APPENDIX F NOISE AND VIBRATION ADVICE LETTER

sonus.

Hills of Gold Wind Farm Pty Limited
Level 33, Rialto South Tower
525 Collins Street
Melbourne VIC 3000

S6400C27

Attention: **Jamie Chivers** **13 December 2021**

Dear Jamie,

HILLS OF GOLD WIND FARM
RESPONSE TO SUBMISSIONS AND DESIGN CHANGES

Sonus previously conducted a Noise and Vibration Assessment of the proposed Hills of Gold Wind Farm, which was summarised in report "S6400C14", dated October 2020 (the ***Original Assessment***).

Following the release of the report, there have been a number of submissions from residents in the vicinity, additional information requested by the Environment Protection Authority (EPA) and small changes to the proposed project. The changes to the project relate to the location of turbines WP12, WP47 and WP50, removal of WP1, WP19, WP23, WP27 and WP30, additional possible batching plant and construction compound locations and alterations to the site access routes.

There have also been a number of development applications approved for new dwellings in the vicinity of the wind farm, which were not previously considered in the assessment.

This report provides:

- Responses to the resident submissions;
- The additional information requested by the EPA;
- An assessment of:
    - the relocated turbines WP50, WP47 and WP12 and the removal of WP1, WP19, WP23, WP27 and WP31;
    - the additional concrete batching location options and construction compound; and,
    - the changes to the site access routes and provision of residences where objective criteria may be exceeded during the peak of construction.
- Further details of the Development Application Dwellings in the vicinity of the wind farm.

RESPONSE TO RESIDENTS' SUBMISSIONS

Submission ID SE-13746714

Redo the Noise Monitoring Assessment without bellowing cattle and generator noise for one of the Non-Associated Dwellings

Background noise measurements (the noise monitoring assessment) are conducted using the "L_{A90}" descriptor. This descriptor records the lowest 10% of noise levels. That is, the highest 90% of the noise in every 10 minute period is excluded, which results in intermittent noise sources being excluded. Therefore, intermittent noise sources such as *bellowing cattle* or traffic on local roads do not increase the background noise levels.

If constant high noise sources had affected the results, the correlations would indicate high noise levels at low wind speeds. The noise from a constantly high source such as a generator would be most noticeable at low wind speeds and would result in a cluster of data points, at approximately the same noise level, for a wide range of wind speeds. The data do not indicate such clusters of data and therefore the generator has not artificially increased background noise levels.

Conduct noise assessments at Timor

Timor is located approximately 13km outside of the 30 dB(A) predicted noise level contour. The noise level at Timor is predicted to be well below 20 dB(A) and is therefore easily compliant with the NSW requirements.

Clarify if the different blade lengths influence wind turbine noise

Each wind turbine model has a sound power level specified by the manufacturer. Many factors contribute to the sound power level, including blade length, rotational speed and blade design. Early wind turbines had smaller blade lengths than contemporary designs, but generally had higher sound power levels. With the increase in blade length, improvements in technology, such as serrated trailing edges and lower rotating speed, have resulted in noise emissions being reduced.

The noise from the final turbine selection will be modelled and tested to ensure that the noise criteria are achieved.

Give detail of noise implications for two rock crushing facilities

The final location the rock crushing facilities has not yet been decided. The Noise and Vibration Assessment provides preliminary noise predictions for example distances from the facilities. The following is taken from the assessment:

Phase	**Main Plant and Equipment**	**Predicted Noise Level at Closest Dwelling** (1050m to activity)	**Outcome/Action**
Road Construction	Mobile crushing and screening plant Dozer Roller Low loader Tipper truck Excavator Scraper Transport truck	50 dB(A)	Predicted to exceed criterion at dwellings 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	49 dB(A)	Predicted to exceed criterion at dwellings 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.

Based on the above, activities which include mobile crushing and screening should include "feasible and reasonable" noise control strategies where residences are within 1,700m. It can be expected that similar distances and strategies would apply to any fixed rock crushing facility associated with the wind farm. "Feasible and reasonable" noise control strategies would include providing acoustic screens or earth mounding which blocks line of sight to the residences within 1,700m.

The assessment will be updated in the Construction Management Plan, once the final locations of this activity are known.

Address topography impacts in the Noise and Vibration Assessment. Local knowledge highlights that noise travels long distances in the Hills of Gold and Wind Turbine, Construction, Blasting and Traffic noise assessment do not take that into account.

The model used to predict the noise from the wind farm includes the topography as an input. Therefore, the local conditions are already inherently incorporated into the Noise and Vibration Assessment.

Take into account wildlife that is also affected by noise and vibration like humans, in the Noise and Vibration Assessment.

Noise levels from the operation of a wind farm are no greater than that of other noise levels in the environment. That is, the noise levels, even close to a wind turbine, are no greater than gusts of wind in trees, birds and other wildlife, cars on public roads or aircraft flying over.

Vibration levels under wind turbines have been measured and are considered acceptable for highly sensitive uses such as an operating theatre. The level of ground vibration from a wind turbine is often less than below a large tree which moves with the wind. This is because the turbines are designed to transfer energy into electrical power, rather than transferring it into the ground.

Submission ID SE-13577869

Background noise monitoring locations justification, specifically a response to why a background noise logger was not hosted around the Crawney Timor area.

Background noise logging locations are chosen based on the following hierarchy, subject to access being granted to the residence;

- Residences closest to the wind farm and having the highest predicted noise level; and,
- Residences in each direction from the wind farm.

At the time of the background noise monitoring regime, preliminary predictions indicated that Crawney was more than 2km outside the 30 dB(A) noise contour, while other residences had much higher noise levels predicted. In addition, although a residence was chosen on the southern side of the wind farm (in the direction of Crawney / Timor) for the noise monitoring, access was not granted.

RESPONSE TO EPA

If a reduced noise mode is intended to be used, Parameters and meteorological conditions in which this would be triggered should be provided.

Provide conditions in which reduced noise modes would be activated

Based on the predictions in the Noise and Vibration Assessment, noise reduced modes would need to be implemented at wind speeds of 8m/s and above. These required modes and resultant sound power levels are detailed in the Noise and Vibration Assessment.

It is noted that the above may change as a result of the final turbine selection and layout. An updated noise assessment will be provided for the final layout and turbine model, prior to construction. This final assessment will detail the noise levels at residences and the curtailment strategy (wind speeds directions and noise reduced mode for each turbine) to ensure the criteria are achieved. It will also incorporate a method of reporting to demonstrate that the modes have been implemented.

