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Our reference:	**Your reference:**	**Date:**
170691-AUME-L-02-C		24 February 2016

Re: EMI assessment for proposed Crookwell 3 Wind Farm

Dear Shaq Mohajerani,

Garrad Hassan Pacific Pty Ltd (now trading as DNV GL) has been commissioned by Union Fenosa Wind Australia Pty Ltd (UFWA) on behalf of Crookwell Development Pty Ltd to independently assess the potential electromagnetic interference (EMI) issues associated with the development and operation of the proposed Crookwell 3 Wind Farm. UFWA intends to amend the proposed Crookwell 3 Wind Farm to use a larger rotor diameter of up to 130 m in comparison to the original proposal of 104 m; this change will result in a reduction in tower height from 105 m to 95 m, and a reduction in number of proposed turbines from 28 to 23. At the request of UFWA, DNV GL has also assessed the possible cumulative EMI impacts from the Crookwell 3 Wind Farm and the adjacent existing Crookwell 1 and proposed Crookwell 2 wind farms.

DNV GL has also assessed the potential EMI-related issues arising from the development and operation of the Crookwell 2 Wind Farm (reported in document 17691-AUME-R-02-A [1]) and further details of the assessment methodologies employed by DNV GL, together with the current turbine layouts and dimensions for all three Crookwell wind farms and the results of an extensive consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms, are described in the same document. Due to the close proximity of the Crookwell 2 and Crookwell 3 wind farms, many of the results of the current EMI assessment for the Crookwell 3 Wind Farm are essentially the same as those reported in [1] and are not repeated here.

In addition, DNV GL has previously assessed the EMI for the Crookwell 3 Wind Farm based on a different turbine layout and dimensions (reported in document 45243/PR/03 issue A [2]). While the previous assessment considered only telecommunication sites with licence frequencies greater than 500 MHz located within a 50 km radius of the proposed wind farm site, the current assessment considers a 75 km radius from the site boundaries and all licence frequencies. The total number of telecommunication sites identified in the current assessment is therefore considerably greater than the number identified in the previous assessment. Consequential differences between the results obtained in the current EMI assessment and those reported in the previous EMI assessment, including details of any new

radiocommunications sites or services identified within 20 km of the proposed wind farm, are described in the following sections.

Telecommunication Towers

The current EMI assessment has identified 26 telecommunication towers within 20 km of the proposed wind farm that were not identified in the previous assessment. Details of these sites are provided in the sections below. Additionally, several sites identified in the previous EMI assessment were not found in the current assessment and are assumed to have been decommissioned.

Fixed Point-to-Point Microwave Links

Three point-to-point links passing through the proposed wind farm site (operated by Airservices Australia, Vertical Telecoms, and Optus Mobile), and three additional links passing near the site through the proposed Crookwell 1 and Crookwell 2 wind farms (operated by the Ambulance Service of NSW, NSW Rural Fire Service, and Radio Goulburn) have been identified in the current EMI assessment. These links are shown in Figure 1, and details are provided in Table 1. The links operated by the Ambulance Service of NSW, NSW Rural Fire Service, and Vertical Telecoms were not identified in the previous EMI assessment, either because the licences had not been granted at the time of the assessment or because the operating frequencies of the links were below the minimum frequency considered in that analysis.

For each of the identified links around the site, an exclusion zone has been established based on their operating frequencies, the second Fresnel zone plus the blade length for turbines with a 130 m rotor diameter. The potential exclusion zones are also shown in Figure 1. Although the larger turbine dimensions considered in the current EMI assessment require larger exclusion zones than those used in the previous assessment, the analysis shows that there are still no turbines located within the exclusion zones for the point-to-point links that pass over or near the proposed Crookwell 3 Wind Farm site. However, two turbines (A32 and A33) are located close to the exclusion zones for the links operated by Vertical Telecoms and Optus Mobile.

Feedback received from Vertical Telecoms during the consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms indicates that the Crookwell 3 Wind Farm should not adversely impact on their services provided that the turbines remain outside an alternative exclusion zone based on the first Fresnel zone, which is less conservative than the exclusion zone calculated by DNV GL and does not contain any turbines in the proposed layout. Feedback received from Airservices Australia and the NSW Rural Fire Service indicate that the Crookwell 3 Wind Farm is not expected to cause any interference to their operations and services. However, no formal responses have been received from Optus Mobile, the Ambulance Service of NSW, or Radio Goulburn to date.

The closest telecommunication tower (Site ID 9016742) identified in the current EMI assessment is located approximately 8.6 km from the proposed site boundary or 8.9 km southwest of the nearest proposed turbine (A28). This site was not identified in the previous EMI assessment, which stated that the closest telecommunication tower was located approximately 11.4 km from the nearest turbine. However, since this tower is located more than 2 km from the proposed wind farm, interference due to near field effects or scattering from the wind turbines is considered unlikely.

Fixed Licences of Point-to-Multipoint Type

The current EMI assessment has identified nine fixed point-to-multipoint Assignment ID's associated with three base stations located within 20 km of the wind farm boundary that were not identified in the previous assessment. Details of these licences are provided in Table 2. However, it is not possible to determine if there are any potential impacts on these services without knowing the locations of each station in the multipoint network. Feedback received from the operators of point-to-multipoint services during the consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms has not raised any concerns regarding potential impacts from the Crookwell 3 Wind Farm.

Other Licence Types

The current EMI assessment has identified 156 Assignment ID's allocated to other types of licences with base stations located within 20 km of the wind farm boundary that were not identified in the previous assessment. A summary of these licences and the number of associated Assignment ID's is provided in Table 3. Most of these licence types can be described as base to mobile station communication and are generally not affected by the presence of wind turbines any more than other effects. Should reception difficulty be encountered, the amelioration method for most services consists of the user simply moving to receive a clearer signal. It is assumed that potential impacts to aeronautical services will be considered as part of an aviation impact study.

