DNV·GL

CROOKWELL 2 WIND FARM

EMI Assessment

Crookwell Development Pty Ltd

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1 EXECUTIVE SUMMARY

Garrad Hassan Pacific Pty Ltd, now trading as DNV GL, has been commissioned by Union Fenosa Australia Pty Ltd (UFWA) on behalf of Crookwell Development Pty Ltd ("the Customer") to independently assess the potential electromagnetic interference (EMI) issues associated with the development and operation of the proposed Crookwell 2 Wind Farm (the "Project").

This report summarises the results of an EMI assessment conducted for the site. Information relating to nearby telecommunication licences has been obtained from the Australian Communications and Media Authority (ACMA) [1]. In accordance with the planning guidelines relevant to the Project, this document assesses the potential risks regarding interference with radiocommunication services operating in the vicinity of the Project, and makes the findings and recommendations discussed below.

Wind turbines may cause interference to television broadcast signals. Historically, analogue television signals have been more likely to suffer from interference. However, digital television services have now replaced analogue broadcasts and are generally more robust to interference from wind farms. Large scale interference to television signals can generally be avoided by placing the wind turbines distant from the broadcast tower. No television broadcast tower has been identified in close proximity to the Project site boundary, with the nearest broadcast tower approximately 12 km from the site, at Wades Hill near Crookwell. The Australian Government mySwitch website indicates that the digital television signal from the Canberra broadcast tower at Black Mountain has 'variable' to 'good' coverage across most of the site, with some areas receiving no signal. The website also indicates that some areas surrounding the Project could receive television signals from the Goulburn, Crookwell, Central Tablelands, and Illawarra broadcast towers, however these towers also have 'variable' coverage across the site. This report highlights the areas around the Project site where interference to terrestrial television broadcasts is most likely occur. A total of 30 houses were identified in the potential interference zone for the Canberra broadcast tower, including seven dwellings belonging to participating landowners. Totals of 12, 36, 19, and 35 houses were observed in the potential interference zones for the Goulburn, Crookwell, Illawarra, and Central Tablelands towers respectively. If residents currently experience poor or marginal reception of the digital signals, they may be susceptible to interference from the Project. For such cases, there is a range of mitigation options available to rectify difficulties encountered with television reception, and dwellings in the area may be eligible for the government funded satellite television service.

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 a previous Project configuration had been granted prior to the installation of the new repeater, the signal between these towers may be intercepted by turbines in the Project, and therefore it is possible that the turbines could impact upon the performance of the repeater. Upper Lachlan Shire Council has indicated that that they will be seeking to impose conditions of consent that require the Customer to take all necessary actions to protect the signal between the Goulburn and Crookwell broadcast towers. It is recommended that the Customer undertakes further engagement with the Upper Lachlan Shire Council prior to construction of the Project, 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.

Wind turbines can potentially cause interference to fixed point-to-point links through diffraction, scattering, or near-field effects. However it is possible to design around this issue, as the path and interference zone of point-to-point signals is generally well known. It has been found that five fixed point-to-point links cross the proposed Project site, consisting of 18 separate Assignment ID's. An exclusion zone has been established around each point-to-point link based on a standard industry methodology. Six turbines proposed for the Project are located within the calculated exclusion zones, and may therefore cause interference to the links. The operators of these links, the Ambulance Service of NSW, NSW Rural Fire Service, Radio Goulburn, Vertical Telecoms, and Optus Mobile, have been contacted by DNV GL to seek feedback regarding the potential for the Project to cause interference to their operations and services. The NSW Rural Fire Service has confirmed that the two turbines located within the exclusion zone calculated by DNV GL are likely to cause interference to their link, which already experiences poor performance, and have recommended an exclusion zone of 150 m in the vicinity of the wind farm. To mitigate the potential impact to their services, the NSW Rural Fire Service has indicated that they are prepared to consider re-routing the link provided that the cost of relocation is covered by the Customer. Vertical Telecoms has indicated that the Project should not adversely impact on their services provided that the turbines remain outside an alternative exclusion zone, which is less conservative than the exclusion zone calculated by DNV GL and does not contain any turbines in the proposed layout. To date, no formal response has been received from the Ambulance Service of NSW, Radio Goulburn, or Optus Mobile.

Wind turbines can also cause interference with fixed point-to-multipoint links; however it is not possible to identify link paths for point-to-multipoint links as only the base-station is licensed and contained in the ACMA Register of Radiocommunications Licences (RRL) database [1]. There are two point-to-multipoint base stations listed in the ACMA database within 20 km of the proposed Project site boundary. These stations are owned by Goulburn City Council (Site ID 35237) and Upper Lachlan Shire Council (Site ID 41454). DNV GL has contacted Goulburn City Council and Upper Lachlan Shire Council station operators as part of the consultation process, and both councils have indicated that they do not foresee any potential impact to their point-to-multipoint systems.

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the site. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the Project, DNV GL has contacted the operators of these stations as part of the consultation process to seek feedback on any potential impact that the Project could have on their operations and services. Responses have been received from a number of operators, and no concerns have been raised to date.

In general, Very High Frequency (VHF) and Ultra High Frequency (UHF) frequency band radio signals, and digital voice based technologies such as mobile phones (e.g. 3G and 4G networks) are unaffected by wind farm development. Some interference is theoretically possible in areas where coverage is marginal and a wind turbine intercepts the signal. However, the signals are generally robust, and should interference from any source occur, the user can move to an area of better reception. DNV GL has contacted mobile phone network operators as part of the consultation process to seek feedback on any potential impact that the Project could have on their services, and no concerns have been raised to date.

Emergency services operating radiocommunications assets in the vicinity of the Project have been identified. Apart from two point-to-point links that pass over the Project boundaries, many of the licences identified can be broadly described as base to mobile station style communications. As per

the above paragraph, these services are typically unaffected by wind farm development. Regardless, the operators of these assets have been contacted as part of the consultation process to seek feedback on any potential impact that the Project development and operation could have on their services. Responses have been received from a number of operators, and no concerns have been raised to date apart from the potential for interference with fixed point-to-point links operated by the Ambulance Service of NSW and NSW Rural Fire Service, as described above.

It is possible that wind turbines could cause interference to satellite television and internet services if a wind turbine intercepts the signal between a satellite and ground based receiver. However it is expected that interference to satellite television or internet services resulting from the development and operation of the Project is unlikely.

Broadcast radio signals do not generally suffer from interference from wind turbines. AM radio signals are very unlikely to be affected by wind farms. FM radio signals may experience interference in the form of low level hiss or distortion, but generally only in close proximity to the wind turbines. Any reception difficulties are likely to be easily rectified through the installation of a high quality antenna.

Wind turbines have the potential to interfere with meteorological and aviation radars. Reflection of radar signals by wind turbine blades may give false readings or create a radar "shadow" behind the turbines. Due to the distance from radar assets, and the high probability that the turbines will lie below the radar line-of-sight, it is unlikely that the Project will cause interference to aviation radar, or any significant interference to meteorological radar. DNV GL has contacted the Australian Bureau of Meteorology to seek feedback regarding the potential EMI impact of the Project on their services and operations. The response received from the BoM indicates that the project is unlikely to have any adverse impact on their services. DNV GL has not considered impact to aircraft navigation systems or aviation radar, as it is assumed these will be considered as part of an aviation impact assessment.

There is a possibility that wind farms can interfere with trigonometrical stations (or trig points) used for surveying purposes. A review of trigonometrical stations in proximity to the Project site has been conducted and it is unlikely that these stations will be subject to EMI from the Project. However, it is possible that there may be other stations in the area that have not been identified or that the sight lines to some nearby stations may be blocked by turbines. To assess these potential impacts, Geoscience Australia and New South Wales Land and Property Information (NSW LPI) have been notified of the development as part of the consultation process. Geoscience Australia has indicated that they do not expect the Project to have any impact on their assets. However, NSW LPI has raised concerns about the potential for disturbance to a trigonometrical station located within the Project boundaries, and has requested that appropriate measures be taken to protect that station during construction. It is recommended that the Customer undertakes further engagement with the NSW LPI prior to the construction of the Project, to discuss these conditions and establish plans to carry out any necessary actions to protect trigonometrical stations in the vicinity of the Project.

Possible cumulative EMI impacts from the proposed Crookwell 2 Wind Farm and the adjacent existing Crookwell 1 and proposed Crookwell 3 wind farms have also been considered and are presented in Section 5.16.

Conclusions and recommendations from this analysis have been made in Section 6 of this report.

2 INTRODUCTION

Union Fenosa Wind Australia Pty Ltd (UFWA), on behalf of Crookwell Development Pty Ltd ("the Customer"), has commissioned Garrad Hassan Pacific Pty Ltd, now trading as DNV GL ("DNV GL"), to carry out an independent assessment of electromagnetic interference (EMI) related impacts associated with the proposed Crookwell 2 Wind Farm ("the Project"). The results of the work are reported here. This document has been prepared pursuant to DNV GL proposal 170691-AUME-P-001 Issue B, dated 16 June 2015, and is subject to the terms and conditions therein.

In accordance with relevant planning guidelines, this assessment investigates the impact of the Project on:

- Fixed point-to-point links,
- Fixed point-to-multipoint links,
- Radiocommunications assets belonging to emergency services,
- Aviation and meteorological radars,
- Trigonometrical stations,
- Citizens Band (CB) radio and mobile phones,
- Wireless internet,
- Broadcast radio,
- Satellite television and internet, and
- Broadcast television.

In order to conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the Project has been obtained from the Australian Communication and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database [1]. Data contained in the RRL is currently being transitioned from the existing RADCOM system to the new SPECTRA system. Both the RADCOM and SPECTRA datasets have been considered in this assessment in order to identify all potentially affected services in the vicinity of the Project; consequently, some licences may be duplicated in the results.

The prospective turbine model and layout considered in this analysis have been provided by the Customer and are detailed in Section 3.2.1.

DNV GL has also undertaken an extensive consultation process with organisations operating services that may be impacted by the Project development and operation. This has involved dissemination of basic information on the Project, and a request for responses from the organisations regarding whether they foresee any potential EMI-related impacts on their operations and services. All responses received to date are summarised in Table 14.

3 DESCRIPTION OF THE SITE AND PROJECT

3.1 General Site Description

The proposed Crookwell 2 Wind Farm is located approximately 13 km southeast of the town of Crookwell and 25 km northwest of Goulburn, NSW. The terrain at the Project site can be described as undulating, with elevations varying between approximately 800 m and 950 m above sea level. The site and surrounds can generally be described as open farmland interspersed with areas of tall trees and wind breaks. The Pejar dam is located to the south of the Project site.

The proposed Project is located beside the existing Crookwell 1 Wind Farm and proposed Crookwell 3 Wind Farm. An assessment of the potential cumulative EMI impacts of the Crookwell 2 Wind Farm and the adjacent Crookwell 1 and Crookwell 3 wind farms has been undertaken and is described in Section 5.16.

3.2 The Project

3.2.1 Proposed wind farm layout

The proposed amendment to the approved Crookwell 2 Wind Farm is for an increase in overall turbine envelope size from 128 m to up to 160 m that includes a hub height of up to 95 m, and a rotor diameter up to 130 m, and a reduction in number of approved wind turbine generator locations from 46 to 33 [2]. The turbines are proposed to be located upon the local hilltops across the site with base elevations ranging from approximately 860 m to 950 m above sea level.

For the purpose of the EMI study, DNV GL has considered a hypothetical turbine with a 95 m hub height and 130 m rotor diameter configuration, as requested by the Customer [2]. These turbine dimensions are intended to encapsulate all possible turbine configurations under consideration for the site. The results generated based on these dimensions will be conservative for turbine configurations with dimensions that remain inside the turbine envelope by satisfying all of the following criteria: a rotor diameter of 130 m or less, and an upper tip height of 160 m or less.

A map of the site with the proposed turbine layout is shown in Figure 1, and the coordinates of the proposed turbine locations are presented in Table 2.

3.2.2 House locations

A list of houses neighbouring the Project was supplied to DNV GL by the Customer [3].

This list of houses also includes several house locations listed as 'uninhabitable'. These locations have been included in the analysis at this stage, however it is understood that the Customer aims to have agreements with the relevant host landowners to disregard these dwellings [4].

