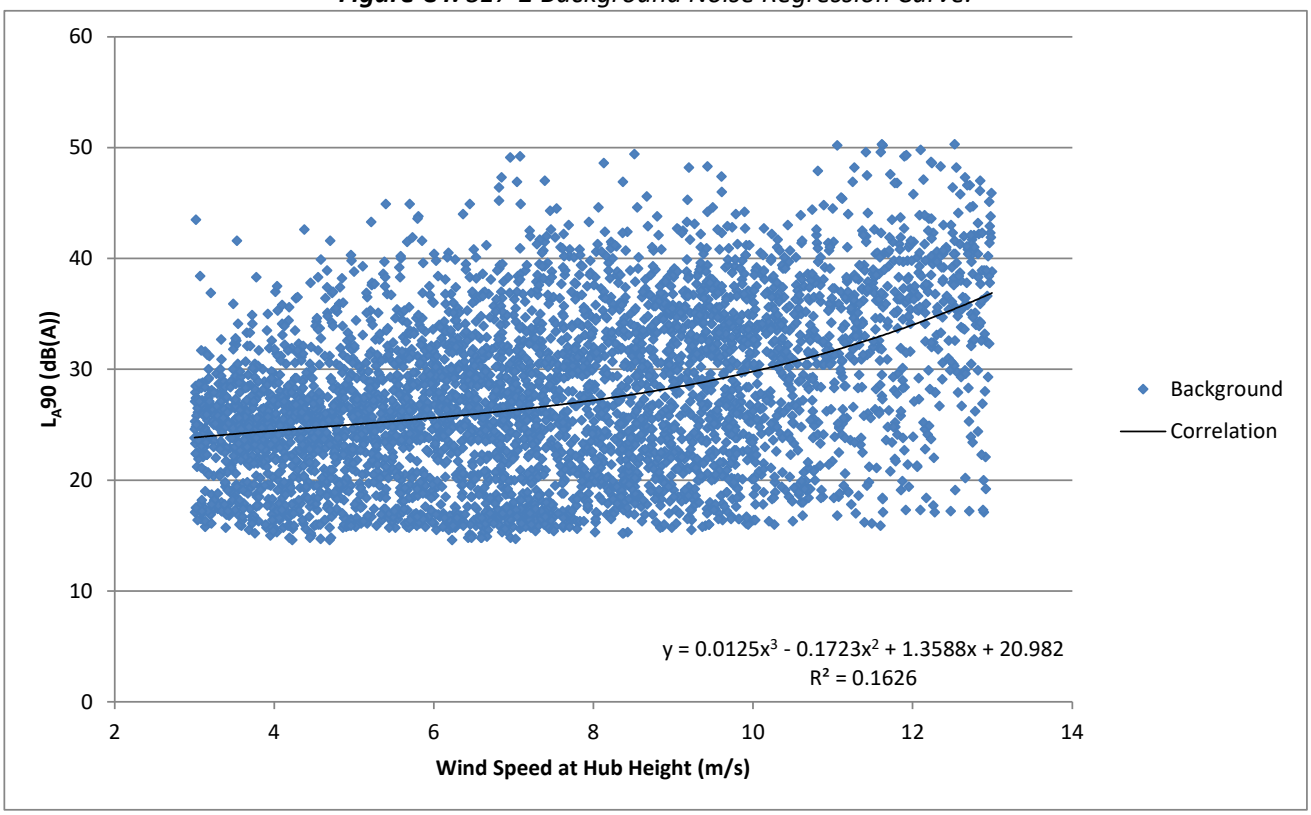


Figure C4: *S17-2 Background Noise Regression Curve.*



APPENDIX D: Residences

Table D1: *Residence Location, Status and Noise Criteria*

Residence ID	Co-ordinates (UTM WGS84 56H)		Status	Baseline Noise Criterion (dB(A))
	Easting	Southing		
D13-1	311060	6432192	Non-associated	35
D16-1	311188	6428808	Non-associated	35
D17-2	311206	6427588	Non-associated	35
D17-3	311154	6427864	Non-associated	35
D18-1	311162	6427424	Non-associated	35
D18-2	311122	6427022	Non-associated	35
D18-3	311190	6426998	Non-associated	35
D18-4	310813	6426974	Non-associated	35
D18-5	310624	6427010	Non-associated	35
D18-6	310871	6427162	Non-associated	35
D18-7	310888	6427403	Non-associated	35
D21-2	311039	6424123	Non-associated	35
D21-4	311002	6423946	Non-associated	35
E11-7	312259	6433803	Non-associated	35
E12-2	311788	6433070	Non-associated	35
E12-5	312185	6432637	Non-associated	35
E17-1	311484	6427657	Non-associated	35
E17-2	311350	6427749	Non-associated	35
E17-3	311725	6427892	Non-associated	35
E17-4	311334	6427568	Non-associated	35
E17-5	311704	6427777	Non-associated	35
E17-6	311475	6428437	Non-associated	35
E18-1	311398	6426729	Non-associated	35
E18-2	311714	6426667	Non-associated	35
E19-1	312047	6426188	Non-associated	35
F11-1	312347	6433664	Non-associated	35
F11-2	312540	6433605	Non-associated	35
F12-1	312732	6433439	Non-associated	35
F12-2	312888	6433332	Non-associated	35
F16-1	313258	6429467	Non-associated	35
F16-2	312703	6429458	Non-associated	35
F17-1	313152	6428054	Non-associated	35
F18-1	313111	6427299	Non-associated	35
F19-1	312566	6426243	Non-associated	35
G11-1	313794	6433566	Non-associated	35
G12-1	313737	6433457	Non-associated	35
G15-1	314172	6429823	Associated	45
G15-2	313809	6429992	Associated	45
G15-3	313842	6429651	Non-associated	35
G17-1	313813	6427584	Non-associated	35
H7-1	314951	6437577	Non-associated	35
H8-1	314953	6437082	Non-associated	35