Emergency Services

The current EMI assessment has identified three emergency services with licences for sites located within 20 km of the wind farm boundary that were not identified in the previous assessment. Details of these emergency services are provided in Table 4, but no direct interference has been determined. Feedback received from emergency services during the consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms has not raised any concerns regarding potential impacts from the Crookwell 3 Wind Farm.

Meteorological Radar

The current EMI assessment has identified the "Wollongong" weather station as the closest Bureau of Meteorology (BoM) radar site; this same weather station was identified in the previous assessment as "Sydney (Appin)". Additionally, the current EMI assessment has identified three BoM radar sites, at Yarrawonga, Namoi, and Bairnsdale, which were not identified in the previous assessment. However, these new sites are all located more than 350 km from the wind farm site boundary and so interference is considered unlikely. Feedback received from the BoM during the consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms has not raised any concerns regarding potential impacts from the Crookwell 3 Wind Farm.

Trigonometrical Stations

The current EMI assessment has identified two trigonometrical stations located within 20 km of the wind farm site boundary that were not identified in the previous assessment. Details of these trig points are provided in Table 5. Additionally, 12 trig stations identified in the previous EMI assessment were found to be located more than 20 km from the wind farm site boundary and were excluded from the current assessment. However, it is unlikely that trig stations located close to the wind farm host equipment that is susceptible to electromagnetic interference.

The closest Global Navigation Satellite Systems (GNSS) station identified in the current EMI assessment is located approximately 95 km southwest of the proposed wind farm site, at Mt Stromlo near Canberra. This site was not identified in the previous EMI assessment, which stated that the nearest such station was located approximately 140 km form the proposed wind farm. However, due to the significant distance of this station from the proposed wind farm, interference is considered unlikely.

Wireless Internet

The previous EMI assessment identified the potential for interference to wireless internet services provided by Cirrus Communications to dwellings in the vicinity of the wind farm. However, a recent review of the Cirrus Communications website suggests that the company is no longer providing services in this region [3]. Furthermore, UFWA has advised DNV GL that the wireless internet tower previously located within the wind farm site, which was understood to be operated by Cirrus Communications, has been decommissioned as of 31 August 2015 and will be dismantled [4]. The potential for interference to wireless internet services provided by Cirrus Communications is therefore no longer considered to be an issue and has not been considered in the current EMI assessment.

Satellite Television and Internet

The previous EMI assessment identified the potential for interference to satellite television services received at two dwellings in the vicinity of the wind farm. However, the current EMI assessment has found that no turbines in the revised turbine layout intercept the line-of-sight from commonly used television and internet satellites to the house locations considered in this analysis.

Terrestrial Television Broadcasting

The current EMI assessment has identified four digital television broadcast towers in the vicinity of the proposed wind farm, at Crookwell, Goulburn, Gunning, and Bungendore, which were not identified in the previous assessment. The closest of these is the Crookwell tower, which is located approximately 16 km northwest of the wind farm site.

The main television transmitter used by residents in the vicinity of the wind farm is the Canberra transmitter at Black Mountain. However, it is also possible that residents to the east of the site receive television signals from the Goulburn transmitter, while residents to the north of the site may receive signals from the Goulburn, Crookwell, Central Tablelands, or Illawarra transmitters. The coverage maps for these transmitters, and the possible interference zones determined for the current Crookwell 3 turbine layout, are shown in Figure 2 to Figure 6. These interference zones differ slightly from those determined in the previous EMI assessment due to the revised turbine layout.

For the current EMI assessment, a total of 25 houses were identified in the potential interference zone for the Canberra broadcast tower, including eight dwellings belonging to participating landowners. Additionally, the analysis identified 30, seven, 24, and one houses in the potential interference zones for the Goulburn, Crookwell, Illawarra, and Central Tablelands broadcast towers respectively. Further details can be seen in Table 6. The results are generally similar to the previous EMI assessment, although the Illawarra broadcast tower was not considered in that analysis and the number of houses in the potential interference zone for the Central Tablelands tower is notably reduced by the revised turbine layout.

DNV GL also understands that the Upper Lachlan Shire Council has recently installed a new free-to-air television repeater on the existing Crookwell broadcast tower at Wades Hill, which relies on a signal received from the transmitter on the Goulburn broadcast tower at Mt Gray. Although planning approval for the Crookwell 3 wind farm was granted prior to the installation of the repeater, the signal between these towers may be intercepted by turbines from the Crookwell 3 wind farm, and therefore it is possible that the turbines could impact upon the performance of the repeater. Feedback received from the Upper Lachlan Shire Council during the consultation process carried out by DNV GL for the Crookwell 2 and 3 wind farms indicates that they will be seeking to impose conditions of consent that require UFWA to take all necessary actions to protect the signal between the Goulburn and Crookwell broadcast towers, as discussed in [1]. It is recommended that UFWA undertakes further engagement with the Upper Lachlan Shire Council prior to the construction of the wind farm, to establish arrangements for monitoring and assessing any potential interference to this signal and identify how issues may be resolved if interference attributable to the wind farm is encountered.

Cumulative Impacts

Two of the point-to-point links that pass through the proposed Crookwell 3 Wind Farm (operated by Vertical Telecoms and Optus Mobile) also pass through the proposed Crookwell 2 Wind Farm. As discussed above, the link operated by Vertical Telecoms was not identified in the previous EMI assessment. However, cumulative impacts on these links are considered unlikely as no turbines from either the Crookwell 2 or Crookwell 3 wind farms are located within the potential exclusion zones. Feedback received from Vertical Telecoms during the consultation process has not raised any issues regarding potential cumulative impacts from the Crookwell wind farms, but no formal response has been received from Optus Mobile to date.