The coordinates of dwellings in the vicinity of the Project are presented in Table 5. DNV GL has assumed that all listed houses are potential inhabited residential locations. It should be noted that DNV GL has not carried out a detailed and comprehensive survey of house locations in the area and is relying on information provided by the Customer.

The locations of these dwellings, and the site boundaries considered in this assessment, are also shown in Figure 1.

4 PLANNING GUIDELINES

The Department of Planning and Environment has acknowledged the Customer's intention to modify the development consent for the Crookwell 2 Wind Farm [5] and has stated the following in regards to EMI-related issues:

> *"… the [Environmental Assessment] should include at least the following: … a telecommunication assessment of the project (as modified) that identifies the potential effects on telecommunication systems;"*

The correspondence also states that "*the assessment must also consider the cumulative impacts of the proposed modification with nearby operating, approved or proposed wind farms.*"

Furthermore, there are two sets of guidelines that are potentially relevant to the assessment of electromagnetic interference impacts for wind farms in New South Wales.

The Draft NSW Planning Guidelines for Wind Farms (Draft NSW Guidelines) [6] currently state:

> *"The potential for a proposed wind farm to cause electromagnetic interference (EMI) with communication signals and services, such as microwave, television, radar and radio transmission signals, should be assessed. Where communication facilities are located in the vicinity of the wind farm, the applicant should:*
>
> - *identify any signals and services which may be affected*
> - *assess the potential for the proposed wind farm to impact on the signals and services*
> - *consult with the relevant parties*
> - *outline proposed measures to avoid or mitigate against electromagnetic interference impacts.*
>
> *Potential electromagnetic interference effects can be calculated from information from affected telecommunications transmitting or receiving stations, local conditions, turbine design and location. The potential for electromagnetic interference from a proposed wind farm should be minimised, if not eliminated, through appropriate turbine design, siting and mitigation. A design measure to reduce EMI is to minimising the use of turbines with metal blades or those with metallic cores. A siting measure is to avoid siting turbines in the 'line of sight' between transmitters and receivers.*
>
> *If a Development Application is approved, detailed conditions of consent will be specified that aim to protect landowners in the area against electromagnetic interference and ensure that any impacts are rectified at the proponent's cost."*

Although the Draft NSW Guidelines describe the requirements for these assessments, they do not provide detailed methodologies for assessing EMI related impacts.

The Environmental Protection and Heritage Council (EPHC), in conjunction with Local Governments and the Planning Ministers' Council released a draft version of the National Wind Farm Development Guidelines in July 2010 (Draft National Guidelines) [7]. The Draft National Guidelines cover a range of issues spanning over the different stages of wind farm development.

The main purpose of the Draft National Guidelines is to provide detailed methodologies to assess issues related to wind farms including community consultations, shadow flicker, noise monitoring, electromagnetic interference, impacts on landscapes, and flora and fauna. Other issues that are

covered to a lesser extent in the draft guidelines include aircraft safety, blade glint, risk of fire and indigenous heritage.

In relation to EMI, the Draft National Guidelines provide advice and methodologies to identify likely affected parties, assess EMI impacts, consult with affected parties and develop mitigation steps to address the likely EMI impacts.

DNV GL considers that the recommendations of the Draft National Guidelines meet, if not exceed, the recommendations of the Draft NSW Guidelines, and therefore the Draft National Guidelines have been used to inform the methodology adopted for this assessment.

5 METHODOLOGY, ANALYSIS AND RESULTS

If not properly designed, wind farms have the potential to interfere with radiocommunications services. Two services that are most likely to be affected include television broadcast signals and fixed point-to-point microwave signals. Terrestrial broadcast signals are commonly used to transmit domestic television, while microwave links are used for line-of-sight connections for data, voice and video. The interference mechanisms are different for each of these, and hence, there are different ways to avoid interference.

The Draft National Guidelines recommend that a radial distance of 50-60 km from the centre of the wind farm would normally capture all of the potentially affected services in the area. However, the methodology for assessing the potential radiocommunications interference used in this assessment is to locate all of the telecommunication towers within approximately 75 km of the proposed wind farm site, and then assess the telecommunication licences attached to these towers. This is to reduce the likelihood that telecommunications links crossing the site are inadvertently excluded from the assessment.

Other services with the potential to experience interference from the project have also been identified, and the potential for interference to those services discussed.

5.1 Telecommunication Towers

An image of the ACMA database dated 5 October 2015 was used for this assessment [1]. From the database, there are 344 telecommunication towers within a nominal 75 km of the Project. The locations of these telecommunication towers relative to the Project are shown in Figure 2.

5.2 Fixed Licences of Point-to-Point (Microwave) Type

5.2.1 Diffraction

Wind turbines can potentially cause interference, or diffraction, of point-to-point microwave signals and in some cases, point-to-point UHF signals. It is possible to design around this issue as the path and interference zone of these signals are well known. The frequency of common microwave signals varies from approximately 1 GHz to 30 GHz. For this analysis DNV GL has used a wider and more conservative frequency range of 0 to 50 GHz. Point-to-point links are often used for line-of-sight connections for data, voice and video. Such links often exist on mobile phone and television broadcast towers.

The criteria used for avoiding diffraction effects of point-to-point signals are normally based on an exclusion zone of circular cross-section around the direct path from the transmitter to the receiver (often called boresight) [7] [8] [9]. This exclusion zone is defined in terms of Fresnel zones. The n^{th} Fresnel zone is comprised of all points for which, if the radio signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional length compared to the straight transmitter-receiver path equals $\frac{n-\lambda}{2}$, where λ = wavelength.

To avoid interference to point-to-point signals, wind turbines, including the blades, should be kept outside the second Fresnel zone. The radius of the second Fresnel zone varies along the length of the signal, and is given by:

$$R_{F2} = \sqrt{\frac{2\lambda d_1 d_2}{D}}$$

Where d_1 is the distance from the transmitter

d_2 is the distance from the receiver

D is the distance from the transmitter to receiver, i.e. $d_1+d_2 = D$

The registered communications licences for each tower according to the ACMA database were analysed to determine the transmission paths of licenced links that may experience interference from wind turbines. Each individual link is given a unique identifier or "Assignment_ID" so that it can be readily distinguished. For links in the RADCOM dataset, which contains data for broadcast licensing services and 900 MHz public telecommunication services licences [1], the Assignment ID is taken as the hyphenated combination of the Access ID and Device ID. For links in the SPECTRA dataset, which contains data for all other licences [1], the Assignment ID is taken as either the Device Registration ID (for spectrum licences associated with the use of certain frequency band within a particular geographic area) or the EFL ID (for apparatus licences associated with the use of a particular device). The paths resulting from the towers analysed are shown in Figure 3. It can be seen that not all of the identified transmission towers have a fixed licence of point-to-point type transmission vector. Some towers have no active licences associated with them, and some towers are used solely for point-to-area style transmissions, such as some NSW Rural Fire Service towers.

A review of the ACMA database shows that there are five links passing over the proposed Project site (operated by the Ambulance Service of NSW, NSW Rural Fire Service, Radio Goulburn, Vertical Telecoms, and Optus Mobile). The links are shown in greater detail in Figure 4.

References [7] [8] [9] state that turbines should be located outside of either the first or second Fresnel zone in order to avoid interference to that link. 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 one blade length for turbines with a 130 m rotor diameter. The potential exclusion zones are also shown in Figure 4.

It is common practice to have multiple Assignment ID's for the same physical link to cover practicalities such as licensing for sending and/or receiving signals. Accordingly, the Fresnel zone setback has been calculated on the Assignment ID with the lowest frequency. Details of the links are provided in Table 6.

The Draft National Guidelines recommend consultation is required if a turbine is within 2 km of a telecommunication site or if a turbine is located within the second Fresnel zone of a point-to-point link. There are six turbines located within the exclusion zones for the point-to-point links that pass over the Project site, and three turbines that are located near to the exclusion zones. The turbines located within or near the second Fresnel zone for each point-to-point link crossing the proposed Project site are summarised in the table below.

Table 1 Details of turbines located within or near the second Fresnel zone for each point-to-point link crossing the Project site

Link No.	Assignment ID's for Minimum Frequency	Operator	Turbines Within Exclusion Zone	Turbines Near Exclusion Zone
1	771111, 771112	Ambulance Service of NSW	F36, F37, F48	F24 (15 m southwest) F40 (44 m southwest)
2	771741, 771742	NSW Rural Fire Service	F19, F26	-
3	848745, 848746	Radio Goulburn	F17, F19	-
4	1009703, 1009704	Vertical Telecoms Pty Limited	-	F9 (15 m northeast)
5	1291302, 1291303	Optus Mobile Pty Limited	-	F9 (35 m northeast)

DNV GL has consulted with the operators of these links to determine if there is any potential for the proposed Project to cause interference to their operations and services. The NSW Rural Fire Service has confirmed that the two turbines located within the exclusion zone calculated by DNV GL are likely to cause interference to their link, which already experiences poor performance, and has recommended an exclusion zone of 1 km from the signal path out to a distance of 15 km from the transmission towers, then 150 m from the signal path at all distances beyond 15 km from the towers [10]. DNV GL has considered the recommended exclusion zone plus one blade length for turbines with a 130 m rotor diameter, and has determined that no additional turbines are located within the revised exclusion zone besides the two turbines already identified in Table 1.

To mitigate the potential impact to their services, the NSW Rural Fire Service has requested that either the two turbines identified by DNV GL (turbines F19 and F26) be relocated outside of the recommended exclusion zone of 150 m, or the fixed point-to-point link be re-routed at the cost of the Customer. The cost to relocate the link from the current path (from site ID 34919 to site ID 201622) to the alternative path (from site ID 9538 to site ID 201622) is estimated by the NSW Rural Fire Service to be in the order of $40,000 [10]. It is recommended that the Customer undertakes further engagement with the NSW Rural Fire Service prior to the construction of the Project, to make arrangements for re-routing the fixed point-to-point link crossing the Project site.

Vertical Telecoms has noted that exclusion zones based on the second Fresnel zone are usually highly conservative in practice, and has proposed an alternative exclusion zone based on the first Fresnel zone plus one turbine blade length [11]. DNV GL has considered this alternative exclusion zone for turbines with a 130 m rotor diameter, and has determined that the turbine identified as being close to the calculated exclusion zone (turbine F9) is approximately 30 m northeast of the exclusion zone based on the first Fresnel zone. Vertical Telecoms has indicated that the Project should not interfere with their operations and services provided that the turbines remain outside the revised exclusion zone for the fixed point-to-point link crossing the Project site.

To date, no formal response has been received from the Ambulance Service of NSW, Radio Goulburn, or Optus Mobile.

A preliminary assessment was also carried out to determine if the links pass over the Project at a height that is well above the highest point of the turbines (hub height + blade length = 160 m). This was achieved by examining the elevation and tower heights at each end of the link, as well as the approximate elevation of the areas within the Project boundaries over which the link crosses.

It was determined that the links do cross the site at a height which has the potential to intersect with turbine blades.

5.2.2 Near field effects and scattering

The Draft National Guidelines [7] mention the possibility of interference to point-to-point links from two additional mechanisms, near field effects and scattering.

According to the Draft National Guidelines, near field effects are usually limited to approximately 720 m from a communication tower and it is recommended that consultation is required if a turbine is within 1 km of a telecommunication site. The Draft National Guidelines also state that scattering is best avoided by placing wind turbines more than 2 km from a communication tower.

All communication towers are greater than 2 km from the Project, with the closest telecommunication tower (Site ID 9536) located approximately 9 km from the proposed site boundary or 9.4 km west of the nearest proposed wind turbine (F3). It is not expected that the neighbouring communication towers will experience interference due to near field effects or scattering.

5.3 Fixed Licences of Point-to-Multipoint Type

Fixed licences of the point-to-multipoint type are a variation of the point-to-point type. The difference between them is administrative. A point-to-point licence permits communication between two static sites, where the locations of the sites are detailed in the licence register. A point-to-multipoint licence allows communication between one or more static sites and multiple points or between the points. The point-to-multipoint type is usually licensed for a defined operational area.