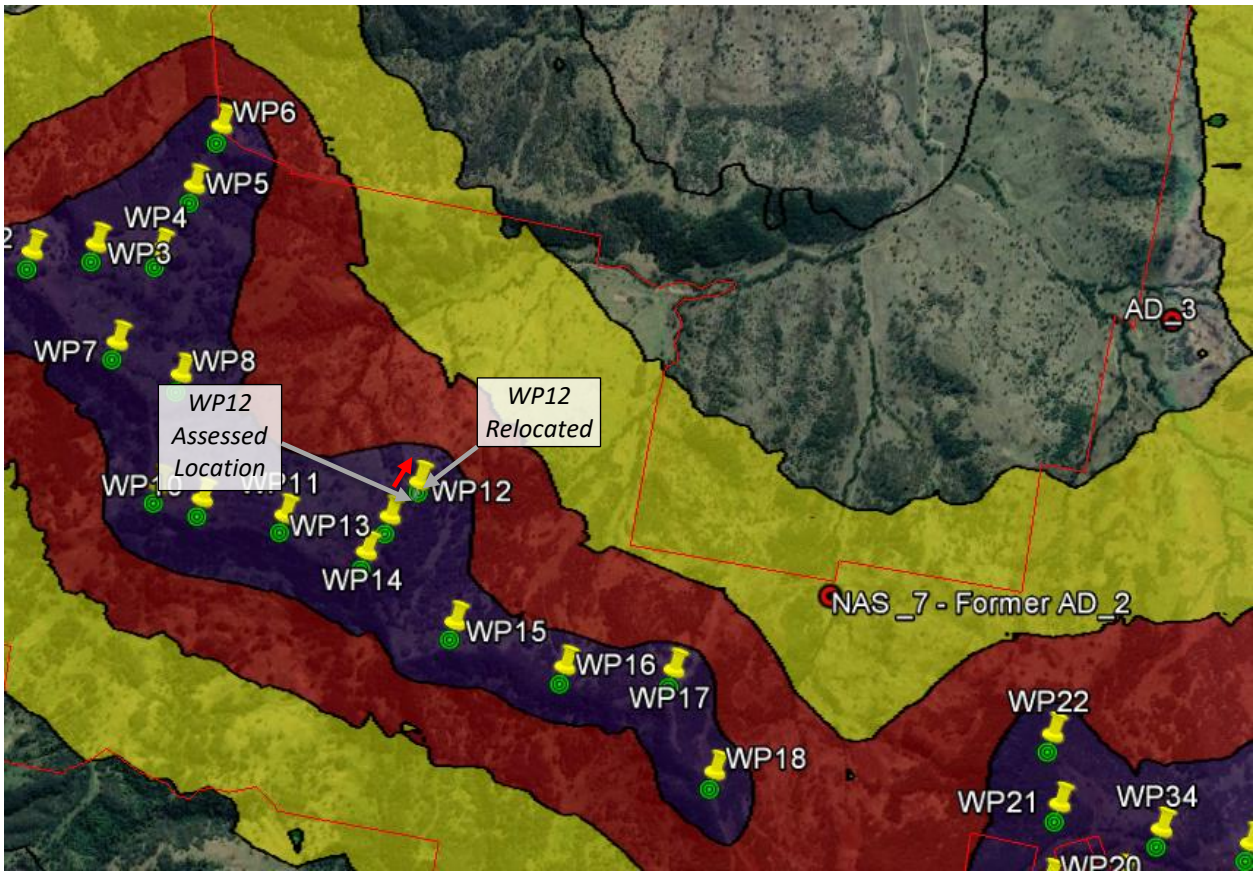
ASSESSMENT OF PROJECT CHANGES

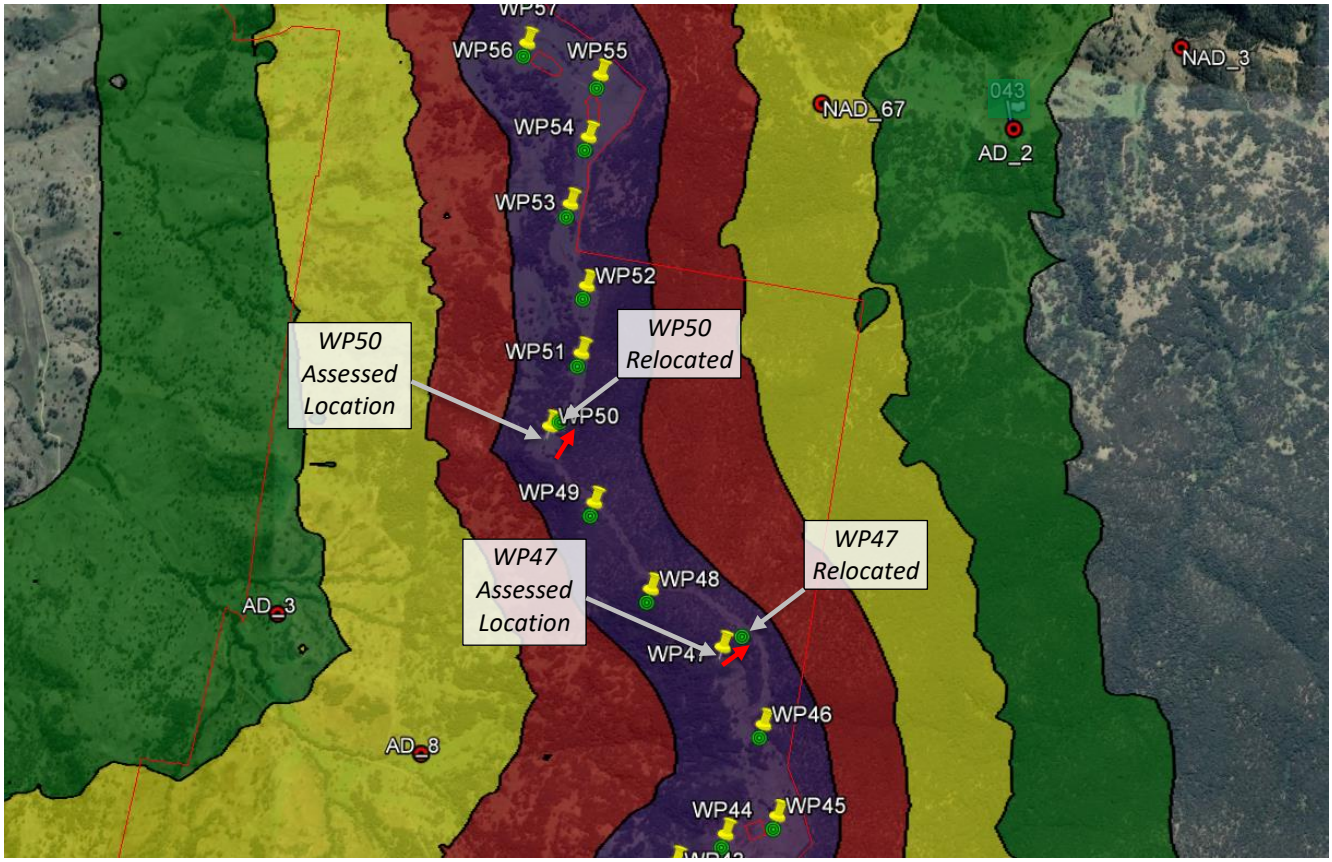
Turbine 12, 47 & 50 Relocation

It is proposed that the location of turbines WP12, WP47 and WP50 be moved to the northeast of their assessed locations. The coordinates of the turbine locations considered in the Original Assessment and the relocated coordinates are provided in the following table:

Turbine ID/Location	Coordinates (UTM WGS84 J56)		Approximate Distance Of Relocation
	Easting	Northing	
WP12 Assessed Location	*319102*	*6501480*	50m
WP12 Relocated	319126	6501524	
WP47 Assessed Location	*326890*	*6502554*	209m
WP47 Relocated	327035	6502705	
WP50 Assessed Location	*325789*	*6503902*	137m
WP50 Relocated	325872	6504011	

The revised locations will result in a negligible change in noise impact at receivers. The images below demonstrate that the relocations are either well separated from all dwellings (in the case of WP12) or are further away from the closest Associated Residences ("AD") and well separated from the nearest Non-Associated Residences ("NAD"). The previously assessed locations are shown as Yellow Pins and the relocated position shown as Green Circles. Given that there are other turbines much closer to the Non-Associated Residences and that the changes in location are relatively minor, the potential noise impact at these residences will not increase as a result of the changes.

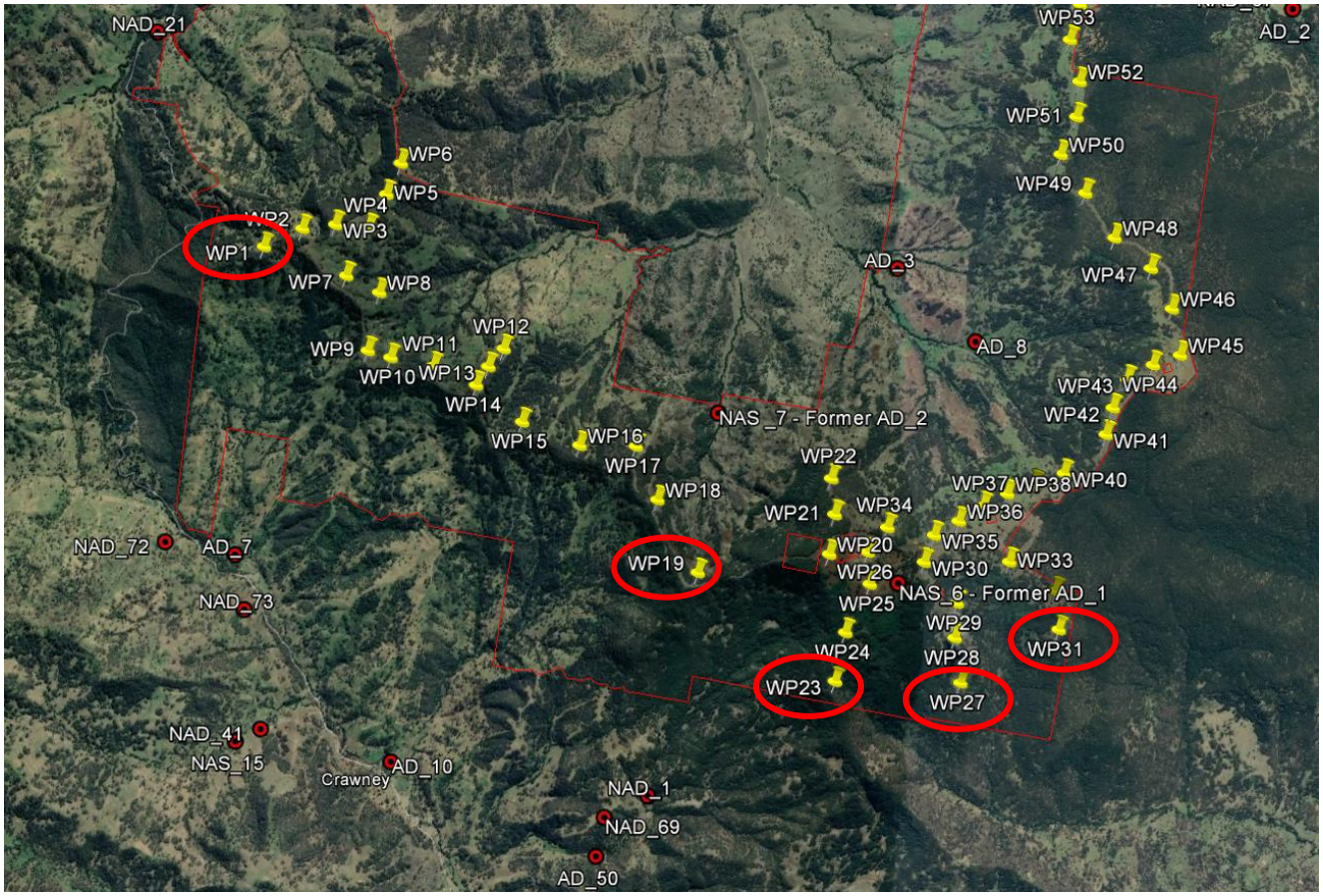




It is noted that prior to construction of the wind farm, the final wind turbine selection and layout will be modelled to ensure the objective project noise criteria are achieved. The final noise model will ensure these changes and any other micro-siting result in compliance with the criteria.

Removal of WP1, WP19, WP23, WP27 and WP31

It is proposed that turbines WP1, WP19, WP23, WP27 and WP31 be removed from the wind farm layout which was included in the Original Assessment. The subject turbines are shown in the following image.



The removal of turbines will not result in any higher noise levels at nearby residences than were predicted in the Noise and Vibration Assessment. It can be expected that noise levels will be marginally lower at NAD_1 and NAD_69 as a result of the turbine removal, therefore not changing compliance of the wind farm.

Batching Plant and Construction Compound Locations

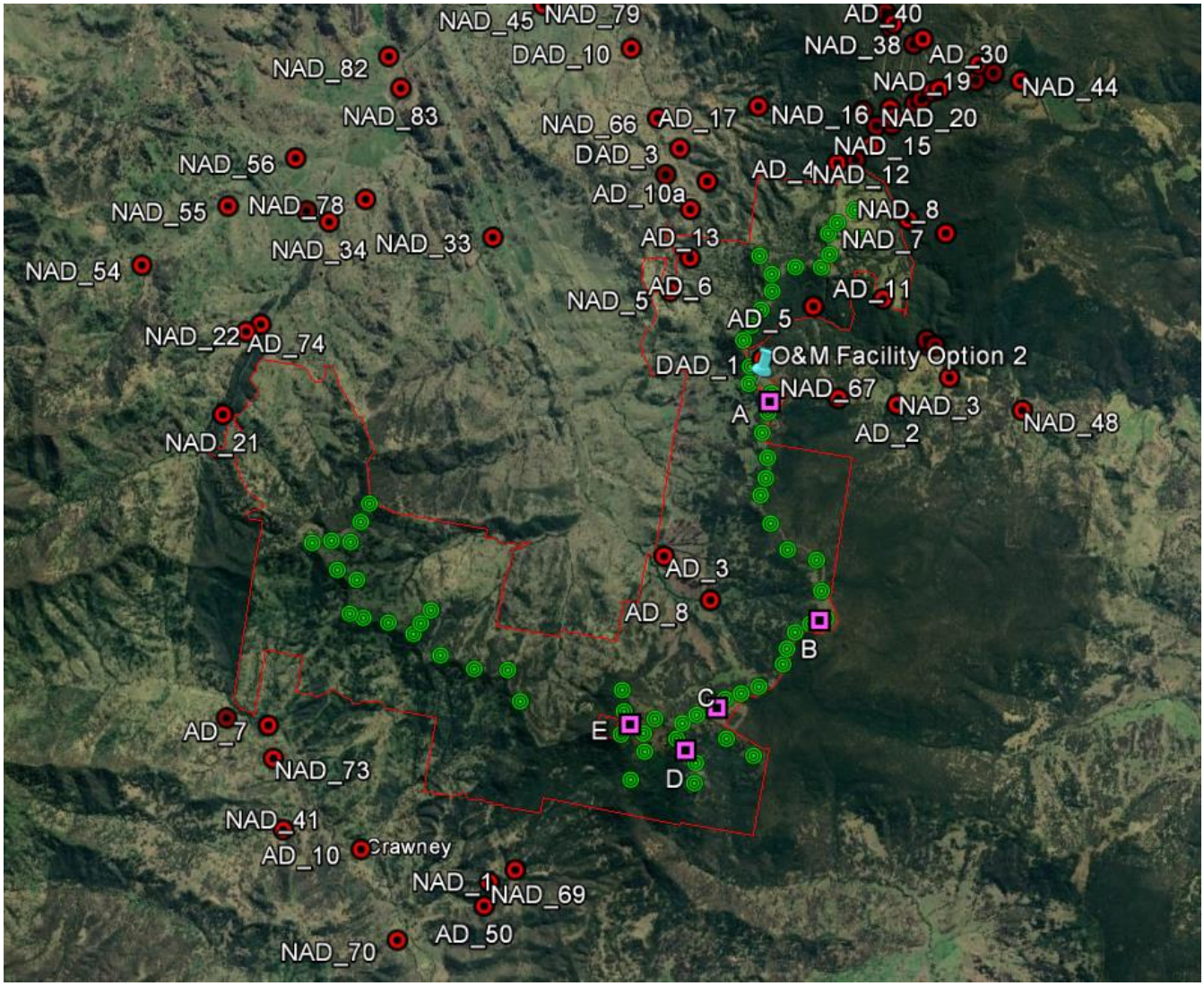
A mobile batching plant is proposed during construction. The two locations included in the Original Assessment are no longer being pursued and have been replaced by five new options to provide flexibility in construction operations. In addition, a second option for the construction compound has been identified, although only one will be constructed.