The current EMI assessment also suggests that there may be cumulative impacts on terrestrial television signals for some residences surrounding the wind farm, particularly for dwellings which have a non-directional or low-gain antenna, and therefore may receive a reflected signal from the surrounding turbines. The possible television interference zones for all three Crookwell wind farms are shown in Figure 19 of the EMI assessment for the proposed Crookwell 2 Wind Farm [1]. These interference zones differ from those determined in the previous EMI assessment, due to the revised turbine layout for the Crookwell 3 Wind Farm and the inclusion of the Illawarra broadcast tower.

In addition, the signal between the new Crookwell broadcast television repeater at Wades Hill and the Goulburn broadcast tower at Mt Gray passes through both the Crookwell 2 and Crookwell 3 wind farms, and therefore there is potential for cumulative impacts from the two projects.

Cumulative impacts for all other services are considered unlikely, and options exist to mitigate most interference issues should they occur.

Please do not hesitate to contact us if you have any queries.

Sincerely
for Garrad Hassan Pacific Pty Ltd

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References

[1] DNV GL, *EMI Assessment of the Crookwell 2 Wind Farm,* Document No 170691-AUME-R-02, Revision B, February 2016.

[2] DNV GL then trading as GL Garrad Hassan, *Assessment of electromagnetic interference issues for the Crookwell 3 Wind Farm,* Document No 45243PR03 Issue A, December 2010.

[3] Cirrus Communications, "Cirrus Communications," 2014. [Online]. Available: http://cirruscomms.com.au/. [Accessed 27 November 2015].

[4] Information within email from S. Mohajerani (UFWA) to T. Gilbert (DNV GL), 8 October 2015.

Table 1 Details of point-to-point links passing over or near the proposed Crookwell 3 Wind Farm

Link No.	Assignment ID	Licence Number	Frequency [MHz]	Postal Address
Links passing over the site				
1	734020, 734021	1105613/1	7685.25	Airservices Australia ACT/NSW Services Locked Bag 747 (Attention Spencer Robinson) EAGLE FARM QLD 4009
	734022, 734023	1105613/1	7524.25	
2	1009701, 1009702	1989792/1	7662.5	Vertical Telecoms Pty Limited PO Box 126 ROSEBERY NSW 2018
	1009703, 1009704	1989792/1	7501.5	
3	1291300, 1291301	1918104/1	8133.145	Optus Mobile Pty Limited PO Box 888 (c/- Jayantha Wickramasinghe) NORTH RYDE NSW 1670
	1291302, 1291303	1918104/1	7821.825	
Links passing near the site				
4	771109, 771110	1214881/1	414.2	Ambulance Service of NSW The Manager of Telecommunications Locked Bag 105 ROZELLE NSW 2039
	771111, 771112	1214881/1	404.75	
5	771739, 771740	1218521/1	413.8	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142
	771741, 771742	1218521/1	404.35	
6	848745, 848746	1622766/1	849.8	Radio Goulburn PO Box 1599 CROWS NEST NSW 1585

Table 2 Details of point-to-multipoint licences within 20 km of the proposed Crookwell 3 Wind Farm, not identified in the previous EMI assessment [2]

Assignment ID	Site ID	Licence No.	Latitude [GDA94]	Longitude [GDA94]	Distance to wind farm [km]	Licence Owner
778878	205697	1231600/1	-34.550008	149.866699	17	Bureau of Meteorology Network Services Operations Manager GPO Box 1289 MELBOURNE VIC 3001
778881	205697	1231600/1	-34.550008	149.866699	17	
1235565-1228611	205697	1231600	-34.550006	149.866693	17	
681534	35237	26488/1	-34.738424	149.687654	19	Goulburn City Council Locked Bag 22 GOULBURN DC NSW 2580
681535	35237	26488/1	-34.738424	149.687654	19	
714556	41454	178455/1	-34.45319	149.483947	14	Upper Lachlan Shire Council PO Box 42 GUNNING NSW 2581
714559	41454	178455/1	-34.45319	149.483947	14	
358979-27327	41454	178455	-34.453188	149.483942	14	
81689-27327	41454	178455	-34.453188	149.483942	14	

Table 3 Details of other licences within 20km of the proposed Crookwell 3 Wind Farm, not identified in the previous EMI assessment [2]

Licence Type	Licence Category	Number of Instances
Aeronautical Assigned System	Aeronautical	6
Broadcast Service	Broadcasting	12
Narrowcasting Service station(s)	Broadcasting	1
Point to Multipoint	Fixed	9
CBRS Repeater	Land Mobile	4
Land Mobile System - > 30MHz	Land Mobile	16
Paging System - Exterior	Land Mobile	4
PMTS Class B	PTS	12
1800 MHz Band	Spectrum	20
2 GHz Band	Spectrum	30
2.5 GHz Band	Spectrum	6
700 MHz Band	Spectrum	18
800 MHz Band	Spectrum	18

Table 4 Emergency services operating radiocommunication assets within 20km of the proposed Crookwell 3 Wind Farm, not identified in the previous EMI assessment [2]

Emergency Service	Contact Details	Distance of closest site from boundary of wind farm [km]
Fire and Rescue NSW	Fire and Rescue NSW Attn: AMO-Comms Level 8, 227 Elizabeth St SYDNEY NSW 2000	14
Laggan and District Bushfire Brigade	Laggan and District Bushfire Brigade PO Box 105 CROOKWELL NSW 2583	14
St John Ambulance Australia Incorporated	St John Ambulance Australia Incorporated Attn: Mr Peter LeCornu CEO PO Box 292 DEAKIN WEST ACT 2600	13

Table 5 Trigonometrical stations within 20 km of the proposed Crookwell 3 Wind Farm, not identified in the previous EMI assessment [2]