Administratively, the ACMA database details the location of the static station for a fixed licence of the point-to-multipoint type. Hence, the location of the transmission vectors is not readily identifiable. A review of fixed licences of point-to-multipoint types was undertaken and 106 Assignment ID's were identified within approximately 75 km of the proposed site. These licences are shown in Figure 5. The details of the licence holders as per the two available ACMA datasets are provided in Table 7.

There are two point-to-multipoint base stations listed in the ACMA database within 20 km of the Project boundary. These stations are owned by Goulburn City Council (Site ID 35237) and Upper Lachlan Shire Council (Site ID 41454). DNV GL has contacted Goulburn City Council and Upper Lachlan Shire Council as part of the consultation process to seek feedback on whether their services are likely to be affected by the Project. Both station operators have indicated that they do not foresee any potential impact to their point-to-multipoint systems arising from the Project [12] [13].

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the site. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the site, DNV GL has contacted the operators of all stations within 60 km of the Project to seek feedback on any potential impact that the Project could have on their services. Responses have been received from a number of operators, as summarised in Table 14, and no concerns have been raised to date.

5.4 Other Licence Types

A review of the ACMA database for other licences was conducted. These licences are shown in Table 8 and Figure 6.

Many of the licences identified can be broadly described as base to mobile station style communications, including radio broadcasting, and commercial and private mobile telephony. These licence types are generally not affected by the presence of wind turbines any more than other effects such as terrain, vegetation and other forms of signal obstruction. Should reception difficulty be encountered, the amelioration method consists of the user simply moving to receive a clearer signal.

A number of broadcasting licences have been identified. These are likely to consist of radio and television broadcasting services, and are broadly covered in Sections 5.14 and 5.15.

A number of aeronautical licences, and radiodetermination licences which may be used for aircraft navigation, have been identified. DNV GL assumes that potential impacts to these services will be considered as part of an aviation impact study.

5.5 Emergency Services

A review of the ACMA database was conducted to identify emergency services with licences for radiocommunications assets operating in the vicinity of the Project. The groups identified are listed in Table 11 along with their contact details. While the potential for interference to point-to-point links operated by the Ambulance Service of NSW and NSW Rural Fire Service has already been identified in Section 5.2.1, DNV GL has also contacted the operators of all other stations within 60 km of the Project to seek feedback regarding any potential impact that the Project could have on their operations and services. Responses have been received from a number of operators, as summarised in Table 14, and no concerns have been raised to date besides those discussed in Section 5.2.1.

5.6 Aircraft Navigation Systems

DNV GL assumes that an aviation impact study will be undertaken to assess the impact of the Project on nearby aviation systems and operations.

5.7 Aviation Radar

Primary surveillance radar (PSR) is used for air traffic control and requires line-of-sight to the target object for successful detection. PSR transmits a pulse of energy that is reflected back to the radar receiver by the target object. Some combinations of turbine orientation and blade angle can cause significant Doppler returns to the illuminating radar, thereby creating false targets on the radar screen. The sporadic nature of these false positives makes them difficult to filter with current radar software. Further, turbines may create a radar obstruction or "shadow" where aircraft are not detected. In Australia, PSR installations are located at major airports and typically have a range of approximately 50 nautical miles (93 km).

Secondary surveillance radar (SSR) is less vulnerable to interference from wind turbines as SSR does not rely on reflections from objects for detection. Aircraft are required to carry a transponder, which replies to radar interrogations. However, SSR may still be affected by a wind farm as an aircraft transponder may respond to a reflected signal and give a false position reading, or SSR

may be obstructed by a wind farm similar to PSR. SSR installations are also typically located at major airports, and have a range of approximately 250 nautical miles (463 km) when detecting aircraft at high altitude. However, at or near ground level, the range of SSR is expected to be less due to terrain obstructions and curvature of the earth.

The Draft National Guidelines recommend that radar operators be notified of the development of wind farms within 250 nautical miles (463 km) of aviation radar operators [7]. Radar installations are typically located at major airports. As shown in Figure 7, the Project is located approximately 90 km from Canberra international airport, and 160 km from Sydney international airport. There are secondary airports at Camden and Bankstown, located 114 km and 144 km from the site respectively, and numerous regional airports across New South Wales and the Australian Capital Territory. The closest regional airport is the Goulburn airport, located at approximately 28 km south southeast of the Project boundaries. DNV GL understands that there is no radar installation at the Goulburn airport.

Due to the significant distance from major airports, and the high probability that the turbines will lie below the radar line-of-sight, it is unlikely that the Project will cause interference with aviation radar. This view is supported by feedback received from Airservices Australia during the consultation process, which indicates that the Project will not cause any adverse impacts to aircraft navigational aids, communications, radar, or control systems [14]. However, DNV GL assumes that an aviation impact study will also be undertaken to assess the impact of the Project to aviation related radar systems.

5.8 Meteorological Radar

The Bureau of Meteorology (BoM) operates a network of weather stations across Australia and uses radar instruments for measuring wind speeds in the upper atmosphere (known as "wind finding" radar), and determining rain and storm activity (known as "weather watch" radar).

The "wind finding" radar uses radar echoes from a target to determine the wind speeds and direction. The radar target is attached to a balloon and tracked by the ground radar. The "weather watch" radar, or "weather surveillance" radar, consists of a rotating antenna located on a building, and kept free from any physical obstruction. The antenna is used to direct a thin beam of radio energy upward into the atmosphere which is then reflected back by a cloud mass. The location of the cloud is then determined by the direction and travel time of the reflected beam.

Wind profile measurements are used to ensure the safe and economical operation of aircraft and provide an important source of data for the BoM's general weather forecasting system. "Weather watch" radars monitor weather situations and are able to indicate the possibility of severe storms out to as distance of 250 km or more. Hence, whilst the uninhibited operation of meteorological radars may not be as critical as aviation radar, there are implications for public safety if severe weather is not predicted or if its approach is masked due to EMI.

Wind farms located at distances greater than 5 km from a BoM weather station are unlikely to affect wind finding operations [7]. Generally, the optimal coverage area for "weather watch" radar extends approximately 200 km from the radar installation at a height of approximately 3000 m [15] [16], and approximately 100 km at a height of 1000 m [16]. Theoretically, wind farms can impact upon weather watch radar when located within several hundred kilometres of a radar station, however, due to the curvature of the earth, and intervening terrain, the range at or near ground level is generally less.

According to the Draft National Wind Farm Development Guidelines, consultations with operators of weather stations within 250 nautical miles (463 km) of the proposed Project should be undertaken [7]. It has been identified that the BoM operates eight weather stations within that range with the closest station "Wollongong" located approximately 120 km east northeast of the Project site. The locations of these stations are shown in Figure 7 and the details of each station can be found in Table 9.

It is not expected that the Project will cause interference with BoM radar installations, as given the distance between the site and radar installations, and the nature of the intervening terrain, it is likely that radar signals will be intercepted before they are able to be influenced by the Project.

DNV GL has contacted the BoM regarding the Project, in accordance with the recommendations of the Draft National Guidelines, to seek feedback on whether interference to their operation and services is likely. The response received from the BoM indicates that the Project is unlikely to cause any significant interference to their meteorological radar systems [17].

5.9 Trigonometrical Stations

A trigonometrical station, also known as a trig point or a trig beacon, is an observation mark used for surveying or distance measuring purposes. Some trig points may host surveying equipment such as GPS antennas and Electronic Distance Measuring (EDM) devices. EDM devices measure the distance from the trig point to the target object by means of a beam of known velocity which is reflected back to the unit from the target object. Most EDM devices require the target object to be highly reflective and, accordingly, a reflective prism is placed on the target object being surveyed. The effective range of EDM devices depends on the wavelength bands used. Light wave and infrared systems have an effective range of 3 to 5 km while microwave systems can measure distances up to 150 km. However, such systems are not limited by the line of sight or affected by visibility [18].

The Global Navigation Satellite Systems (GNSS) Network is comprised of permanent stations which provide the geodetic framework for the spatial data infrastructure in Australia and its territories. The GNSS network also provides information to the International GNSS Service. Eight stations from the GNSS database in Australia form the Australian Fiducial Network (AFN) [19] [20]. The AFN stations are equipped with EDM devices and GPS receivers and transmit data to GeoScience Australia via phone lines, internet and/or satellite [20].

The closest GNSS station is located at approximately 98 km south southwest of the Project, at Mt Stromlo near Canberra. Due to the significant distance between the Project and the GNSS stations, it is deemed unlikely that the Project will cause interference to the GNSS network.

DNV GL has also undertaken a review of the Primary Geodetic Network of Australia [21] and it has been observed that the Project is located within the second-order triangulation region. First-order triangulation depends on trigonometrical stations of known positions, baselines and heights, with the highest degree of accuracy. Points determined from first-order triangulation are then used for second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

According to the database from Geoscience Australia [22], there are 32 trig points within 20 km of the Project site boundary. One of these trig points, 'Pejar', is located within the Project site boundary. The details of all 32 trig points are provided in Table 12 and illustrated in Figure 8.

Although it is unlikely that the trig points in close proximity to the Project host EDM devices or other equipment that is likely to be subject to electromagnetic interference, DNV GL has contacted Geoscience Australia and New South Wales Land and Property Information (NSW LPI) to inform them of the Project development, and seek feedback regarding whether interference to their systems is possible. Geoscience Australia has indicated that they do not expect the Project to have any impact on their assets [23]. NSW LPI has not identified any potential EMI-related impacts on their assets arising from the Project, but has raised concerns about the close proximity of turbine F1 to trig point 'Pejar' and the potential for that point to be disturbed during construction of the Project. NSW LPI has requested that turbine F1 be relocated to a distance of at least 100 m from trig point 'Pejar', and that any trig points located within 200 m of a turbine or construction access road be appropriately identified, recorded, and protected before and during construction of the project [24]. Further details of the requirements and conditions set out by the NSW LPI are provided in Table 14. It is recommended that the Customer undertakes further engagement with the NSW LPI prior to the construction of the Project, to discuss these conditions and establish plans to carry out any necessary actions to identify and protect trig points in the vicinity of the Project during construction.

5.10 Citizens Band Radio

Citizen's Band Radio, also known as CB radio, is a class-licensed two-way, short distance, communication service that can be used by any person in Australia, for private or work purposes. The class licence implies that all users of the CB radio operate within the same frequency range on a shared basis and no individual licence is required.

The CB radio service can be used for voice communications activities, telemetry, and telecommand applications. The radio service operates on two frequency bands, namely the High Frequency (HF) band at between 26.965 MHz and 27.405 MHz, and the Ultra High Frequency (UHF) band at between 476.425 MHz and 477.400 MHz.

The 27 MHz CB radio service was legalised in Australia in the 1970s as a temporary move to switch to UHF CB over the following five years. 27 MHz CB transmit signals in either AM or SSB (Single Side Band) transmission mode. The actual range over which the signal is transmitted depends on the antenna used, the terrain and the interference levels. Over the last decade, the use of 27 MHz CB radio service has declined and has been replaced by UHF CB radio service.

The UHF CB radio service is unique in Australia and uses the FM transmission mode. It provides clear communication over 5-20 km and is less susceptible to power line noise. However, the UHF CB radio service requires "line-of-sight" and is easily hindered by hilly terrain and forested areas. If located on a hilltop, CB radio signals can be transmitted over at least 50 km. Repeater stations are set up on hilltops by community groups and commercial organisations to transmit signals from one channel to another.

No individual or organisation owns or has the right to use a channel exclusively. However, out of the 40 channels available, some of them will be allocated to emergency, telemetry or repeater inputs.

Since users of CB radio service do not require a licence, there is no record of users of the service and their locations and the channels are shared among the users and the repeater stations without a right of protection from interference. The impact of the Project on CB radio service is expected

to be minimal. In the event of interference from the wind turbines, simple steps such as moving a short distance until the signal strength improves would help to mitigate the impact.

5.11 Mobile Phones

Mobile phone networks typically operate at frequencies of either between 800 and 900 MHz, or between 1800 and 2100 MHz. At such frequencies, signals are likely to be affected by physical obstructions such as buildings and wind turbines. However, mobile phone networks are designed to operate in such conditions and in most cases, if there is sufficient mobile network coverage and signal strength, the presence of wind turbines is unlikely to cause any interference.