H10-1	315013	6435129	Associated	45
H10-2	315296	6435082	Associated	45

Residence ID	Co-ordinates (UTM WGS84 56H)		Status	Baseline Noise Criterion (dB(A))
	Easting	Southing		
H11-1	315191	6433888	Non-associated	35
H11-2	314494	6434012	Non-associated	35
H12-1	314868	6433173	Non-associated	35
H12-2	315185	6433415	Non-associated	35
H12-3	315261	6433530	Non-associated	35
I23-1	316043	6421983	Associated	45
I24-2	316137	6421166	Non-associated	35
K23-1	317385	6421864	Non-associated	35
K23-2	318217	6421840	Non-associated	35
L23-1	319272	6422349	Non-associated	35
L23-2	318314	6421607	Non-associated	35
M8-1	320082	6437188	Associated	45
M9-1	320282	6436407	Associated	45
M9-2	320257	6436505	Associated	45
M23-1	320085	6422043	Associated	45
M23-2	319759	6422294	Non-associated	35
N21-1	320963	6423624	Non-associated	35
N21-2	321222	6423592	Non-associated	35
N22-1	320354	6422835	Non-associated	35
O22-1	321352	6423111	Non-associated	35
P4-1	323108	6440977	Non-associated	35
P7-1	322700	6437968	Non-associated	35
P22-1	323064	6422790	Non-associated	35
P22-4	322897	6422961	Non-associated	35
Q5-1	323789	6440464	Non-associated	35
Q17-1	323721	6427957	Non-associated	35
Q17-2	323699	6428199	Non-associated	35
Q17-3	323876	6428122	Non-associated	35
R17-1	325271	6428010	Associated	45
S4-1	325899	6440586	Non-associated	35
S5-1	325882	6440197	Associated	45
S15-1	325932	6430456	Associated	45
S17-1	325386	6428328	Associated	45
S17-2	325802	6428222	Non-associated	35
T5-1	326331	6440032	Non-associated	35
T6-1	326585	6438548	Associated	45
T6-2	326985	6439520	Non-associated	35
T6-9	326505	6439309	Non-associated	35
T15-1	326538	6429690	Non-associated	35
T15-2	326725	6429565	Non-associated	35
U6-1	327602	6438713	Associated	45
V20-1	328889	6424697	Non-associated	35
V20-2	328911	6424902	Associated	45
V25-2	328599	6420472	Non-associated	35
W8-1	329417	6436770	Non-associated	35
W14-1	329674	6431158	Non-associated	35
W20-1	329305	6425504	Associated	45