Station Name	Datum	Latitude	Longitude	Distance to site [km]
Mary	GDA94 AGD66	S34°38' 07.92" S34°38' 13.54"	E149°20' 59.00" E149°20' 54.71"	19
Tarlo	AGD66 GDA94	S34°36' 53.80" S34°36' 48.16"	E149°49' 10.21" E149°49' 14.48"	14

Table 6 Surrounding houses with potential to experience EMI to DTV from television broadcast towers

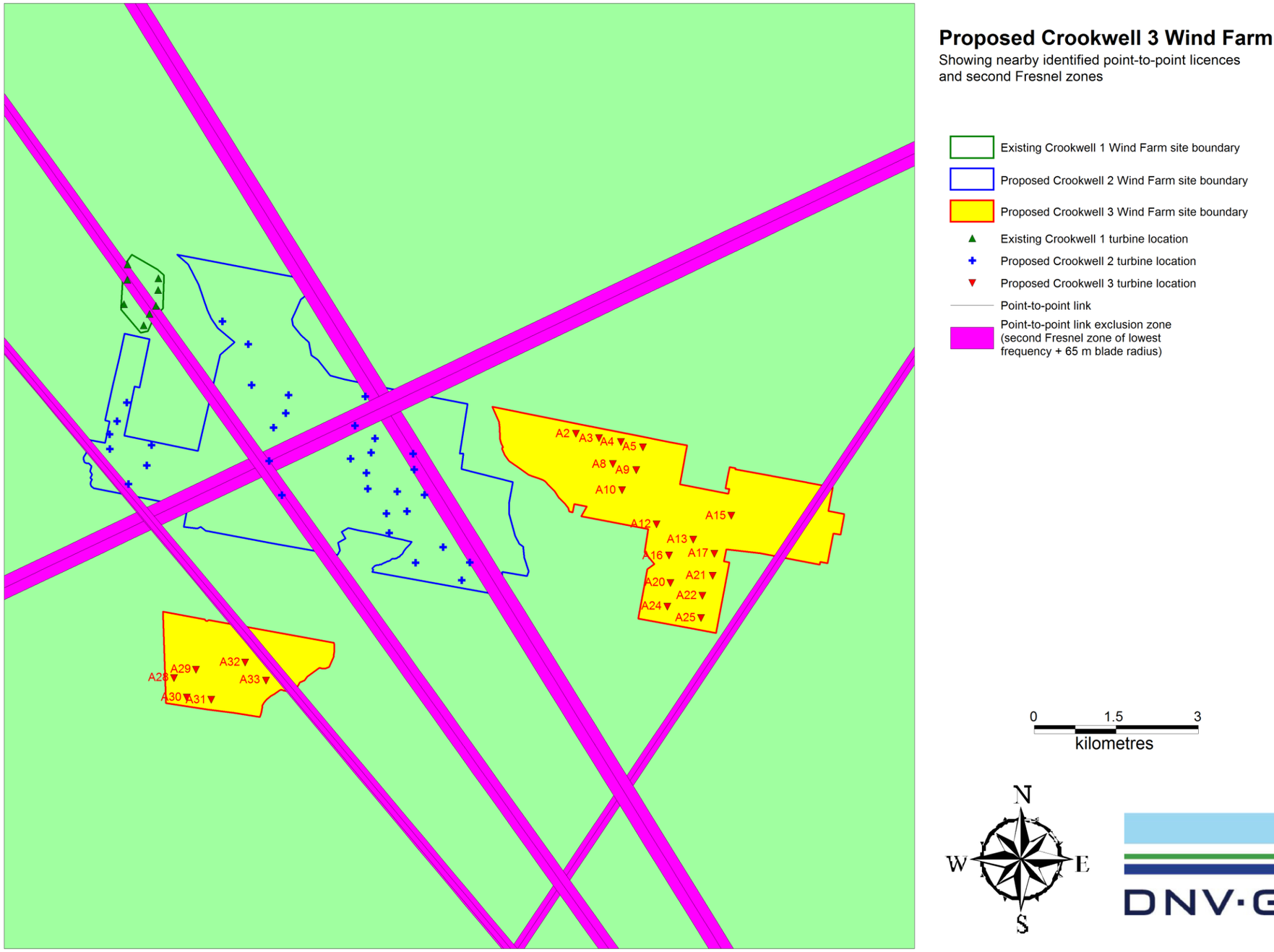
House ID	Easting[1] [m]	Northing[1] [m]	Located in the potential interference zone				
			Canberra	Goulburn	Crookwell	Illawarra	Central Tablelands
1	731647	6172983		X			
2	731698	6172026		X		X	
3	731516	6171362				X	
4	730825	6171246				X	
5	731037	6171145				X	
6	731060	6170869				X	
7	731103	6170322				X	
8	733838	6172296		X			
16	737882	6167951			X		
18	*736232*	*6171276*	*X*				
19	735698	6171835	X				
20	*735970*	*6172727*	*X*				
22	*733964*	*6173999*		*X*			
23	*736342*	*6174616*	*X*			*X*	
24	*736082*	*6174316*	*X*				
25	*736368*	*6174580*	*X*			*X*	
26	*736458*	*6174487*	*X*			*X*	
27	*736496*	*6174408*	*X*			*X*	
28	*736395*	*6174209*	*X*			*X*	
29	738978	6167634			X		
30	739244	6167665			X		
31	739448	6167994			X		
32	739063	6168245			X		
41	738995	6167592			X		
58	741473	6171450				X	
59	741415	6171733				X	
60	740389	6172231				X	
61	741369	6171908				X	
62	741337	6172055				X	
63	741181	6173622				X	
64	740395	6174100				X	
65	740315	6174217				X	
66	743524	6174343	X	X	X		
67	743724	6174675	X	X			
68	*739684*	*6175594*		*X*		*X*	
69	740191	6175752		X		X	
70	739339	6175736				X	
71	739396	6176926		X			
72	739448	6177340		X			
73	739184	6177867		X			
74	739107	6178738		X			