In rural areas, the mobile network coverage may be more susceptible to physical obstructions due to the large distance between the phone towers and the mobile phone user. In that case, it is theoretically possible that wind turbines could cause some interference to the signal, although there is little evidence of this in the literature.

A review of mobile phone towers in the vicinity of the proposed Project has been carried out. The locations of these towers are shown in Figure 9. The nearest mobile phone tower is located approximately 12 km to the northwest of the Project boundary, at Old Binda Road, Crookwell (Site ID 135332).

Mobile phone network coverage maps have been obtained for Optus, Telstra, and Vodafone.

Figure 10 shows the Optus network coverage for the Project area [25]. The map shows outdoor 3G coverage at most locations in the vicinity of the Project, however some areas require an external antenna to receive 3G coverage, and other areas appear to have no coverage. Some locations to the southeast of the Project may receive outdoor 4G coverage.

Figure 11 shows the Telstra network coverage for the Project area [26]. The map also shows 3G coverage in the vicinity of the Project, however only some areas show 3G device only coverage. Other areas require an external antenna to receive 3G coverage, or may have no coverage. Some areas to the northwest and southeast of the Project may receive either 4G or 4GX coverage.

Figure 12 shows the Vodafone network coverage for the Project area [27]. Most locations in the vicinity of the Project have only outdoor coverage, although some locations have both outdoor and limited indoor coverage.

In general, for areas with good coverage, interference to mobile phone signals is unlikely. However, for areas where the reception is likely to be marginal, such as those where an external antenna is required, the possibility for interference exists if a wind turbine intercepts the signal between a mobile phone and the tower.

In cases of marginal network coverage, simple procedures are available to mitigate interference, such as moving a short distance to a new or higher location until the signal improves, or using an external antenna to improve the signal.

DNV GL has contacted Optus, Telstra, and Vodafone to inform them of the Project development as part of the consultation process and to seek feedback on any potential impact that the Project could have on their services. Feedback received from Telstra indicates that the Project will have no impact on their operations and services, although they note that there are buried copper cables located within the wind farm boundaries that should be identified prior to construction [28]. No formal response has been received from either Optus or Vodafone to date.

5.12 Wireless Internet

YLess4U Pty Ltd holds point-to-multipoint licences in the vicinity of the Project, with one base station located near the town of Goulburn, 22 km south southwest of the Project site. ACE Internet Services Pty Ltd also holds several point-to-multipoint licences in in the vicinity of the Project with base stations located 60 km and 72 km east of the site, near the town of Bowral. As the locations of YLess4U and ACE Internet Services customers are not known, it is not possible to determine whether there is the potential for interference to these services, however it is possible that stations at these distances may be servicing customers in the vicinity of the proposed Project. YLess4U and ACE Internet Services have been contacted by DNV GL as part of the consultation process to seek feedback regarding the potential for interference to their services. Both operators have indicated that they do not foresee any potential for interference, and do not have any concerns regarding the Project [29] [30].

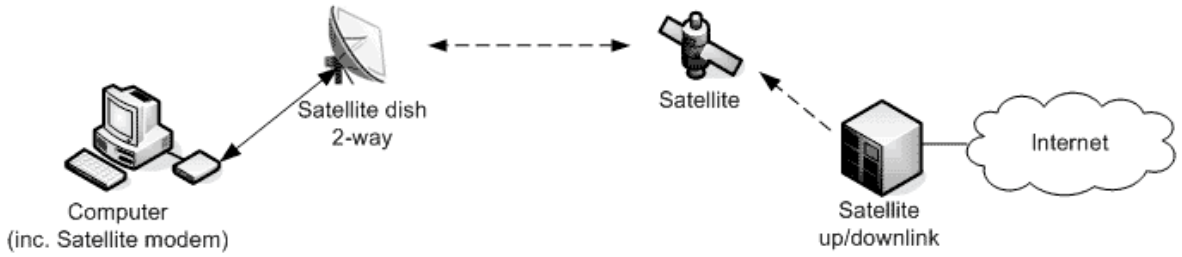
Additionally, residents in the vicinity of the Project are likely to utilise Telstra wireless broadband services. Telstra's mobile broadband service utilises the same network as Telstra's mobile phone service, and therefore the comments made in Section 5.11 are applicable here. Specifically, the presence of wind turbines is unlikely to cause any interference if the existing coverage is good, however interference may be possible in areas where coverage is marginal. Should interference occur, the simple mitigation options given in Section 5.11 may be applicable.

The NBN (National Broadband Network) website [31] indicates that the network is not yet available in areas surrounding the Project and is not expected to be available in the near future. However, it is possible that the network in this area will be provided by the NBN "Sky Muster" satellite service [32], in which case the analysis and conclusions made in Section 5.13 will also be applicable here. Nevertheless, NBN Co has also been contacted by DNV GL to inform them of the Project and seek feedback regarding the potential for interference to their operations and services. No formal response has been received from NBN Co to date.

5.13 Satellite Television and Internet

In some rural or remote areas, television and internet access can be provided through satellite only. Satellite television is delivered via a communication satellite to a satellite dish connected to a set-top box. The satellite transmits television signals to the user's antenna at two frequency bands; the C band at between 4 GHz and 8 GHz, and the Ku band at between 12 GHz and 18 GHz. Signals in the C band are susceptible to interference due to radio relay links, radar systems and other devices operating at a similar frequency while signals in the Ku band are most likely to be affected by rain which acts as an excellent absorber of microwave signals at this frequency. DNV GL understands that there are currently 20 satellites that provide television to the east coast of Australia [33].

In the case of satellite internet, the user's computer is connected to a satellite modem which is in turn linked to a satellite dish/antenna mounted on the building roof. When the user accesses the internet, a request is sent to the operation centre of the satellite internet provider via the satellite antenna. Data is then sent back to the user's computer via the same path as shown in the figure below.



2-way Connection to the Internet via Satellite [34]

Due to marginal coverage of some communication services, a number of residents in the vicinity of the Project may utilise satellite television and internet.

A number of satellites transmit television signals that can be received in Australia. DNV GL has analysed the line-of-sight for satellites which provide any television services to eastern Australia. Although only a small number of satellites are likely to be providing television services intended for Australia (e.g., Optus C1, D1, and D2) [35], all viewable satellites have been considered.

The analysis has shown that signals from the Apstar-7, Thaicom 5, and NSS-6 satellites may be intercepted by turbines at the Project for several existing house locations considered in this analysis. From the Project site, the Apstar-7, Thaicom 5, and NSS-6 satellites have elevations of approximately 5.2°, 6.8°, and 20.3° respectively [36]. However it is DNV GL's understanding that these satellites do not transmit programming designed for Australian audiences [35], and as such it is unlikely that residents in the vicinity of the SHWF WEF will be receiving television signals from these satellites. From the Project site, the Optus C1, D1, and D2 satellites have elevations of approximately 49.3°, 48.3°, and 49.8° respectively [37], and are unlikely to be intercepted by turbines for houses in the vicinity of the Project.

The main satellites for providing satellite internet in Australia are the IPSTAR and Optus D2 satellites. From the Project site, the IPSTAR and Optus D2 satellites have elevations of approximately 38.7° and 49.8° respectively [37]. Therefore it is unlikely that the proposed Project will impact upon the line-of-sight from these satellites to any house.

5.14 Radio broadcasting

DNV GL has assumed that broadcast radio includes both Amplitude Modulation (AM) and Frequency Modulation (FM) radio used to broadcast audio signals. In Australia, AM radio operates in the Medium Wave (MW) band at frequencies of between 520 kHz and 1610 kHz, while FM radio operates in the very high frequency band (VHF) between 87.5 MHz and 108 MHz. The locations of the AM and FM broadcast transmitters in the vicinity of the Project are shown in Figure 13.

5.14.1 AM Radio

Amplitude Modulation, or AM, radio signals are diffracted by the ground as they propagate, such that they follow the curvature of the earth, and are also reflected or refracted by the ionosphere at night. This means that AM radio waves are able to travel significant distances under the right conditions. Due to their long wavelength, they can readily propagate around relatively small physical obstructions on the surface of the earth (such as wind turbines), however they do not propagate easily through some dense building materials such as brick, concrete and aluminium.

The distance over which AM radio signals can travel means that the signal may be weak and susceptible to interference by the time it reaches a receiver. Some of the possible sources of interference to AM radio waves include changes in atmospheric conditions, signals from distant AM broadcasters operating on a similar frequency, electrical power lines and electrical equipment including electric motors.

As AM radio signals are able to propagate around obstructions such as turbines, it is expected that a wind farm would not cause significant interference for a receiver. Additionally, due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a turbine [38]. Any interference problems are likely to be easily resolved through the installation of a high quality antenna and/or amplifier.

5.14.2 FM Radio

Frequency Modulation, or FM, radio signals are suited to short range broadcasting. Unlike lower frequency signals (such as AM signals), they are not reflected or refracted off the ionosphere. The waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon, however they may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage and this means that signals are less susceptible to interference from distant FM broadcasters. FM signals are also less susceptible to interference from changes in atmospheric conditions and electrical equipment than AM signals.

FM radio signals are susceptible to interference from buildings and other structures, although they are less vulnerable than higher frequency signals. Reflection or scattering of radio waves by physical structures can reduce signal strength at a receiver, or can cause multi-path errors through reception of a reflected signal in addition to the primary signal from the transmitter. This can cause hissing or distortion to be heard by a listener. However, generally any interference will only be likely in the immediate vicinity of the wind turbine [38], and should be easily rectified through the installation of a high quality antenna and/or amplifier.

5.14.3 Digital Radio

Digital radio services have been introduced in metropolitan licence areas from July 2009. The digital radio services offered use an updated version of the digital audio broadcasting (DAB) digital radio standard, DAB+, to broadcast digital radio to Adelaide, Brisbane, Perth, Melbourne and Sydney [39]. According to the digital radio coverage map available on the ABC website [40], digital radio is not yet available in the Project region.

5.15 Terrestrial Television Broadcasting

Terrestrial television is broadcast in Australia by a number of networks, both public and commercial. As of December 2013, all television broadcasts in New South Wales are now digital broadcasts [41]. Digital television (DTV) signals are typically more robust in the presence of interference than analogue television signals, and are generally unaffected by interference from wind turbines. DNV GL has experience in situations where houses were able to receive adequate digital television reception in an area of adequate signal strength where the digital television signal is passing through a wind farm.

However, the UK telecommunications regulator Ofcom [42], states the following with regard to interference to digital television reception.

"Digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting. However a digital receiver that has to deal with reflections needs a somewhat higher signal level than one that has to deal with the direct path only. This can mean that viewers in areas where digital signals are fairly weak can experience interruptions to their reception should new reflections appear… reflections may still affect digital television reception in some areas, although the extent of the problem should be far less than for analogue television".

DNV GL has drawn two conclusions from this report:

- Firstly that digital television is very robust and does not suffer from ghosting. In most cases digital television should not be susceptible to interference from wind farm developments.
- Secondly, that areas of weak digital television signal can experience interruptions to their reception should new reflections appear, such as those from nearby wind turbines.

The Broadcast Transmitter Database [41] was examined to identify broadcasters nearby to the proposed Project, with those found shown in Figure 13. The main television transmitter used by residents in the vicinity of the Project 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.

For television broadcast signals, which are omni-directional or point-to-area signals, interference from wind turbines is dependent on many factors including:

- proximity of wind turbines to television broadcast tower;
- proximity of wind turbines to receivers (houses);
- location of wind turbines in relation to houses and television broadcast towers;
- the rotor blade material, rotor speed and rotor blade direction (always into the wind);
- type of receiving antenna (e.g. directional and height);
- location of the television receiver in relation to terrain and other obstacles; and
- frequency and power of the television broadcast signal.