Residence ID	Co-ordinates (UTM WGS84 56H)		Status	Baseline Noise Criterion (dB(A))
	Easting	Southing		
W22-1	330082	6422955	Non-associated	35
X17-1	331246	6428360	Associated	45
X17-2	330809	6428505	Associated	45
X17-3	331100	6428271	Associated	45
X21-1	331206	6423556	Non-associated	35
X22-1	330874	6423143	Non-associated	35
Y15-1	331399	6430135	Non-associated	35
Y17-1	331787	6427873	Non-associated	35
Y17-2	331513	6428089	Non-associated	35
Y18-1	331803	6427210	Non-associated	35
Y19-1	332158	6426088	Non-associated	35
Y19-2	332096	6426274	Non-associated	35
Y19-3	331893	6426536	Non-associated	35
Y19-4	331839	6426121	Non-associated	35
Y19-5	331755	6426427	Non-associated	35
Y20-1	331470	6425175	Non-associated	35
Y20-2	331513	6424729	Non-associated	35
Y21-3	331420	6423970	Non-associated	35

APPENDIX E: WTG Locations

Table E1: *WTG Locations*

WTG ID	Co-ordinates (UTM WGS84 56H)	
	Easting	Southing
6	326641	6425938
7	327090	6426042
8	326607	6426600
9	327253	6427327
10	327671	6427498
12	326127	6437085
13	325782	6434694
14	325907	6435040
15	325709	6435849
16	325821	6436296
17	325986	6436709
18	326167	6425180
19	325701	6424256
20	326457	6425481
21	325559	6434354
22	324402	6422259
23	324441	6422683
24	324468	6423318
25	324556	6423809
26	320963	6429776
27	320742	6428949
28	320897	6429356
29	320906	6430194
30	321236	6430487
31	321617	6430718
32	319486	6426773
33	319292	6426414
34	318636	6432530
35	317972	6430942
36	317607	6431408
37	318345	6431731
38	319354	6432404
39	319155	6432041
40	318479	6432142
41	317652	6428942
42	317341	6429767
43	317872	6429637
44	318747	6430296
45	318812	6430696
46	317729	6430189
47	317937	6430494
48	316690	6426659
49	318072	6427316
50	318791	6427627
51	317846	6433652

WTG ID	Co-ordinates (UTM WGS84 56H)	
	Easting	Southing
52	318208	6432995
57	317749	6434174
58	316718	6429096
59	316312	6427955
60	315743	6429184
61	315870	6429605
63	316770	6429613
64	315658	6426711
66	315104	6425568
67	315329	6425926
68	315493	6426309
69	315911	6427045
70	316004	6427446
71	325370	6434047
72	325676	6425133

