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# Proposed Modification to Sapphire Wind Farm Noise Impact Assessment

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Wind Prospect CWP Pty Ltd  
45 Hunter Street  
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# Proposed Modification to Sapphire Wind Farm

## Noise Impact Assessment

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### DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
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## EXECUTIVE SUMMARY

This report details a revised noise impact assessment for a proposed modification to the approved Sapphire Wind Farm. The proposed modified project utilises a reduced number of wind turbine generators (WTGs), each of greater size and capacity to those in the approved project. The proposed modification to Sapphire Wind Farm incorporates a layout of up to 109 WTGs, with a maximum tip height of 200 m and 3 MW to 3.4 MW capacities, whereas the approved wind farm had two alternative layout options of 159 WTGs and 125 WTGs with a maximum tip height of 159 m and between 2MW and 3MW capacity respectively.

Background noise monitoring was undertaken in July 2009. Full details of the monitoring are provided in the original Sapphire Wind Farm Noise Assessment report (reference: report 40.1822 – R1R3 Section 6, dated August 2011).

The noise criteria adopted for both the original Sapphire Wind Farm Noise Assessment in 2011 and this updated assessment are based on the South Australia EPA *Noise Guidelines for Wind Farms*, 2003 (SA EPA Guidelines). Where noise levels at project-involved residences do not comply with the SA EPA Guidelines, the proponent intends to enter into agreements with the owners of those residences to achieve noise criteria in accordance with World Health Organisation (WHO) Guidelines.

Noise predictions of the proposed modification to the wind farm layout were made using the SoundPLAN software package, utilising ISO9613 algorithms and have assumed acoustically hard ground. Four alternative turbine models were considered, being:

- Vestas V126 Standard Blade
- Vestas V126 Serrated Blade Option - Mode 0
- GE 137 3.4 MW (which uses a serrated blade design)
- Senvion M122

The results for the Vestas V126 – Standard blade model, indicated that the wind farm may potentially exceed the relevant noise limits at up to 11 receptors.

The results for the Vestas V126 – serrated blade Option model, indicated that the wind farm may potentially marginally exceed the relevant noise limits at a single receptor.

A mitigation investigation was undertaken for the Vestas V126 serrated blade Option model utilising Sound Management Mode. Compliance at all receptors can be achieved using a mitigated layout where three WTGs are operated in Sound Management Mode 2. It should be noted that when WTGs are configured in Sound Management Mode they are always operating in the reduced noise mode, which is distinctly different from Sector Management.

The results for the Senvion M122, indicated that the wind farm would comply with relevant noise limits at all receptors.

The results for the GE 137 WTG, indicated that the wind farm may potentially marginally exceed the relevant noise limits at a single receptor. It is anticipated that a mitigation layout for the GE137 model will be possible through the implementation of a reduced output Sound Management Mode or the removal of a turbine from the current layout.

This noise impact assessment of the proposed modifications to Sapphire Wind Farm has shown that compliance with the noise limit requirements is attainable.

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## **1 INTRODUCTION**

SLR Consulting Australia Pty Ltd (SLR) have been engaged by Wind Prospect CWP Pty Ltd to complete a noise impact assessment for a proposed modification to the approved Sapphire Wind Farm, located approximately 28 km east of Inverell and approximately 18 km west of Glen Innes in NSW.

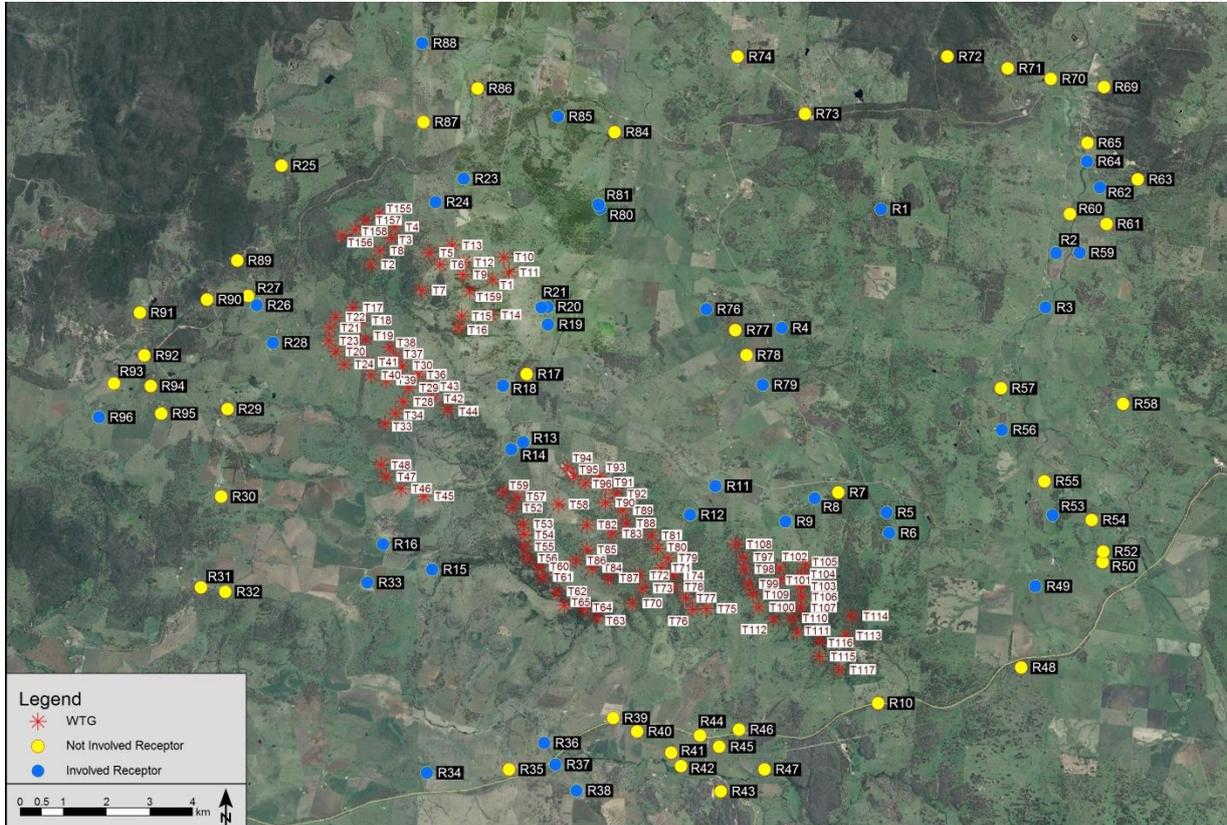
SLR (previously Heggies Pty Ltd) has been involved with the project since 2009 having previously completed the original noise impact assessments for Sapphire Wind Farm EIS. The original noise impact assessment report (reference: 40.1822 – R1R3, dated August 2011) is still relevant as it details the baseline noise monitoring undertaken for the project in 2009.

The modified project utilises a reduced number of wind turbine generators (WTGs), each with greater size and capacity. A layout of 109 WTGs is now being considered, whereas the approved wind farm had two alternative layout options of 159 WTGs and 125 WTGs. The maximum tip height will be increased to 200 m (previously 159 m) and WTGs of 3 MW to 3.4 MW size are being considered.

## 2 SITE LAYOUT

Figure 1 shows the locations of all receptor and the proposed WTG positions of the modified layout for Sapphire Wind Farm.

Figure 1 Site overview (image courtesy Google Earth)



A tabulated list of the receptors with details including their position, distance to closest WTGs from Sapphire Wind Farm and project involved host property status are included in **Table 1**.

A tabulated list of the proposed WTG positions for the modified layout for Sapphire Wind Farm is included in **Table 2**.

**Table 1** Receptor locations (UTM, GDA 94)

ID	Property Name	X (m East)	Y (m North)	Closest WTG (km)	Project Involved?
R4	Bon Vista	353963	6715399	5.2	No
R5*	Evergreen	356394	6711085	2.2	Yes
R6*	Farley	356456	6710613	2.1	Yes
R7	Arranmore	355281	6711556	1.8	No
R8*	Woodburn	354732	6711418	1.6	Yes
R9	Tomali Park	354057	6710881	1.1	No
R10*	Osterley	356198	6706640	1.2	Yes
R11*	Yarrabin	352430	6711700	1.4	Yes

<b>ID</b>	<b>Property Name</b>	<b>X (m East)</b>	<b>Y (m North)</b>	<b>Closest WTG (km)</b>	<b>Project Involved?</b>
R12*	Mubbarra	351836	6711039	1.0	Yes
R13*	Narren Vale	347974	6712731	1.2	Yes
R14*	Kingshill	347698	6712560	1.0	Yes
R15*	Kia-Tami	345866	6709763	1.7	Yes
R16*	Woodstock	344726	6710350	1.4	Yes
R17	Strathdarr	348058	6714317	1.6	No
R18*	Yarrandoo	347511	6714046	1.4	Yes
R19*	Warrandah	348550	6715477	1.3	Yes
R20*	Lochlea	348541	6715879	1.2	Yes
R21*	311	348398	6715876	1.1	Yes
R23*	Carinya	346594	6718876	1.6	Yes
R24*	Derra Downs	345940	6718333	1.1	Yes
R25	Coleraine	342378	6719178	2.1	No
R26*	Spring Creek	341800	6715923	1.8	Yes
R27	Frasers Creek	341601	6716137	2.0	No
R28*	Tralee	342175	6715048	1.3	Yes
R29	Krystal Blue	341123	6713504	2.8	No
R30	Argyle	340979	6711465	3.8	No
R31	Glen Valley	340512	6709341	5.0	No
R32	Swan Peak	341074	6709238	4.6	No
R33*	Highlands	344366	6709456	2.3	Yes
R34*	Bellview	345747	6705021	5.0	Yes
R35	Golden Grove	347645	6705095	4.0	No
R36*	Yarrawa Park	348460	6705713	3.2	Yes
R37*	Coorimbla Park	348720	6705206	3.6	Yes
R38*	Inverness	349208	6704597	4.1	Yes
R39	Bon Vista	350062	6706296	2.4	No
R40	Hillview	350617	6705977	2.8	No
R41	Royal Oaks	351407	6705486	3.4	No
R42	Ashgrove	351629	6705174	3.7	No
R43	Warrawee	352554	6704583	3.9	No
R44	Mindora	352071	6705883	2.9	No
R45	Glen Idle	352517	6705629	3.1	No
R46	Alkoomie	352981	6706029	2.5	No
R47	Pieta	353569	6705096	2.9	No
R48	Adavale	359518	6707474	4.1	No
R49*	Evergreen	359844	6709367	4.3	Yes
R50	Waterloo	361396	6709936	5.9	No
R52	Waterloo Cottage	361416	6710180	6.0	No
R53*	Maids Valley	360243	6711025	5.2	Yes
R54	Fassifern	361144	6710913	6.0	No

<b>ID</b>	<b>Property Name</b>	<b>X (m East)</b>	<b>Y (m North)</b>	<b>Closest WTG (km)</b>	<b>Project Involved?</b>
R55	Tarana	360055	6711821	5.5	No
R56*	Fruin Glen	359066	6713012	5.5	Yes
R76*	Cubba	352218	6715832	4.6	Yes
R77	Meadow Vale	352892	6715346	4.7	No
R78	Pine Grove	353148	6714764	4.4	No
R79*	Woodburn	353527	6714064	3.8	Yes
R80*	Weean Cottage	349763	6718186	2.5	Yes
R81*	Weean	349717	6718265	2.5	Yes
R84	Glenidle	350098	6719960	3.9	No
R85*	Windemere	348773	6720327	3.5	Yes
R86	Millie	346918	6720977	3.7	No
R87	Croye	345670	6720193	2.4	No
R88*	Woodlands	345634	6722038	4.1	Yes
R89	Tomali Park	341348	6716963	2.5	No
R90	Wirra Willa	340648	6716052	2.9	No
R91	Roseana	339091	6715753	4.4	No
R92	Lambert	339201	6714752	4.3	No
R93	Swamp Oak	338494	6714102	5.1	No
R94	The Knoll	339343	6714044	4.3	No
R95	Rock Leigh	339587	6713397	4.2	No
R96	Unknown	338144	6713314	5.6	No

**Table 2 Sapphire - proposed WTG locations (UTM, GDA 94)**

<b>Name</b>	<b>X</b>	<b>Y</b>	<b>Name</b>	<b>X</b>	<b>Y</b>
1	347266	6716525	60	348340	6709831
2	344448	6716872	61	348429	6709584
3	344926	6717491	62	348750	6709223
4	344998	6717747	63	349698	6708647
5	345798	6717147	64	349373	6708822
6	346048	6716872	65	348923	6708922
7	345625	6716269	70	350498	6708972
8	344648	6717197	71	351173	6709797
9	346578	6716639	72	350664	6709622
10	347523	6717047	73	350748	6709322
11	347648	6716697	74	351458	6709627
12	346598	6716922	75	352223	6708847
13	346324	6717322	76	351898	6708822
14	347223	6715697	77	351748	6709097
15	346548	6715672	78	351455	6709353
16	346473	6715397	79	351323	6710022
17	344023	6715872	80	351097	6710241
18	344223	6715572	81	350946	6710557
19	344323	6715147	82	349451	6710805
20	343623	6714847	83	350035	6710600
21	343498	6715397	84	349573	6709797
22	343623	6715647	85	349448	6710222
23	343473	6715097	86	349198	6709972
24	343823	6714547	87	349954	6709563
28	345198	6713672	88	350351	6710840
29	345323	6713997	89	350285	6711138
30	345173	6714497	90	349873	6711322
33	344774	6713167	91	349898	6711697
34	345018	6713397	92	350142	6711527
36	345542	6714321	93	349726	6711927
37	345023	6714722	94	349003	6712128
38	344873	6714947	95	349149	6711937
39	344798	6714172	96	349420	6711771
40	344448	6714297	97	353073	6710047
41	344373	6714597	98	353098	6709772
42	345898	6713747	99	353198	6709422
43	345848	6713997	100	353433	6708881
44	346223	6713497	101	353923	6709522
45	345673	6711472	102	353923	6709797
46	345148	6711647	103	354398	6709372

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<b>Name</b>	<b>X</b>	<b>Y</b>	<b>Name</b>	<b>X</b>	<b>Y</b>
47	344798	6711922	104	354423	6709647
48	344673	6712197	105	354523	6709872
155	344633	6718073	106	354423	6709122
156	343761	6717550	107	354398	6708872
157	344316	6717905	108	352898	6710349
158	344086	6717689	109	353300	6709174
159	346737	6716252	110	354198	6708622
52	347723	6711197	111	354323	6708297
53	347973	6710822	112	353774	6708606
54	347998	6710572	113	355441	6708221
55	347998	6710297	114	355598	6708672
56	348073	6710022	115	354843	6707728
57	347848	6711447	116	354848	6708097
58	348794	6711276	117	355298	6707422
59	347498	6711572			

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### 3 LEGISLATION & GUIDELINES

The noise criteria adopted for both the original Sapphire Wind Farm Noise Assessment in 2011 and this updated assessment are based on the South Australia EPA *Noise Guidelines for Wind Farms*, 2003 (SA EPA Guidelines).

The SA EPA Guidelines are still the current assessment guideline adopted in NSW.

#### 3.1 SA EPA Wind Farm Noise Guidelines

The SA EPA Guidelines recommend the following noise criteria for new wind farms,

*“The predicted equivalent noise level ( $L_{Aeq, 10min}$ ), adjusted for tonality in accordance with these guidelines, should not exceed:*

- 35 dBA, or
- the background noise level by more than 5 dBA,

*whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG.”*

The guidelines also provide information on measuring the background noise levels, locations and requirements on the number of valid data points to be obtained and the methodology for excluding invalid data points. It also outlines the process for determining lines of best fit for the background data, and determination of the noise limit.

The Guideline explicitly states that the “swish” or normal modulation noise from wind turbines is a fundamental characteristic of such turbines; however, it specifies that tonal or annoying characteristics of turbine noise should be penalised.

A 5 dBA penalty should be applied to the measured noise level if an “authorised” officer determines that tonality is an issue and that tonality should be assessed in a way acceptable to the EPA.

The Guideline does not provide an assessment for the potential of low frequency noise or infrasound, but it does state that recent turbine designs do not appear to generate significant levels of infrasound, as the earlier turbine models did.

The Guideline accepts that wind farm developers commonly enter into agreements with private landowners in which they are provided compensation. The guideline is intended to be applied to premises that do not have an agreement with the wind farm developer. This does not absolve the obligations of the wind farm developer entirely as appropriate action can be taken under the *Environmental Protection Act* if a development ‘unreasonably interferes’ with the amenity of an area. The guideline lists that there is unlikely to be unreasonable interference if:

- a formal agreement is documented between the parties
- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect on the landowner’s amenity
- the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance)

The proponent has discussed the possible noise implications of the proposed turbine layout with the involved residents whose property the turbines would be located on and will enter into agreements with these parties.

These agreements would specify that:

(a) The proponent would ensure that noise levels at the properties meet the World Health Organisation noise guidelines (see **Section 3.2**); and,

(b) The proponent would implement an adaptive management approach which could include the use of building treatments and turbine operation / management strategies if operational noise causes significant impact to the amenity of involved residents.

This noise agreement would only be required under those turbine configurations where the SA EPA Guidelines would be exceeded for that particular property.

### 3.2 World Health Organisation (WHO) Guidelines

Where noise levels at project-involved residences do not comply with the SA EPA Guidelines, the proponent intends to enter into agreements with the owners of those residences to achieve noise criteria in accordance with World Health Organisation (WHO) Guidelines. The proponent will apply those guidelines as necessary to ensure that the project does not result in an ‘unreasonable interference’ with the amenity or cause any adverse health effects at those residences. (See **Section 3.1**)

The WHO publication ‘*Guidelines for Community Noise*’ identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

The appropriate guideline limits are listed in **Table 3** below.

**Table 3 WHO Guideline values for environmental noise in specific environments**

Specific Environment	Critical Health Effect(s)	Leq (dBA)	Time base (hours)	LMax (dBA, Fast)
Outdoor living area	Serious Annoyance, daytime & evening	55	16	-
	Moderate annoyance, daytime & evening	50	16	-
Dwelling indoors	Speech Intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance – window open, night-time	45	8	60

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

## 4 BACKGROUND NOISE LEVELS

Background noise monitoring was undertaken in July 2009. The noise data was correlated to wind speed at a reference height of 100 m above ground level. Full details of the monitoring are provided in the original Sapphire Wind Farm Noise Assessment report (reference: report 40.1822 – R1R3 Section 6, dated August 2011).