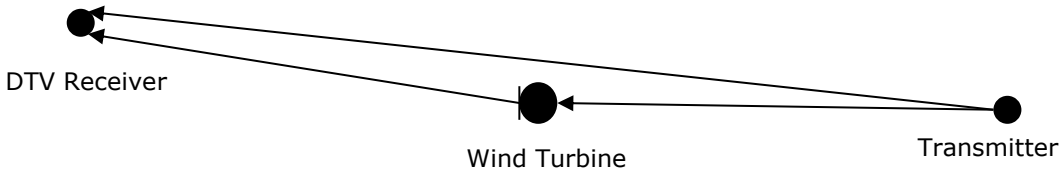
5.15.1 Large Scale Interference

For broadcast signals large scale interference can generally be avoided by placing the wind turbines distant from the broadcast tower. Broadcast towers may be either relay or primary transmitters. Relay TV transmitters are more commonly found in rural areas. Primary TV transmitter towers are higher power and are more commonly located near large urban areas. A clearance of at least 1 km is recommended for relay TV transmitters, while a clearance of at least 6 km is recommended for primary TV transmitters [9]. The closest digital television transmitter to the Project is the Crookwell transmitter at Wades Hill, which is approximately 12 km away, and so the Project is not expected to cause large scale interference.

5.15.2 Forward and Back Scatter

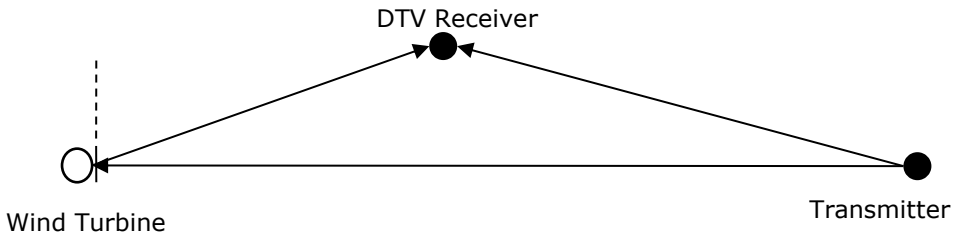
Wind turbines cause interference to television signals by introducing reflections that may be received by the antenna at a dwelling, in addition to the signal received directly from the transmitter, which causes multipath errors. A wind turbine has the potential to scatter electromagnetic waves carrying television signals both forward and back.

Forward scatter can occur when the transmitter, one or more wind turbines, and receiver are almost aligned as shown below. The forward scatter region in this case is characterised by a shadow zone of reduced signal strength behind the turbine, where direct and scattered signals can be received, with the blade rotation introducing a rapid variation in the scattered signal [43]. Both of these effects can potentially degrade the DTV signal quality.



Forward Scatter Signal Path

Back scatter from wind turbines occurs when DTV signals are reflected from turbine towers and turbine blades onto a DTV receiver as shown below. The reflected signals are attenuated, time-delayed and phase-shifted (due to a longer path from transmitter to receiver) compared to the original signal. The reflected signals are also time-varying due to the rotation of the blades and vary with wind direction. The resultant signal at the receiver includes the original signal (transmitter to receiver) and a series of time-varying multipath signals (transmitter to turbine to receiver).



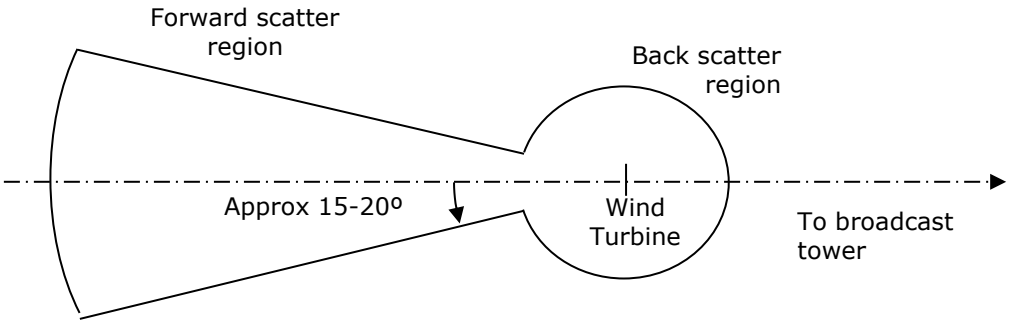
Back Scatter Signal Path

Interference of DTV signals from wind turbine developments can potentially occur in both the forward and backward scatter region. The effect of a wind turbine on a DTV signal can be different depending on the scattering region where the receiver is located [43].

According to Ofcom [42], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [9] [44]. Interference may extend beyond 5 km if the houses are screened from the broadcast tower, but do have line-of-sight to the wind turbines [42]. The shape of this region, assuming a relatively high gain, directional antenna, can be represented by a circular segment with an azimuthal range of approximately ±15° to ±20°, corresponding to the beam width of the antenna. If a lower gain or omni-directional antenna is being used, this region is likely to be larger.

Back scattered signals arrive at the house delayed relative to the source signal from the broadcast tower. The back scatter region generally does not extend further than 500 m [9] [45], assuming a high gain, directional antenna that has a relatively high front-to-back ratio (meaning the signal received by the front of the antenna is much higher than that received from the back). If an antenna with a lower front-to-back ratio, or an omni-directional antenna is used, this region is likely be larger.

The combination of the forward and back scatter regions, as shown in the following figure, resembles a keyhole.



Potential television interference zones around a wind turbine

Television interference mechanisms rely on many factors (as previously mentioned) and are complex to calculate. Previous experience has shown that even after great effort has been put into performing such calculations, they tend to have limited accuracy, and would require field validation after the wind farm is operational.

In Australia, digital television signals are transmitted using the DVB-T (Digital Video Broadcasting – Terrestrial) standard. The International Telecommunication Union (ITU) Recommendation BT.1893 [46] states the following in regards to the forward scatter region for DVB-T signals:

"In most of the situations where the impact of a wind farm to DVB-T reception quality was analyzed, the threshold C/N [carrier-to-noise] ratios obtained were similar to those expected in environments with the absence of wind farms. More precisely, in the forward scattering of the wind turbines, where the transmit antenna, one or more turbines and the receive antenna are lined-up (±60° behind the wind turbine), the DVB-T reception quality may not be affected though further work of analysis is needed in order to confirm this point, especially in the vicinity of 0°."

In other words, wind turbines are not generally expected to affect DVB-T DTV signals in the forward scatter region. However, the ITU [47] also highlight that in the case where there is significant blockage of the direct signal, but clear line-of-sight to one or more wind turbines, interference to the reception of the DTV signal is possible. Results of studies reported by the ITU also suggest that interference may be more likely in in areas where the existing DTV signal is already weak or degraded [47].

With regards to back scattering, the ITU states:

"In the case of the backscattering region, in those situations where the scattered signals from wind turbines are significant in amplitude and variability, the threshold C/N ratio necessary for quasi error free (QEF) condition is higher."

In other words, the C/N ratio needs to be higher in the presence of significant back scatter to achieve the same QEF condition as is the case without the presence of wind turbines.

5.15.3 Theoretical models for wind turbine scattering estimation

Various theoretical scatter models to predict scatter of terrestrial television signals have been proposed, some dating back to the late 1970s. A review of these models, as well as a comparison against empirical data has been reported in [48]. This comparison with empirical data found:

"…none of the analyzed methods seems to be accurate enough to provide realistic estimations of the signal scattered by the wind turbines. In conclusion, a more complete scattering model is needed in order to provide more practical estimations of the scattered signals and evaluate their potential impact on the broadcasting services."

Notably, the scattering model proposed by the ITU to specifically address DTV signals [46], was found to be the most inaccurate, and does not provide signal estimations in the forward scattering zone of the blades. Additionally, DNV GL notes that it only applies to a single wind turbine rather than a wind farm as a whole. Due to the lack of an accurate scattering model, DNV GL has not performed detailed scatter calculations to predict DTV interference.

As an alternative, it is common practice to identify those dwellings or areas that are most likely to experience potential television interference based on likely forward and back scatter regions. As introduced above, this is often referred to as the 'keyhole' approach, and is an established technique for predicting where terrestrial television interference is most likely, based on a number of assumptions regarding receiving antenna characteristics. The approach involves combining multiple keyhole shaped areas that are placed over each turbine location [42]. The union of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

5.15.4 Potentially affected dwellings

Dwellings that have the potential to receive back-scattered or forward-scattered signals from a turbine (assuming an antenna with a sufficiently narrow beam width and sufficiently high front-to-back ratio is being used) have been highlighted using the 'keyhole' approach described above.

The results of the analysis can be seen in Figure 15 to Figure 19 and Table 13. The dwellings that are most likely to be susceptible to interference include those within the possible interference zones. A total of 30 houses were identified in the potential interference zone for the Canberra broadcast tower at Black Mountain, including seven dwellings belonging to participating landowners. Additionally, the analysis identified 12 houses in the potential interference zone for the Goulburn broadcast tower, 36 houses in the potential interference zone for the Crookwell broadcast tower, 19 houses in the potential interference zone for the Illawarra broadcast tower, and 35 houses in the potential interference zone for the Central Tablelands broadcast tower. Further details can be seen in Table 13. Note that if the signal received at a dwelling from the transmitter is sufficiently weak, or an antenna with insufficient directional discrimination is installed (i.e., a low gain or omni-directional antenna), interference may still occur outside of the identified interference zones.

According to the Australian Government mySwitch website [45], the area around the Project is able to receive digital television signals from the Canberra, Goulburn, Crookwell, Illawarra, and Central Tablelands broadcast towers. The coverage maps (reproduced in Figure 15 to Figure 19) suggest that the majority of the area surrounding the Project receives 'variable' coverage.

Thus, although digital television signals are generally unlikely to be susceptible to interference from wind turbines in areas of adequate signal strength, interference could be encountered in areas where reception is marginal and antennas at dwellings may receive a reflected signal from a turbine that is of sufficient power to interfere with the signal received directly from the transmitter. Based on the coverage maps for the area around the Project, it is possible that some areas could be deemed to have marginal reception, and interference could be encountered. If reception difficulties are encountered, there are a number of mitigation options available, and these are discussed in further detail in Section 5.15.6.

The method used here to assess the potential interference to television signals from the Project represents a simplified approach which is expected to capture locations where interference is most likely to occur. This simplified analysis is deemed appropriate as the implications of potential television interference are reasonably low given the large range of mitigation options available.

5.15.5 Crookwell repeater

DNV GL 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 [12] [49] [50] [51]. The line-of-sight between the Goulburn and Crookwell broadcast towers, relative to the proposed Project, is shown in Figure 14. Although planning approval had been granted for a previous Project configuration prior to the installation of the new repeater, it can be seen that the signal between these towers may be intercepted by turbines at the Project, 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 has also highlighted their concerns about the potential impact of the Project on this new repeater service [12]. Upper Lachlan Shire Council has indicated that they will be seeking to impose conditions of consent that require the Customer to provide assurance that all necessary actions will be taken to protect the signal from Mt Gray to Wades Hill, before construction commences. It is recommended that the Customer undertakes further engagement with the Upper Lachlan Shire Council prior to the construction of the Project, to establish suitable arrangements for monitoring and assessing any potential interference to this signal, which may include pre- and post-construction television reception surveys in the area serviced by the repeater, and to identify how issues may be resolved if interference attributable to the Project is encountered.

5.15.6 Mitigation options

In the event that TV interference is an issue during wind farm construction or after wind farm commissioning, there are several amelioration options available, in approximate order of increasing cost:

1. Realigning the householder's TV antenna more directly towards their existing transmitter;
2. Tuning the householder's antenna into alternative sources of the same or suitable TV signal;
3. The installation of more directional and/or higher gain antenna at the affected house;
4. Relocating the antenna to a less affected position;
5. The installation of cable/satellite TV at the affected house; and
6. Installation of a TV relay station.

In the event of significant interference in the backscatter region, a more directional antenna should ensure a stronger signal from the transmitter since the backscattered signal will originate from a different direction. In the case of forward scatter, the antenna will be pointed towards both the original and scattered signal and hence a more directional antenna may not alleviate a forward scatter issue, however, as noted in [43] DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [47] identified that the receiver height can also affect interference. In areas that are relatively flat and free of vegetation, reflections can enhance or decrease the received signal strength relative to the free path signal strength. The ITU found that the received signal strength may not increase monotonically with receiver height. In other words, lowering the receiver height can improve reception in some cases.

In the event that terrestrial DTV reception cannot be improved, satellite television represents another potential amelioration option. Satellite based television comprises of both free to air and subscription based broadcasts. Residents in areas which are unable to receive digital TV through their normal TV antenna due to local interference, terrain or distance from the transmitter in their area may be eligible to access the Australian Government funded Viewer Access Satellite Television (VAST) service [52].