It is noted that the construction compound locations (now two) being considered are in the vicinity of the batching plants, at significant distances to any non-associated dwellings. They do not include any significant noise sources with the potential for a greater impact than batching plant and any larger equipment would only operate during the daytime period. The following assessment therefore considers the equipment and noise sources associated with batching activity, which occurs early in the morning, but would also ensure no adverse impact from the construction compound operations during the day time at the proposed sites.

The Original Assessment considered two locations for the batching plant, as summarised in the table below. These locations have now been replaced by the five locations labelled as A to E, which were previously only considered as laydown areas. A map showing the locations is also provided below.

ID	Approximate Coordinates (UTM WGS84 J56)	
	Easting	Northing
Original Assessment Locations		
1	*320548*	*6502812*
2	*327195*	*6508738*

ID	Approximate Coordinates (UTM WGS84 J56)	
	Easting	Northing
Revised Batching Locations		
A	326044	6505957
B	327140	6501513
C	325068	6499684
D	324444	6498799
E	323277	6499300



The noise level from each of the proposed batching plant locations has been predicted using the methodology in the Original Assessment. The predicted noise levels at residences have been compared against the management level of 35 dB(A) for a residence being "Noise affected", as described in the Original Assessment.

Based on the predictions, all locations are at a separation distance of approximately 1440m or more from Non Associated Residences.

Based on the five proposed batching locations, the prediction table from the Original Report has been updated and is provided below. The updates relate to the noise level resulting at the new minimum separation distance of 1440m and the change in "Noise Affected" residence (those at a distance of 2400m or less to the activity) for the new locations.

Phase	Main Plant and Equipment	Predicted Noise Level at Closest Dwelling	Outcome/Action
Batching *(Assessed Locations)*	*Front end loader* *Truck*	*38 dB(A)* *(2000m from Dwelling)*	*Predicted to exceed criterion at dwellings within 2,400m of the construction activity (NAD_8 and NAD_11).* *Implement "feasible and reasonable" noise control strategies to minimise noise during construction in accordance with the recommendations below.*
Batching (Revised Batching Locations)	Front end loader Truck	40 dB(A) (1440m from Dwelling, NAD_67)	Predicted to exceed criterion at dwellings within 2,400m of the construction activity (NAD_67). Implement "feasible and reasonable" noise control strategies to minimise noise during construction in accordance with the recommendations below.

As the predicted noise level at the closest residence exceeds the 35 dB(A) "Noise affected" management level, "feasible and reasonable" noise control measures which should be applied at the concrete batching locations to achieve the intent of the Interim Construction Noise Guideline. The Original Assessment provides further information on "feasible and reasonable" noise control measures which should be applied.

Changes to Traffic Route

The proposed access route options to the wind farm previously included two separate tracks, being either:

- Head of Peel Road; or,
- Barry Road and Morrisons Gap Road.

The previous noise predictions were based on the conservative assumption that all vehicles would use a single route, being either of the above options.

The transport route has now been updated to remove Head of Peel Road, with all traffic now proposed to use the Barry Road and Morrisons Gap Road access track.

Given all traffic was assumed to use a single access route, the proposal to remove one of the access tracks therefore will not result in increased noise levels at residences, above that which were provided in the Original Assessment.

In addition, the number of trips to and from the wind farm site during the peak of construction has been reduced with the project changes. The following table compares the number of trips considered in the Original Assessment and the number of trips now predicted.

The table also provides the predicted noise level at 25m from highways and 10m from a road within townships (corresponding to the predictions and distances provided in the Original Assessment).

	Assumed Number of Trips within 1 Hour		**Predicted Noise Level at a Residence**	
	Light Vehicles	**Heavy Vehicles**	**25m from the Road (country road)**	**10m from the road (within township)**
Original Assessment	109	18	58 dB(A)	60 dB(A)
Revised Project	70	10	56 dB(A)	58 dB(A)

The predictions demonstrate that the revised project would result in noise levels being 2 dB(A) less than that in the Original Assessment.

The Original Assessment was based on the preliminary access routes and was conservatively compared against the “Local Roads” criterion of 55 dB(A) under the *Department of Environment, Climate Change and Water NSW Road Noise Policy* (the Road Noise Policy).

The assessment has now been updated based on the final access route (being Barry Road and Morrisons Gap Road), which includes the "Sub-Arterial Roads" of Oakenville Street and Barry Road. The criterion for these sub-arterial roads under the Road Noise Policy is an average noise level of 60 dB(A).

It was noted in the Original Assessment that the noise criterion of 55 dB(A) was predicted to be exceeded during the peak of construction activity. As provided above however, the highest noise level at a residence is 58 dB(A) during the peak of construction activity and would therefore achieve the most relevant 60 dB(A) criterion for sub-arterial roads.

Residences along the final access route have been identified and those with the highest predicted traffic noise levels during the peak of construction are included in the table below.

Dwelling ID	Distance to Road	Residence Coordinates		Predicted Noise Level (dB(A))
		Easting	Northing	
TR1	11m	322218	6517795	58
TR2	11m	328439	6514703	58
TR3	12m	322240	6517788	57
TR4	12m	322230	6517792	57
TR5	16m	322292	6517743	56
TR6	17m	328126	6515339	56
TR7	18m	322107	6517801	56
TR8	19m	324386	6516929	55
TR9	19m	328019	6515604	55
TR10	20m	323395	6517912	55
TR11	20m	322111	6517839	55

These residences are on the transport route either in the township of Nundle, or between Nundle and the Wind Farm. It is understood that for these roads, vehicles accessing the site will travel at reduced speeds (heavy vehicles at less than 50km/hr, passenger vehicles less than 80km/hr), rather than at highway speeds.

The following images show the location of the residences identified above, relative to the access route.

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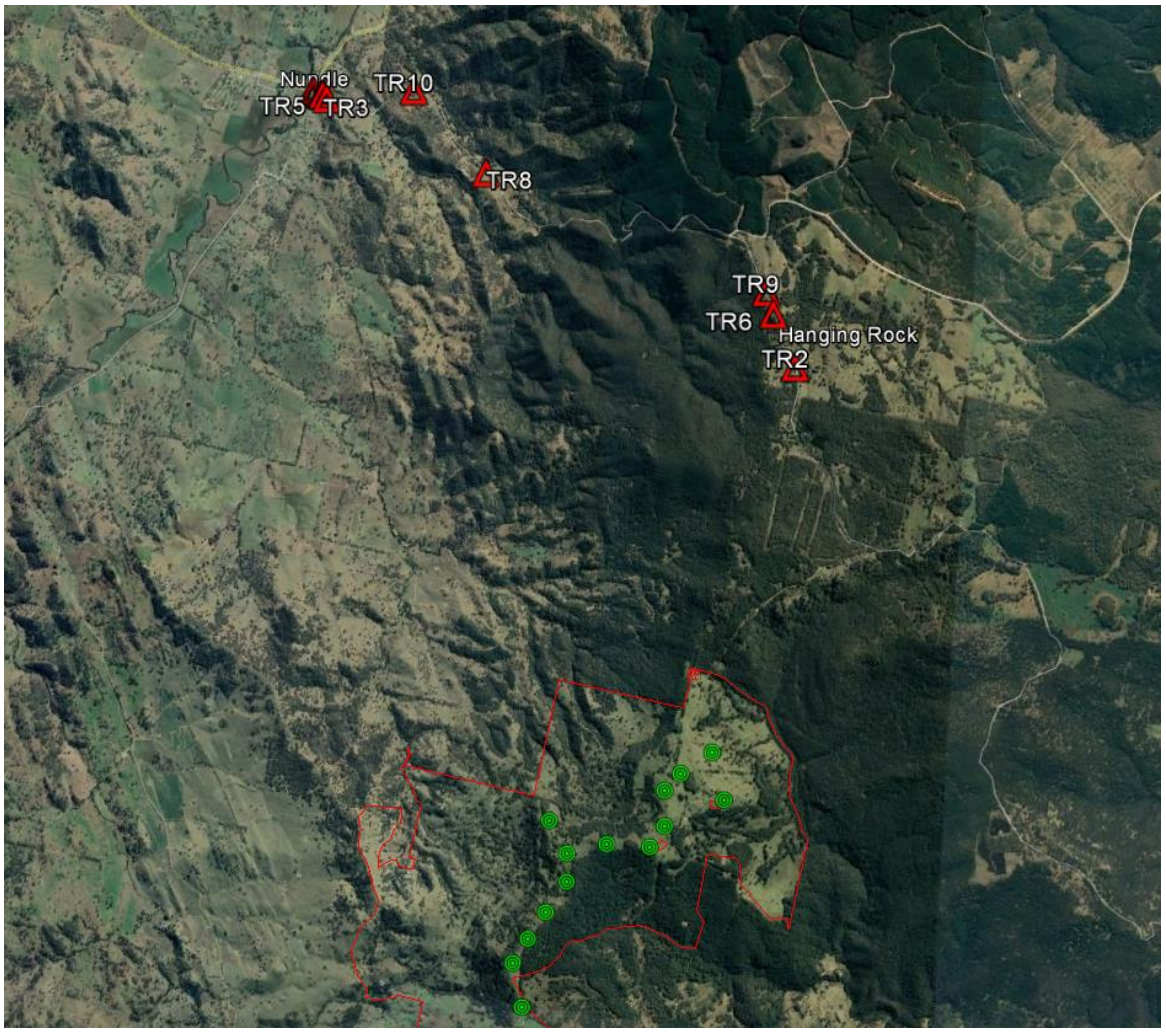