APPENDIX F: Closest WTG

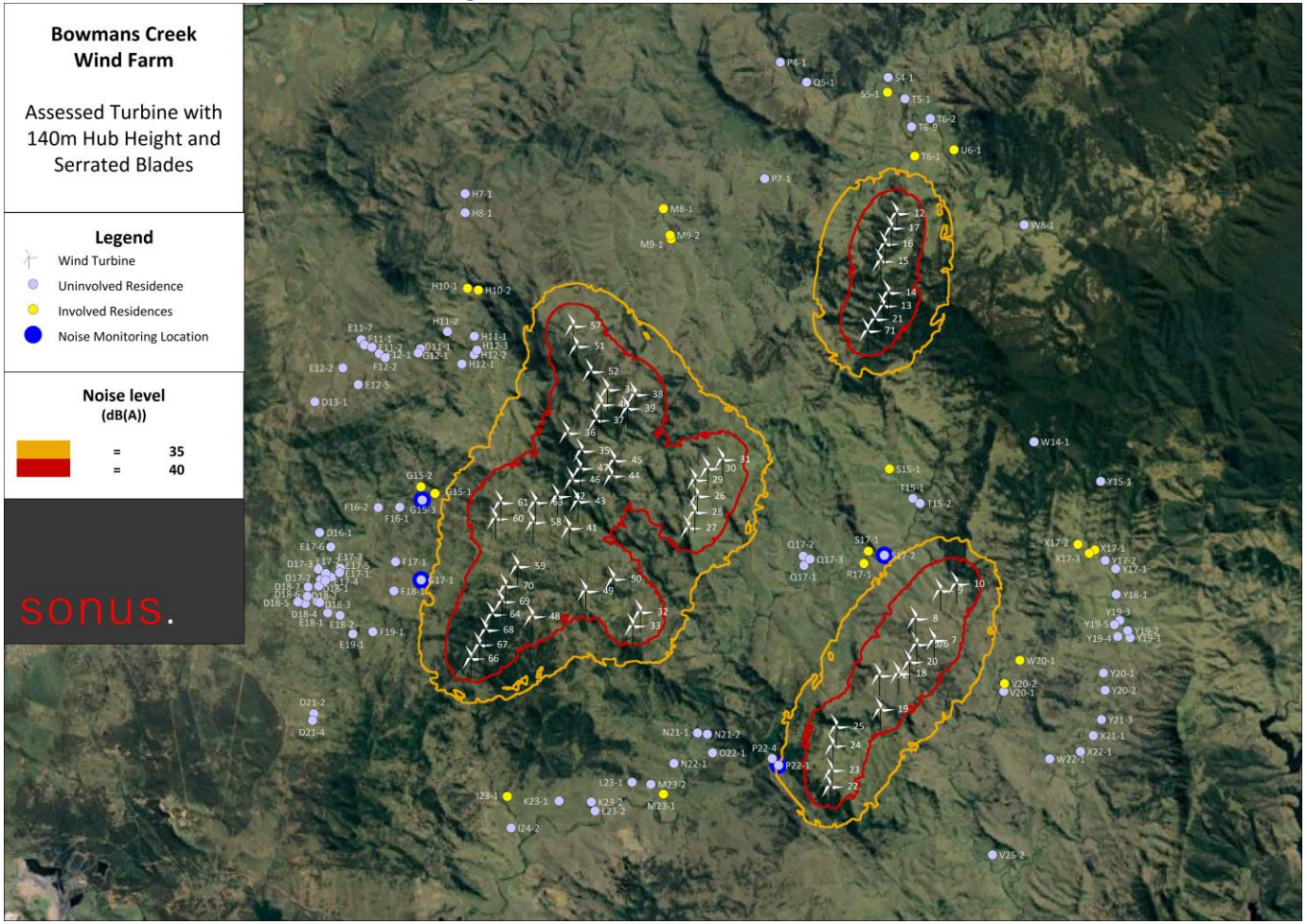
Table F1: *Closest WTG to each residence with distance and angle*