**Table 4** shows the background noise at each monitoring location, regressed to a third order polynomial function.

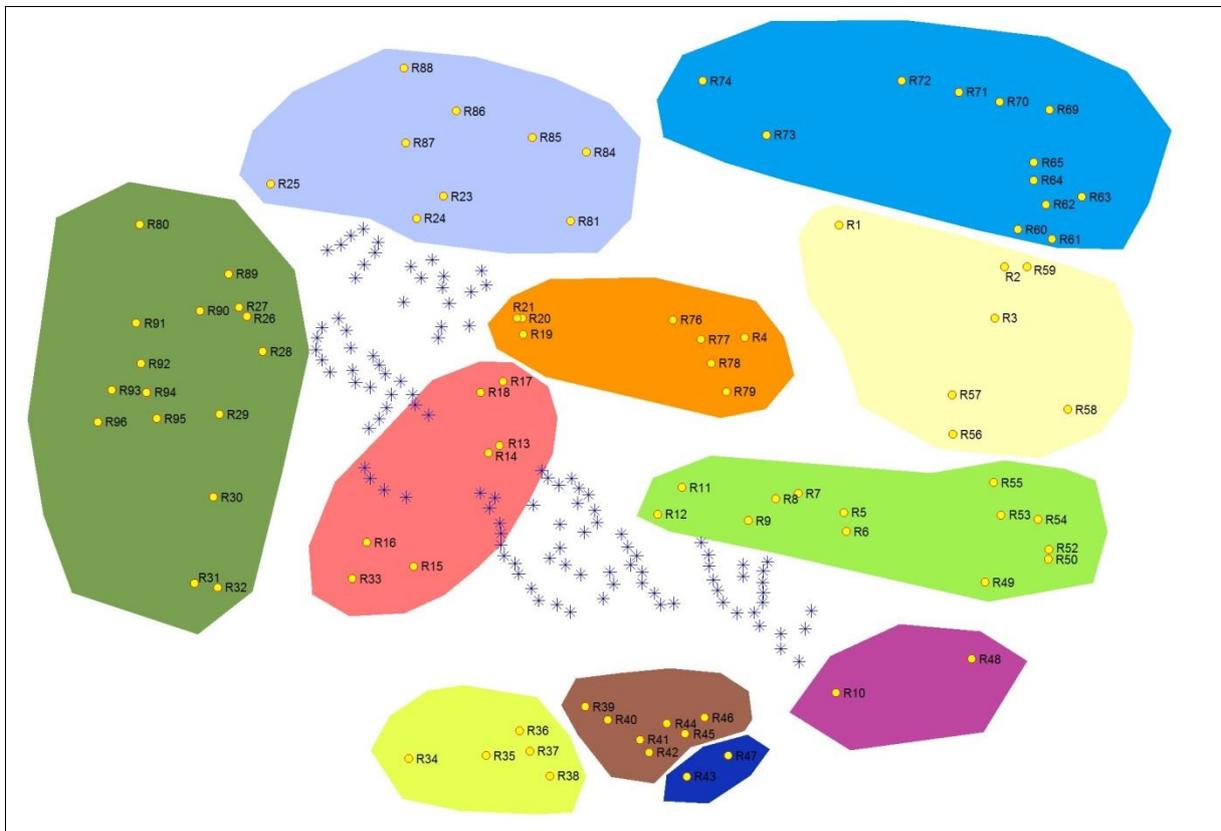
**Table 4 Background noise regression equations**

Location	Indicative of	
R3-Falkland *	R1*, R3*, R59*, R2*, R57, R56*, R58	$y = -0.0119x^3 + 0.2502x^2 - 1.1965x + 29.512$
R64-Springfield	R60, R61, R62*, R63, R64*, R65, R73, R72, R71, R70, R69, R74	$y = 0.0016x^3 - 0.114x^2 + 1.8662x + 21.965$
R43- Ardleigh	R43, R47	$y = -0.0118x^3 + 0.4502x^2 - 3.071x + 33.042$
R5- Down Field *	R5*, R55, R49*, R53, R54, R6*, R52, R50, R7, R8*, R9*, R11*, R12*	$y = -0.0185x^3 + 0.4987x^2 - 3.4598x + 45.145$
R14-Kingshill *	R14*, R13*, R17, R18*, R15*, R16*, R33*	$y = 0.0079x^3 - 0.1564x^2 + 1.6257x + 33.331$
R23-Carinya *	R24*, R23*, R25, R87, R86, R80*, R81*, R84, R85*, R88*	$y = 0.0137x^3 - 0.2774x^2 + 2.6662x + 18.733$
R28-Tralee *	R28*, R26*, R27, R29, R90, R30, R94, R91, R93, R92, R31, R32, R89, R95, R96	$y = 0.0191x^3 - 0.4642x^2 + 4.0333x + 18.138$
R36 Yarrawah Park *	R36*, R37*, R35, R38*, R34*	$y = 0.0056x^3 - 0.0723x^2 + 0.5553x + 27.644$
R44-Mindora	R46, R45, R41, R42, R39, R40, R44	$y = 0.0296x^3 - 0.6802x^2 + 5.6064x + 15.111$
R10-Mt Buckley	R10, R48	$y = -0.0168x^3 + 0.5433x^2 - 3.3808x + 32.251$
R19-Warrandah *	R20*, R21*, R19*, R76*, R77, R4*, R78, R79*	$y = -0.0301x^3 + 0.894x^2 - 6.3934x + 39.852$

Note: \* denotes that property is project involved

Receptors were grouped into general regions where background noise monitoring locations were deemed indicative of the receptors of that region. The groupings are presented pictorially in **Figure 2**.

Figure 2 Receptor groupings for background noise



## 5 OPERATIONAL NOISE CRITERIA

As discussed in **Section 4** the noise criteria for the project are based on the monitoring and analysis completed for the original Noise Impact Assessment for Sapphire Wind Farm and are re-presented in **Table 5** as a function of hub height wind speed.

**Table 5 Wind Farm Noise Criteria**

Receiver Location / Group	Noise Limit, dBA at Hub-height Wind Speed (m/s)									
	4.3	5.7	7.2	8.6	10.0	11.5	12.9	14.3	15.8	17.2
R3-Falkland *	35	35	35	35	35	35	35	36	36	36
R64-Springfield	35	35	35	35	35	35	36	36	36	36
43- Ardleigh *	35	35	35	35	35	36	38	41	43	46
R5- Down Field *	44	43	43	43	44	45	46	47	48	48
R14-Kingshill *	42	43	44	44	45	45	46	47	48	49
R23-Carinya *	35	35	35	35	35	35	35	36	38	39
R28-Tralee *	35	35	35	35	35	35	36	36	37	38
R36 Yarrawah Park *	35	35	35	35	35	35	36	37	37	39
R44-Mindora	35	35	35	36	36	37	37	38	39	41
R10-Mt Buckley	35	35	35	35	35	36	39	41	43	46
R19-Warrandah *	35	35	35	35	35	36	38	40	43	45

Note: \* denotes that property is project involved

## 6 NOISE ASSESSMENT

### 6.1 Model Inputs

Noise emissions for the proposed WTG have been determined or estimated by the manufacturers from measurements conducted in accordance with International Standard IEC 61400-11. Copies of the certification test or manufacturers documentation that give the sound power level variation with wind speed, frequency spectra and tonality assessment have been provided to SLR by Wind Prospect CWP Pty Ltd and will be made available on request

**Table 6** and **Table 7** summarise the relevant turbine input data used for noise level prediction.

**Table 6 WTG Manufacturers data**

Make, model, power	Vestas V126 3.3 MW	GE 137 3.4 MW	Senvion M122 3.0 MW
Rotor diameter	126 m	137 m	122 m
Hub height	137 m	135 m	139 m
Cut-in wind speed	3 m/s	3 m/s	3 m/s
Rated wind speed	7.5 m/s		11 m/s
Rotor speed	5.3 -16.5 rpm		5.6 -11.3 rpm
'Standard Mode' Sound Power Level, LWA,ref 8 m/s	108.5 <sup>1</sup> dBA	106 dBA	103.9 dBA

Note: 1 Sound power level of standard blade option

**Table 7 WTG Sound Power Level values (dBA)**

Wind Turbine Model	Wind speed Vs (m/s) ref: 10 m AGL									
	3	4	5	6	7	8	9	10	11	12
Vestas V126 Standard Blade	95.2	98.3	103.1	107.8	108.5	108.5	108.5	108.5	108.5	108.5
Vestas V126 Serrated Blade - Mode 0	93.4	96.3	101.1	105.0	106.0	106.0	106.0	106.0	106.0	106.0
Vestas V126 Serrated Blade - Mode 2	93.4	96.3	100.6	102.6	103.1	104.2	104.5	104.5	104.5	104.5
GE 137 3.4 MW	93.5	98.5	103.3	106.0	106.0	106.0	106.0	106.0	106.0	106.0
Senvion M122		99.8	103.1	104.5	104.4	103.9	103.8	103.8		

### 6.2 Assessment of Tonality and Infrasound

A part of IEC 61400-11 noise testing is to conduct an assessment of the audibility of any tones present.

The tonal audibility is assessed using the methodology outlined in *Joint Nordic Method Version 2 – Objective Method for Assessing the Audibility of Tones in Noise* (JNM2). It should be noted that JNM2 imposes a sliding scale tonality penalty commencing when the tonal audibility  $\Delta L_{A,k} > 4$  dB, and reaches the maximum allowable penalty of +6 dB when the tonal audibility  $\Delta L_{A,k} > 10$  dB. The absence of any audible tones when tested in the near field as per IEC 61400-11 requirements, ensures that no audible tones will be experienced in the far field at receptors.

The tonal audibility data  $\Delta L_{A,k}$  values have been supplied by the WTG manufacturers as follows:

**Table 8 Audible tonality  $\Delta L_{A,k}$  assessment to IEC 61400-11**

Wind Turbine Model	Wind speed Vs (Hub Height) (m/s)									
	7	8	9	10	11	12	13	14	15	16
Vestas V126 3.3MW	-0.49	-2.47	-	-2.5	-0.34	-0.99	-1.71	-2.64	-	-
GE 137 3.4 3.4MW	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4

The Senvion M122 has no statement with regard to tonality. Confirmation of the  $\Delta L_{A,k}$  tests should be provided by the manufacturer prior to approval.

Infrasound is not tested as an obligatory part of IEC 61400-11. It is noted that, in general, modern WTG's do not exhibit significant levels of infrasound emissions.

### 6.3 Noise Model Predictions

The results of noise modelling are presented in **Table 9** for all assessed receptor locations for the three investigated WTG models for Sapphire Wind Farm at a reference wind speed of 8 m/s (10m AGL).

**Table 9 Predicted Noise Levels – dBA Leq**

Receiver	Vestas V126 Standard Blade	Vestas V126 serrated blade Option Mode 0	Senvion M122	GE 137	Receiver	Vestas V126 Standard Blade	Vestas V126 serrated blade Option Mode 0	Senvion M122	GE 137
R1	24.7	22.2	20.8	22.9	R46	38.9	36.4	34.6	36.8
R2	22.4	19.9	18.6	20.6	R47	36.2	33.7	31.9	34.2
R3	24.8	22.2	20.8	22.9	R48	30.6	28.0	26.4	28.6
R4	33.2	30.7	29.1	31.4	R49	30.6	28.1	26.5	28.7
R5	36.6	34.1	32.3	34.4	R50	24.4	21.9	20.4	22.6
R6	39.0	36.5	34.8	36.9	R52	24.3	21.8	20.4	22.5
R7	40.3	37.8	36.0	38.1	R53	26.1	23.6	22.0	24.2
R8	42.0	39.5	37.7	39.8	R54	24.7	22.2	20.7	22.9
R9	46.1	43.6	41.8	43.8	R55	27.9	25.4	23.8	26.0
R10	39.8	37.3	35.5	37.6	R56	26.5	24.0	22.4	24.6
R11	43.6	41.1	39.3	41.5	R57	25.9	23.4	21.9	24.1
R12	47.0	44.5	42.7	44.7	R58	22.5	20.0	18.6	20.7
R13	45.4	42.9	41.1	43.1	R59	21.8	19.2	17.9	19.9
R14	45.8	43.3	41.5	43.5	R60	21.8	19.2	18.0	19.9
R15	40.4	37.9	36.1	38.3	R61	22.3	19.7	18.4	20.4
R16	39.9	37.4	35.6	37.6	R62	21.5	18.9	17.7	19.6
R17	41.8	39.3	37.6	39.7	R63	21.4	18.8	17.6	19.5
R18	43.9	41.4	39.6	41.7	R64	20.7	18.2	16.9	18.8
R19	42.0	39.5	37.7	39.8	R65	20.4	17.8	16.6	18.5
R20	43.0	40.5	38.7	40.7	R69	19.2	16.7	15.5	17.3
R21	43.6	41.1	39.3	41.3	R70	19.3	16.8	15.6	17.5

Receiver	Vestas V126 Standard Blade	Vestas V126 serrated blade Option Mode 0	Senvion M122	GE 137	Receiver	Vestas V126 Standard Blade	Vestas V126 serrated blade Option Mode 0	Senvion M122	GE 137
R23	41.1	38.6	36.7	38.8	R71	20.0	17.5	16.3	18.2
R24	45.5	43.0	41.2	43.2	R72	20.6	18.1	16.8	18.7
R25	37.0	34.5	32.6	34.7	R73	25.1	22.6	21.2	23.3
R26	41.2	38.7	36.9	39.0	R74	27.3	24.8	23.3	25.4
R27	39.5	37.0	35.1	37.2	R76	34.1	31.6	29.9	32.2
R28	43.0	40.5	38.7	40.7	R77	33.2	30.7	29.0	31.2
R29	37.5	35.0	33.2	35.4	R78	35.9	33.4	31.7	34.0
R30	35.2	32.7	31.0	33.2	R79	36.6	34.1	32.4	34.6
R31	32.2	29.7	28.1	30.3	R80	32.6	30.1	28.4	30.6
R32	32.7	30.2	28.6	30.9	R81	32.6	30.1	28.4	30.6
R33	38.1	35.6	33.8	36.0	R84	31.0	28.5	26.8	29.1
R34	32.5	30.0	28.4	30.6	R85	32.4	29.9	28.2	30.4
R35	34.2	31.7	30.0	32.3	R86	32.7	30.2	28.4	30.6
R36	35.9	33.4	31.6	33.9	R87	35.6	33.1	31.3	33.4
R37	35.1	32.6	30.9	33.1	R88	28.5	26.0	24.4	26.6
R38	34.2	31.7	30.1	32.3	R89	36.4	33.9	32.1	34.3
R39	38.4	35.9	34.1	36.3	R90	36.2	33.7	31.9	34.1
R40	37.7	35.2	33.5	35.7	R91	33.3	30.8	29.1	31.4
R41	36.4	33.9	32.1	34.3	R92	30.0	27.5	25.8	28.1
R42	36.0	33.5	31.8	34.0	R93	31.5	29.0	27.4	29.7
R43	35.1	32.6	30.9	33.2	R94	33.7	31.2	29.5	31.8
R44	36.1	33.6	31.8	34.0	R95	34.0	31.5	29.8	32.1
R45	37.2	34.7	32.9	35.1	R96	31.4	28.9	31.4	31.4

The full assessment graphs are presented in;

- **Appendix A1** for the Vestas V126 Standard Blade layout
- **Appendix A2** for the Vestas V126 Serrated Blade Option (Mode 0) layout
- **Appendix A3** for the Senvion M122 layout
- **Appendix A4** for the GE 137 layout

Noise contour plots calculated at a reference wind speed of 8 m/s (10m AGL) are presented in;

- **Appendix B1** for the Vestas V126 Standard Blade layout
- **Appendix B2** for the Vestas V126 Serrated Blade Option (Mode 0) layout
- **Appendix B3** for the Senvion M122 layout
- **Appendix B4** for the GE 137 layout

The predicted exceedances for each turbine type are shown in **Table 10** and **Table 12**.

**Table 10 Vestas V126 Standard Blade - Predicted Exceedances (dBA)**

Location	Hub height wind speed, m/s										Maximum	
	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0		
R24* Derra Downs				0.5	0.5	0.5	0.5					0.5
R25 Coleraine				1.7								1.7
R87 Croye				0.4								0.4
R27 Frasers Creek			1.4	3.7	3.0	1.8						3.7
R29 Krystal Blue				1.7	1.1							1.7
R90 Wirra Willa				0.4								0.4
R46 Alkoomie				1.8	0.6							1.8
R45 Glen Idle				0.1								0.1
R39 Bon Vista				1.4	0.2							1.4
R40 Hillview				0.7								0.7
R10 Mt Buckley			1.8	1.3								1.8

Note: \* denotes that property is project involved and predicted exceedance is from the WHO limit

The highest predicted exceedance for the Vestas V126 (Standard Blade) layout is at location R27 Frasers Creek with a level 3.7 dBA higher than the SA EPA limit.

**Table 11 Vestas V126 Serrated Blade Option (Mode 0) - Predicted Exceedances (dBA)**

Location	Hub height wind speed, m/s										Maximum	
	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0		
R27 Frasers Creek				0.2	0.5							0.5

The highest predicted exceedance for the Vestas V126 Serrated Blade Option layout is at location R27 Frasers Creek with a level 0.5 dBA higher than the SA EPA limit.

**Table 12 GE137 - Predicted Exceedances (dBA)**

Location	Hub height wind speed, m/s										Maximum	
	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0		
R27 Frasers Creek				1.5	0.8							1.5

The highest predicted exceedance for the GE 137 layout is at location R27 Frasers Creek with a level 1.5 dBA higher than the SA EPA limit.

The predicted noise levels for the Senvion M122 layout complies with all applicable noise limits.

## 6.4 Mitigation Layout

Information regarding Noise Management Mode for the GE137 WTG model was not available at the time of compiling this report as the turbine is relatively new. It is expected that subsequent testing will be undertaken to show the possibility of operating in Noise Management Mode.

A mitigated layout was developed using Mode 2 of the Vestas V126 WTG Serrated Blade Option. A total of 3 WTGs were placed into Mode 2 operation, which reduces the sound power output of those turbines compared to standard Mode 0 operation. **Table 13** shows a list of the WTGs placed in Mode 2 for the mitigated scenario.

**Table 13 Mitigated Turbine Layout - Vestas V126 WTG Serrated Blade Option**

Turbine Name	Type
T21	Mode 2
T22	Mode 2
T23	Mode 2

Full results at all wind speeds are shown in **Appendix A5**.

A noise contour plot is shown in **Appendix B5**.

The mitigated layout is shown to comply at all receptors at all wind speeds.

## **7 COMPARISON TO ORIGINAL LAYOUTS**

The proposed modification to Sapphire Wind Farm incorporates a layout of up to 109 WTGs, with a maximum tip height of 200 m and 3 MW to 3.4 MW capacities, whereas the approved wind farm had two alternative layout options of 159 WTGs and 125 WTGs with a maximum tip height of 159 m and between 2 MW and 3 MW capacity respectively.