5.16 Cumulative Impacts

As mentioned in Section 3.1, the Project is located in an area of high wind farm development activity, with the existing Crookwell 1 Wind Farm and the proposed Crookwell 3 Wind Farm located adjacent to the Crookwell 2 Wind Farm site to the northwest, east, and south.

DNV GL has been informed that the Crookwell 1 Wind Farm consists of eight operational turbines with a rotor diameter of 44 m and hub height of 45 m [4]. Crookwell 3 consists of 23 proposed turbines, which, for the purposes of this assessment, have been assumed to have a rotor diameter of 130 m and a hub height of 95 m [50]. The locations and turbine layouts of the existing Crookwell 1 and proposed Crookwell 3 wind farms are shown in Figure 1.

As requested by the Customer, all three Crookwell wind farms have been considered in the cumulative impact assessment described below.

5.16.1 Fixed point-to-point microwave links

Sensible design of a wind farm will avoid the path of point-to-point links which are generally well known. As discussed in Section 5.2.1, five point-to-point links pass through the proposed site boundaries and six turbines proposed for the Project fall within the second Fresnel zone of the links.

One of these links, operated by Radio Goulburn, also passes through the existing Crookwell 1 Wind Farm site, with four turbines located within the second Fresnel zone of the link. It is therefore possible that cumulative impacts will occur to this link as the exclusion zone intersects turbines from both the Crookwell 2 Wind Farm and the neighbouring Crookwell 1 Wind Farm.

Another two of the links crossing the Crookwell 2 Wind Farm – those operated by Vertical Telecoms Pty Limited and Optus Mobile Pty Limited – also pass through the proposed Crookwell 3 Wind Farm. However none of the Crookwell 3 turbines intersect the link exclusion zones, and therefore cumulative impacts are not expected.

Feedback received from Vertical Telecoms during the consultation process described in Section 5.2.1 has not raised any issues regarding potential cumulative impacts from the Crookwell wind farms. However, no formal response has been received from either Radio Goulburn or Optus Mobile to date.

5.16.2 Point-to-multipoint microwave links

As noted earlier, there are two point-to-multipoint stations located within 20 km of the Project site boundary with the closest station located at approximately 9 km northwest of the site, at Hay Street Reservoir, Crookwell.

It is common practice for a point-to-multipoint link to have several unregistered end points and therefore, it is not possible at this stage to determine whether the links are passing through the neighbouring wind farms as well. However, given that the nearest point-to-multipoint station is located approximately 9 km from the Project, and interference from the Project is considered unlikely, the potential for cumulative impacts is also considered unlikely.

Feedback received from the operators of point-to-multipoint services during the consultation process described in Section 5.3 has not raised any issues regarding potential cumulative impacts from the Crookwell wind farms.

5.16.3 Other licence types

These licence types are not generally affected by the presence of wind turbines, and therefore there are not expected to be any cumulative impacts from the Project.

5.16.4 Emergency services

As discussed in Section 5.5, DNV GL does not expect the proposed Project to directly impact on emergency services, apart from the potential for interference to the point-to-point links operated by the Ambulance Service of NSW and NSW Rural Fire Service that pass over the Project site. Neither of these links passes through the neighbouring Crookwell 1 and Crookwell 3 wind farms, and so there are not expected to be any cumulative impacts on emergency services from the Project. Feedback received from emergency services operators during the consultation process described in Section 5.5 has not raised any issues regarding potential cumulative impacts from the Crookwell wind farms.

5.16.5 Aviation radar

It is assumed that an aviation impact study is being undertaken to assess any potential cumulative impacts to aviation radar from the proposed development.

5.16.6 Meteorological radar

It is not expected that the Project will result in any adverse impact on BoM radar installations and therefore, it is not expected that there will be cumulative impacts to BoM radars.

5.16.7 Trigonometrical stations

It is not expected that there will be any electromagnetic interference to trigonometrical stations in the vicinity of the Project. Therefore, it is expected that there will be no cumulative impacts to trigonometrical stations from the proposed Project.

5.16.8 Citizens Band radio

It is possible that the potential for interference to CB radio systems could be increased due to cumulative impacts from multiple wind farms. The greater the number of turbines between two CB transceivers, the greater the potential for interference. However, as discussed previously, there is no right of protection for CB radio, and it should be possible to rectify interference problems to these services by moving to a location where signal strength and quality are improved, or through the use of an external antenna.

5.16.9 Mobile phones

Although mobile phone signals are generally not susceptible to interference from wind turbines, it is possible that the potential for interference to mobile phone services could be increased due to cumulative impacts from multiple wind farms. The greater the number of turbines between a mobile phone user and mobile phone tower, the greater the potential for interference. However, it should be possible to rectify mobile phone interference issues by moving to a location where signal strength and quality are improved, or through the use of an external antenna.

5.16.10 Wireless internet

As noted in Section 5.12, it is most likely that residents utilise the Telstra mobile broadband services. Consequently, the comments made in Section 5.16.9 above are also applicable here.

5.16.11 Satellite television and internet

As discussed previously, it is unlikely that satellite television and internet signals will experience interference from the Crookwell 2 Wind Farm and therefore there are unlikely to be any cumulative impacts from the Project.

5.16.12 Radio broadcasting

The impact of the Project on radio broadcasting services is expected to be minimal, and any interference encountered is likely to be easily rectified through the installation of a high quality antenna. As such, cumulative impacts from the Project are not expected to be significant.

5.16.13 Terrestrial television broadcasting

The areas that are most likely to experience interference to terrestrial television reception are presented in Section 5.15.4 for the Project in isolation. A similar analysis, repeated to include the adjacent Crookwell 1 and Crookwell 3 wind farms, adds to these potential interference zones and is shown in Figure 20.

The results of the analysis suggest that there may be cumulative impacts on terrestrial television signals for some residences surrounding the wind farms, particularly for dwellings which have a non-directional or low-gain antenna, and therefore may receive a reflected signal from the surrounding turbines. However, it is expected that any interference to terrestrial television can be mitigated by improving the equipment at a house location or other options as listed in Section 5.15.6.

In addition, the free-to-air television repeater recently installed at Wades Hill in Crookwell (as discussed in section 5.15.5) receives a signal from the Goulburn broadcast tower at Mt Gray. The signal between these towers passes through both the Crookwell 2 and Crookwell 3 wind farms, as shown in Figure 14, and therefore there is potential for cumulative impacts from the two projects. As stated in section 5.15.5, it is recommended that the Customer undertakes further engagement with the Upper Lachlan Shire Council prior to the construction of the wind farms, to establish

suitable arrangements for monitoring and assessing any potential interference to this signal and to identify how issues may be resolved if interference attributable to the wind farms is encountered.

6 CONCLUSIONS

Broadcast towers and transmission paths around the Project were investigated to determine if EMI would be experienced as a result of the development and operation of the Project. The proposed Project would involve the installation of 33 wind turbine generators. DNV GL has considered a turbine geometry that will be conservative for turbine configurations with dimensions satisfying all of the following criteria: a rotor diameter of 130 m or less, and an upper tip height of 160 m or less.

6.1 Fixed Point-to-Point Microwave Links

Several point-to-point microwave links were identified with a path over, or near the proposed Project boundary. Of these, five links (involving 18 Assignment ID's in total) were identified passing within the site boundary. The potential interference zones around these point-to-point links have been identified and it has been found that six turbines from the Project have the potential to cause interference to three of these links. DNV GL has contacted the operators of these links, the Ambulance Service of NSW, NSW Rural Fire Service, Radio Goulburn, Vertical Telecoms, and Optus Mobile, to seek feedback regarding the potential for interference caused by the development and operation of the proposed Project.

The NSW Rural Fire Service has confirmed that the two turbines located within the exclusion zone calculated by DNV GL are likely to cause interference to their link, which already experiences poor performance, and have recommended an exclusion zone of 150 m in the vicinity of the wind farm. To mitigate the potential impact to their services, the NSW Rural Fire Service has indicated that they are prepared to consider re-routing the link provided that the cost of relocation is covered by the Customer. It is recommended that the Customer undertakes further engagement with the NSW Rural Fire Service prior to the construction of the Project, to make arrangements for re-routing the fixed point-to-point link crossing the Project site.

Vertical Telecoms has indicated that the Project should not adversely impact on their services provided that the turbines remain outside an alternative exclusion zone, which is less conservative than the exclusion zone calculated by DNV GL and does not contain any turbines in the proposed layout. To date, no formal response has been received from the Ambulance Service of NSW, Radio Goulburn, or Optus Mobile.

6.2 Point-to-Multipoint Microwave Links

There are two point-to-multipoint base stations listed in the ACMA database within 20 km of the Project boundary. These stations are owned by Goulburn City Council (Site ID 35237) and Upper Lachlan Shire Council (Site ID 41454). DNV GL has contacted Goulburn City Council and Upper Lachlan Shire Council to seek feedback regarding any potential EMI impacts that may arise from the development and operation of the Project. Both councils have indicated that they do not foresee any potential impact to their point-to-multipoint systems.

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the site. Although it is not possible to determine if there are any potential impacts without knowing the locations of each station in the multipoint network, it is unlikely that stations at this distance will be servicing customers in the vicinity of the site. DNV GL has contacted the operators of these stations to inform them of the proposed development and seek feedback on any potential impact

that the Project could have on their services. Responses have been received from a number of operators, and no concerns have been raised to date.

6.3 Other Licence Types

A review of other licences within 75 km of the Project site was conducted. Many of the licences identified can broadly be described as base to mobile station style communication, and include radio broadcasting, commercial and private mobile telephony. These licence types are generally not affected by the presence of wind turbines any more than other effects such as terrain, vegetation and other forms of signal obstruction. For most services, should reception difficulty be encountered, the amelioration method consists of the user simply moving to receive a clearer signal.

A number of aeronautical and radiodetermination licenses have been identified. DNV GL assumes that potential impacts to these services will be considered as part of an aviation impact study.

6.4 Emergency Services

Emergency services with radiocommunications assets in the vicinity of the site have been identified and have been contacted as part of the consultation process to seek feedback on the potential for adverse impacts to their services. Responses have been received from a number of operators, and no concerns have been raised to date apart from the potential for interference with fixed point-to-point links operated by the Ambulance Service of NSW and NSW Rural Fire Service, as described in Section 6.1.

6.5 Aircraft Navigation Systems

DNV GL assumes that an aviation impact study will be undertaken to assess the impact of the Project on nearby aviation systems.

6.6 Aviation Radar

The Project is located approximately 90 km from Canberra Airport. Due to the significant distance of the major airports from the Project and the high probability that the turbines will lie below the aviation radar line-of-sight, it is unlikely that the Project will have an impact on aviation radar. However, it is recommended that organisations operating aviation radar assets are consulted as part of a detailed aviation study.

6.7 Meteorological Radar

DNV GL has also undertaken an assessment of the Bureau of Meteorology (BoM) radar stations operating in the vicinity of the proposed Project and the closest station is located approximately 120 km east northeast of the site. Due to the distance between the station and the site, and the intervening terrain, it is unlikely that the Project would have an impact on meteorological radar operations. However, in accordance with the Draft National Wind Farm Development Guidelines, DNV GL has contacted the BoM to inform them of the Project and seek feedback on the potential for interference. The response received from the BoM indicates that the Project is unlikely to cause any significant interference to their meteorological radar systems.

6.8 Trigonometrical Stations

A total of 32 trigonometrical stations have been identified within 20 km of the Project, and although they are unlikely to host equipment that is susceptible to electromagnetic interference, Geoscience Australia and New South Wales Land and Property Information (NSW LPI) have been contacted as part of the consultation process to inform them of the Project, and seek feedback regarding whether there is potential for interference to their systems. Geoscience Australia has indicated that they do not expect the Project to have any impact on their assets. However, NSW LPI has raised concerns about the potential for disturbance to a trigonometrical station located within the Project boundaries, and has requested that appropriate measures be taken to identify and protect that station before and during construction. It is recommended that the Customer undertakes further engagement with the NSW LPI prior to the construction of the Project, to discuss these conditions and establish plans to carry out any necessary actions to protect trigonometrical stations in the vicinity of the Project.