Note 1. Coordinate system: MGA zone 55, GDA94 datum
Stakeholder dwellings are indicated by *underlined italic text*

Table 6 Surrounding houses with potential to experience EMI to DTV from television broadcast towers(concluded)

House ID	Easting[1] [m]	Northing[1] [m]	Located in the potential interference zone				
			Canberra	Goulburn	Crookwell	Illawarra	Central Tablelands
75	739013	6178876		X			
76	739250	6178840		X			
79	*740830*	*6174323*		*X*		*X*	
80	*741434*	*6172956*				*X*	*X*
81	739537	6178821		X			
82	739732	6178548		X			
99	747850	6176725	X				
100	747569	6176543	X				
102	746121	6177583	X				
103	745231	6178338	X				
104	743973	6176996	X	X			
105	743875	6177928	X	X			
106	742598	6176726	X	X			
107	743258	6178256	X	X			
108	742847	6178538	X				
109	740622	6178917		X			
110	740029	6179174		X			
111	739678	6179037		X			
112	739674	6179055		X			
113	742622	6178593	X				
114	743051	6177981	X	X			
115	739626	6179103		X			
116	739578	6179174		X			
R117	735603	6172925	X				
R118	734952	6173081	X				
R119	734950	6172706	X				
R124	731448	6174361		X			
R125	730942	6174100		X			

Note 1. Coordinate system: MGA zone 55, GDA94 datum
Stakeholder dwellings are indicated by *underlined italic text*



Proposed Crookwell 3 Wind Farm

Showing nearby identified point-to-point licences and second Fresnel zones

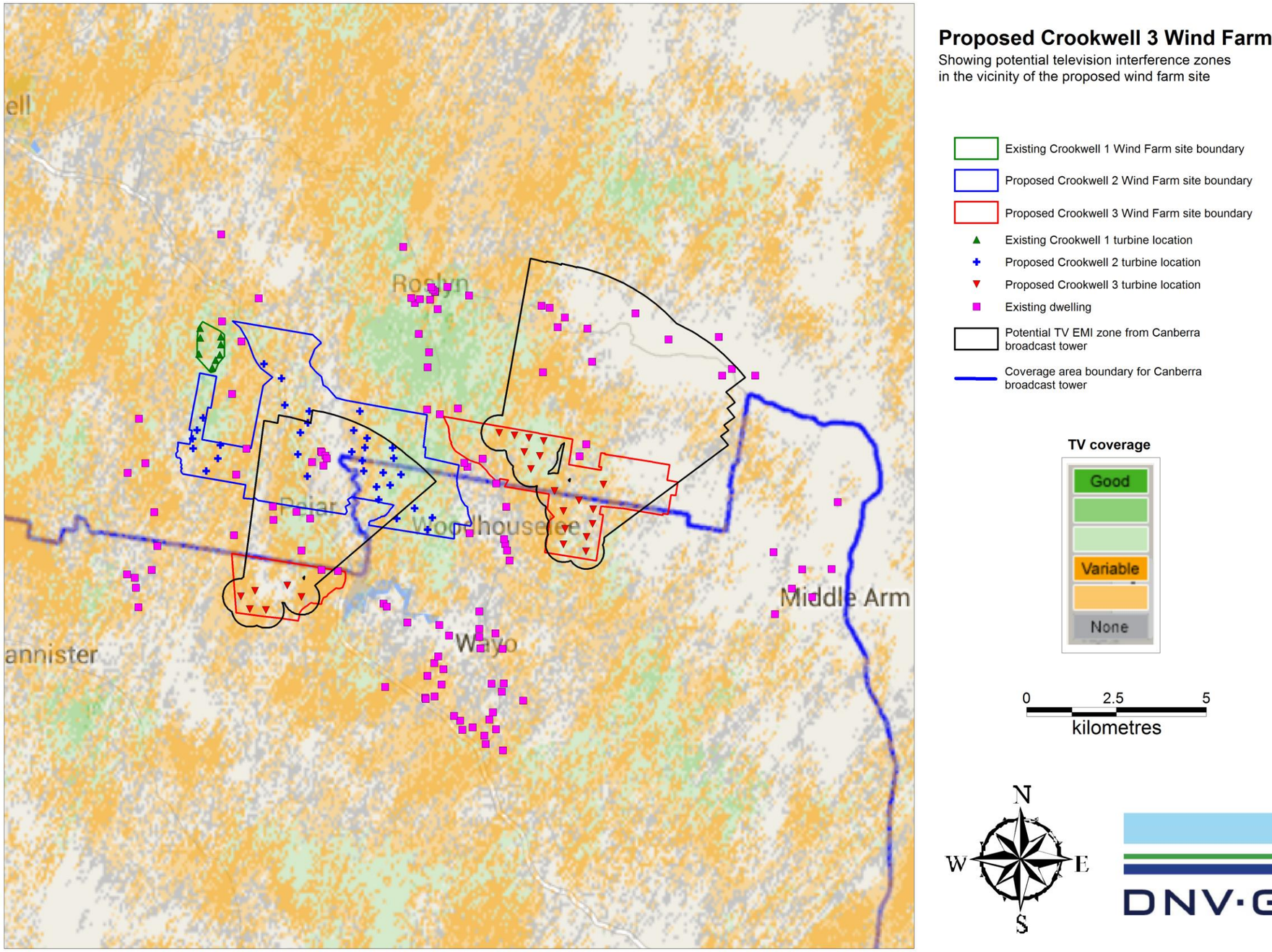
- Existing Crookwell 1 Wind Farm site boundary
- Proposed Crookwell 2 Wind Farm site boundary
- Proposed Crookwell 3 Wind Farm site boundary
- Existing Crookwell 1 turbine location
- Proposed Crookwell 2 turbine location
- Proposed Crookwell 3 turbine location
- Point-to-point link
- Point-to-point link exclusion zone (second Fresnel zone of lowest frequency + 65 m blade radius)