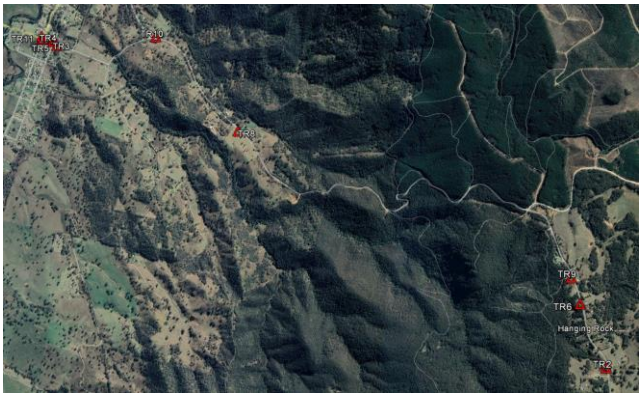

As these residences are adjacent to sub-arterial roads, the noise criteria under the Road Noise Policy are therefore predicted to be achieved, even during the peak of construction activity.

DEVELOPMENT APPLICATION DWELLINGS

Since the Original Assessment, a total of three dwellings have been granted approval to be constructed in the vicinity of the wind farm. It is not known if these dwellings will be constructed, however each location has been assessed against the project noise criteria to determine the potential impact. The assessments determine the noise level at each location and the changes needed to ensure compliance with the noise criteria, should they be constructed.

The assessments are summarised in the reports provided as Appendix A.

Yours faithfully
Sonus Pty Ltd

Chris Turnbull
Principal

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Appendix A: Development Application Dwelling Reports

Hills of Gold Wind Farm

Noise Assessment for Approved Dwelling (DAD_1)

August 2021

S6400C22

sonus.

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Document Title	:	Hills of Gold Wind Farm Noise Assessment for Approved Dwelling (DAD_1)
Document Reference	:	S6400C22
Date	:	August 2021
Author	:	Chris Turnbull, MAAS
Reviewer	:	Alexander Lee, MAAS

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).
Background noise level	The ambient noise level which excludes intermittent noise sources.
C-weighting	Frequency adjustment applied to measured noise levels to indicate low frequency content.
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.
dB(C)	C-weighted noise in decibels.
EPA	Environment Protection Authority.
Equivalent noise level	Energy averaged noise level over a period of time.
$L_{A90, \text{ time period}}$	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	The Rating Background Level is an overall, single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period
SA Noise Guidelines	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.
NPI	New South Wales Environment Protection Authority *Noise Policy for Industry* (2017).
The Project	Hills of Gold Wind Farm
The Bulletin	New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (2016).
Weather category 6	The CONCAWE weather conditions which is most conducive for the propagation of noise, resulting in highest predicted noise levels.
Worst-case	Operational and weather conditions which result in the highest noise level at dwelling
WTG	Wind turbine generator.

1 INTRODUCTION

Sonus has previously conducted an assessment of the environmental noise from the proposed Hills of Gold Wind Farm (the **Project**). The Project is located approximately 50km south of Tamworth, New South Wales (NSW).

Since preparing the original assessment, a request has been made by Herbert Smith Freehills (on behalf of Hills of Gold Wind Farm Pty Ltd) to prepare a report, which addresses

> *… the likely impacts of the Project on the level of noise experienced at the dwelling at Glen Rai 828 Morrisons Gap Road Hanging Rock NSW 2340 (Lot 47 in DP 753722), which is the subject of Complying Development Certificate PrivCD2021/0123 (accepted 12 November 2020).*

The assessment has been made based on the current wind turbine layout, consisting of up to 68 wind turbine generators (WTGs). It also considers the ancillary infrastructure layout, including a switching station, and a substation. The noise from the proposed batching plants and construction activity has not been considered in this report as it is unlikely to constrain the layout of the project in the way that operational noise levels might.

The NSW Department of Planning and Environment has provided *Secretary's Environmental Assessment Requirements* (SEARS) for the assessment of noise and vibration from the Project. The NSW EPA has also provided *Environmental Assessment Requirements* (EARS) relating to operation of the wind farm in a separate letter, which are addressed by the SEARs. The noise and vibration related sections of the SEARS and EARs are provided in Appendix A of this report.

This assessment considers the resulting noise levels at the approved dwelling in comparison to the requirements of the SEARS and EARs. The assessment provides predictions of the noise levels as a result of operation of the wind farm and compares the levels against relevant criteria.

2 PROJECT LAYOUT

The coordinates of the 68 WTG layout are provided in Table 1 and the locations of the ancillary infrastructure are provided in Table 2.

It is noted that the layout considered in this assessment includes the removal of WP19 and WP23, as well as the relocation of WP74, which are recent changes. These are highlighted below as **RED** text.

Table 1: Coordinates of wind turbine layout.

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP1	316191	6502649
WP2	316660	6502870
WP3	317062	6502923
WP4	317449	6502903
WP5	317647	6503321
WP6	317818	6503696
WP7	317184	6502322
WP8	317589	6502127
WP9	317453	6501426
WP10	317732	6501347
WP11	318251	6501256
WP12	319102	6501480
WP13	318924	6501259
WP14	318778	6501033
WP15	319341	6500599
WP16	320042	6500329
WP17	320736	6500326
WP18	321007	6499685
~~WP19~~	~~321513~~	~~6498816~~
WP20	323083	6499077
WP21	323138	6499551
WP22	323096	6499977
~~WP23~~	~~323199~~	~~6497538~~
WP24	323308	6498134
WP25	323581	6498726
WP26	323546	6499107
WP27	324704	6497556
WP28	324613	6498100
WP29	324632	6498515
WP30	324229	6498998
WP31	325873	6498218
WP32	325819	6498682
WP33	325258	6499019
WP34	323773	6499406
WP35	324342	6499322
WP36	324635	6499495
WP37	324928	6499683
WP38	325217	6499831
WP39	325543	6499949
WP40	325908	6500089

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP41	326394	6500562
WP42	326467	6500881
WP43	326624	6501222
WP44	326930	6501400
WP45	327249	6501520
WP46	327153	6502077
WP47	327039	6502711
WP48	326439	6502906
WP49	326079	6503434
WP50	325789	6503902
WP51	325975	6504360
WP52	326002	6504778
WP53	325888	6505289
WP54	325995	6505707
WP55	326064	6506092
WP56	325597	6506290
WP57	325618	6506645
WP58	325469	6507177
WP59	325633	6507483
WP60	325827	6507814
WP61	326056	6508202
WP62	326036	6508551
WP63	325788	6508927
WP64	326519	6508699
WP65	327050	6508701
WP66	327215	6508969
WP67	327185	6509403
WP68	327367	6509623
WP69	327737	6509901
WP70	327922	6509331

Table 2: Coordinates of Ancillary Infrastructure.

ID	Approximate Coordinates (UTM WGS84 J56)	
	Easting	Northing
Sub-Station		
1	*323393*	*6499304*
Switching Station		
1	303376	6510523

The location of the approved dwelling is provided in Table 3 below.

Table 3: Approved Dwelling Location

Dwelling ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
DAD_1	325891	6506835

3 SEARS AND EARS

The noise related SEARs for the Project specify that the following must be considered for the operation of the wind farm:

- *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);*

In response to consultation regarding the content of the SEARs, the NSW EPA provided its EARs, which are consistent with the SEARS in relation to the noise from the wind farm operation.

3.1 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 wind turbines.

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

The Bulletin states:

> [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 [the SA Noise Guidelines] will be applied in NSW. This Criteria is 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."

3.1.1 Special Noise Characteristics

The Bulletin prescribes a 5 dB(A) penalty adjustment (added to the measured or predicted noise level) for the presence of repeated and excessive tonality and/or low frequency which occurs for more than 10 percent of an assessment period. Excessive tonality and low frequency are determined as follows:

Tonality

The Bulletin references the methodology described in *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)*. Excessive tonality is present at a particular one-third octave band level if the band level exceeds the adjacent bands on both sides by at least:

- 5 dB , if the centre frequency of the band is in the range 500 Hz to 10,000 Hz;
- 8 dB, if the centre frequency of the band is in the range 160 Hz to 400 Hz; and/or
- 15 dB, if the centre frequency of the band is in the range 25 Hz to 125 Hz.

The penalty for tonality only applies if the tone from the wind farm is audible at the receiver location. The absence of a tone at an intermediate location will be sufficient to demonstrate that the wind farm noise at the relevant receiver location is non-tonal.

Low Frequency Noise

Excessive low frequency noise is present if the low frequency noise levels at the receiver location exceed 60 dB(C).

3.2 Ancillary Infrastructure

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

The NPI establishes *noise trigger levels* based on either the:

- existing background noise environment (intrusiveness noise levels); or,
- the amenity for particular land uses (amenity noise levels).

The *noise trigger levels* are the lower of the values provided by the two methods, which in a rural environment will generally be the *intrusiveness noise levels.*

In accordance with the NPI, the Rating Background Level (**RBL**) is used to determine 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.

Further detail is provided regarding the existing background noise environment and resulting criteria in the Ancillary Infrastructure Section of this report.

4 WIND TURBINE OPERATION

4.1 Criteria

The operational noise criteria for the Project are presented in Sonus report "S6400C10" (the **Background Noise Report**). The Background Noise Report provides Project specific noise criteria for each of the dwellings in the vicinity of the wind farm based on the procedures contained in the Bulletin, the SA Noise Guidelines and the outcomes of background noise monitoring at reference locations in the vicinity of the wind farm.

Based on the approach in the Background Noise Report, noise criteria have been assigned to the approved dwelling location based on the noise logging conducted at AD_2. The following table provides the criteria based on this method.

Table 4: Project Noise Criteria – Wind Turbine Noise

	Representative Noise Logging Location	Wind Speed (m/s) at 150m									
		3	4	5	6	7	8	9	10	11	12
DAD_1 Noise Criteria (dB(A))	AD_2	35	35	35	35	35	35	35	35	35	35

Notwithstanding the above, there is the potential that background noise levels at the approved dwelling location may differ from those at the assigned representative logging location. In particular, the approved dwelling location is is at a higher elevation in comparison to the representative location and therefore wind speeds and the noise from wind in trees might be higher. As a result, conducting additional noise monitoring at the approved dwelling location has the potential to increase the criteria at some wind speeds.