Making a precise comparison of the predicted noise levels between the approved layouts and the proposed modification is difficult given the potential number of combinations of layouts and turbine models involved. However, in general a comparative evaluation reveals that noise levels will be marginally higher at some receptors (where nearby turbines are common to both the approved and proposed modified layout, owing to the larger size and marginally higher sound power level of the latter) and lower at others (where clusters of turbines have been dropped from the approved layout). Furthermore, in regions where noise levels are expected to be higher compared to the approved layout, there are a high proportion of project involved receptors.

It should be noted that whilst the predicted noise level for the proposed modified layout may be marginally higher than approved layouts at some receptors, the noise level will be below the appropriate limit.

## 8 CONCLUSION

SLR has conducted a noise impact assessment of the proposed modification to Sapphire Wind Farm.

Computer noise modelling using the standard ISO9613 algorithm was completed for four alternative WTG models.

The results for the Vestas V126 – Standard blade model, indicated that the wind farm may potentially exceed the relevant noise limits at up to 11 receptors.

The results for the Vestas V126 – serrated blade Option model, indicated that the wind farm may potentially marginally exceed the relevant noise limits at a single receptor.

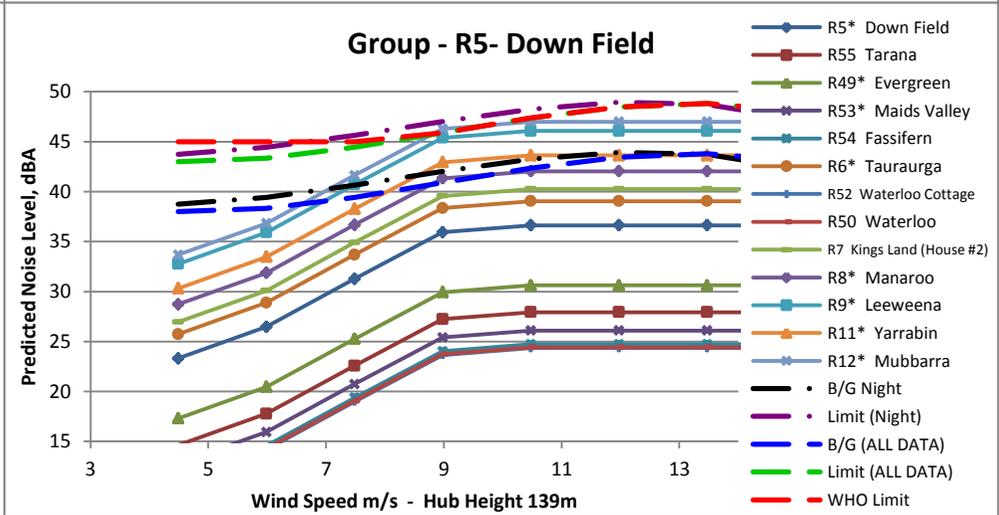
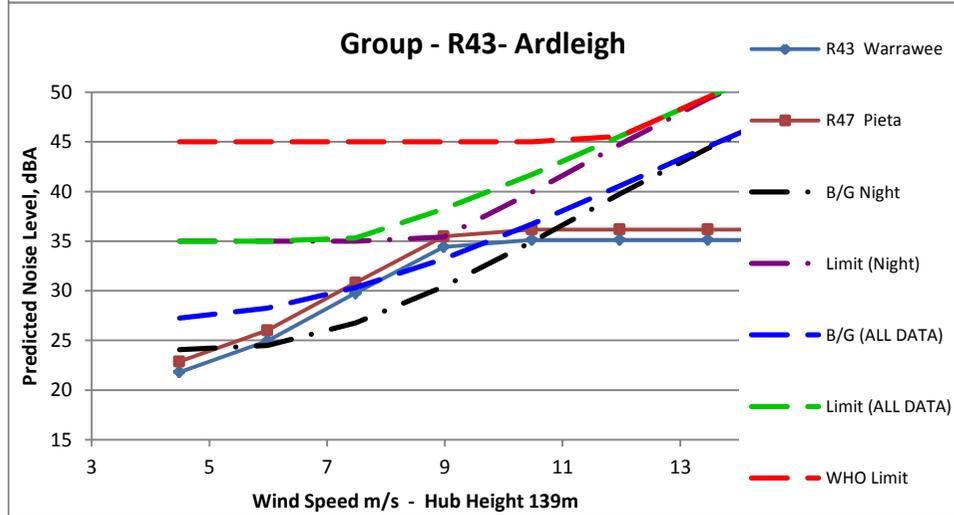
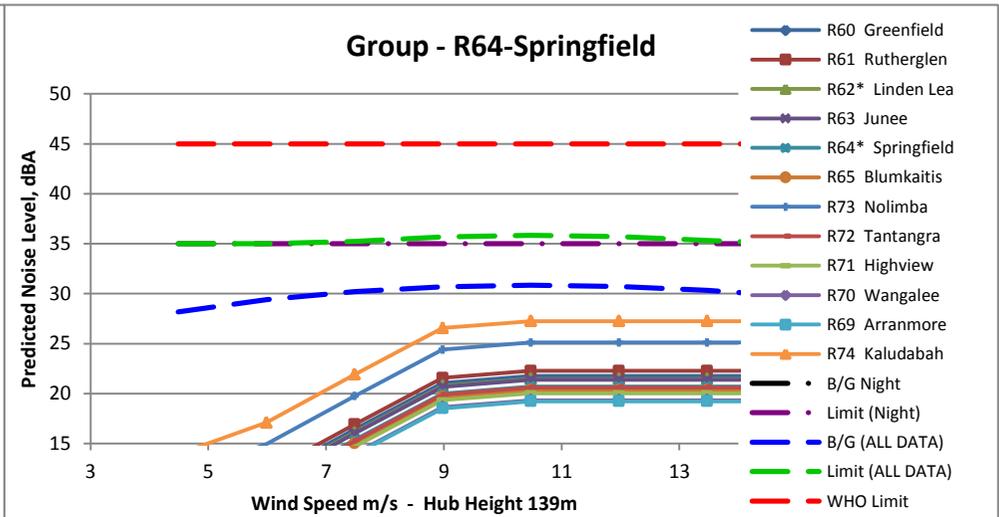
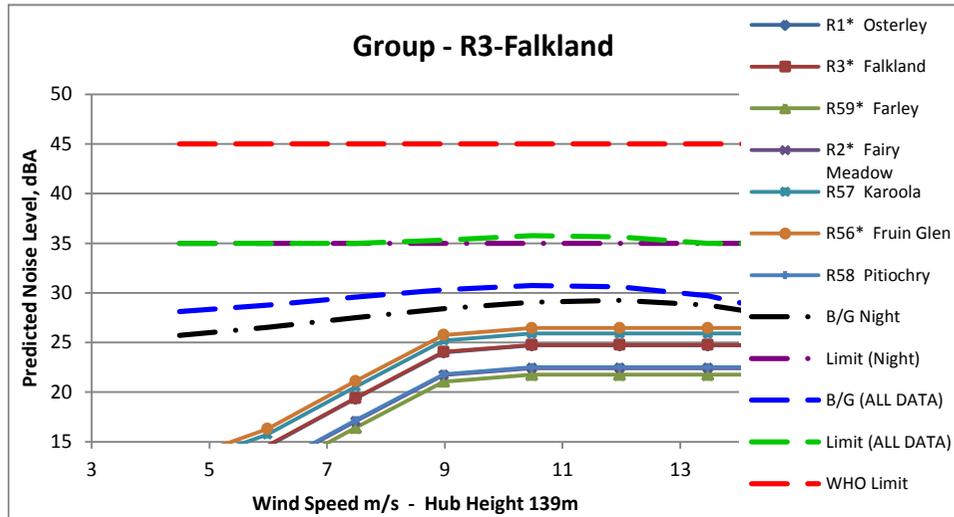
A mitigation investigation was undertaken for the Vestas V126 serrated blade Option model utilising Sound Management Mode. Compliance at all receptors can be achieved using a mitigated layout where three WTGs are operated in Sound Management Mode 2. It should be noted that when WTGs are configured in Sound Management Mode they are always operating in the reduced noise mode, which is distinctly different from Sector Management.

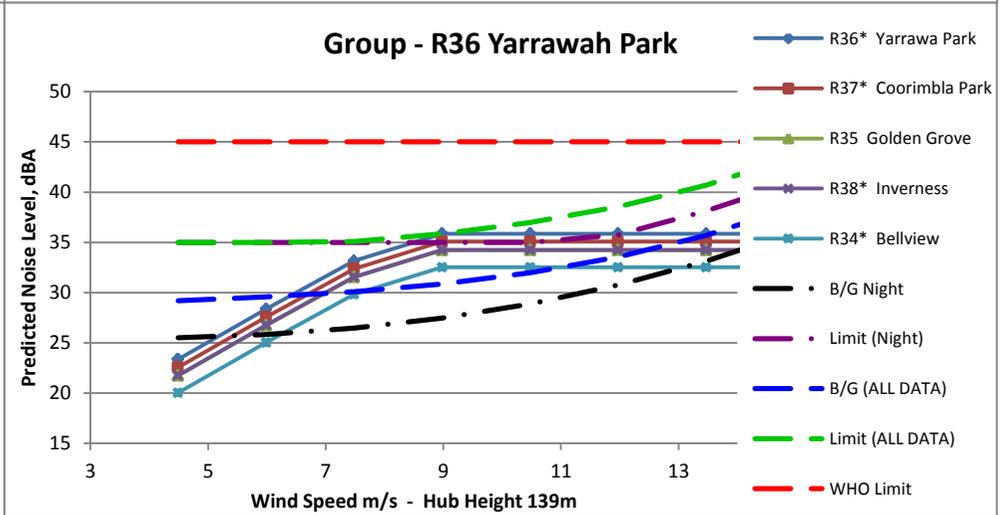
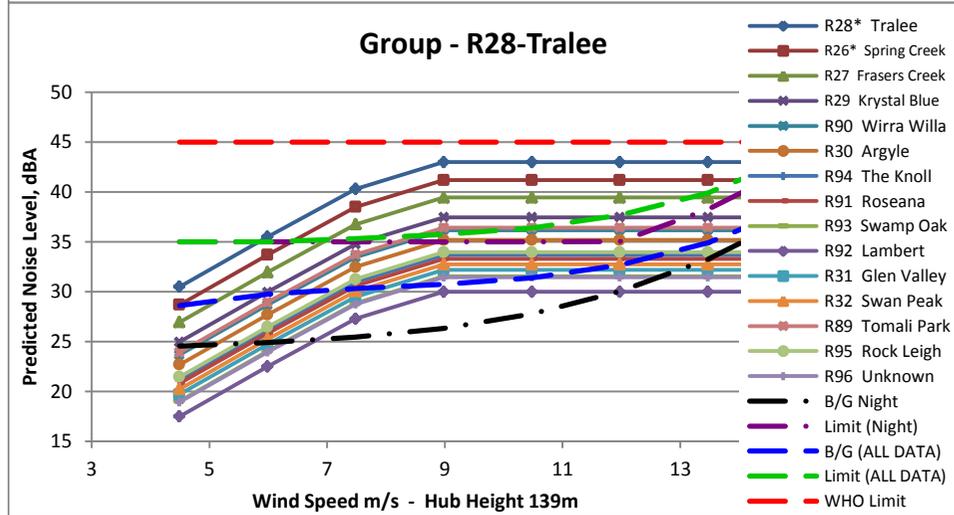
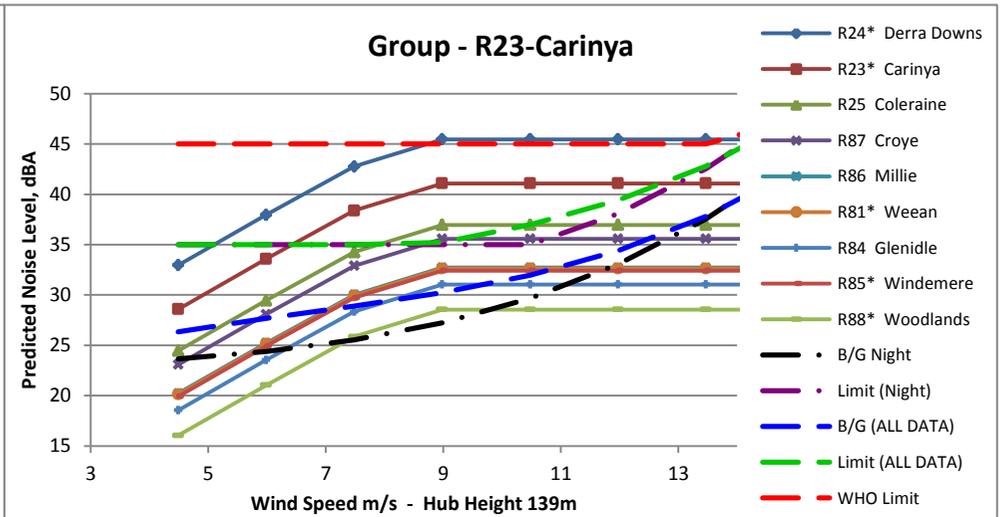
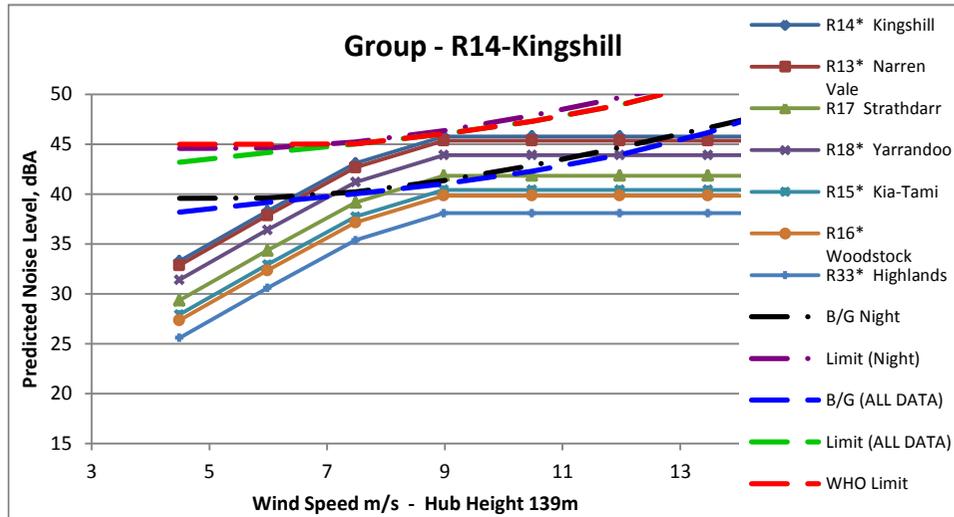
The results for the Senvion M122, indicated that the wind farm would comply with relevant noise limits at all receptors.

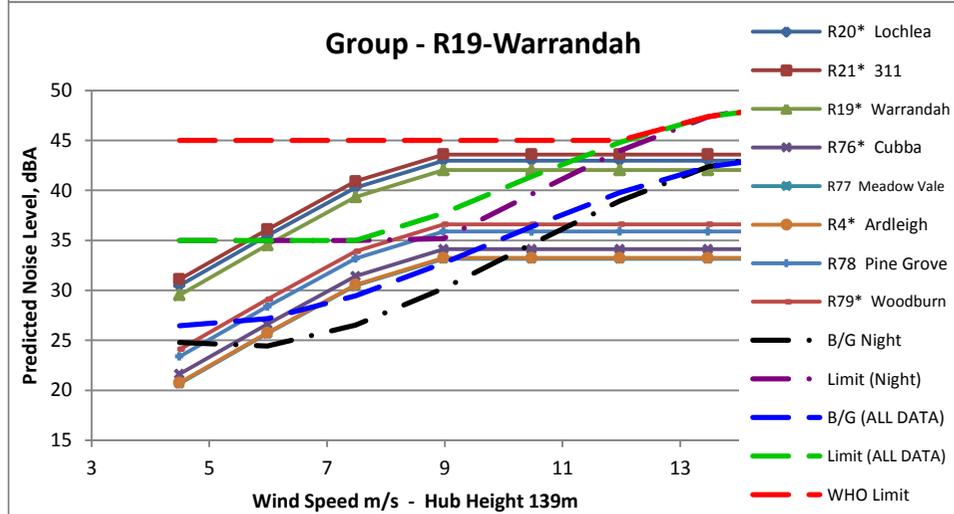
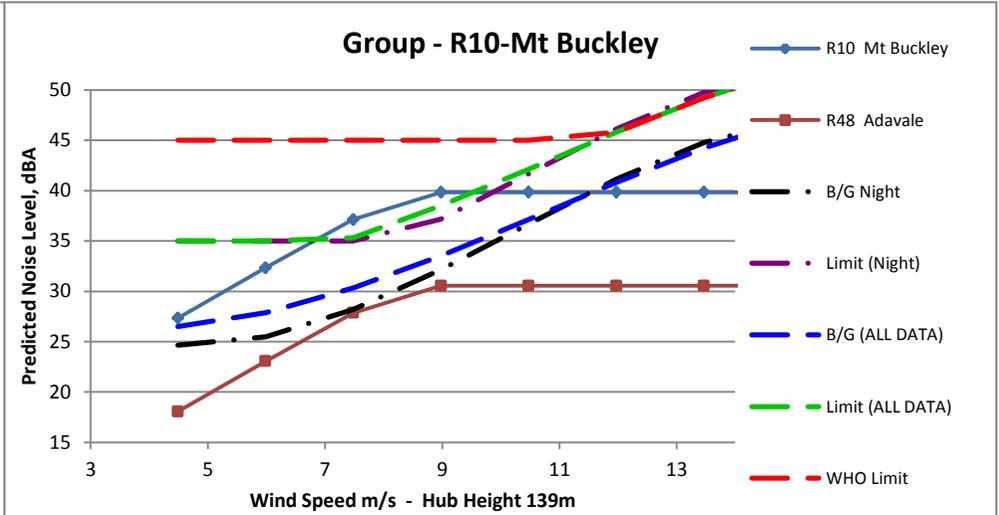
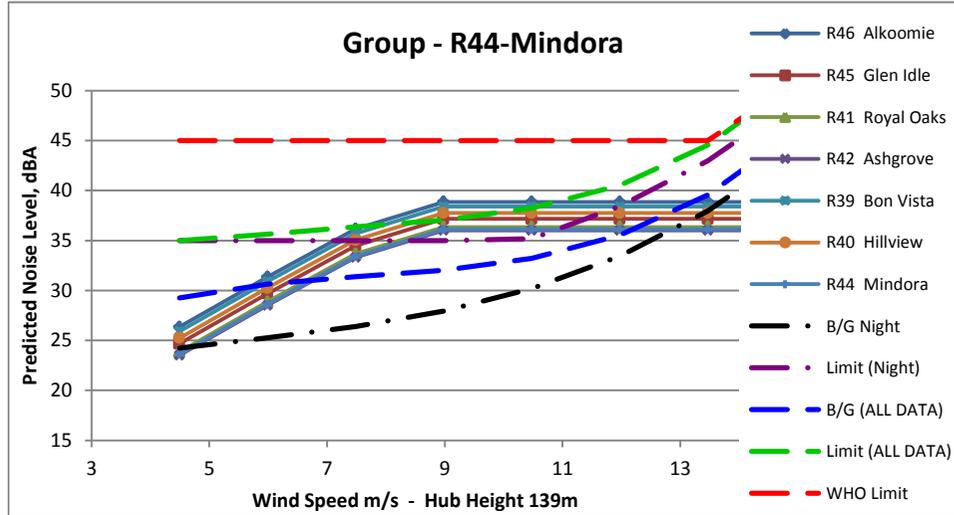
The results for the GE 137 WTG, indicated that the wind farm may potentially marginally exceed the relevant noise limits at a single receptor. It is anticipated that a mitigation layout for the GE137 model will be possible through the implementation of a reduced output Sound Management Mode or the removal of a turbine from the current layout.