0 1.5 3
kilometres

N
W E
S

DNV·GL

Figure 1 **Identified telecommunication vectors and second Fresnel zones plus 65 m buffer for the proposed Crookwell 3 Wind Farm**



Proposed Crookwell 3 Wind Farm

Showing potential television interference zones
in the vicinity of the proposed wind farm site

- Existing Crookwell 1 Wind Farm site boundary
- Proposed Crookwell 2 Wind Farm site boundary
- Proposed Crookwell 3 Wind Farm site boundary
- Existing Crookwell 1 turbine location
- Proposed Crookwell 2 turbine location
- Proposed Crookwell 3 turbine location
- Existing dwelling
- Potential TV EMI zone from Canberra broadcast tower
- Coverage area boundary for Canberra broadcast tower

TV coverage

Good
Variable
None

0 2.5 5
kilometres

N
W E
S

DNV·GL

Figure 2 **Potential TV EMI zones from the Canberra broadcast tower**

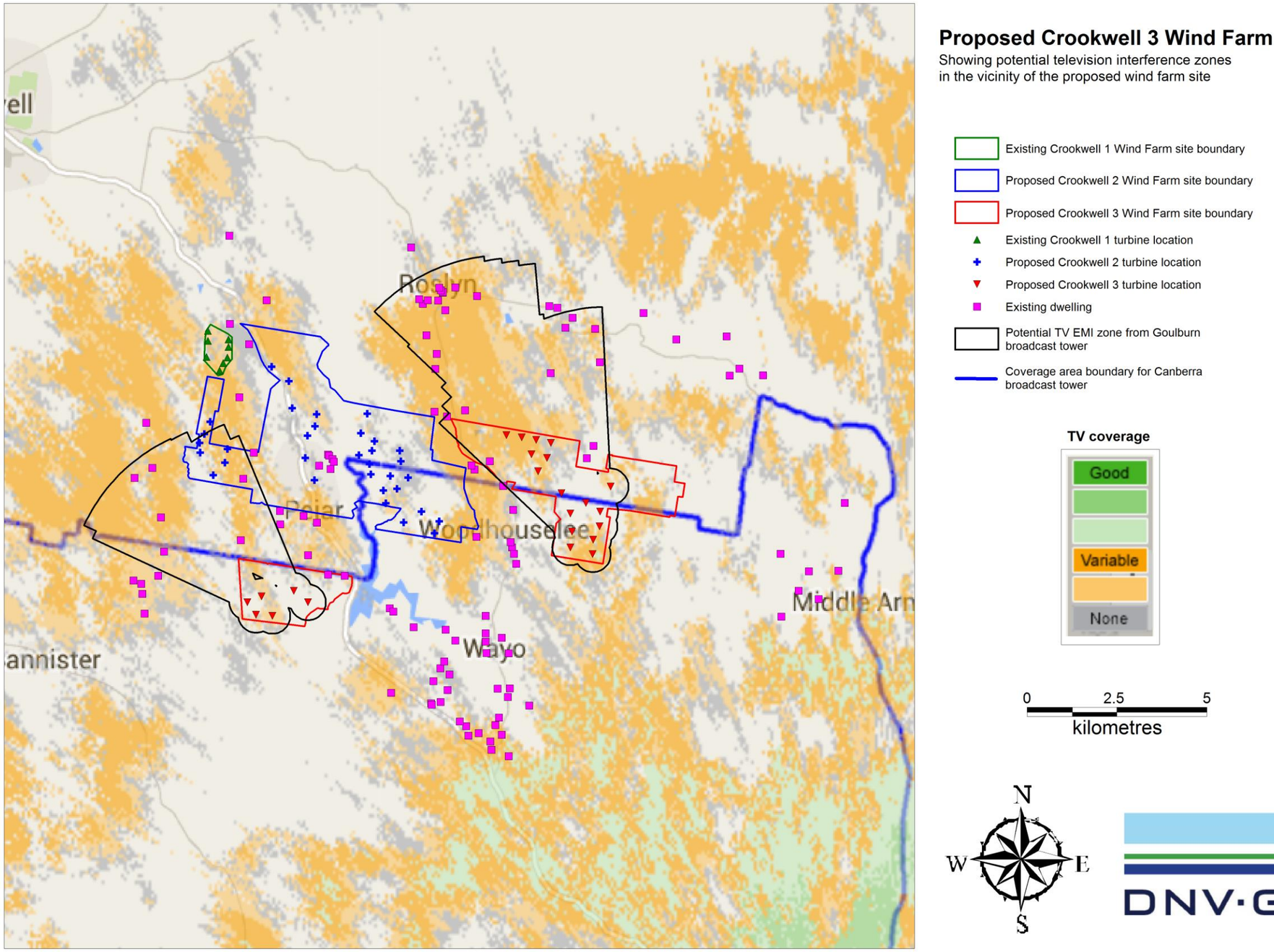