Residence ID (*Associated)	Closest WTG to Residence	Distance to closest WTG (m)	Angle to closest WTG (deg)
D13-1	61	5462	118
D16-1	60	4570	85
D17-2	66	4390	117
D17-3	66	4569	120
D18-1	66	4357	115
D18-2	66	4239	110
D18-3	66	4167	110
D18-4	66	4515	108
D18-5	66	4706	108
D18-6	66	4523	111
D18-7	66	4598	114
D21-2	66	4314	70
D21-4	66	4411	68
E11-7	57	5503	86
E12-2	61	5354	130
E12-5	61	4772	129
E17-1	66	4180	120
E17-2	66	4342	120
E17-3	68	4087	113
E17-4	66	4268	118
E17-5	66	4055	123
E17-6	60	4333	80
E18-1	66	3884	107
E18-2	66	3564	108
E19-1	66	3119	101
F11-1	61	5375	139
F11-2	61	5205	140
F12-1	61	4954	141
F12-2	61	4773	141
F16-1	60	2501	96
F16-2	60	3052	95
F17-1	60	2827	66
F18-1	68	2580	113
F19-1	66	2626	105
G11-1	57	4001	81
G12-1	57	4076	80
G15-1*	60	1696	112
G15-2*	60	2096	113
G15-3	60	1958	104
G17-1	64	2041	115
H7-1	57	4406	141
H8-1	57	4034	136
H10-1*	57	2898	109
H10-2*	57	2616	110
H11-1	57	2574	84
H11-2	57	3259	87
H12-1	51	3016	81
H12-2	51	2672	85
H12-3	57	2570	75
I23-1*	66	3706	345
I24-2	66	4522	347
K23-1	66	4350	328
K23-2	33	4699	13
L23-1	33	4065	0
L23-2	33	4905	12
M8-1*	57	3811	218
M9-1*	57	3377	229
M9-2*	57	3424	227
M23-1*	22	4322	87
M23-2	33	4146	354
N21-1	33	3252	329
N21-2	24	3258	95
N22-1	33	3733	343
O22-1	23	3119	98
P4-1	12	4926	142
P7-1	17	3519	111
P22-1	23	1381	94
P22-4	23	1569	100
Q5-1	12	4109	145
Q17-1	27	3140	288
Q17-2	28	3031	292
Q17-3	8	3126	119
R17-1*	8	1942	137
S4-1	12	3508	176
S5-1*	12	3122	175
S15-1*	9	3396	157
S17-1*	8	2116	145
S17-2	9	1705	122
T5-1	12	2954	184
T6-1*	12	1533	197
T6-2	12	2582	199
T6-9	12	2256	190
T15-1	10	2467	153
T15-2	10	2273	155
U6-1*	12	2197	222
V20-1	7	2246	307
V20-2*	7	2148	302
V25-2	22	4562	293
W8-1	12	3305	275
W14-1	10	4172	209

Residence ID (*Associated)	Closest WTG to Residence	Distance to closest WTG (m)	Angle to closest WTG (deg)
W20-1*	7	2279	284
W22-1	7	4299	316
X17-1*	10	3677	256
X17-2*	10	3296	252
X17-3*	10	3515	257
X21-1	7	4808	301
X22-1	7	4767	307
Y15-1	10	4566	235
Y17-1	10	4133	265
Y17-2	10	3887	261
Y18-1	10	4142	274
Y19-1	10	4703	287
Y19-2	10	4591	285
Y19-3	10	4330	283
Y19-4	10	4390	288
Y19-5	10	4222	285
Y20-1	10	4453	301
Y20-2	7	4614	287
Y21-3	7	4800	296

APPENDIX G: Noise Prediction Contours

Figure G1: *Noise Prediction Contours*



APPENDIX H: Substation and Batch Plant Locations

Table H1: *Substation equipment locations and closest non-associated residence with distance between them*

Substation	Co-ordinates (UTM WGS84 56H)		Closest Non-associated Residence	Distance to closest non-associated Residence (m)
	Easting	Southing		
1a	315945	6426870	G17-1	2248
1b	317165	6427310	G17-1	3363
2	325810	6424920	S17-2	3302

Table H2: *Batch plant locations and closest uninvolved residence with distance between them*

Batch Plant	Co-ordinates (UTM WGS84 56H)		Closest non-associated Residence	Distance to closest non-associated Residence (m)
	Easting	Southing		
1	315885	6426830	G17-1	2205
2	325755	6424975	S17-2	3247
3	322130	6429805	Q17-2	2245