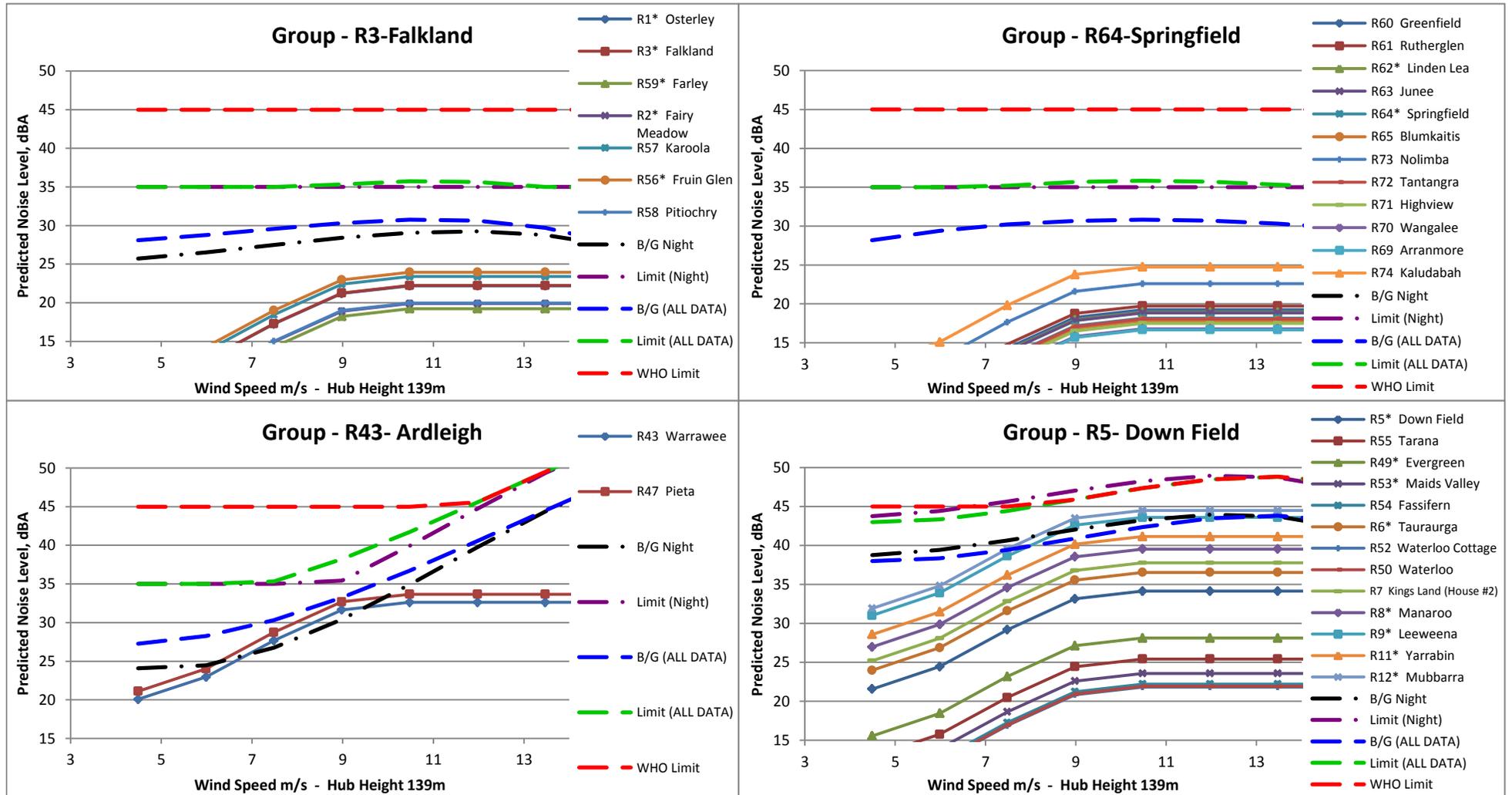
This noise impact assessment of the proposed modifications to Sapphire Wind Farm has shown that compliance with the noise limit requirements is attainable.

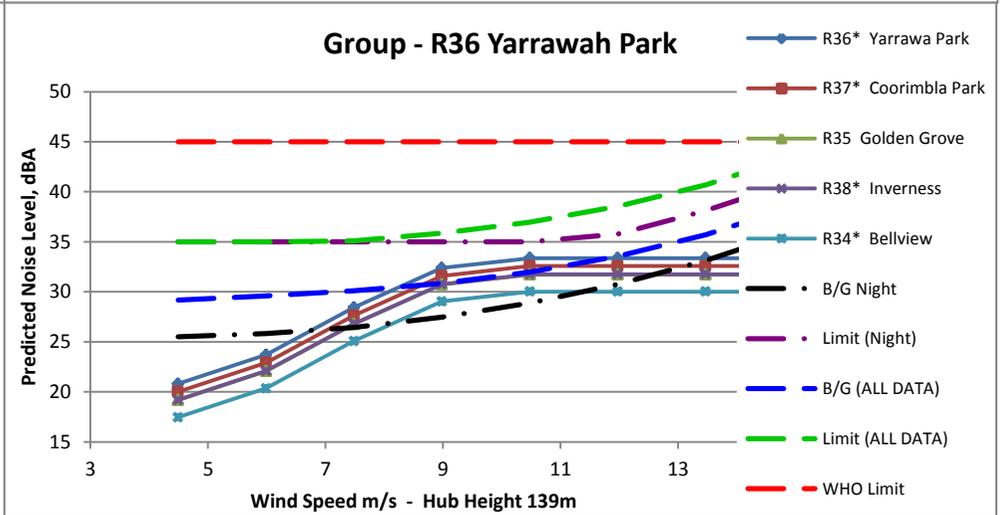
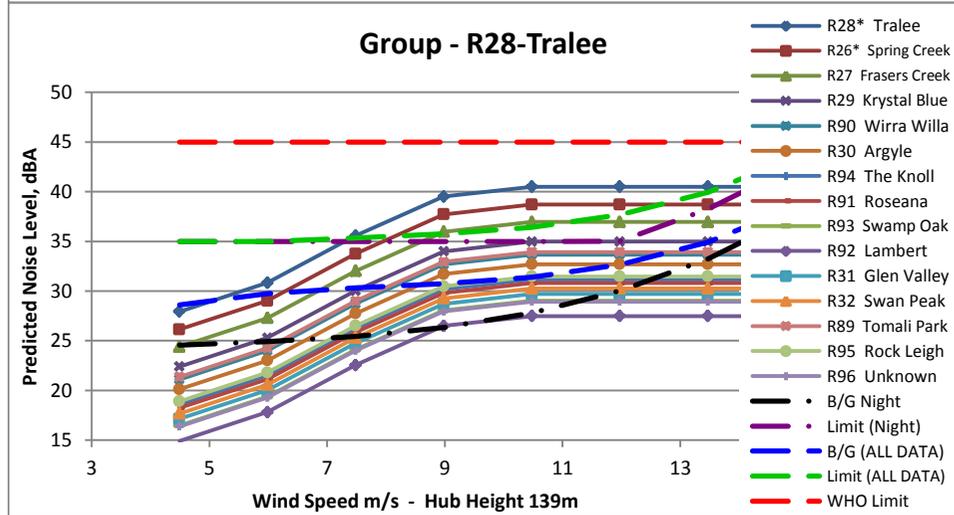
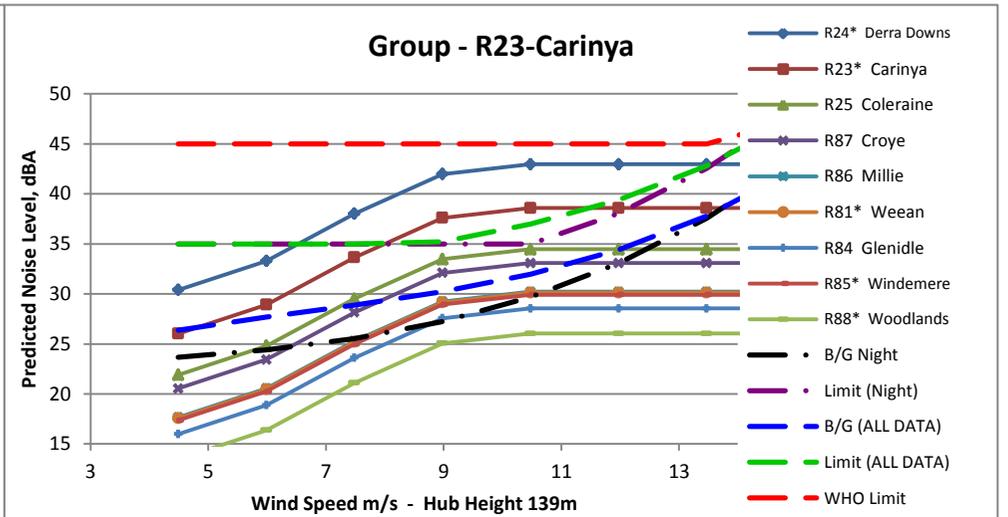
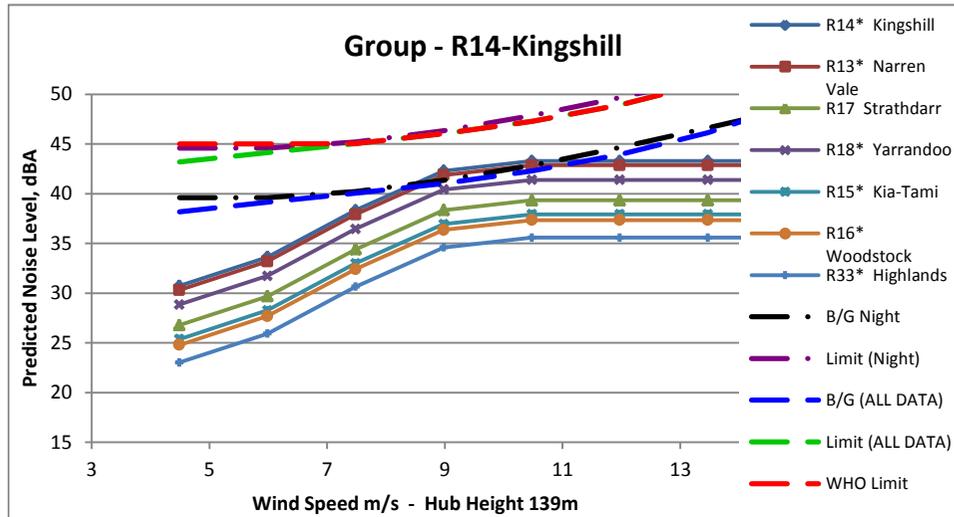
## **APPENDIX A      NOISE ASSESSMENT GRAPHS**

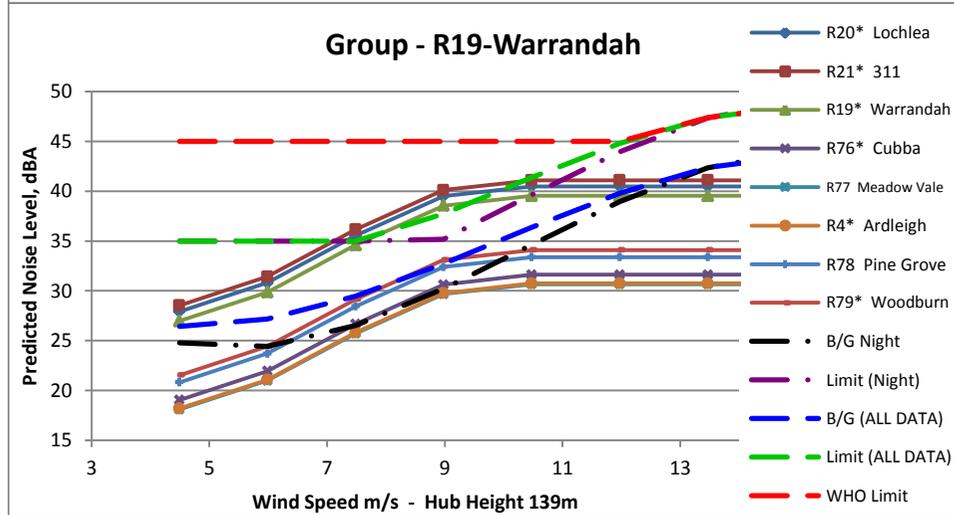
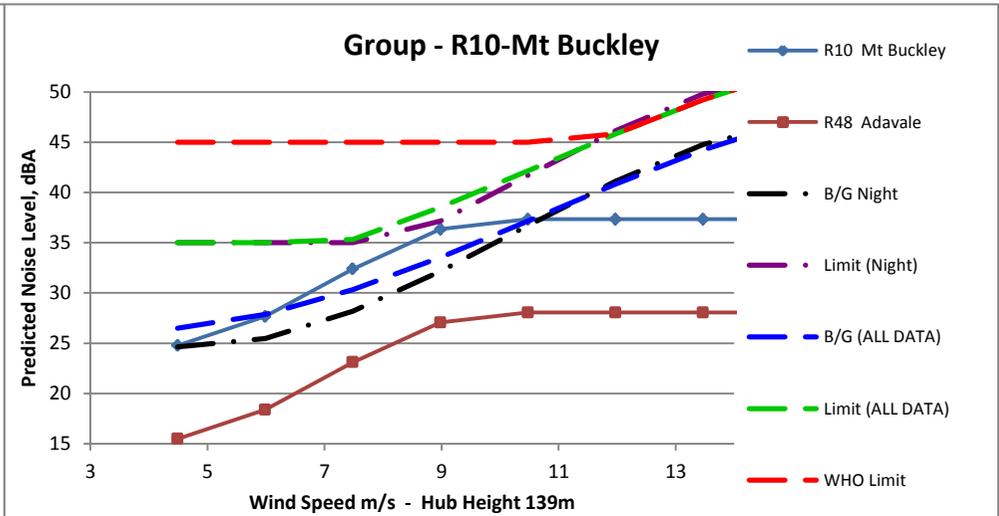
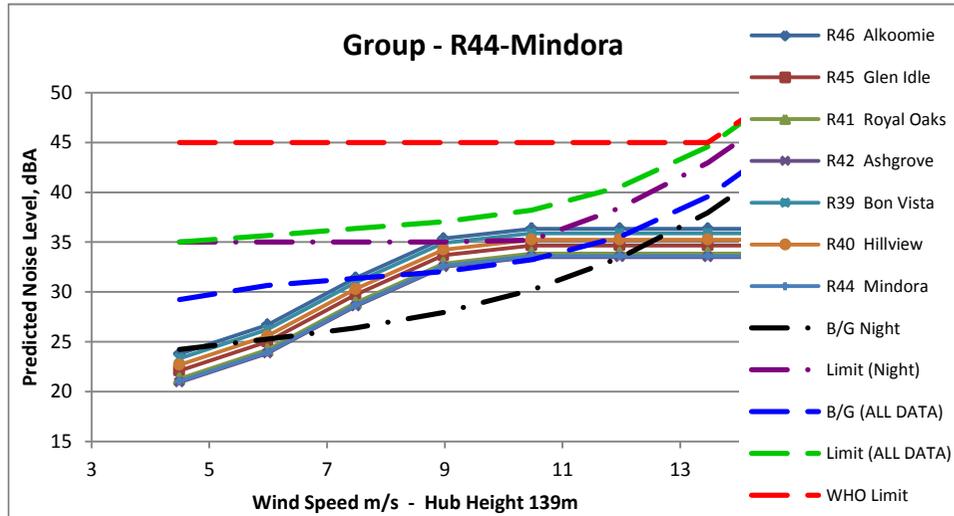