4.2 Assessment

Noise Sources

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

- A candidate wind turbine for the project, with a hub height of 150m;[1]
- Sound Power Levels for the representative wind turbine, as provided in the following table for the "Normal" operating mode.

[1] The assessment is based on the highest hub height being considered and is a conservative approach. For lower hub heights, the noise criteria which are adjusted for background noise would be less onerous.

Table 5: *WTG Sound Power Level – "Normal" Operating Mode.*

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

It is noted that the sound power levels for the representative turbine are at the lower end of the range for modern turbines. The outcomes of this report could therefore change where an alternate turbine is selected which has a higher sound power level.

The Bulletin requires that the WTG noise level be adjusted where excessive levels of tonality and/or low frequency noise is identified to a maximum adjustment of 5 dB(A). This assessment has been made based on the assumption that the turbine model selected for the project will be free of any excessive levels of tonality or any other special noise characteristics.

The assumption has been confirmed for the representative wind turbine model by reviewing the 1/3 octave band data. This confirms that the noise from the operation of this turbine model would not incur a penalty for the characteristic of tonality. The application of a penalty for the noise character of low frequency is discussed further below.

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 dwellings;
- 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, which have been widely accepted for the assessment of wind turbine noise:

- weather category 6 (representing a temperature inversion and wind conditions that assist with the propagation of noise);
- atmospheric conditions at 10°C and 80% relative humidity (representing conditions that result in low levels of noise absorption from the atmosphere);
- wind direction from all noise sources to the particular dwelling under consideration, even in circumstances where sources are located in opposite directions from the dwelling (representing the absolute worst-case noise propagation from the wind). This will overestimate the predicted noise level where receptors have WTGs located around them in more than a singular direction or quadrant as wind is not able to blow in more than one directional quadrant simultaneously;
- acoustically soft ground (representing the pastoral nature of the land); and,
- maximum barrier attenuation from topography of 2 dB(A) (representing a conservative assessment of any shielding provided by topography).

Noise Predictions

The operational noise level outside of the approved dwelling has been predicted for all integer wind speeds from cut in to rated power and compared with the relevant criterion as outlined in Table 6. Where the predicted noise level exceeds the operational noise criterion, it is shown in **RED**.

Table 6: *Wind Farm Noise Predictions at dwellings.*

Dwelling ID	Noise Level at Hub Height integer wind speeds, 150m AGL (dB(A))																			
	3 m/s		4 m/s		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s	
	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
DAD_1	35	37	35	38	35	38	35	41	35	44	35	47	35	48	35	48	35	48	35	48

The highest predicted low frequency noise level at the approved dwelling is 62 dB(C) for high wind speeds (above 9m/s), which is greater than the 60 dB(C) criterion. Therefore, a penalty for excessive low frequency noise would need to be added to the predicted noise level provided above. It is noted that where the wind farm layout is modified such that the criteria in Table 6 are achieved, the low frequency noise level would be reduced to a level which would not warrant a penalty.

Based on the predictions above, without any noise mitigation measures, the noise from the 68 WTGs will not achieve the operational noise criteria at the approved dwelling by a significant margin (18 dB(A) when including a penalty for low frequency).

Noise Mitigation

Predictions have been made to determine the number of turbines which would need to be removed to achieve the criteria under all wind speeds.

Based on ranking the contribution of noise from each WTG, a total of nine (9) turbines would need to be removed from the layout to achieve the noise criteria. The following table provides the nine (9) turbines to be removed, resulting in a noise level of 35 dB(A) at high wind speeds (lower noise levels are predicted for lower wind speeds).

Table 7: *Wind turbines requiring removal.*

Turbines Requiring Removal
WP53
WP54
WP55
WP56
WP57
WP58
WP59
WP60
WP61

Should the criterion be increased at specific wind speeds as a result of additional noise monitoring, the number of turbines requiring removal may be less.

Given that the noise assessment has been made based on a representative background noise monitoring location, the currently proposed WTG and layout, the turbines requiring removal might change as the Project develops.

5 ANCILLARY INFRASTRUCTURE - SUBSTATIONS

5.1 Criteria

The NPI 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 level* is the lower value provided by the two methods.

In order to determine the appropriate noise criteria, reference is made to the Background Noise Report. The background noise environment was monitored at a number of dwellings in the vicinity of the wind farm and was often below 30 dB(A). Therefore, in accordance with the NPI, the minimum RBL becomes 30 dB(A) during the evening and night and 35dB(A) during the day.

As such, for activity occurring during the day, evening and night, the noise trigger level is based on the *project intrusiveness noise level* of 35 dB(A).

If noise assessed under the NPI 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 dwelling before comparison with the project *noise trigger levels*.

5.2 Assessment

Noise Sources

The Project will comprise of a single substation and one switching station, both at significant distances from the approved dwelling, DAD_1.

There is not proposed to be any significant noise sources at the switching station and therefore the assessment does not consider the location as a noise source.

The proposed substation will include transformers which have been assessed against the objective noise criteria.

The predictions have been made based on a high-voltage transformer(s) with an overall capacity of 500MVA. The sound power level for the prediction has been determined derived from the Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD)* and is summarised in the following table.

Table 8: *500 MVA substation transformer sound power levels.*

Octave Band Centre Frequency (Hz)	Sound Power Level (dB(A) re 1 pW)
63 Hz	83
125 Hz	91
250 Hz	98
500 Hz	101
1,000 Hz	93
2,000 Hz	90
4,000 Hz	83
Total	**104**

Noise Predictions

Based on the predictions of the current ancillary infrastructure layout and the assumed size of the Substation, a noise level of less than 20 dB(A) is predicted at the approved dwelling, therefore easily achieving the criteria.

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 dwellings. Notwithstanding, the preliminary predictions have been based on the inclusion of a penalty.

6 CONCLUSION

An assessment has been made of the potential impact on Project layout, which may result from noise at an approved dwelling in the vicinity of the proposed Hills of Gold Wind Farm.

The assessment has been made based on the requirements of the "Secretary's Environmental Assessment Requirements" issued for the Project (SSD 9679) dated 22 November 18.

Noise predictions have been made for the 68 WTG layout and the substation operation. Based on the predictions, the noise from operation of WTGs would exceed the criteria by a significant margin and would require the removal of nine (9) WTGs from the current layout. The noise from the operation of the site substation is predicted to easily achieve the noise criteria without any Project changes.

APPENDIX A: Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs)

Environmental Assessment Requirements **Section 4.12 (8A) of the *Environmental Planning and Assessment Act 1979*** **Schedule 2 of the *Environmental Planning and Assessment Regulation 2000***	
Application Number	SSD 9679
Development	Hills of Gold Wind Farm which includes: The construction, operation and decommissioning of a wind farm with: • a maximum of 97 turbines, a maximum of 410 megawatts (MW) and maximum height of 220 metres (to blade tip); and • ancillary infrastructure including access tracks, road upgrades, battery storage, underground and overhead electricity cabling, substations and grid connection to the 330 kV Liddell to Tamworth transmission line.
Location	Morrisons Gap Road, Hanging Rock
Proponent	Wind Energy Partners
Date of Issue	22 November 2018

...

	Noise and Vibration – the EIS must: • 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 (DECC, 2006);

...

Noise and Vibration	
	NSW Wind Energy: Noise Assessment Bulletin (EPA/DPE)
	NSW Noise Policy for Industry (EPA)
	Interim Construction Noise Guidelines (EPA)
	NSW Road Noise Policy (EPA)
	Assessing Vibration: A Technical Guideline (EPA)
	Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZEC)

ATTACHMENT A: Environmental Assessment Requirements – EAR (SSD 9679) – 'Hills of Gold' Windfarm.

4. Noise and Vibration

The EA must assess the following noise and vibration aspects of the proposed development

4.1. Construction noise associated with the proposed development should be assessed using the *Interim Construction Noise Guideline (*DECC, 2009). These are available at:https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

4.2. Vibration from all activities (including construction and operation) to be undertaken on the premises should be assessed using the guidelines contained in the *Assessing Vibration: a technical guideline* (DEC, 2006). These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/assessing-vibration

4.3. If blasting is required for any reasons during the construction or operational stage of the proposed development, blast impacts should be demonstrated to be capable of complying with the guidelines contained in *Australian and New Zealand Environment Council – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC, 1990).These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

Industry

4.4. Operational noise from all industrial activities (including private haul roads) to be undertaken on the premises should be assessed using the guidelines contained in the *NSW Noise Policy for Industry* (EPA, 2017). https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)

Wind Farms

4.5. Operational noise activities from Wind Farms should be accessed against the South Australian EPA's *Wind Farm- Environmental Noise Guidelines* (2009) and the DPE's *Wind Energy: Noise Assessment Bulletin* (2016), available at: www.planning.nsw.gov.au/~/media/Files/DPE/Bulletins-and-Community-Updates/wind-energy-noise-assessment-bulletin-2016-12.ashx

Roads

4.6. Noise on public roads from increased road traffic generated by land use developments should be assessed using the guidelines contained in the *NSW Road Noise Policy* and associated application notes (EPA, 2011).https://www.epa.nsw.gov.au/your-environment/noise/transport-noise

Hills of Gold Wind Farm

Noise Assessment for Approved Dwelling (DAD_2)

August 2021

S6400C23

sonus.

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Document Title	:	Hills of Gold Wind Farm Noise Assessment for Approved Dwelling (DAD_2)
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Author	:	Chris Turnbull, MAAS
Reviewer	:	Alexander Lee, MAAS

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).
Background noise level	The ambient noise level which excludes intermittent noise sources.
C-weighting	Frequency adjustment applied to measured noise levels to indicate low frequency content.
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.
dB(C)	C-weighted noise in decibels.
EPA	Environment Protection Authority.
Equivalent noise level	Energy averaged noise level over a period of time.
$L_{A90, \text{ time period}}$	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	The Rating Background Level is an overall, single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period
SA Noise Guidelines	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.
NPI	New South Wales Environment Protection Authority *Noise Policy for Industry* (2017).
The Project	Hills of Gold Wind Farm
The Bulletin	New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (2016).
Weather category 6	The CONCAWE weather conditions which is most conducive for the propagation of noise, resulting in highest predicted noise levels.
Worst-case	Operational and weather conditions which result in the highest noise level at dwelling
WTG	Wind turbine generator.

1 INTRODUCTION

Sonus has previously conducted an assessment of the environmental noise from the proposed Hills of Gold Wind Farm (the **Project**). The Project is located approximately 50km south of Tamworth, New South Wales (NSW).