6.9 Citizens Band Radio

Users of Citizen Band radio do not require a licence and DNV GL is not able to identify the users of the service and their locations. The channels are shared equally among the different users without the right of protection from interference. If interference is experienced it should be possible to improve signal quality by moving a short distance. It is therefore considered that the impact of the Project on the CB radio service will be minimal.

6.10 Mobile Phones

In general, mobile phone signals are not susceptible to interference from wind turbines. The nearest mobile phone base station is located approximately 12 km northwest of the site boundary.

Published mobile network coverage has been reviewed for the area around the proposed Project. It has been found that there is generally fair to good network coverage in most areas around the proposed Project, and mobile signals are unlikely to be affected. However there are some areas where coverage may be marginal and therefore mobile signals may be susceptible to interference from the Project. DNV GL notes that if interference is encountered, mitigation options are available, such as installation of an external antenna or moving a short distance until the signal improves.

Optus, Telstra and Vodafone have been contacted as part of the consultation process to seek feedback on any potential impact that the Project could have on their services. Feedback received from Telstra indicates that the Project will have no impact on their operations and services, but no formal response has been received from either Optus or Vodafone to date.

6.11 Wireless Internet

YLess4U and ACE Internet Services may provide wireless internet services to houses in the vicinity of the Project; however it is not possible to identify customers who are using these services. YLess4U and ACE Internet Services have been contacted by DNV GL as part of the consultation process, and both operators have indicated that they do not see any potential for interference to their services arising from the Project.

A review of the NBN availability map indicates that work for a fixed wireless network has not yet commenced for the area surrounding the Project, and is not planned at this stage. In the event

that the NBN is provided to this area via satellite, it is considered unlikely that the signals from the satellite will be subject to interference from the Project. Nevertheless, NBN Co has also been contacted by DNV GL to inform them of the Project and seek feedback regarding the potential for interference to their services. No formal response has been received from NBN Co to date.

DNV GL's comments on Telstra's mobile coverage in the Section 6.10 are also applicable to Telstra's mobile broadband services.

6.12 Satellite Television and Internet

Residents in the vicinity of the Project may also have access to satellite television and internet. DNV GL has reviewed the line-of-sight of commonly used TV and internet satellites and has found that the Project is unlikely to cause interference to the signals received from these satellites at the houses considered in this analysis.

6.13 Radio Broadcasting

An examination of the likely impact of the Project on radio broadcasting has also been carried out. It is unlikely that the proposed Project will have an impact on AM radio as the signals are able to propagate around obstructions and buildings. FM signals however may be susceptible to interference from objects such as wind turbines, resulting in hissing and distortion of the signal. This can be mitigated by the installation of a high quality antenna. At present, digital radio is not available in the Project area.

6.14 Television Broadcasting

Broadcast towers around the proposed Project were investigated to see if television interference is possible as a result of the Project. Television interference mechanisms are complex to calculate and can have limited predictive accuracy. Television interference around wind turbines is generally limited to less than 5 km and is a function of the visibility of the wind turbines and the transmitter from the receptor. Digital terrestrial broadcasts have now replaced analogue broadcasts in New South Wales and are generally much less susceptible to interference from wind farms. However, interference is possible in some areas of low signal strength.

DNV GL has highlighted the areas around the Project site where interference to terrestrial television broadcasts is more likely occur. According to the mySwitch website, residents around the Crookwell 2 Wind Farm can receive television signals from the Canberra, Goulburn, Crookwell, Illawarra, and Central Tablelands broadcast towers, with the majority of the site receiving signals from the Canberra tower at Black Mountain. A total of 30 houses were identified in the potential interference zone for the Canberra broadcast tower at Black Mountain, including seven dwellings belonging to participating landowners. Totals of 12, 36, 19, and 35 houses were identified in the potential interference zones from the Goulburn, Crookwell, Illawarra, and Central Tablelands towers respectively.

The Project is in a location for which there is 'variable' digital terrestrial television coverage across much of the area surrounding the site according to the Australian Government Digital Ready mySwitch website, and therefore interference could be encountered.

In areas where digital reception is marginal, residents in the vicinity of the Project may be eligible to receive access to the government funded satellite television service to view free-to-air television.

Should interference be encountered that is attributable to the Project, the amelioration options below should be followed in order to rectify the problem:

1. Realigning the householders TV antenna more directly towards their existing transmitter;
2. Adjusting the height of the TV antenna;
3. Tuning the householders antenna into alternative sources of the same or suitable TV signal;
4. The installation of a more directional and/or higher gain antenna at the affected building;
5. Relocating the antenna to a less affected position;
6. The installation of a cable or satellite TV receiver at the affected house;
7. Installation of a TV relay station.

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 had been granted for a previous Project configuration prior to the installation of the repeater, the signal between these towers may be intercepted by turbines at the Project, and therefore it is possible that the turbines could impact upon the performance of the repeater. Upper Lachlan Shire Council has indicated that they will be seeking to impose conditions of consent that require the Customer to take all necessary actions to protect the signal between the Goulburn and Crookwell broadcast towers. It is recommended that the Customer undertakes further engagement with the Upper Lachlan Shire Council prior to the construction of the Project, 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 Project is encountered.

6.15 Cumulative Impacts

Possible cumulative impacts from the Project and nearby wind farms have been considered in Section 5.16. Cumulative impacts are not expected to occur for many of the services considered, however the possibility exists for cumulative impacts to point-to-point and point-to-multipoint links, mobile phones, wireless internet, CB radio, and television services. Options exist to mitigate most interference issues should they occur.

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television signals from a wind turbine," Report ITU-R BT.2142-1, July 2015.

[48] I. Angulo, et al., "An Empirical Comparative Study of Prediction Methods for Estimating Multipath Due to Signal Scattering from Wind Turbines on Digital TV Services," *IEEE Transactions on Broadcasting,* vol. 57, no. 2, June 2011.

[49] Information within email from P. Newham (Upper Lachlan Shire Council) to T. Gilbert (DNV GL), 16 January 2015.

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

[51] Telephone conversation between P. Newham (Upper Lachlan Shire Council) and T. Gilbert (DNV GL), 1 December 2015.

[52] Australian Government, "VAST - Viewer Access Satellite Television," [Online]. Available: https://www.myvast.com.au/. [Accessed 16 November 2015].

[53] LyngSat, "Free TV from Australia," [Online]. Available: http://www.lyngsat.com/freetv/Australia.html. [Accessed 7 December 2015].

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

LIST OF TABLES

Table 2 Proposed turbine layout for the Crookwell 2 Wind Farm

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
F1	733099	6175609	948
F2	732921	6175270	910
F3	732784	6175029	900
F4	732790	6174758	888
F5	733554	6174834	880
F7	733468	6174459	870
F9	733130	6174119	870
F10	734850	6177095	910
F11	735322	6176679	890
F12	735383	6175929	890
F17	735938	6173914	860
F19	735702	6174542	890
F21	735787	6175152	870
F22	736007	6175416	880
F23	736060	6175745	860
F24	737463	6175724	899
F26	737273	6175188	880
F27	737640	6174955	875
F28	737568	6174695	870
F29	737195	6174580	860
F30	737485	6174324	870
F31	737509	6174035	860
F32	737847	6173582	867
F35	738050	6173982	872
F36	738339	6174672	893
F37	738359	6174384	898
F40	738544	6173920	890
F41	738227	6173622	871
F43	737901	6173227	870
F45	738887	6172965	870
F47	738381	6172683	860
F48	739373	6172687	889
F50	739227	6172360	881

Note 1. Coordinate system: MGA zone 55, GDA94 datum

Table 3 Turbine layout for the existing Crookwell 1 Wind Farm

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
B1	733051	6177408	920
B2	733681	6177885	950
B3	733676	6177669	940
B4	733633	6177379	930
B5	733514	6177230	930
B6	733408	6177025	925
B7	733109	6177860	940
B8	733113	6178135	940

Note 1. Coordinate system: MGA zone 55, GDA94 datum

Table 4 Proposed turbine layout for the Crookwell 3 Wind Farm

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
A2	741318	6175038	910
A3	741739	6174961	920
A4	742142	6174888	920
A5	742545	6174793	917
A8	741992	6174487	910
A9	742420	6174375	910
A10	742163	6174009	900
A12	742793	6173382	880
A13	743466	6173101	868
A15	744163	6173538	890
A16	743023	6172812	870
A17	743851	6172845	880
A20	743049	6172311	881
A21	743818	6172439	893
A22	743634	6172076	902
A24	742989	6171875	870
A25	743605	6171669	930
A28	733966	6170569	800
A29	734365	6170720	820
A30	734198	6170212	810
A31	734648	6170173	820
A32	735268	6170853	800
A33	735649	6170525	790

Note 1. Coordinate system: MGA zone 55, GDA94 datum

Table 5 Dwellings in the vicinity of the proposed Crookwell 2 Wind Farm

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine [km]
1	731647	6172983	Non-participant	1.9
2	731698	6172026	Non-participant	2.5
3	731516	6171362	Non-participant	3.2
4	730825	6171246	Non-participant	3.7
5	731037	6171145	Non-participant	3.6
6	731060	6170869	Non-participant	3.9
7	731103	6170322	Non-participant	4.3
8	733838	6172296	Non-participant	2.0
12	740272	6166772	Non-participant	5.7
13	739985	6166712	Non-participant	5.7
14	739932	6166971	Non-participant	5.4
15	739764	6167108	Non-participant	5.3
16	737882	6167951	Non-participant	4.6
17	*736692*	*6171234*	*Host landowner*	*2.2*
18	*736232*	*6171276*	*Host landowner*	*2.6*
19	735698	6171835	Non-participant	2.1
20	735970	6172727	Non-participant	1.2
21	*734279*	*6174723*	*Host landowner*	*0.7*
22	*733964*	*6173999*	*Host landowner*	*0.7*
23	*736342*	*6174616*	*Host landowner*	*0.6*
24	*736082*	*6174316*	*Host landowner*	*0.4*
25	*736368*	*6174580*	*Host landowner*	*0.7*
26	*736458*	*6174487*	*Host landowner*	*0.7*
27	*736496*	*6174408*	*Host landowner*	*0.7*
28	*736395*	*6174209*	*Host landowner*	*0.5*
29	738978	6167634	Non-participant	4.7
30	739244	6167665	Non-participant	4.7
31	739448	6167994	Non-participant	4.4
32	739063	6168245	Non-participant	4.1
33	739518	6168420	Non-participant	4.0
34	739270	6168600	Non-participant	3.8
35	739384	6168786	Non-participant	3.6
36	739709	6169363	Non-participant	3.0
37	738567	6169756	Non-participant	2.7
38	738011	6170209	Non-participant	2.5
39	737919	6170298	Non-participant	2.4
40	739452	6169668	Non-participant	2.7
41	738995	6167592	Non-participant	4.8
43	741086	6166113	Non-participant	6.5
45	740618	6166300	Non-participant	6.2
46	740589	6166536	Non-participant	6.0
47	740918	6166707	Non-participant	5.9

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

Table 5 Dwellings in the vicinity of the proposed Crookwell 2 Wind Farm (continued)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine [km]
48	740743	6166982	Non-participant	5.6
49	740850	6167190	Non-participant	5.4
50	741118	6167758	Non-participant	5.0
51	740840	6167997	Non-participant	4.7
52	741178	6167993	Non-participant	4.8
53	740567	6168992	Non-participant	3.6
54	740557	6169539	Non-participant	3.1
55	741001	6169408	Non-participant	3.4
56	740550	6169310	Non-participant	3.3
57	740578	6170029	Non-participant	2.7
58	741473	6171450	Non-participant	2.4
59	741415	6171733	Non-participant	2.2
60	740389	6172231	Non-participant	1.1
61	741369	6171908	Non-participant	2.1
62	741337	6172055	Non-participant	2.1
63	741181	6173622	Non-participant	2.0
64	740395	6174100	Non-participant	1.7
65	740315	6174217	Non-participant	1.8
66	743524	6174343	Non-participant	4.5
67	743724	6174675	Non-participant	4.8
68	*739684*	*6175594*	*Host landowner*	*1.6*
69	740191	6175752	Non-participant	2.1
70	739339	6175736	Non-participant	1.5
71	739396	6176926	Non-participant	2.3
72	739448	6177340	Non-participant	2.6
73	739184	6177867	Non-participant	2.7
74	739107	6178738	Non-participant	3.4
75	739013	6178876	Non-participant	3.5
76	739250	6178840	Non-participant	3.6
77	738837	6180318	Non-participant	4.8
79	*740830*	*6174323*	*Host landowner*	*2.2*
80	*741434*	*6172956*	*Host landowner*	*2.1*
81	739537	6178821	Non-participant	3.7
82	739732	6178548	Non-participant	3.6
83	741707	6167504	Non-participant	5.5
84	741184	6168967	Non-participant	3.9
87	748793	6169806	Non-participant	9.8
88	749841	6170267	Non-participant	10.7
89	749291	6170516	Non-participant	10.1
90	749595	6171049	Non-participant	10.3
91	748820	6171555	Non-participant	9.5