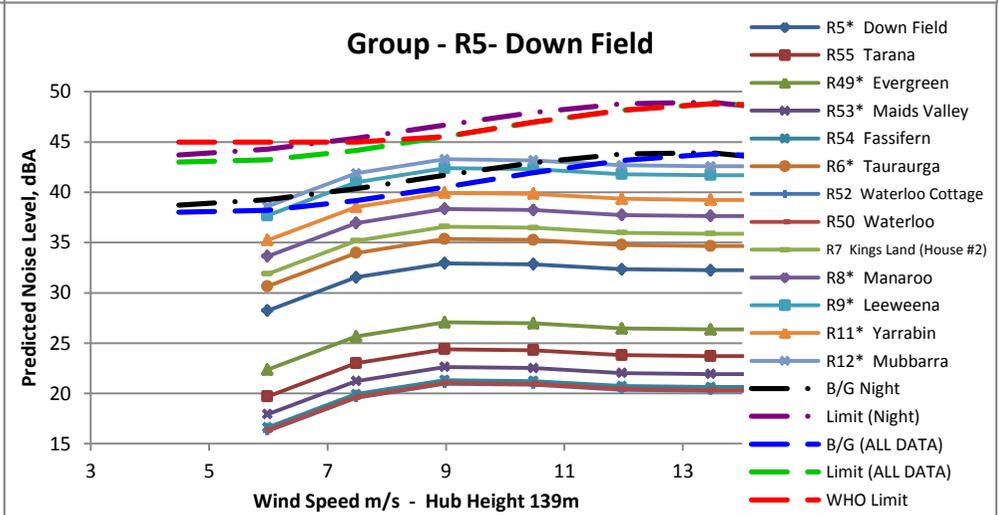
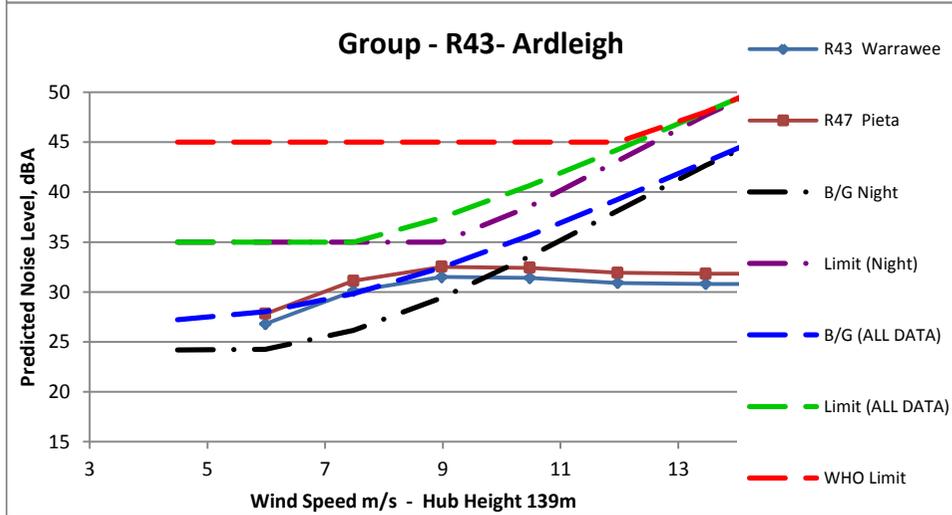
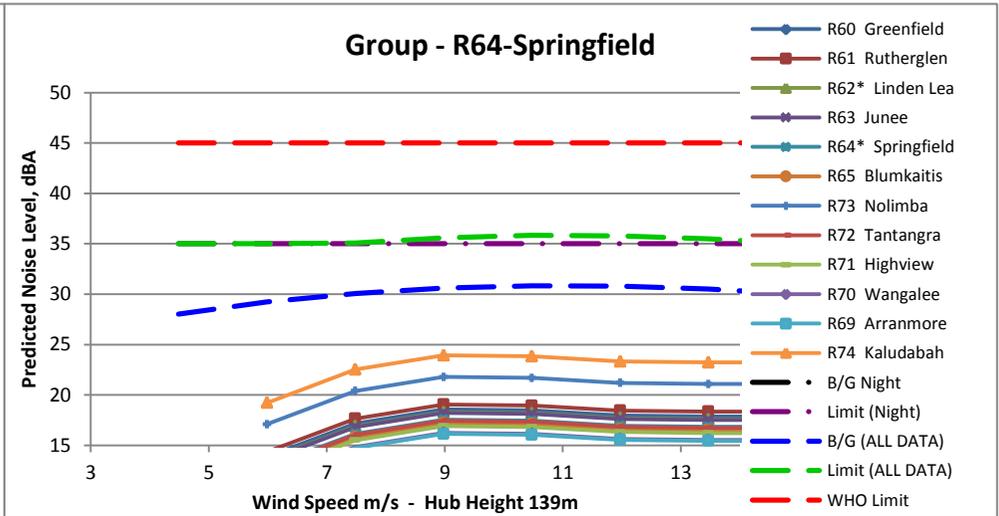
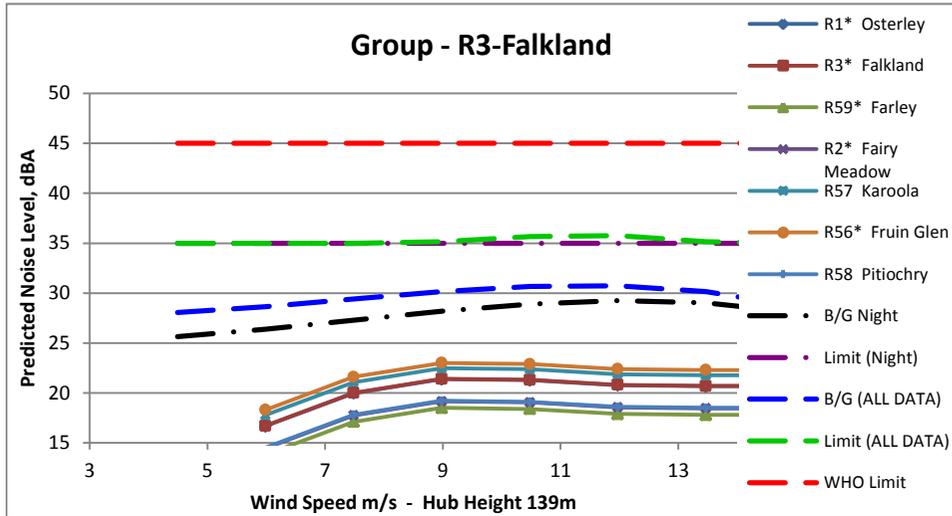


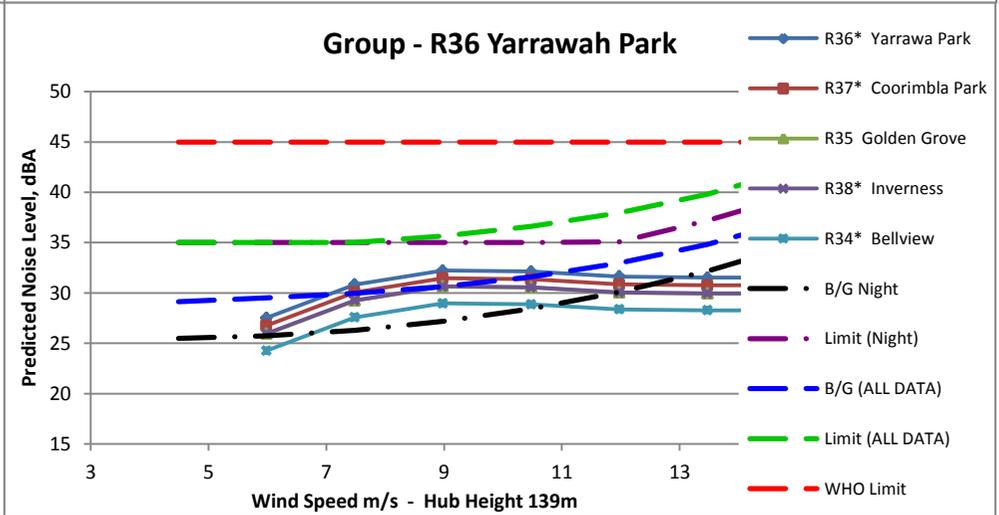
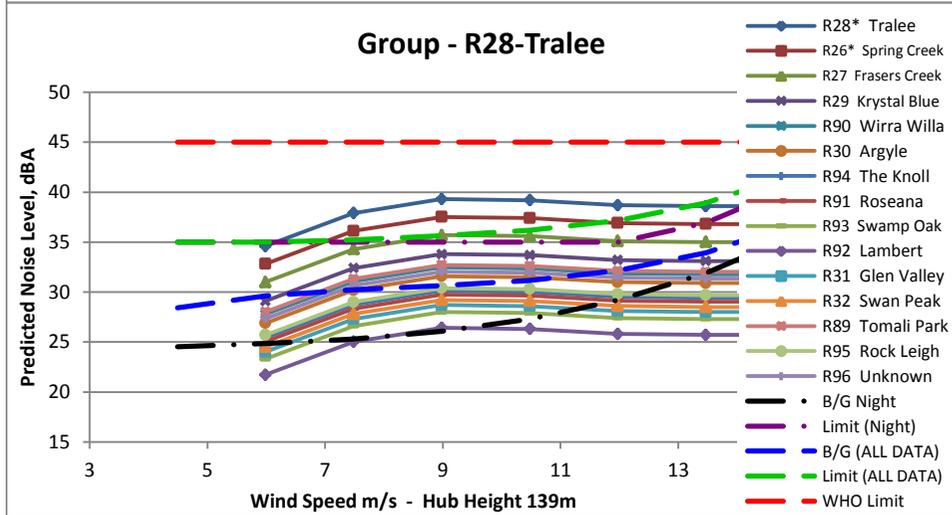
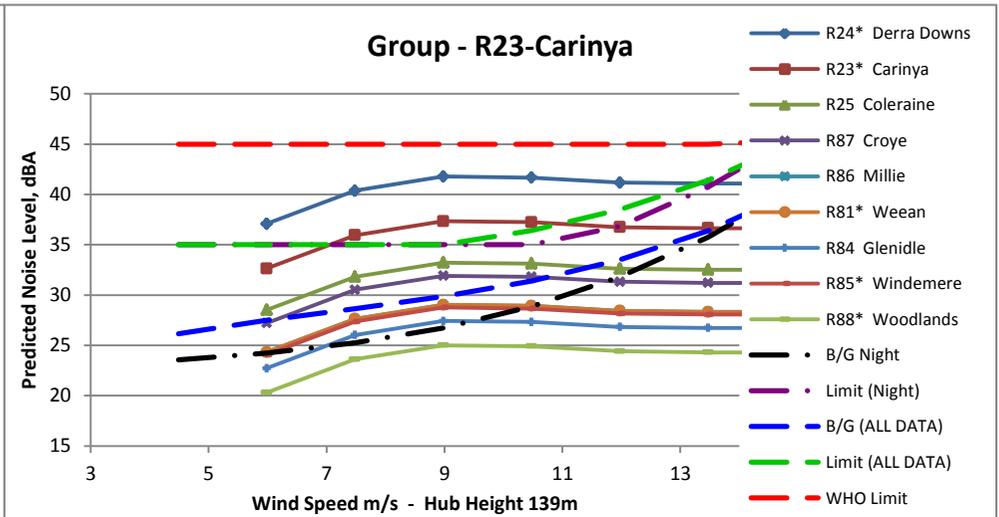
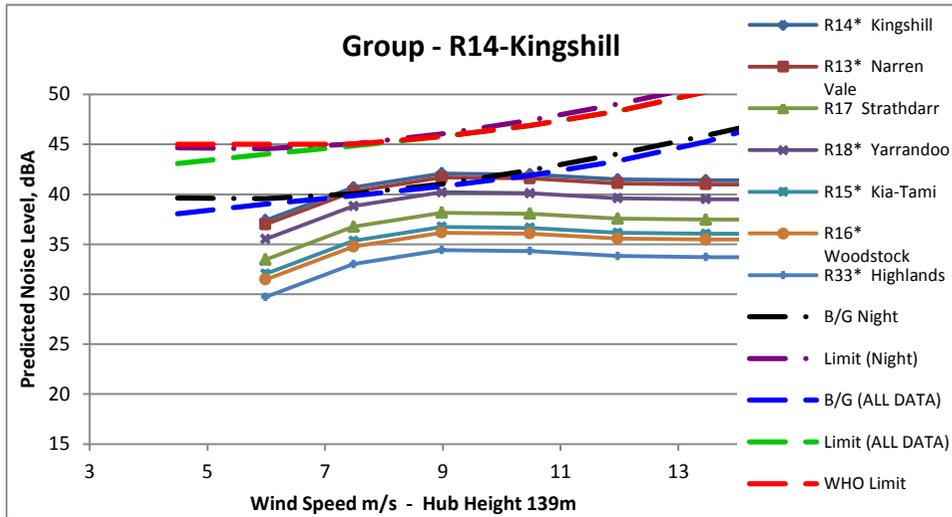


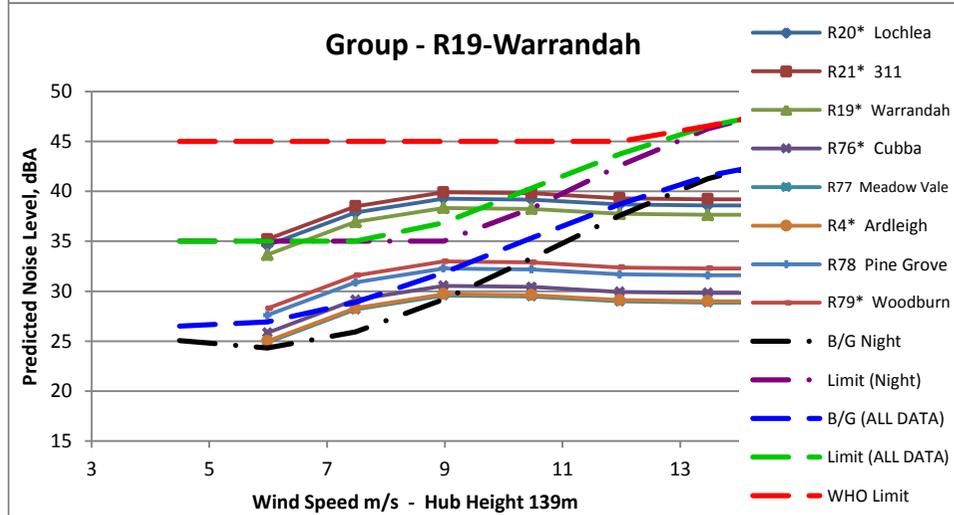
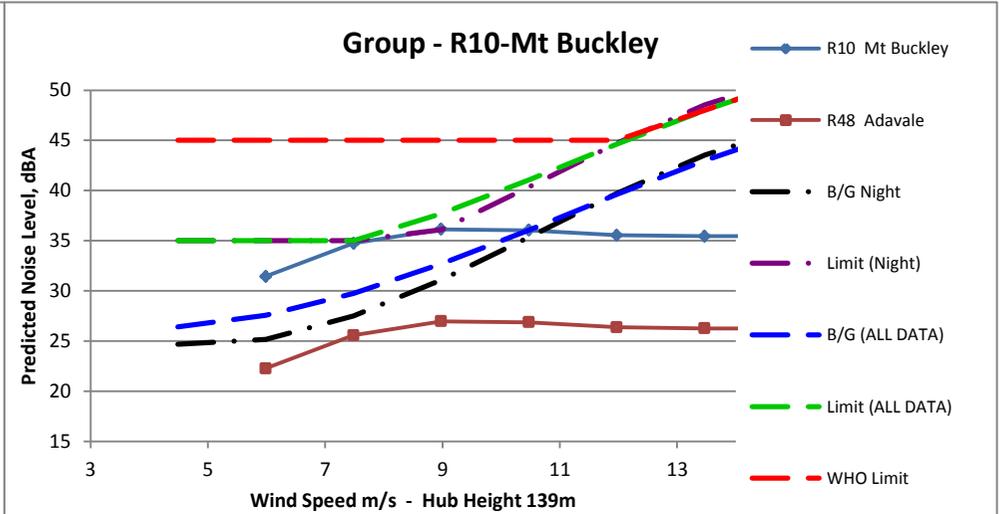
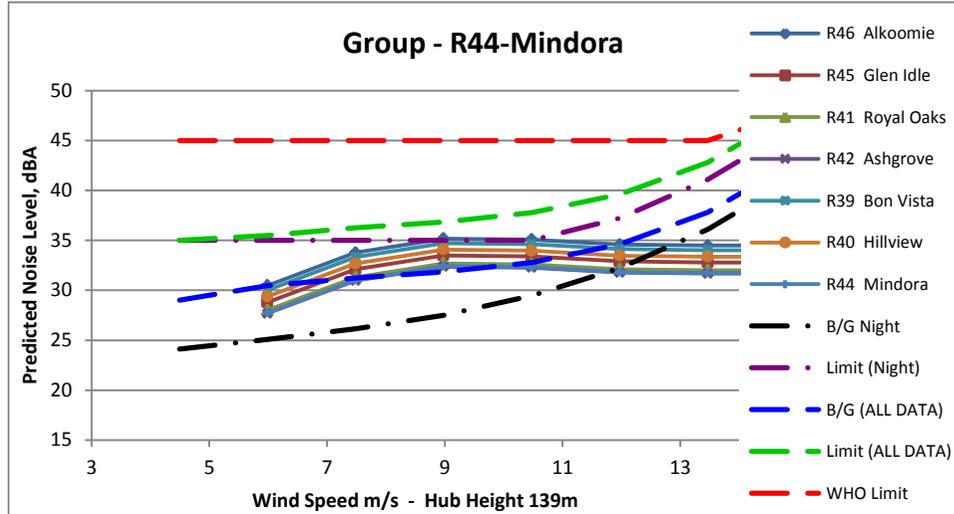