Since preparing the original assessment, a request has been made by Herbert Smith Freehills (on behalf of Hills of Gold Wind Farm Pty Ltd) to prepare a report, which addresses

> *… the likely impacts of the Project on the level of noise experienced at the dwelling at Morrisons Gap Road Hanging Rock NSW 2340 (Lot 2 in DP712947).*

The assessment has been made based on the current wind turbine layout, consisting of up to 68 wind turbine generators (WTGs). It also considers the ancillary infrastructure layout, including a switching station, and a substation. The noise from the proposed batching plants and construction activity has not been considered in this report as it is unlikely to constrain the layout of the project in the way that operational noise levels might.

The NSW Department of Planning and Environment has provided *Secretary's Environmental Assessment Requirements* (SEARS) for the assessment of noise and vibration from the Project. The NSW EPA has also provided *Environmental Assessment Requirements* (EARS) relating to operation of the wind farm in a separate letter, which are addressed by the SEARs. The noise and vibration related sections of the SEARS and EARs are provided in Appendix A of this report.

This assessment considers the resulting noise levels at the approved dwelling in comparison to the requirements of the SEARS and EARs. The assessment provides predictions of the noise levels as a result of operation of the wind farm and compares the levels against relevant criteria.

2 PROJECT LAYOUT

The coordinates of the 68 WTG layout are provided in Table 1 and the locations of the ancillary infrastructure are provided in Table 2.

It is noted that the layout considered in this assessment includes the removal of WP19 and WP23, as well as the relocation of WP74, which are recent changes. These are highlighted below as **RED** text.

Table 1: Coordinates of wind turbine layout.

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP1	316191	6502649
WP2	316660	6502870
WP3	317062	6502923
WP4	317449	6502903
WP5	317647	6503321
WP6	317818	6503696
WP7	317184	6502322
WP8	317589	6502127
WP9	317453	6501426
WP10	317732	6501347
WP11	318251	6501256
WP12	319102	6501480
WP13	318924	6501259
WP14	318778	6501033
WP15	319341	6500599
WP16	320042	6500329
WP17	320736	6500326
WP18	321007	6499685
~~WP19~~	~~321513~~	~~6498816~~
WP20	323083	6499077
WP21	323138	6499551
WP22	323096	6499977
~~WP23~~	~~323199~~	~~6497538~~
WP24	323308	6498134
WP25	323581	6498726
WP26	323546	6499107
WP27	324704	6497556
WP28	324613	6498100
WP29	324632	6498515
WP30	324229	6498998
WP31	325873	6498218
WP32	325819	6498682
WP33	325258	6499019
WP34	323773	6499406
WP35	324342	6499322
WP36	324635	6499495
WP37	324928	6499683
WP38	325217	6499831
WP39	325543	6499949
WP40	325908	6500089

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP41	326394	6500562
WP42	326467	6500881
WP43	326624	6501222
WP44	326930	6501400
WP45	327249	6501520
WP46	327153	6502077
WP47	327039	6502711
WP48	326439	6502906
WP49	326079	6503434
WP50	325789	6503902
WP51	325975	6504360
WP52	326002	6504778
WP53	325888	6505289
WP54	325995	6505707
WP55	326064	6506092
WP56	325597	6506290
WP57	325618	6506645
WP58	325469	6507177
WP59	325633	6507483
WP60	325827	6507814
WP61	326056	6508202
WP62	326036	6508551
WP63	325788	6508927
WP64	326519	6508699
WP65	327050	6508701
WP66	327215	6508969
WP67	327185	6509403
WP68	327367	6509623
WP69	327737	6509901
WP70	327922	6509331

Table 2: Coordinates of Ancillary Infrastructure.

ID	Approximate Coordinates (UTM WGS84 J56)	
	Easting	Northing
Sub-Station		
1	*323393*	*6499304*
Switching Station		
1	303376	6510523

The location of the approved dwelling is provided in Table 3 below.

Table 3: Approved Dwelling Location

Dwelling ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
DAD_2	327332	6510716

3 SEARS AND EARS

The noise related SEARs for the Project specify that the following must be considered for the operation of the wind farm:

- *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);*

In response to consultation regarding the content of the SEARs, the NSW EPA provided its EARs, which are consistent with the SEARS in relation to the noise from the wind farm operation.

3.1 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 wind turbines.

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

The Bulletin states:

> [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 [the SA Noise Guidelines] will be applied in NSW. This Criteria is 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."

3.1.1 Special Noise Characteristics

The Bulletin prescribes a 5 dB(A) penalty adjustment (added to the measured or predicted noise level) for the presence of repeated and excessive tonality and/or low frequency which occurs for more than 10 percent of an assessment period. Excessive tonality and low frequency are determined as follows:

Tonality

The Bulletin references the methodology described in *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)*. Excessive tonality is present at a particular one-third octave band level if the band level exceeds the adjacent bands on both sides by at least:

- 5 dB , if the centre frequency of the band is in the range 500 Hz to 10,000 Hz;
- 8 dB, if the centre frequency of the band is in the range 160 Hz to 400 Hz; and/or
- 15 dB, if the centre frequency of the band is in the range 25 Hz to 125 Hz.

The penalty for tonality only applies if the tone from the wind farm is audible at the receiver location. The absence of a tone at an intermediate location will be sufficient to demonstrate that the wind farm noise at the relevant receiver location is non-tonal.

Low Frequency Noise

Excessive low frequency noise is present if the low frequency noise levels at the receiver location exceed 60 dB(C).

3.2 Ancillary Infrastructure

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

The NPI establishes *noise trigger levels* based on either the:

- existing background noise environment (intrusiveness noise levels); or,
- the amenity for particular land uses (amenity noise levels).

The *noise trigger levels* are the lower of the values provided by the two methods, which in a rural environment will generally be the *intrusiveness noise levels.*

In accordance with the NPI, the Rating Background Level (**RBL**) is used to determine 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.

Further detail is provided regarding the existing background noise environment and resulting criteria in the Ancillary Infrastructure Section of this report.

4 WIND TURBINE OPERATION

4.1 Criteria

The operational noise criteria for the Project are presented in Sonus report "S6400C10" (the **Background Noise Report**). The Background Noise Report provides Project specific noise criteria for each of the dwellings in the vicinity of the wind farm based on the procedures contained in the Bulletin, the SA Noise Guidelines and the outcomes of background noise monitoring at reference locations in the vicinity of the wind farm.

Based on the approach in the Background Noise Report, noise criteria have been assigned to the approved dwelling location based on the noise logging conducted at NAD_11. The following table provides the criteria based on this method.

Table 4: Project Noise Criteria – Wind Turbine Noise

	Representative Noise Logging Location	Wind Speed (m/s) at 150m									
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
DAD_2 Noise Criteria (dB(A))	NAD_11	35	35	35	35	35	35	35	36	38	40

Notwithstanding the above, there is the potential that background noise levels at the approved dwelling location may differ from those at the assigned representative logging location. Conducting additional noise monitoring at the approved dwelling location may increase the criterion at some wind speeds if higher levels are measured or lower the criterion where lower levels are measured.

It is expected that the background noise levels will be similar, given the proximity to the representative location and the density of significant trees at both locations.

4.2 Assessment

Noise Sources

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

- A candidate wind turbine for the project, with a hub height of 150m;[1]
- Sound Power Levels for the representative wind turbine, as provided in the following table for the "Normal" operating mode.

[1] The assessment is based on the highest hub height being considered and is a conservative approach. For lower hub heights, the noise criteria which are adjusted for background noise would be less onerous.

Table 5: *WTG Sound Power Level – "Normal" Operating Mode.*

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

It is noted that the sound power levels for the representative turbine are at the lower end of the range for modern turbines. The outcomes of this report could therefore change where an alternate turbine is selected which has a higher sound power level.

The Bulletin requires that the WTG noise level be adjusted where excessive levels of tonality and/or low frequency noise is identified to a maximum adjustment of 5 dB(A). This assessment has been made based on the assumption that the turbine model selected for the project will be free of any excessive levels of tonality or any other special noise characteristics.

The assumption has been confirmed for the representative wind turbine model by reviewing the 1/3 octave band data. This confirms that the noise from the operation of this turbine model would not incur a penalty for the characteristic of tonality. The application of a penalty for the noise character of low frequency is discussed further below.

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 dwellings;
- 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, which have been widely accepted for the assessment of wind turbine noise:

- weather category 6 (representing a temperature inversion and wind conditions that assist with the propagation of noise);
- atmospheric conditions at 10°C and 80% relative humidity (representing conditions that result in low levels of noise absorption from the atmosphere);
- wind direction from all noise sources to the particular dwelling under consideration, even in circumstances where sources are located in opposite directions from the dwelling (representing the absolute worst-case noise propagation from the wind). This will overestimate the predicted noise level where receptors have WTGs located around them in more than a singular direction or quadrant as wind is not able to blow in more than one directional quadrant simultaneously;
- acoustically soft ground (representing the pastoral nature of the land); and,
- maximum barrier attenuation from topography of 2 dB(A) (representing a conservative assessment of any shielding provided by topography).

Noise Predictions

The operational noise level outside of the approved dwelling has been predicted for all integer wind speeds from cut in to rated power and compared with the relevant criterion as outlined in Table 6. Where the predicted noise level exceeds the operational noise criterion, it is shown in **RED**.

Table 6: *Wind Farm Noise Predictions at dwellings.*

Dwelling ID	Noise Level at Hub Height integer wind speeds, 150m AGL (dB(A))																			
	3 m/s		4 m/s		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s	
	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
DAD_2	35	28	35	28	35	29	35	32	35	35	35	38	35	39	36	39	38	39	40	39

The highest predicted low frequency noise level at the approved dwelling is 53 dB(C) for high wind speeds (above 9m/s), which achieves the 60 dB(C) criterion. Therefore, a penalty for excessive low frequency noise would not be added to the predicted noise level provided above.

Based on the predictions above, without any noise mitigation measures, the noise from the 68 WTGs will not achieve the operational noise criteria at the approved dwelling by up to 4 dB(A) at 9m/s.

Noise Mitigation

Predictions have been made to determine the number of turbines which would need to be removed to achieve the criteria under all wind speeds.

Based on ranking the contribution of noise from each WTG, a total of three (3) turbines would need to be removed from the layout to achieve the noise criteria. The following table provides the three (3) turbines to be removed, resulting in a noise level of 35 dB(A) at high wind speeds (lower noise levels are predicted for lower wind speeds).

Table 7: *Wind turbines requiring removal.*

Turbines Requiring Removal
WP69
WP68
WP67

Given that the noise assessment has been made based on the currently proposed turbine layout, an assessed representative WTG and that both the project layout and WTG model selection may change during the detailed design, the turbines requiring removal might also change.

5 ANCILLARY INFRASTRUCTURE - SUBSTATIONS

5.1 Criteria

The NPI 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 level* is the lower value provided by the two methods.