Figure 3 **Potential TV EMI zones from the Goulburn broadcast tower**

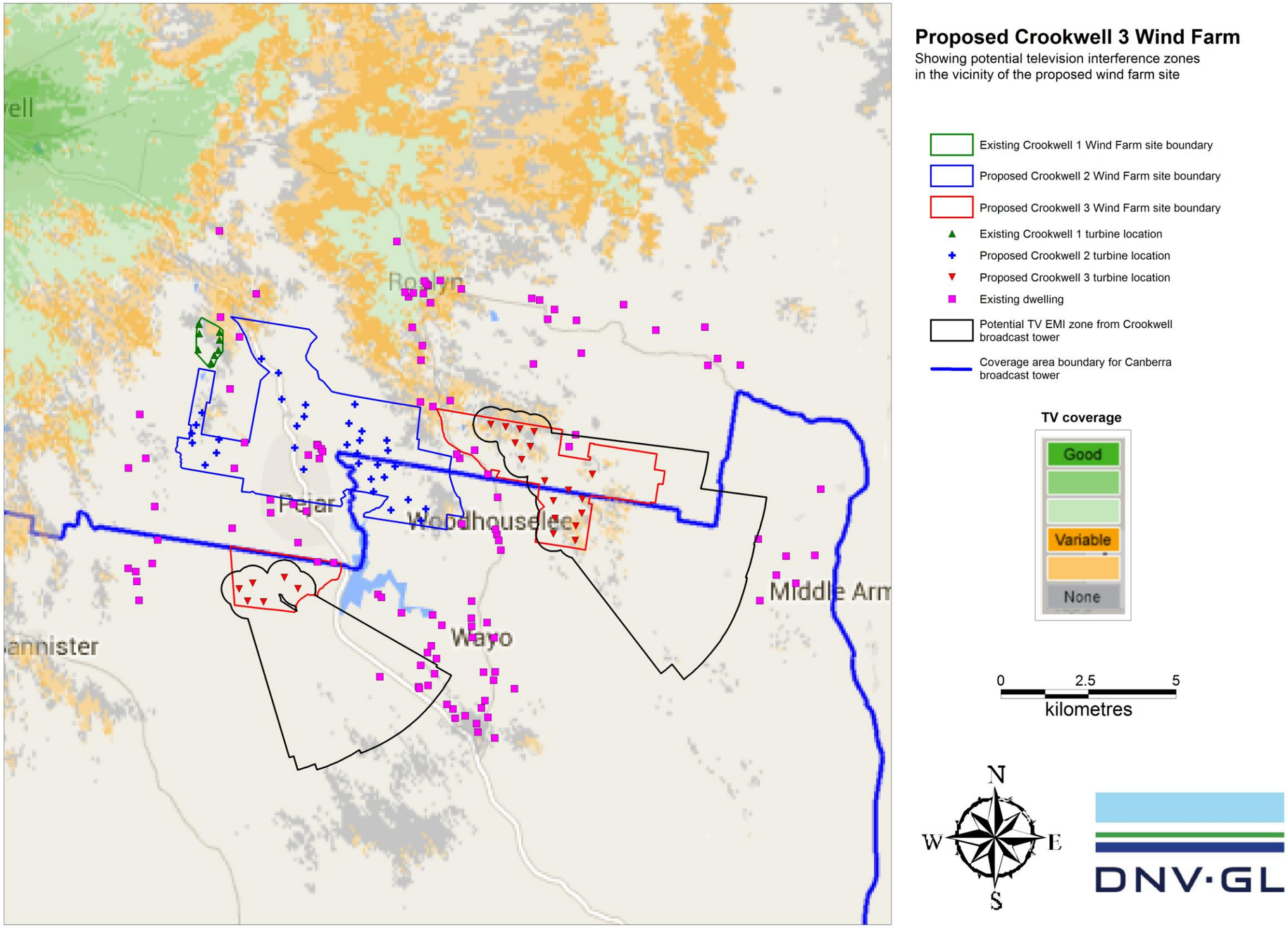


Figure 4 **Potential TV EMI zones from the Crookwell broadcast tower**

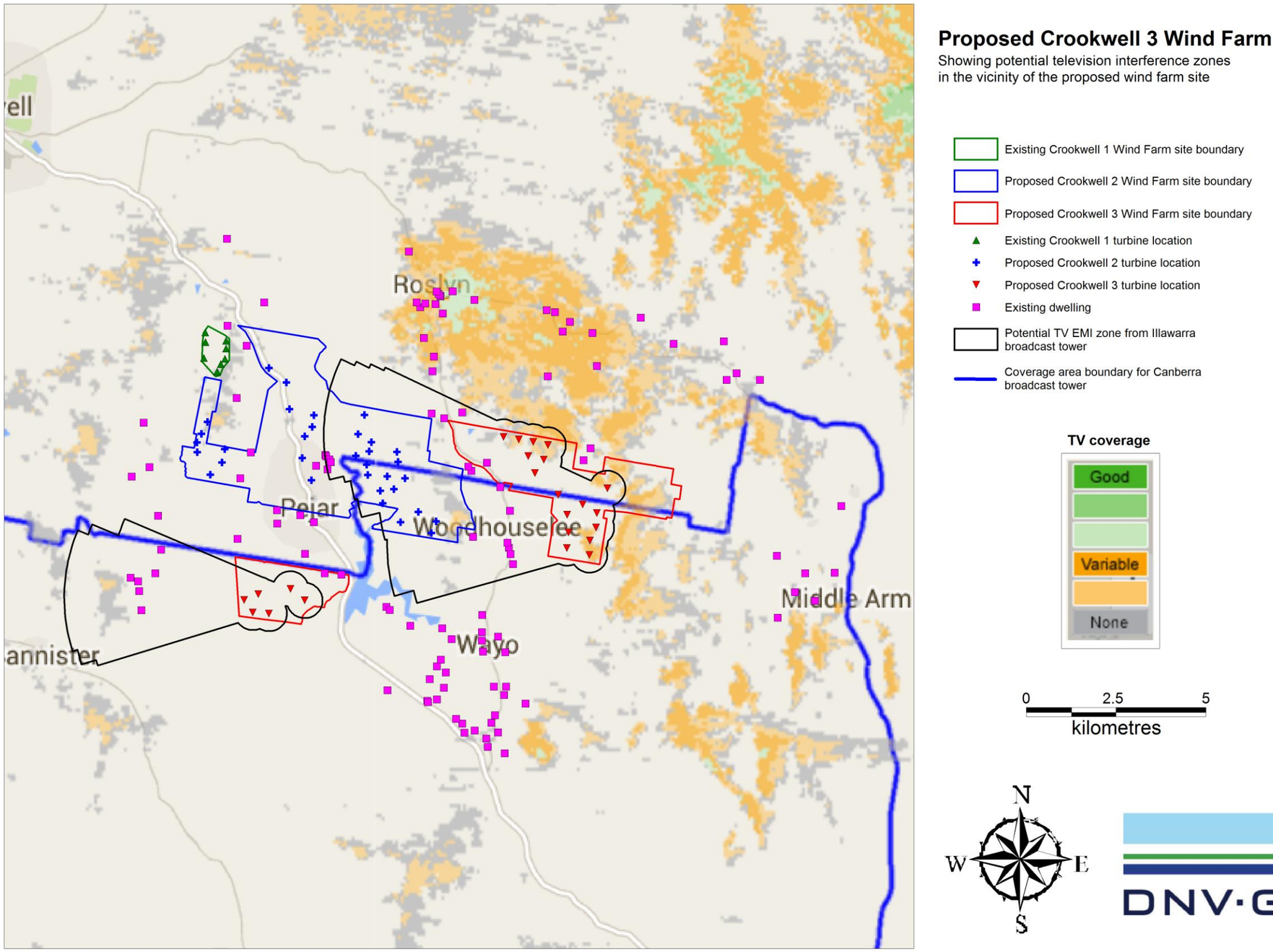


Figure 5 **Potential TV EMI zones from the Illawarra broadcast tower**

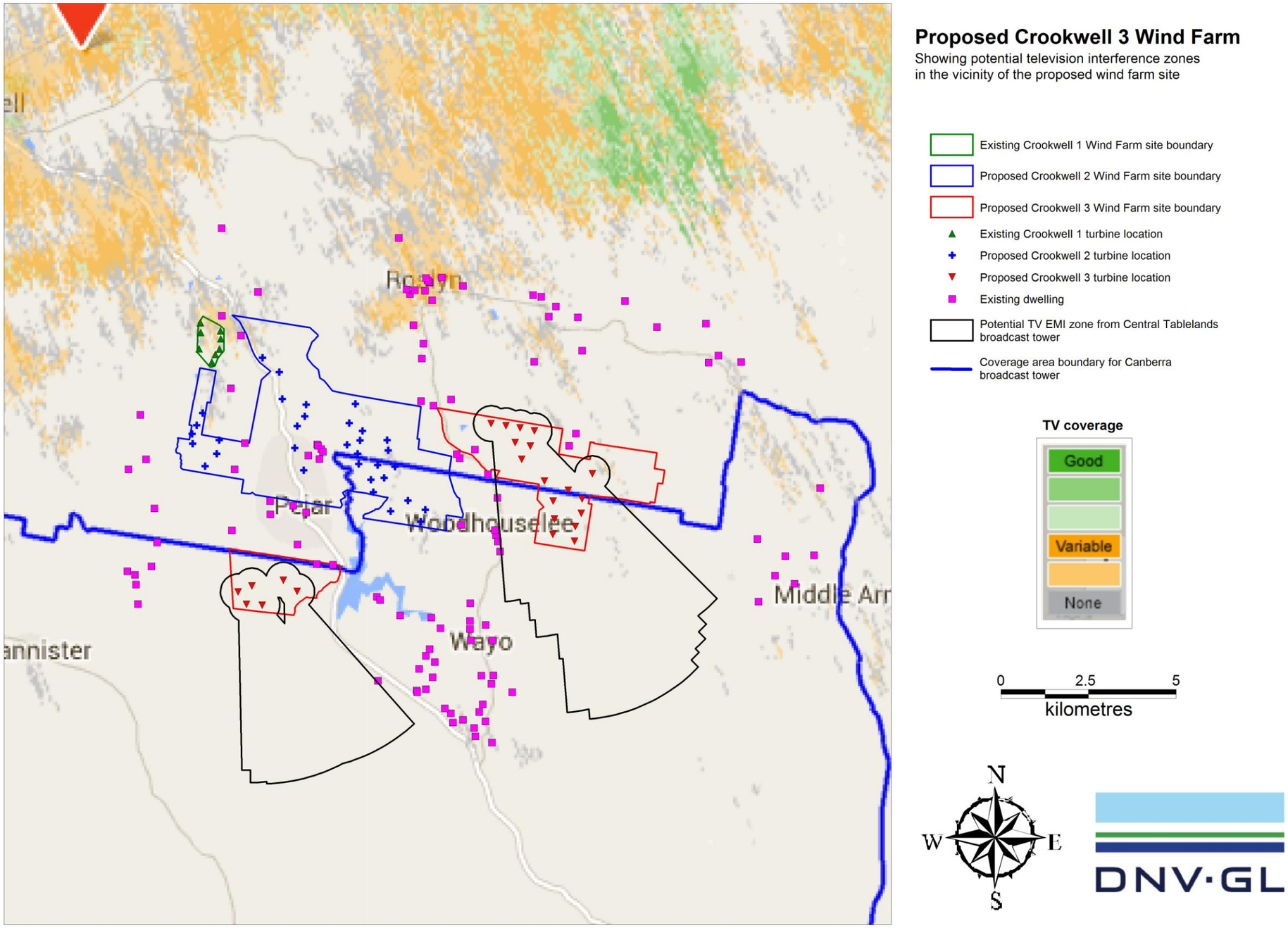


Figure 6 **Potential TV EMI zones from the Central Tablelands broadcast tower**