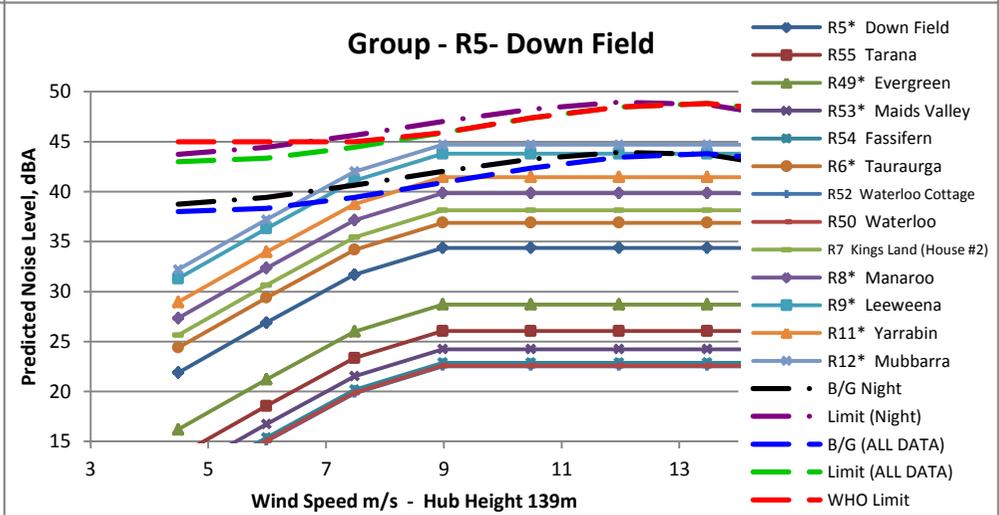
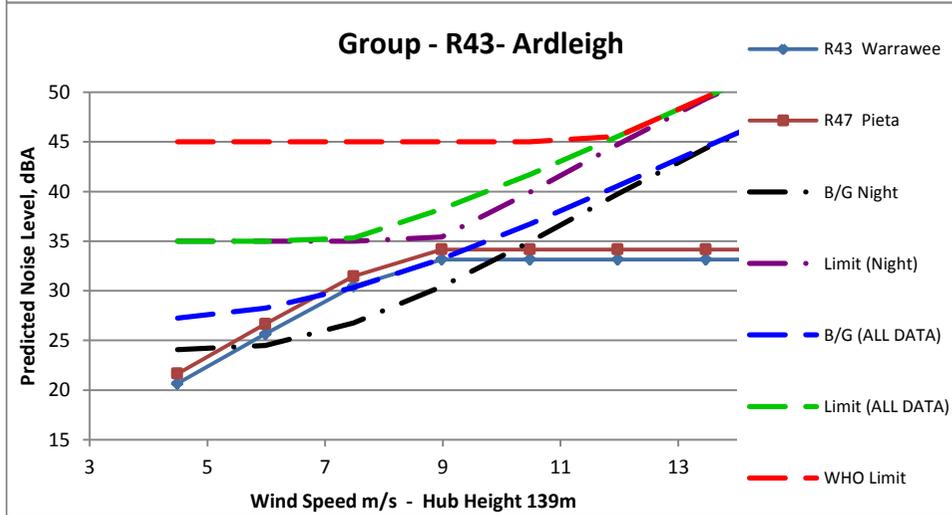
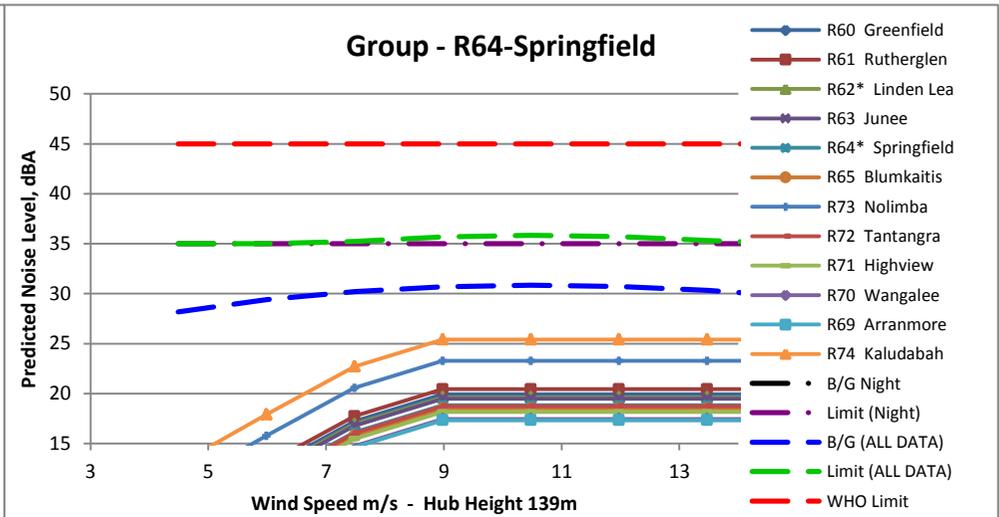
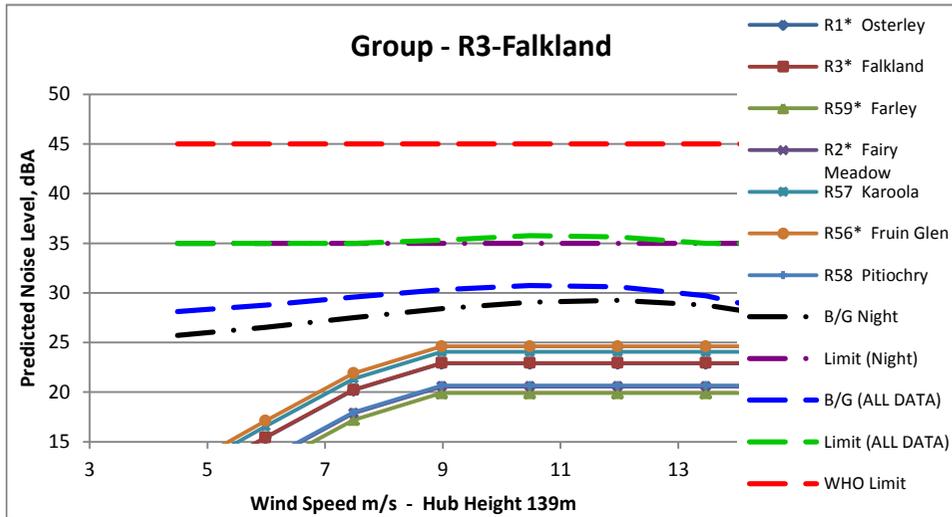


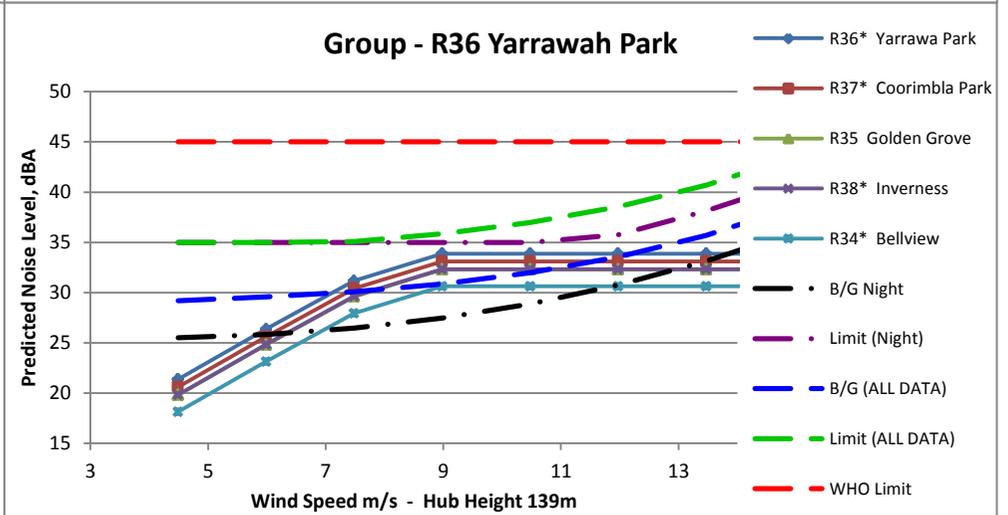
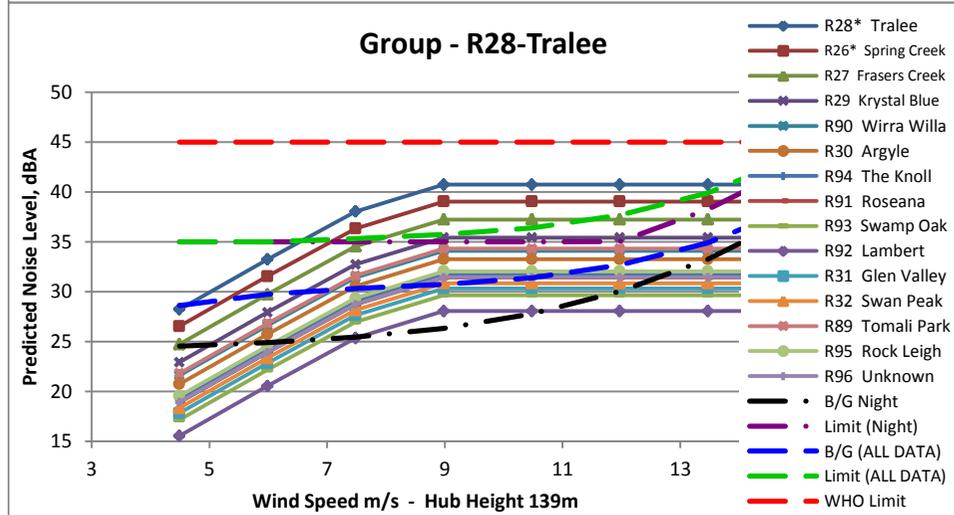
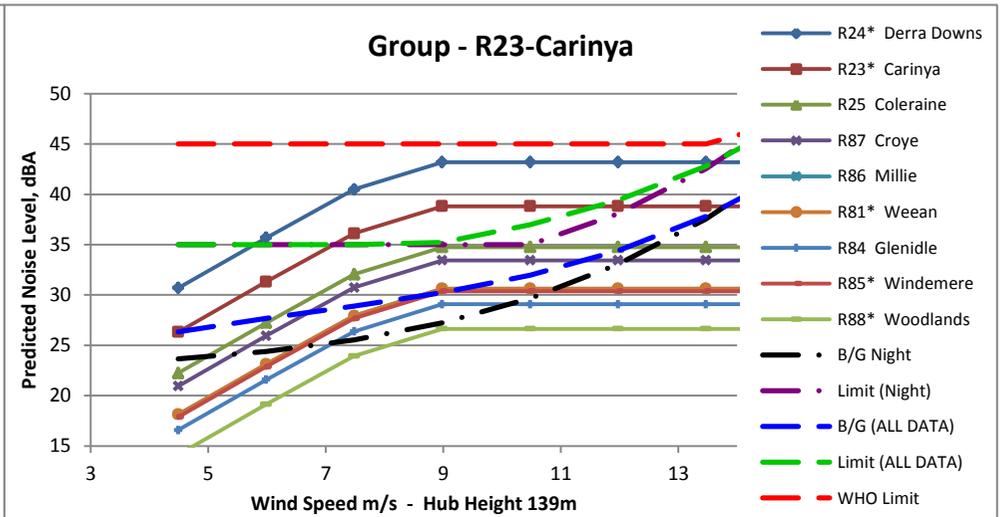
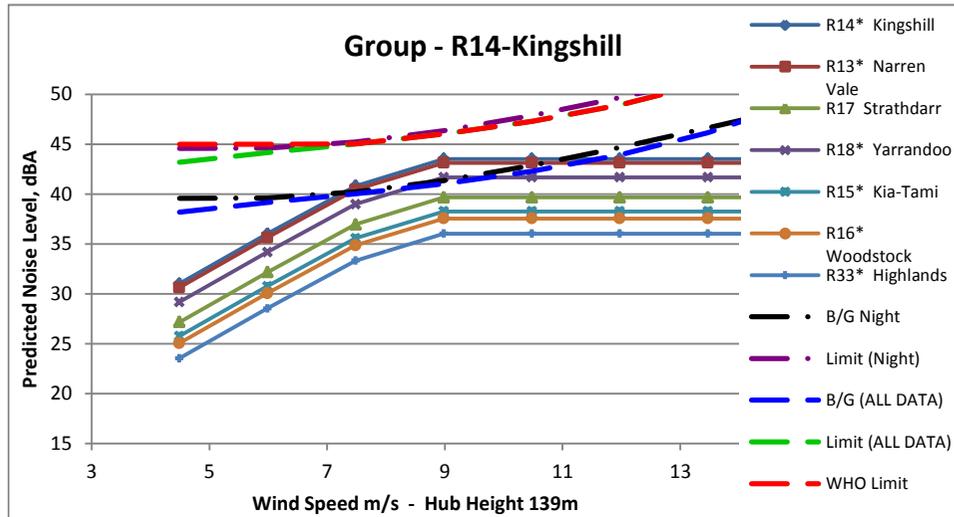


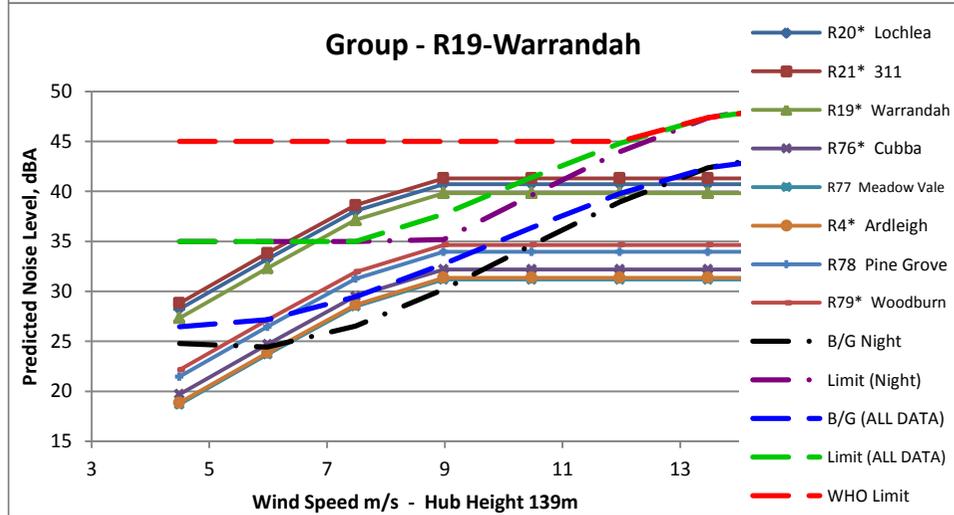
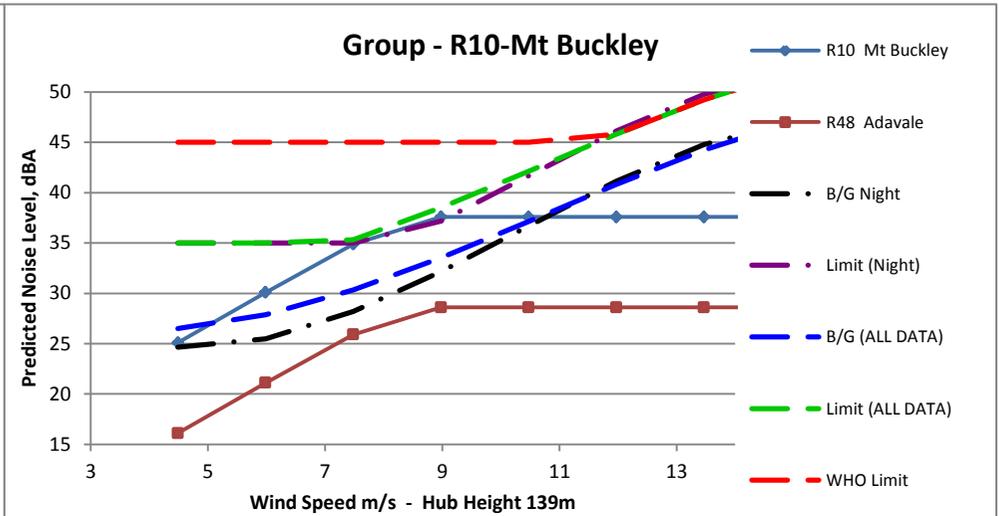
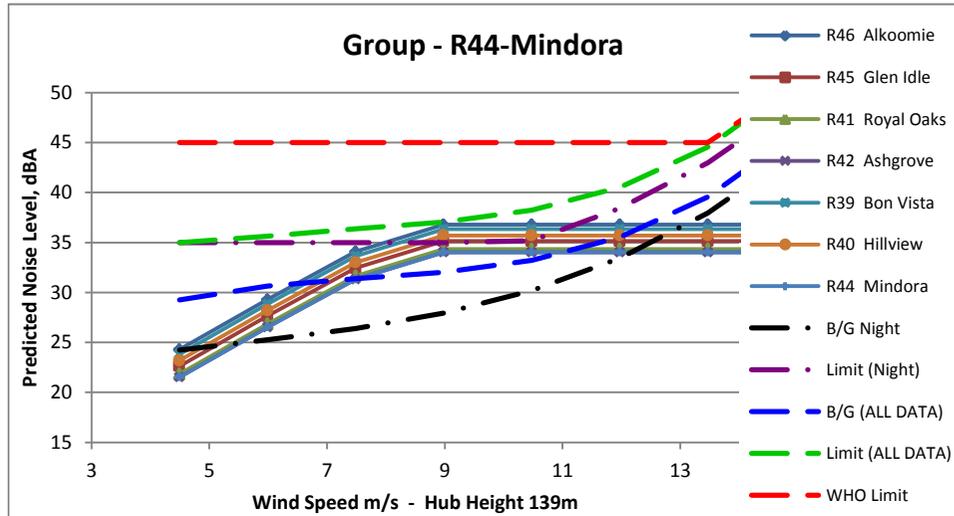


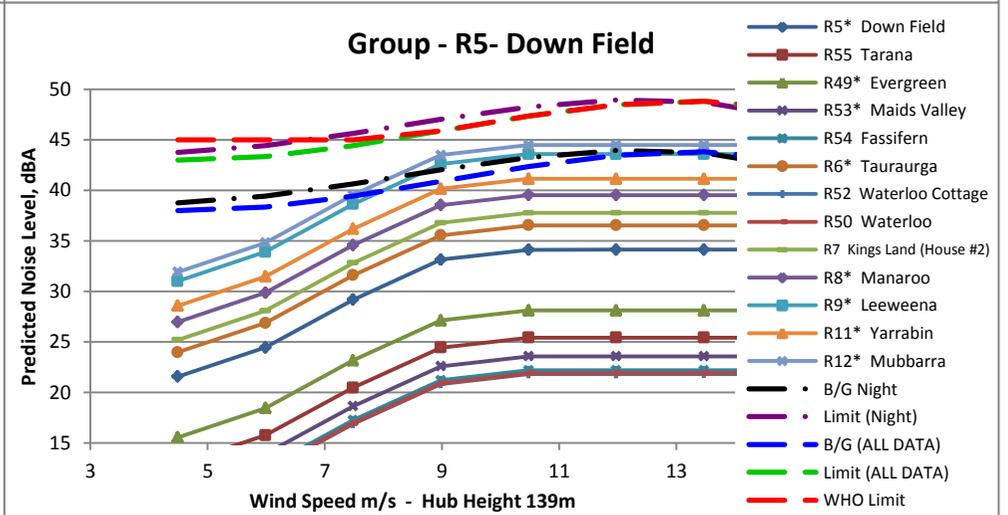
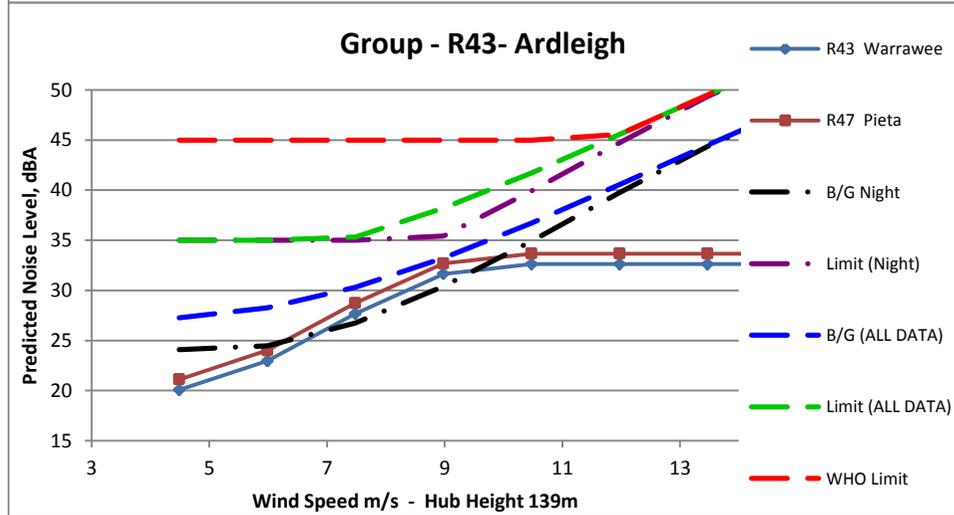
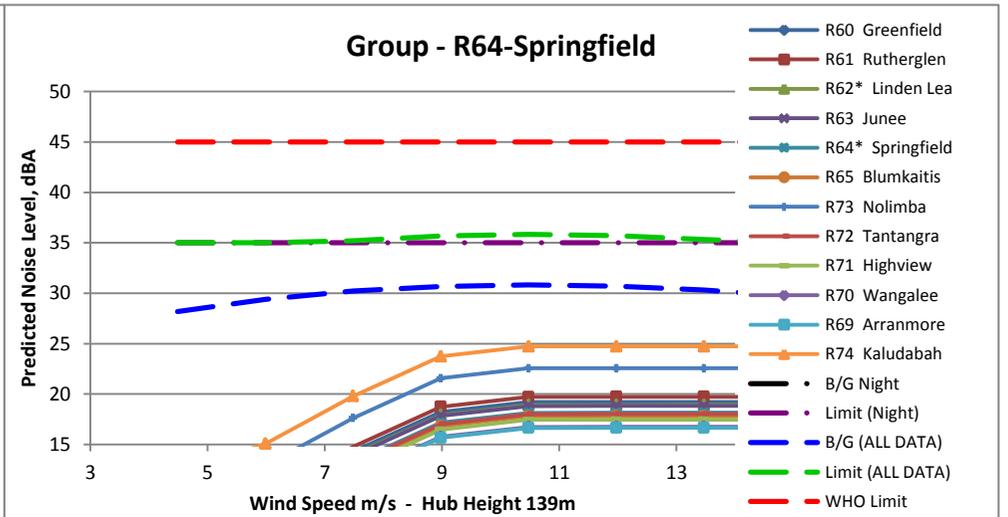
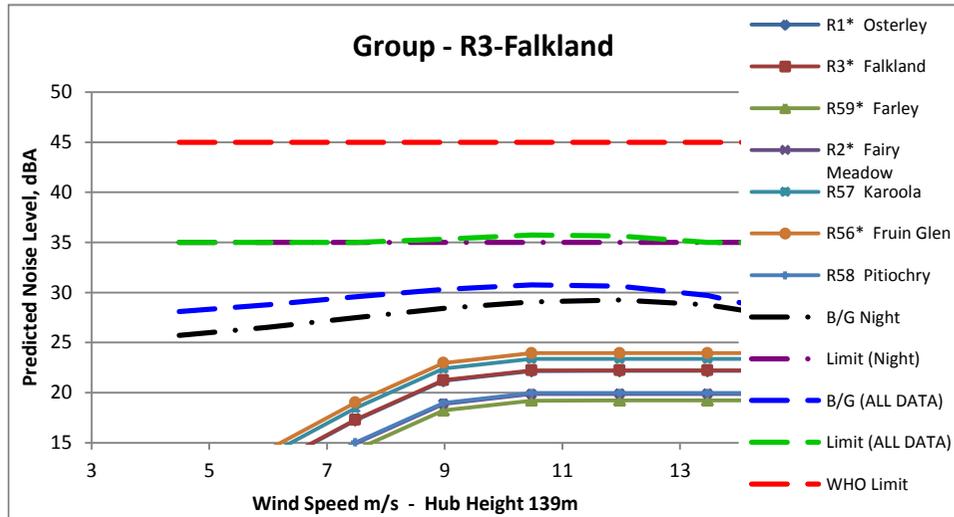