In order to determine the appropriate noise criteria, reference is made to the Background Noise Report. The background noise environment was monitored at a number of dwellings in the vicinity of the wind farm and was often below 30 dB(A). Therefore, in accordance with the NPI, the minimum RBL becomes 30 dB(A) during the evening and night and 35dB(A) during the day.

As such, for activity occurring during the day, evening and night, the noise trigger level is based on the *project intrusiveness noise level* of 35 dB(A).

If noise assessed under the NPI 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 dwelling before comparison with the project *noise trigger levels*.

5.2 Assessment

Noise Sources

The Project will comprise of a single substation and one switching station, both at significant distances from the approved dwelling, DAD_2.

There is not proposed to be any significant noise sources at the switching station and therefore the assessment does not consider the location as a noise source.

The proposed substation will include transformers which have been assessed against the objective noise criteria.

The predictions have been made based on a high-voltage transformer(s) with an overall capacity of 500MVA. The sound power level for the prediction has been determined derived from the Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD)* and is summarised in the following table.

Table 8: *500 MVA substation transformer sound power levels.*

Octave Band Centre Frequency (Hz)	Sound Power Level (dB(A) re 1 pW)
63 Hz	83
125 Hz	91
250 Hz	98
500 Hz	101
1,000 Hz	93
2,000 Hz	90
4,000 Hz	83
Total	**104**

Noise Predictions

Based on the predictions of the current ancillary infrastructure layout and the assumed size of the Substation, a noise level of less than 20 dB(A) is predicted at the approved dwelling, therefore easily achieving the criteria.

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 dwellings. Notwithstanding, the preliminary predictions have been based on the inclusion of a penalty.

6 CONCLUSION

An assessment has been made of the potential impact on Project layout, which may result from noise at an approved dwelling in the vicinity of the proposed Hills of Gold Wind Farm.

The assessment has been made based on the requirements of the "Secretary's Environmental Assessment Requirements" issued for the Project (SSD 9679) dated 22 November 18.

Noise predictions have been made for the 68 WTG layout and the substation operation. Based on the predictions, the noise from operation of WTGs would exceed the criteria by up to 4 dB(A), and would require the removal of three (3) WTGs from the current layout. The noise from the operation of the site substation is predicted to easily achieve the noise criteria without any Project changes.

APPENDIX A: Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs)

Environmental Assessment Requirements

Section 4.12 (8A) of the *Environmental Planning and Assessment Act 1979*
Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*

Application Number	SSD 9679
Development	Hills of Gold Wind Farm which includes: The construction, operation and decommissioning of a wind farm with: • a maximum of 97 turbines, a maximum of 410 megawatts (MW) and maximum height of 220 metres (to blade tip); and • ancillary infrastructure including access tracks, road upgrades, battery storage, underground and overhead electricity cabling, substations and grid connection to the 330 kV Liddell to Tamworth transmission line.
Location	Morrisons Gap Road, Hanging Rock
Proponent	Wind Energy Partners
Date of Issue	22 November 2018

...

	Noise and Vibration – the EIS must: • 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 (DECC, 2006);

...

Noise and Vibration	
	NSW Wind Energy: Noise Assessment Bulletin (EPA/DPE)
	NSW Noise Policy for Industry (EPA)
	Interim Construction Noise Guidelines (EPA)
	NSW Road Noise Policy (EPA)
	Assessing Vibration: A Technical Guideline (EPA)
	Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZEC)

ATTACHMENT A: Environmental Assessment Requirements – EAR (SSD 9679) – 'Hills of Gold' Windfarm.

4. Noise and Vibration

The EA must assess the following noise and vibration aspects of the proposed development

4.1. Construction noise associated with the proposed development should be assessed using the *Interim Construction Noise Guideline (*DECC, 2009). These are available at:https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

4.2. Vibration from all activities (including construction and operation) to be undertaken on the premises should be assessed using the guidelines contained in the *Assessing Vibration: a technical guideline* (DEC, 2006). These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/assessing-vibration

4.3. If blasting is required for any reasons during the construction or operational stage of the proposed development, blast impacts should be demonstrated to be capable of complying with the guidelines contained in *Australian and New Zealand Environment Council – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC, 1990).These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

Industry

4.4. Operational noise from all industrial activities (including private haul roads) to be undertaken on the premises should be assessed using the guidelines contained in the *NSW Noise Policy for Industry* (EPA, 2017). https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)

Wind Farms

4.5. Operational noise activities from Wind Farms should be accessed against the South Australian EPA's *Wind Farm- Environmental Noise Guidelines* (2009) and the DPE's *Wind Energy: Noise Assessment Bulletin* (2016), available at: www.planning.nsw.gov.au/~/media/Files/DPE/Bulletins-and-Community-Updates/wind-energy-noise-assessment-bulletin-2016-12.ashx

Roads

4.6. Noise on public roads from increased road traffic generated by land use developments should be assessed using the guidelines contained in the *NSW Road Noise Policy* and associated application notes (EPA, 2011).https://www.epa.nsw.gov.au/your-environment/noise/transport-noise

Hills of Gold Wind Farm

Noise Assessment for Approved Dwelling (DAD_3)

September 2021

S6400C25

sonus.

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Document Title	:	Hills of Gold Wind Farm Noise Assessment for Approved Dwelling (DAD_3)
Document Reference	:	S6400C25
Date	:	September 2021
Author	:	Chris Turnbull, MAAS
Reviewer	:	Alexander Lee, MAAS

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).
Background noise level	The ambient noise level which excludes intermittent noise sources.
C-weighting	Frequency adjustment applied to measured noise levels to indicate low frequency content.
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.
dB(C)	C-weighted noise in decibels.
EPA	Environment Protection Authority.
Equivalent noise level	Energy averaged noise level over a period of time.
$L_{A90,\ time\ period}$	A-weighted noise level exceeded for 90% of defined time period. Represents the background noise level for the defined time period.
$L_{Aeq,\ time\ period}$	A-weighted equivalent noise level over a defined time period.
RBL	The Rating Background Level is an overall, single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period
SA Noise Guidelines	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.
NPI	New South Wales Environment Protection Authority *Noise Policy for Industry* (2017).
The Project	Hills of Gold Wind Farm
The Bulletin	New South Wales Planning and Environment *Wind Energy: Noise Assessment Bulletin* (2016).
Weather category 6	The CONCAWE weather conditions which is most conducive for the propagation of noise, resulting in highest predicted noise levels.
Worst-case	Operational and weather conditions which result in the highest noise level at dwelling
WTG	Wind turbine generator.

1 INTRODUCTION

Sonus has previously conducted an assessment of the environmental noise from the proposed Hills of Gold Wind Farm (the **Project**). The Project is located approximately 50km south of Tamworth, New South Wales (NSW).

Since preparing the original assessment, a request has been made by Herbert Smith Freehills (on behalf of Hills of Gold Wind Farm Pty Ltd) to prepare a report, which addresses

> *… the likely impacts of the Project on the level of noise experienced at the dwelling at Nundle Creek Road, Nundle, NSW 2340 (Lot 2 in DP 1139717), which is the subject of development consent DA2021/0172 (approved 24 November 2020).*

The assessment has been made based on the current wind turbine layout, consisting of up to 68 wind turbine generators (WTGs). It also considers the ancillary infrastructure layout, including a switching station, and a substation. The noise from the proposed batching plants and construction activity has not been considered in this report as it is unlikely to constrain the layout of the project in the way that operational noise levels might.

The NSW Department of Planning and Environment has provided *Secretary's Environmental Assessment Requirements* (SEARS) for the assessment of noise and vibration from the Project. The NSW EPA has also provided *Environmental Assessment Requirements* (EARS) relating to operation of the wind farm in a separate letter, which are addressed by the SEARs. The noise and vibration related sections of the SEARS and EARs are provided in Appendix A of this report.

This assessment considers the resulting noise levels at the approved dwelling in comparison to the requirements of the SEARS and EARs. The assessment provides predictions of the noise levels as a result of operation of the wind farm and compares the levels against relevant criteria.

2 PROJECT LAYOUT

The coordinates of the 68 WTG layout are provided in Table 1 and the locations of the ancillary infrastructure are provided in Table 2.

It is noted that the layout considered in this assessment includes the removal of WP19 and WP23, as well as the relocation of WP74, which are recent changes. These are highlighted below as **RED** text.

Table 1: Coordinates of wind turbine layout.

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP1	316191	6502649
WP2	316660	6502870
WP3	317062	6502923
WP4	317449	6502903
WP5	317647	6503321
WP6	317818	6503696
WP7	317184	6502322
WP8	317589	6502127
WP9	317453	6501426
WP10	317732	6501347
WP11	318251	6501256
WP12	319102	6501480
WP13	318924	6501259
WP14	318778	6501033
WP15	319341	6500599
WP16	320042	6500329
WP17	320736	6500326
WP18	321007	6499685
~~WP19~~	~~321513~~	~~6498816~~
WP20	323083	6499077
WP21	323138	6499551
WP22	323096	6499977
~~WP23~~	~~323199~~	~~6497538~~
WP24	323308	6498134
WP25	323581	6498726
WP26	323546	6499107
WP27	324704	6497556
WP28	324613	6498100
WP29	324632	6498515
WP30	324229	6498998
WP31	325873	6498218
WP32	325819	6498682
WP33	325258	6499019
WP34	323773	6499406
WP35	324342	6499322
WP36	324635	6499495
WP37	324928	6499683
WP38	325217	6499831
WP39	325543	6499949
WP40	325908	6500089

Turbine ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
WP41	326394	6500562
WP42	326467	6500881
WP43	326624	6501222
WP44	326930	6501400
WP45	327249	6501520
WP46	327153	6502077
WP47	327039	6502711
WP48	326439	6502906
WP49	326079	6503434
WP50	325789	6503902
WP51	325975	6504360
WP52	326002	6504778
WP53	325888	6505289
WP54	325995	6505707
WP55	326064	6506092
WP56	325597	6506290
WP57	325618	6506645
WP58	325469	6507177
WP59	325633	6507483
WP60	325827	6507814
WP61	326056	6508202
WP62	326036	6508551
WP63	325788	6508927
WP64	326519	6508699
WP65	327050	6508701
WP66	327215	6508969
WP67	327185	6509403
WP68	327367	6509623
WP69	327737	6509901
WP70	327922	6509331

Table 2: Coordinates of Ancillary Infrastructure.

ID	Approximate Coordinates (UTM WGS84 J56)	
	Easting	Northing
Sub-Station		
1	*323393*	*6499304*
Switching Station		
1	303376	6510523

The location of the approved dwelling is provided in Table 3 below.