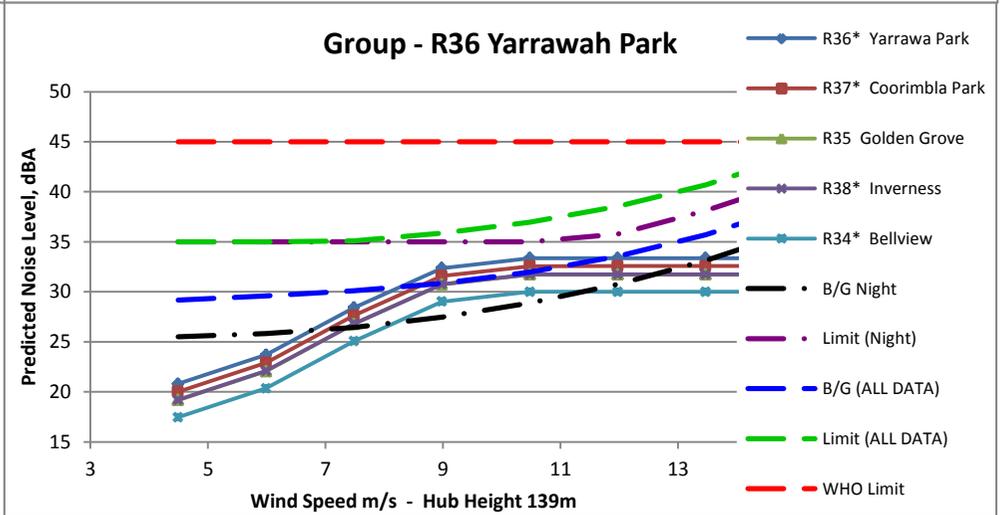
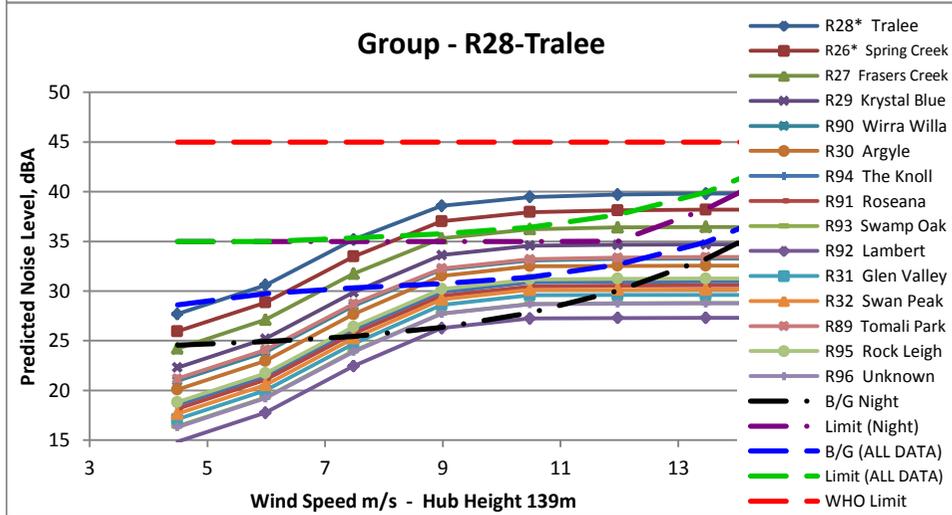
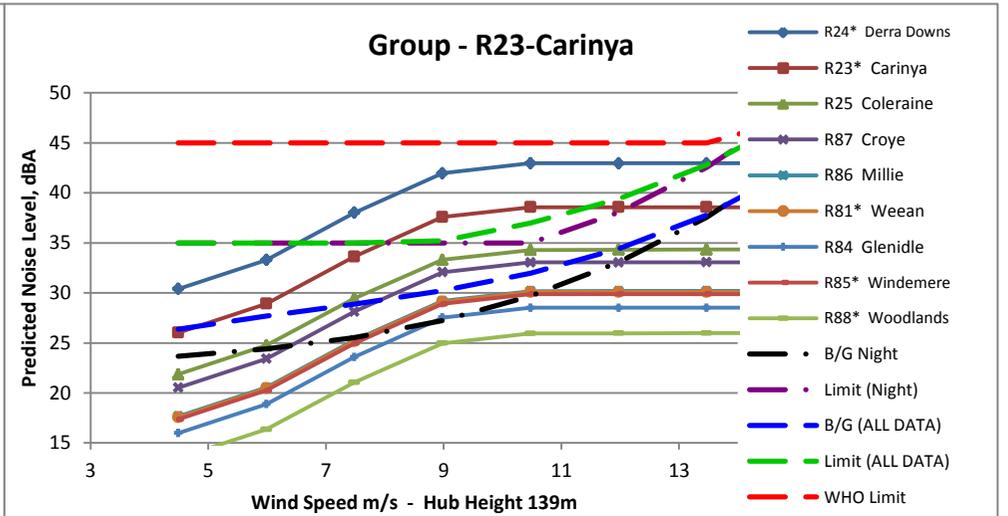
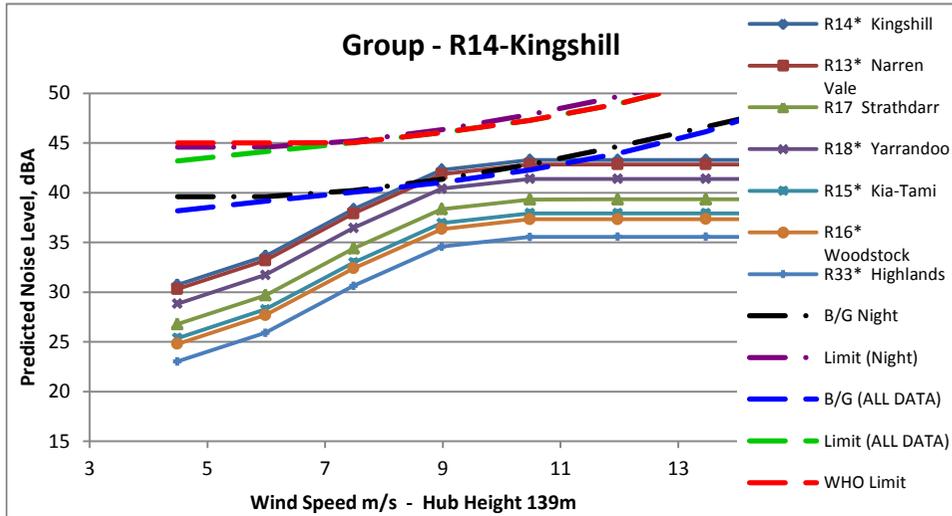


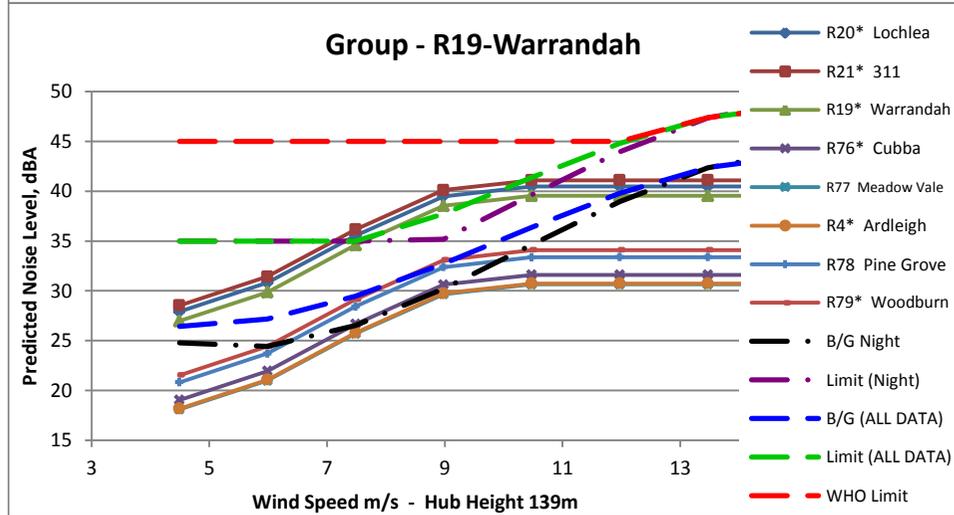
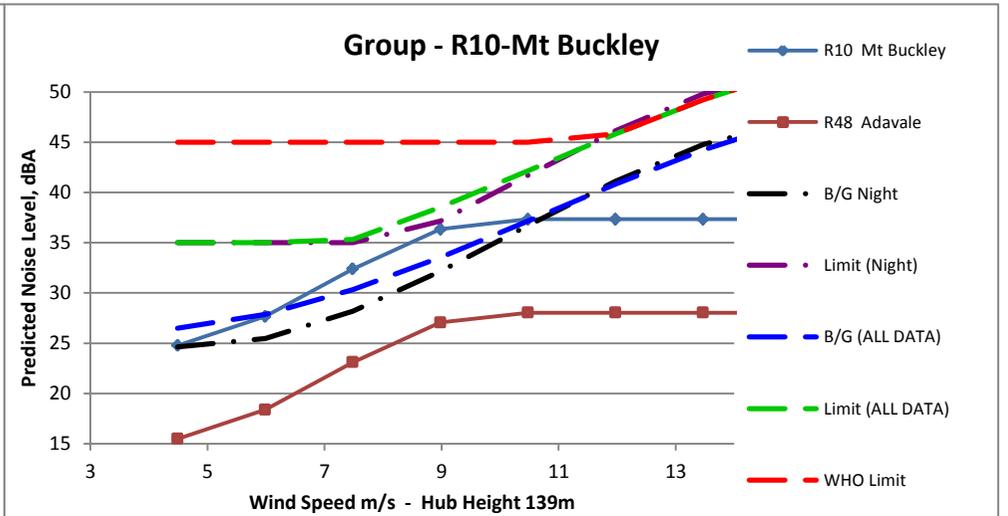
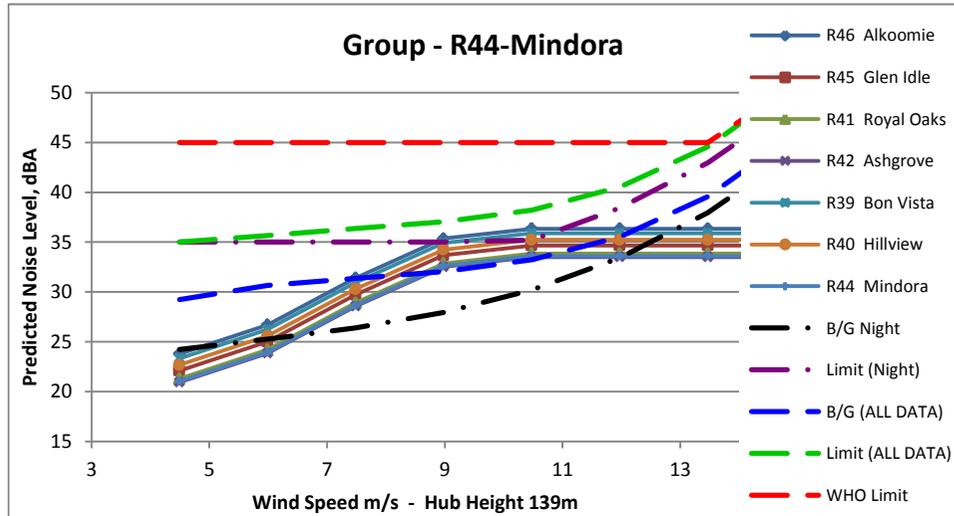


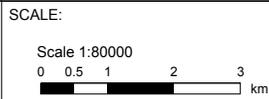
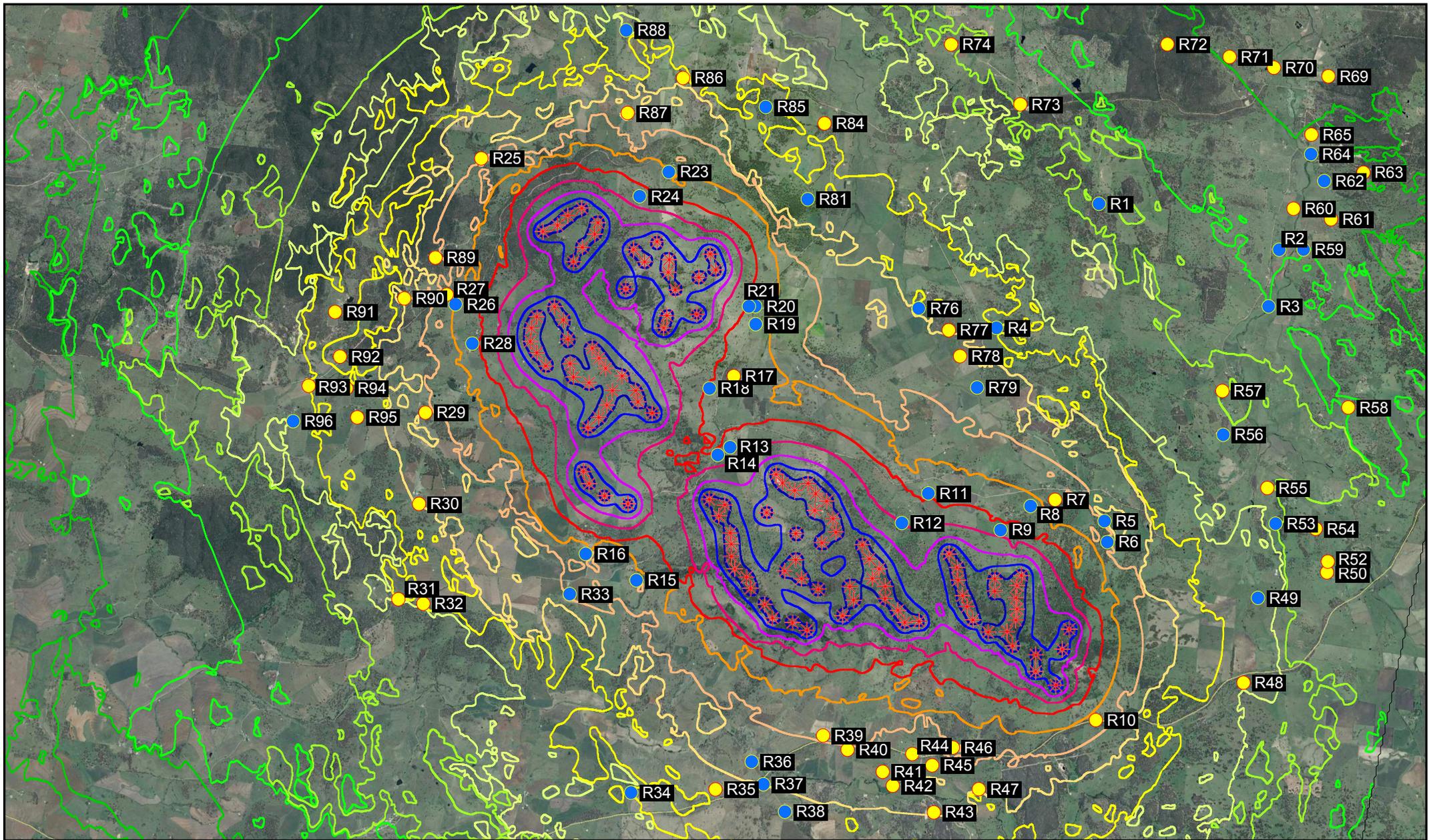












**PROJECT NO.** 640.11227

**REPORT NO.** 640.11227-R1

**APPENDIX:** B1

**PREPARED:** DWW

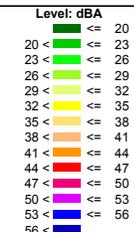
**DATE** 10/02/2016

**PREDICTION ALGORITHM:**  
ISO 9613-2 1996

**CLIENT:**  
Wind Prospect CWP Pty Ltd

**PROJECT:**  
Sapphire Wind Farm Revised NIA

**DESCRIPTION:**  
109 x Vestas V126 Standard 3.3MW  
Hub Height 139m



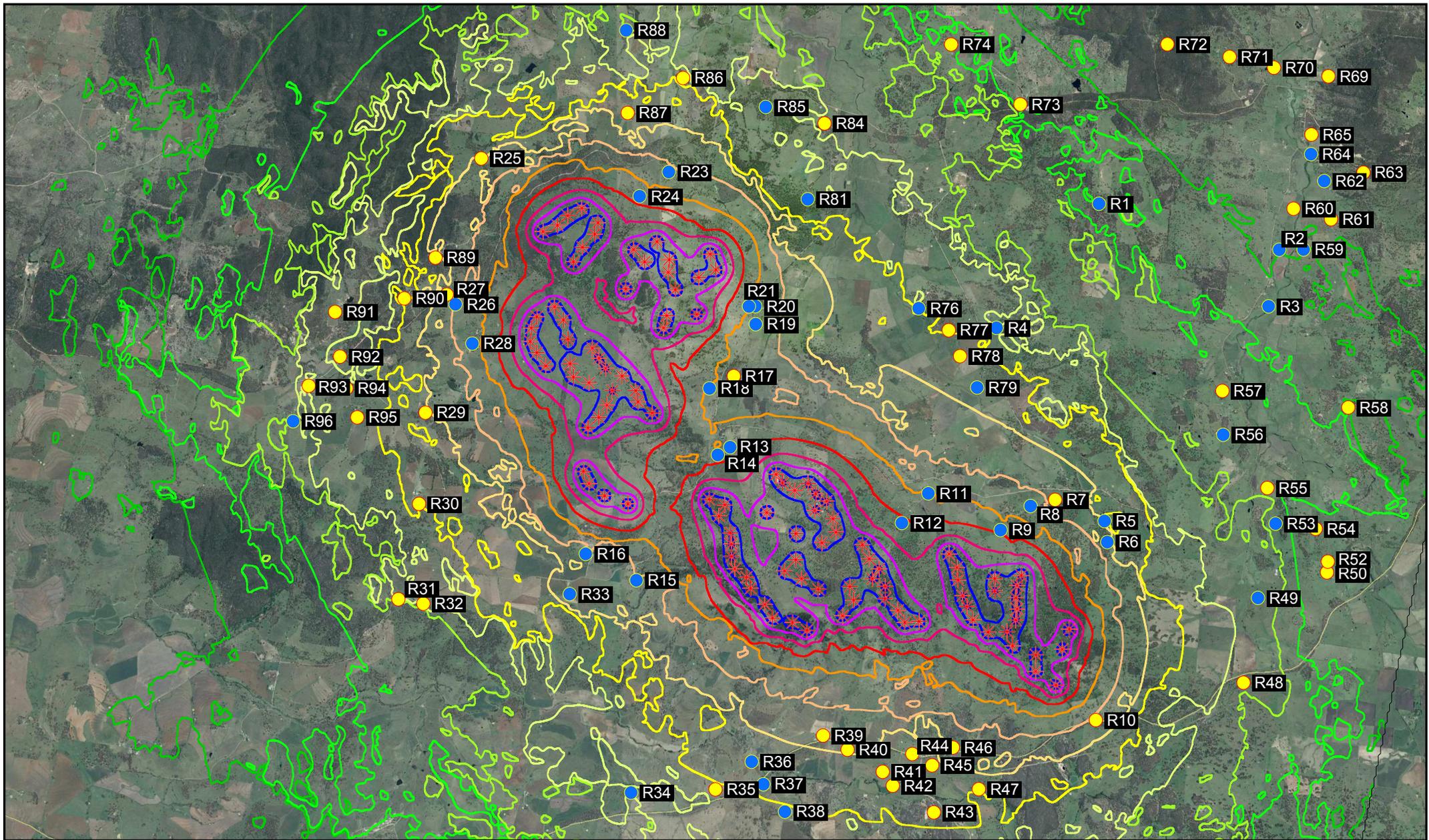
REV NO. :  
001

MAP NO. :  
001

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Balwyn North  
VIC 3104  
Australia



SCALE:

Scale 1:80000



ORIENTATION:



PROJECT NO. 640.11227

REPORT NO. 640.11227-R1

APPENDIX: B2

PREPARED: DWW

DATE 10/02/2016

PREDICTION ALGORITHM:  
ISO 9613-2 1996

CLIENT:

Wind Prospect CWP Pty Ltd

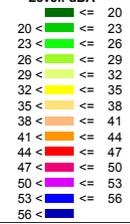
PROJECT:

Sapphire Wind Farm Revised NIA

DESCRIPTION:

109 x Vestas V126 Serrated 3.3MW  
Hub Height 139m

Level: dBA



REV NO. :

001

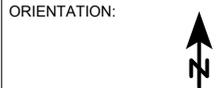
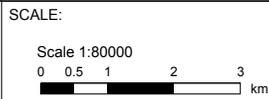
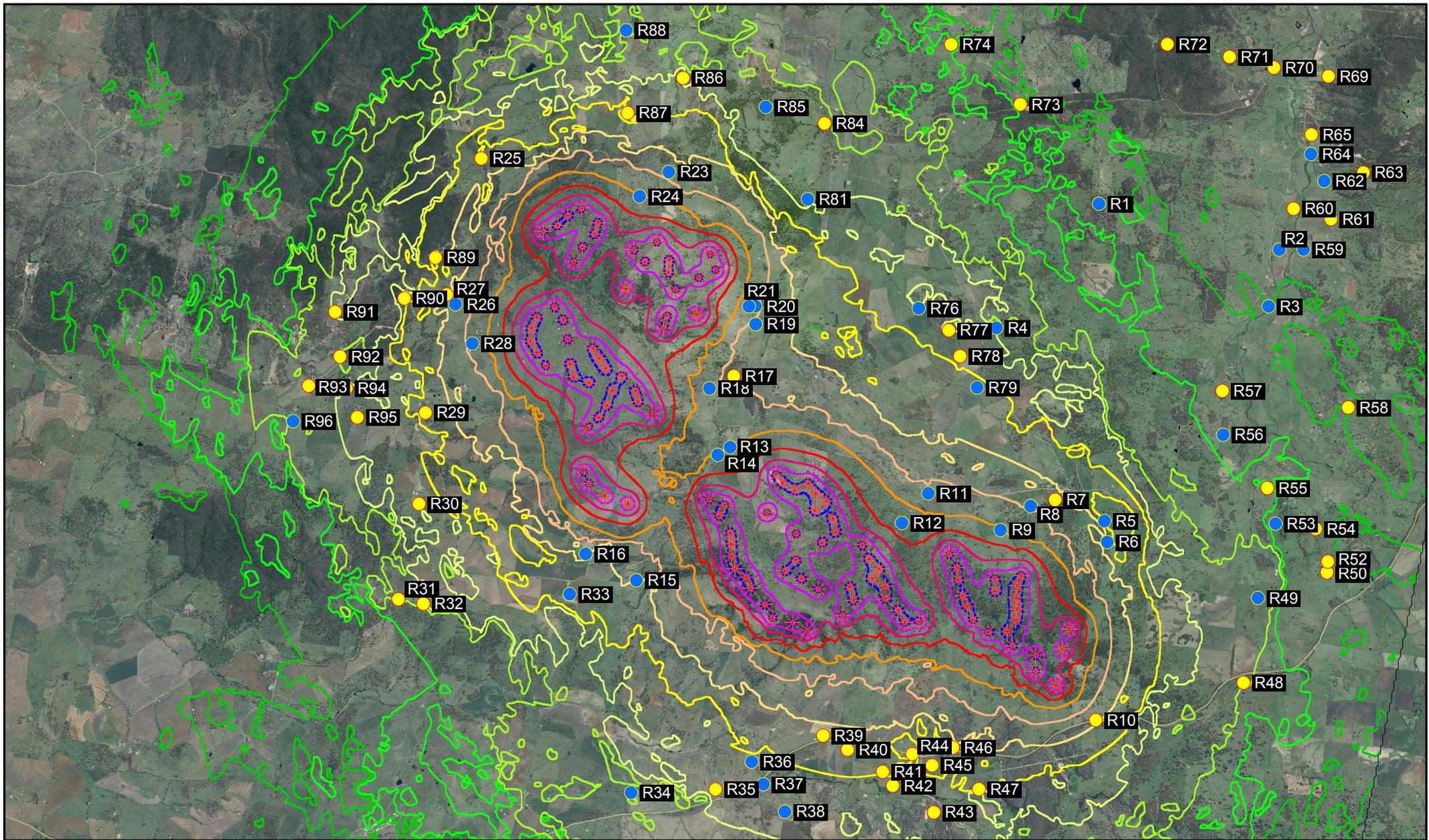
MAP NO. :

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VIC 3104  
Australia



**PROJECT NO.** 640.11227

**REPORT NO.** 640.11227-R1

**APPENDIX:** B3

**PREPARED:** DWW

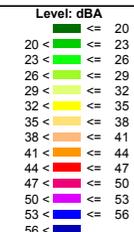
**DATE** 10/02/2016

**PREDICTION ALGORITHM:**  
ISO 9613-2 1996

**CLIENT:** Wind Prospect CWP Pty Ltd

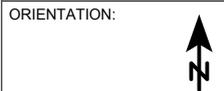
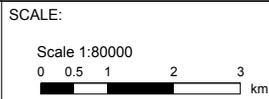
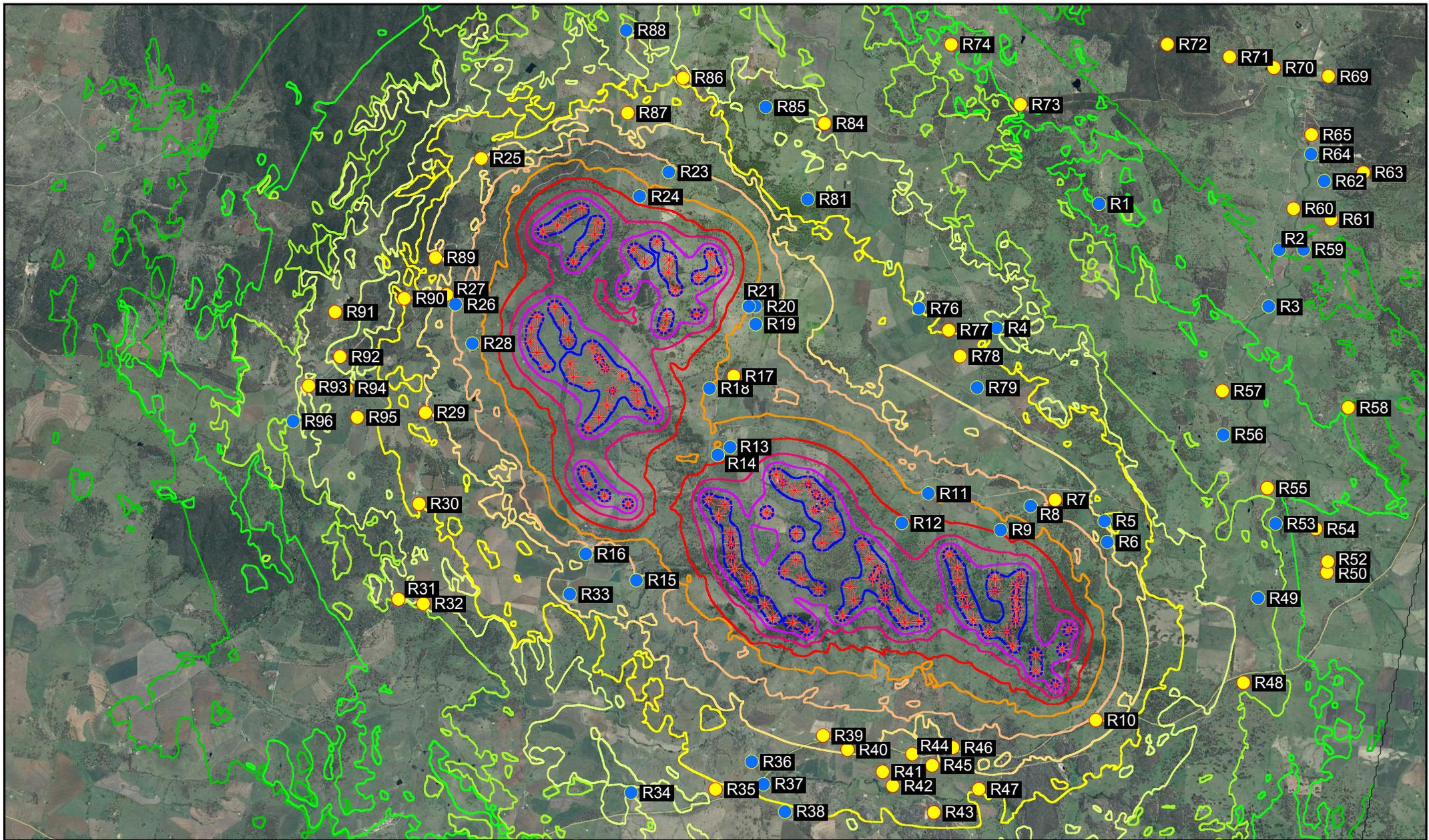
**PROJECT:** Sapphire Wind Farm Revised NIA

**DESCRIPTION:**  
109 x Senvion M122 3.0MW  
Hub Height 139m



REV NO. :  
001

MAP NO. :  
003



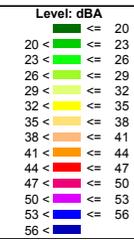
<b>PROJECT NO.</b>	640.11227
<b>REPORT NO.</b>	640.11227-R1
<b>APPENDIX:</b>	B4
<b>PREPARED:</b>	DWW
<b>DATE</b>	10/02/2016

**PREDICTION ALGORITHM:**  
ISO 9613-2 1996

**CLIENT:**  
Wind Prospect CWP Pty Ltd

**PROJECT:**  
Sapphire Wind Farm Revised NIA

**DESCRIPTION:**  
109 x GE 137 3.4MW  
Hub Height 139m



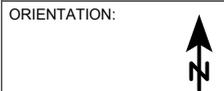
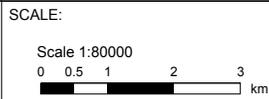
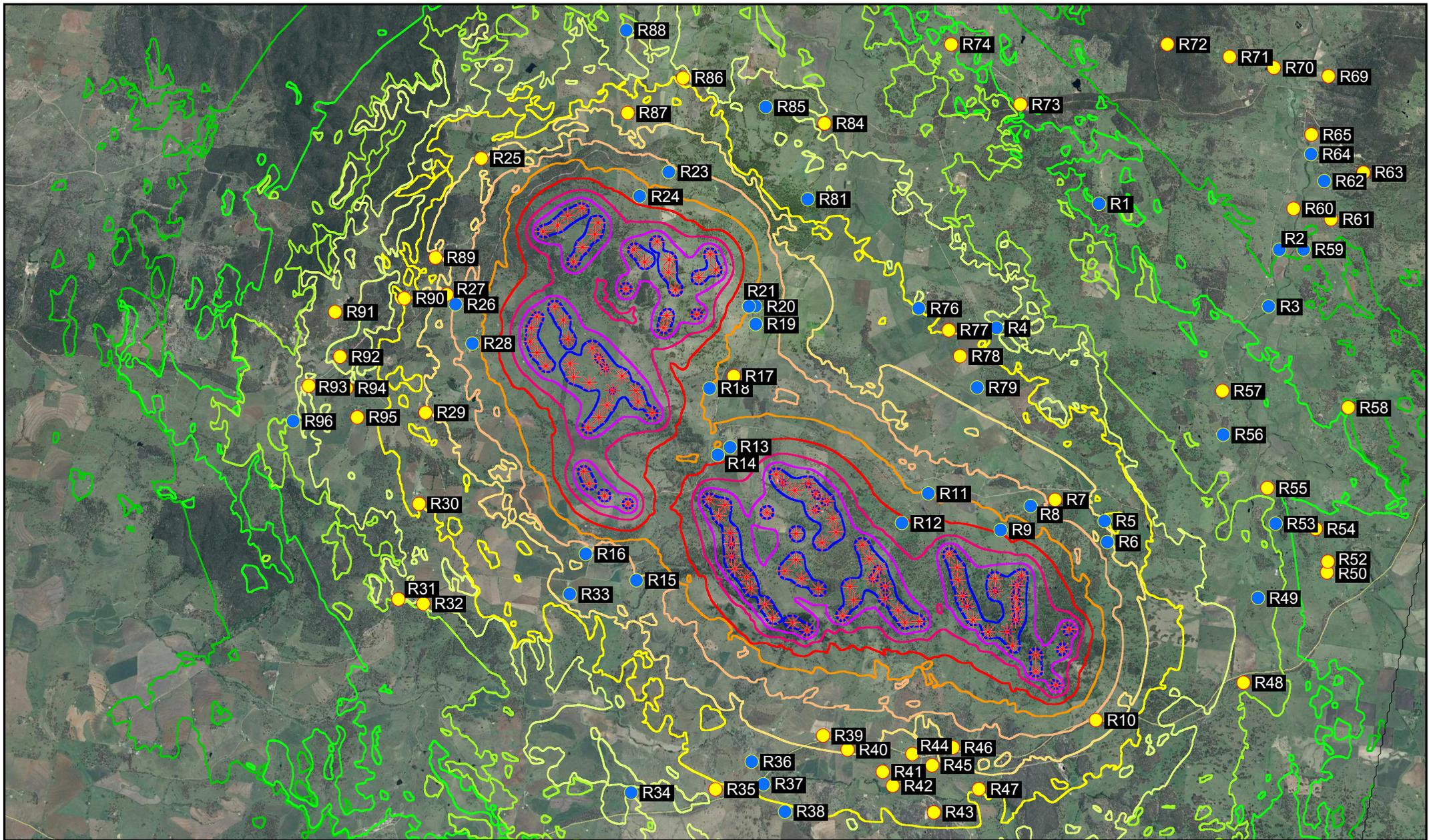
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MAP NO. :  
004

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Balwyn North  
VIC 3104  
Australia



**PROJECT NO.** 640.11227

**REPORT NO.** 640.11227-R1

**APPENDIX:** B5

**PREPARED:** DWW

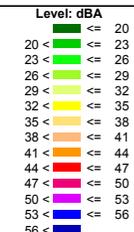
**DATE** 10/02/2016

**PREDICTION ALGORITHM:**  
ISO 9613-2 1996

**CLIENT:**  
Wind Prospect CWP Pty Ltd

**PROJECT:**  
Sapphire Wind Farm Revised NIA

**DESCRIPTION:**  
106 x Vestas V126 Serrated Mode 0 3.3MW  
3 x Vestas V126 Serrated Mode 2 3.3MW  
Hub Height 139m



REV NO. :

001

MAP NO. :

005

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Balwyn North  
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