Table 3: Approved Dwelling Location

Dwelling ID	Coordinates (UTM WGS84 J56)	
	Easting	Northing
DAD_3	324167	6511232

3 SEARS AND EARS

The noise related SEARs for the Project specify that the following must be considered for the operation of the wind farm:

- *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);*

In response to consultation regarding the content of the SEARs, the NSW EPA provided its EARs, which are consistent with the SEARS in relation to the noise from the wind farm operation.

3.1 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 wind turbines.

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

The Bulletin states:

> [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 [the SA Noise Guidelines] will be applied in NSW. This Criteria is 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."

3.1.1 Special Noise Characteristics

The Bulletin prescribes a 5 dB(A) penalty adjustment (added to the measured or predicted noise level) for the presence of repeated and excessive tonality and/or low frequency which occurs for more than 10 percent of an assessment period. Excessive tonality and low frequency are determined as follows:

Tonality

The Bulletin references the methodology described in *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)*. Excessive tonality is present at a particular one-third octave band level if the band level exceeds the adjacent bands on both sides by at least:

- 5 dB , if the centre frequency of the band is in the range 500 Hz to 10,000 Hz;
- 8 dB, if the centre frequency of the band is in the range 160 Hz to 400 Hz; and/or
- 15 dB, if the centre frequency of the band is in the range 25 Hz to 125 Hz.

The penalty for tonality only applies if the tone from the wind farm is audible at the receiver location. The absence of a tone at an intermediate location will be sufficient to demonstrate that the wind farm noise at the relevant receiver location is non-tonal.

Low Frequency Noise

Excessive low frequency noise is present if the low frequency noise levels at the receiver location exceed 60 dB(C).

3.2 Ancillary Infrastructure

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

The NPI establishes *noise trigger levels* based on either the:

- existing background noise environment (intrusiveness noise levels); or,
- the amenity for particular land uses (amenity noise levels).

The *noise trigger levels* are the lower of the values provided by the two methods, which in a rural environment will generally be the *intrusiveness noise levels.*

In accordance with the NPI, the Rating Background Level (**RBL**) is used to determine 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.

Further detail is provided regarding the existing background noise environment and resulting criteria in the Ancillary Infrastructure Section of this report.

4 WIND TURBINE OPERATION

4.1 Criteria

The operational noise criteria for the Project are presented in Sonus report "S6400C10" (the **Background Noise Report**). The Background Noise Report provides Project specific noise criteria for each of the dwellings in the vicinity of the wind farm based on the procedures contained in the Bulletin, the SA Noise Guidelines and the outcomes of background noise monitoring at reference locations in the vicinity of the wind farm.

Based on the approach in the Background Noise Report, noise criteria have been assigned to the approved dwelling location based on the noise logging conducted at NAD_5. The following table provides the criteria based on this method.

Table 4: Project Noise Criteria – Wind Turbine Noise

	Representative Noise Logging Location	Wind Speed (m/s) at 150m									
		3	4	5	6	7	8	9	10	11	12
DAD_3 Noise Criteria (dB(A))	NAD_5	35	35	35	35	35	35	35	35	35	36

Notwithstanding the above, there is the potential that background noise levels at the approved dwelling location may differ from those at the assigned representative logging location.

4.2 Assessment

Noise Sources

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

- A candidate wind turbine for the project, with a hub height of 150m;[1]
- Sound Power Levels for the representative wind turbine, as provided in the following table for the "Normal" operating mode.

Table 5: *WTG Sound Power Level – "Normal" Operating Mode.*

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

[1] The assessment is based on the highest hub height being considered and is a conservative approach. For lower hub heights, the noise criteria which are adjusted for background noise would be less onerous.

It is noted that the sound power levels for the representative turbine are at the lower end of the range for modern turbines. The outcomes of this report could therefore change where an alternate turbine is selected which has a higher sound power level.

The Bulletin requires that the WTG noise level be adjusted where excessive levels of tonality and/or low frequency noise is identified to a maximum adjustment of 5 dB(A). This assessment has been made based on the assumption that the turbine model selected for the project will be free of any excessive levels of tonality or any other special noise characteristics.

The assumption has been confirmed for the representative wind turbine model by reviewing the 1/3 octave band data. This confirms that the noise from the operation of this turbine model would not incur a penalty for the characteristic of tonality. The application of a penalty for the noise character of low frequency is discussed further below.

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 dwellings;
- 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, which have been widely accepted for the assessment of wind turbine noise:

- weather category 6 (representing a temperature inversion and wind conditions that assist with the propagation of noise);
- atmospheric conditions at 10°C and 80% relative humidity (representing conditions that result in low levels of noise absorption from the atmosphere);
- wind direction from all noise sources to the particular dwelling under consideration, even in circumstances where sources are located in opposite directions from the dwelling (representing the absolute worst-case noise propagation from the wind). This will overestimate the predicted noise level where receptors have WTGs located around them in more than a singular direction or quadrant as wind is not able to blow in more than one directional quadrant simultaneously;
- acoustically soft ground (representing the pastoral nature of the land); and,
- maximum barrier attenuation from topography of 2 dB(A) (representing a conservative assessment of any shielding provided by topography).

Noise Predictions

The operational noise level outside of the approved dwelling has been predicted for all integer wind speeds from cut in to rated power and compared with the relevant criterion as outlined in Table 6.

Table 6: *Wind Farm Noise Predictions at dwellings.*

Dwelling ID	Noise Level at Hub Height integer wind speeds, 150m AGL (dB(A))																			
	3 m/s		4 m/s		5 m/s		6 m/s		7 m/s		8 m/s		9 m/s		10 m/s		11 m/s		12 m/s	
	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction	Criterion	Prediction
DAD_3	35	18	35	18	35	19	35	21	35	24	35	27	35	28	35	28	35	28	36	28

The highest predicted low frequency noise level at the approved dwelling is less than 50 dB(C) for high wind speeds (above 9m/s), which achieves the 60 dB(C) criterion. Therefore, a penalty for excessive low frequency noise would not be added to the predicted noise level provided above.

Based on the predictions above, without any noise mitigation measures, the noise from the 68 WTGs will achieve the operational noise criteria at the approved dwelling. It is noted that the noise levels achieve the criteria without any adjustment for the background noise level at this location. Therefore additional background noise measurements would not change the outcome.

Given that the noise assessment has been made based on the currently proposed turbine layout, an assessed representative WTG and that both the project layout and WTG model selection may change during the detailed design, outcomes above might also change.

5 ANCILLARY INFRASTRUCTURE - SUBSTATIONS

5.1 Criteria

The NPI 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 level* is the lower value provided by the two methods.

In order to determine the appropriate noise criteria, reference is made to the Background Noise Report. The background noise environment was monitored at a number of dwellings in the vicinity of the wind farm and was often below 30 dB(A). Therefore, in accordance with the NPI, the minimum RBL becomes 30 dB(A) during the evening and night and 35dB(A) during the day.

As such, for activity occurring during the day, evening and night, the noise trigger level is based on the *project intrusiveness noise level* of 35 dB(A).

If noise assessed under the NPI 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 dwelling before comparison with the project *noise trigger levels*.

5.2 Assessment

Noise Sources

The Project will comprise of a single substation and one switching station, both at significant distances from the approved dwelling, DAD_3.

There is not proposed to be any significant noise sources at the switching station and therefore the assessment does not consider the location as a noise source.

The proposed substation will include transformers which have been assessed against the objective noise criteria.

The predictions have been made based on a high-voltage transformer(s) with an overall capacity of 500MVA. The sound power level for the prediction has been determined derived from the Australian/New Zealand Standard AS/NZS60076.10:2009, *Power transformers - Determination of sound levels (IEC 60076-10, Ed. 1(2001) MOD)* and is summarised in the following table.

Table 7: *500 MVA substation transformer sound power levels.*

Octave Band Centre Frequency (Hz)	Sound Power Level (dB(A) re 1 pW)
63 Hz	83
125 Hz	91
250 Hz	98
500 Hz	101
1,000 Hz	93
2,000 Hz	90
4,000 Hz	83
Total	**104**

Noise Predictions

Based on the predictions of the current ancillary infrastructure layout and the assumed size of the Substation, a noise level of less than 20 dB(A) is predicted at the approved dwelling, therefore easily achieving the criteria.

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 dwellings. Notwithstanding, the preliminary predictions have been based on the inclusion of a penalty.

6 CONCLUSION

An assessment has been made of the potential impact on Project layout, which may result from noise at an approved dwelling in the vicinity of the proposed Hills of Gold Wind Farm.

The assessment has been made based on the requirements of the "Secretary's Environmental Assessment Requirements" issued for the Project (SSD 9679) dated 22 November 18.

Noise predictions have been made for the 68 WTG layout and the substation operation. Based on the predictions, the noise from operation of WTGs would achieve the criteria at all wind speeds for the current layout. The noise from the operation of the site substation is predicted to easily achieve the noise criteria without any Project changes.

APPENDIX A: Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs)

Environmental Assessment Requirements

Section 4.12 (8A) of the *Environmental Planning and Assessment Act 1979*
Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*

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Location	Morrisons Gap Road, Hanging Rock
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	Noise and Vibration – the EIS must: • 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 (DECC, 2006);

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Noise and Vibration	
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	Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZEC)

ATTACHMENT A: Environmental Assessment Requirements – EAR (SSD 9679) – 'Hills of Gold' Windfarm.

4. Noise and Vibration

The EA must assess the following noise and vibration aspects of the proposed development

4.1. Construction noise associated with the proposed development should be assessed using the *Interim Construction Noise Guideline (*DECC, 2009). These are available at:https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

4.2. Vibration from all activities (including construction and operation) to be undertaken on the premises should be assessed using the guidelines contained in the *Assessing Vibration: a technical guideline* (DEC, 2006). These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/assessing-vibration

4.3. If blasting is required for any reasons during the construction or operational stage of the proposed development, blast impacts should be demonstrated to be capable of complying with the guidelines contained in *Australian and New Zealand Environment Council – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC, 1990).These are available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/interim-construction-noise-guideline

Industry

4.4. Operational noise from all industrial activities (including private haul roads) to be undertaken on the premises should be assessed using the guidelines contained in the *NSW Noise Policy for Industry* (EPA, 2017). https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)

Wind Farms

4.5. Operational noise activities from Wind Farms should be accessed against the South Australian EPA's *Wind Farm- Environmental Noise Guidelines* (2009) and the DPE's *Wind Energy: Noise Assessment Bulletin* (2016), available at: www.planning.nsw.gov.au/~/media/Files/DPE/Bulletins-and-Community-Updates/wind-energy-noise-assessment-bulletin-2016-12.ashx

Roads

4.6. Noise on public roads from increased road traffic generated by land use developments should be assessed using the guidelines contained in the *NSW Road Noise Policy* and associated application notes (EPA, 2011).https://www.epa.nsw.gov.au/your-environment/noise/transport-noise