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

Table 5 Dwellings in the vicinity of the proposed Crookwell 2 Wind Farm (concluded)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine [km]
93	750414	6171045	Non-participant	11.1
96	750652	6172926	Non-participant	11.3
97	748494	6176524	Non-participant	9.9
98	748494	6176524	Non-participant	9.9
99	747850	6176725	Non-participant	9.4
100	747569	6176543	Non-participant	9.0
101	747522	6177634	Non-participant	9.5
102	746121	6177583	Non-participant	8.3
103	745231	6178338	Non-participant	7.8
104	743973	6176996	Non-participant	6.1
105	743875	6177928	Non-participant	6.4
106	742598	6176726	Non-participant	4.7
107	743258	6178256	Non-participant	6.1
108	742847	6178538	Non-participant	5.9
109	740622	6178917	Non-participant	4.5
110	740029	6179174	Non-participant	4.3
111	739678	6179037	Non-participant	4.0
112	739674	6179055	Non-participant	4.0
113	742622	6178593	Non-participant	5.8
114	743051	6177981	Non-participant	5.8
115	739626	6179103	Non-participant	4.0
116	739578	6179174	Non-participant	4.1
R117	735603	6172925	Non-participant	1.0
R118	734952	6173081	Non-participant	1.3
R119	734950	6172706	Non-participant	1.6
R120	733927	6176267	Non-participant	1.1
R123	731321	6175616	Non-participant	1.6
R124	731448	6174361	Non-participant	1.4
R125	730942	6174100	Non-participant	2.0
R130	734250	6177739	Non-participant	0.9
R131	733732	6178313	Non-participant	1.7
R132	734771	6178947	Non-participant	1.9
R133	733794	6180765	Non-participant	3.8

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

Table 6 Details of point-to-point links crossing the proposed Crookwell 2 Wind Farm site

Link No.	Assignment ID	Licence Number	Frequency [MHz]	Postal Address
1	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	
2	771739, 771740	1218521/1	413.8	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142
	771741, 771742	1218521/1	404.35	
3	848745, 848746	1622766/1	849.8	Radio Goulburn PO Box 1599 CROWS NEST NSW 1585
4	1009701, 1009702	1989792/1	7662.5	Vertical Telecoms Pty Limited PO Box 126 ROSEBERY NSW 2018
	1009703, 1009704	1989792/1	7501.5	
5	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	

Table 7 Details of point-to-multipoint licences within 75 km of the proposed Crookwell 2 Wind Farm

Assignment ID	Site ID	Licence No.	Latitude [GDA94]	Longitude [GDA94]	Distance to wind farm [km]	Licence Owner
914297	9011047	1938510/1	-34.480467	150.397803	72	Ace Internet Services Pty Ltd Locked Bag 4000 BOWRAL NSW 2576
914300	9011047	1938510/1	-34.480467	150.397803	72	
929811	9015800	1948869/1	-34.45704	150.267086	60	
929814	9015800	1948869/1	-34.45704	150.267086	60	
929819	9015800	1948870/1	-34.45704	150.267086	60	
929822	9015800	1948870/1	-34.45704	150.267086	60	
929827	9015800	1948871/1	-34.45704	150.267086	60	
929830	9015800	1948871/1	-34.45704	150.267086	60	
968961	9011047	1969885/1	-34.480467	150.397803	72	
968964	9011047	1969885/1	-34.480467	150.397803	72	
991458	9011047	1981076/1	-34.480467	150.397803	72	
991461	9011047	1981076/1	-34.480467	150.397803	72	
1005218	9011047	1987472/1	-34.480467	150.397803	72	
1005221	9011047	1987472/1	-34.480467	150.397803	72	
8415512-8479338	9011047	1981076	-34.480463	150.397797	72	
780397	202399	1234158/1	-34.779321	149.219711	38	Australian Rail Track Corporation Limited PO Box 10343 Gouger St ADELAIDE SA 5000
780400	202399	1234158/1	-34.779321	149.219711	38	
771591	203217	1217864/1	-34.491563	150.417273	73	Bowral Golf Club PO Box 934 BOWRAL NSW 2576
771594	203217	1217864/1	-34.491563	150.417273	73	
778870	9480	1231599/1	-34.566753	149.992804	34	Bureau of Meteorology Network Services Operations Manager GPO Box 1289 MELBOURNE VIC 3001
778873	9480	1231599/1	-34.566753	149.992804	34	
778878	205697	1231600/1	-34.550008	149.866699	23	
778881	205697	1231600/1	-34.550008	149.866699	23	
778930	205701	1231607/1	-34.758319	149.764504	25	
778933	205701	1231607/1	-34.758319	149.764504	25	
778946	35638	1231609/1	-34.430142	150.234346	58	
778949	35638	1231609/1	-34.430142	150.234346	58	
778954	54625	1231610/1	-34.370992	150.335529	69	
778957	54625	1231610/1	-34.370992	150.335529	69	
779054	205716	1231626/1	-34.810015	150.199791	60	
779057	205716	1231626/1	-34.810015	150.199791	60	
779058	205714	1231627/1	-33.896705	149.850474	73	
779061	205714	1231627/1	-33.896705	149.850474	73	
1235564-1228610	9480	1231599	-34.566751	149.992798	34	
1235565-1228611	205697	1231600	-34.550006	149.866693	23	
1235572-1228618	205701	1231607	-34.758317	149.764499	25	
1235574-1228620	35638	1231609	-34.43014	150.234339	58	
1235575-1228621	54625	1231610	-34.370989	150.335522	69	
1235591-1228637	205716	1231626	-34.810012	150.199786	60	
1235592-1228638	205714	1231627	-33.8967	149.850468	73	

Table 7 Details of point-to-multipoint licences within 75 km of the proposed Crookwell 2 Wind Farm (continued)

Assignment ID	Site ID	Licence No.	Latitude [GDA94]	Longitude [GDA94]	Distance to wind farm [km]	Licence Owner
681787	9362	32207/1	-34.464479	150.428231	75	Endeavour Energy PO Box 6366 BLACKTOWN DC NSW 2148
681790	9362	32207/1	-34.464479	150.428231	75	
755165	9002254	1184813/1	-34.645547	150.146264	49	
755168	9002254	1184813/1	-34.645547	150.146264	49	
770287	9362	1213142/1	-34.464479	150.428231	75	
770290	9362	1213142/1	-34.464479	150.428231	75	
806517	403407	1424378/1	-34.535375	150.392281	71	
806520	403407	1424378/1	-34.535375	150.392281	71	
984598	204067	1977802/1	-34.370793	150.335481	69	
984601	204067	1977802/1	-34.370793	150.335481	69	
984606	204067	1977804/1	-34.370793	150.335481	69	
984609	204067	1977804/1	-34.370793	150.335481	69	
808691	404074	1427988/1	-34.768958	149.731685	25	Essential Energy PO Box 5730 PORT MACQUARIE BC NSW 2444
808694	404074	1427988/1	-34.768958	149.731685	25	
810233	404074	1429638/1	-34.768958	149.731685	25	
810236	404074	1429638/1	-34.768958	149.731685	25	
681534	35237	26488/1	-34.738424	149.687654	20	Goulburn City Council Locked Bag 22 GOULBURN DC NSW 2580
681535	35237	26488/1	-34.738424	149.687654	20	
733524	100872	1105029/1	-34.700488	149.999667	38	Goulburn Mulwaree Council Locked Bag 22 GOULBURN NSW 2580
733527	100872	1105029/1	-34.700488	149.999667	38	
749231	205716	1148261/1	-34.810015	150.199791	60	Sydney Catchment Authority PO Box 323 PENRITH NSW 2751
749234	205716	1148261/1	-34.810015	150.199791	60	
765530	200490	1202370/1	-34.773274	150.325603	69	
765531	200490	1202370/1	-34.773274	150.325603	69	
765561	9377	1202981/1	-34.308131	150.075344	50	Telstra Corporation Limited Attn: Tom Fairbrother (Radio Engineering) Radio, Transport Engineering Locked Bag 810 ADELAIDE SA 5000
765564	9377	1202981/1	-34.308131	150.075344	50	
765570	200515	1202983/1	-34.286221	149.981055	44	
765571	200515	1202983/1	-34.286221	149.981055	44	
765577	200514	1202984/1	-34.336316	150.165254	55	
765580	200514	1202984/1	-34.336316	150.165254	55	
765943	10409	1204710/1	-34.180079	150.07548	58	
765946	10409	1204710/1	-34.180079	150.07548	58	

Table 7 Details of point-to-multipoint licences within 75 km of the proposed Crookwell 2 Wind Farm (concluded)

Assignment ID	Site ID	Licence No.	Latitude [GDA94]	Longitude [GDA94]	Distance to wind farm [km]	Licence Owner
714556	41454	178455/1	-34.45319	149.483947	9	Upper Lachlan Shire Council PO Box 42 GUNNING NSW 2581
714559	41454	178455/1	-34.45319	149.483947	9	
905376	139601	1932398/1	-34.39563	149.841513	26	
905379	139601	1932398/1	-34.39563	149.841513	26	
965098	9019482	1968121/1	-34.396663	149.813611	24	
965101	9019482	1968121/1	-34.396663	149.813611	24	
965102	9019481	1968122/1	-34.770829	149.269588	35	
965105	9019481	1968122/1	-34.770829	149.269588	35	
358979-27327	41454	178455	-34.453188	149.483942	9	
81689-27327	41454	178455	-34.453188	149.483942	9	
8391720-8445823	9019482	1968121	-34.396661	149.813605	24	
8391721-8445824	9019482	1968121	-34.396661	149.813605	24	
8391722-8445825	9019481	1968122	-34.770827	149.269586	35	
8391723-8445826	9019481	1968122	-34.770827	149.269586	35	
1006490	9362	1988079/1	-34.464479	150.428231	75	Vertical Telecoms Pty Limited PO Box 126 ROSEBERY NSW 2018
1006493	9362	1988079/1	-34.464479	150.428231	75	
773118	100685	1220705/1	-33.992033	149.301995	62	Water NSW Private Bag 2 (C/- A Burrell) WODONGA VIC 3691
773121	100685	1220705/1	-33.992033	149.301995	62	
773126	9534	1220708/1	-34.160731	149.238193	48	
773129	9534	1220708/1	-34.160731	149.238193	48	
885474	138680	1918930/1	-34.656487	150.30618	64	Wingecarribee Shire Council Water and Sewer PO Box 141 MOSS VALE NSW 2577
885477	138680	1918930/1	-34.656487	150.30618	64	
970045	9362	1970395/1	-34.464479	150.428231	75	
970046	9362	1970395/1	-34.464479	150.428231	75	
1205748	9362	96701/1	-34.464479	150.428231	75	
1205749	9362	96701/1	-34.464479	150.428231	75	
1824200-2240090	138680	1918930	-34.656483	150.306174	64	
1824201-2240090	138680	1918930	-34.656483	150.306174	64	
8392504-8446919	9362	1970395	-34.464475	150.428224	75	
8392505-8446920	9362	1970395	-34.464475	150.428224	75	
776168	9529	1227638/1	-34.8492	148.970603	61	Yass Valley Council PO Box 6 YASS NSW 2582
776171	9529	1227638/1	-34.8492	148.970603	61	
983443	9484	1977109/1	-34.756348	149.688344	22	YLESS4U Pty Ltd 62 Newington Rd BYWONG NSW 2621
983446	9484	1977109/1	-34.756348	149.688344	22	

Table 8 Details of other licences identified within 75 km of the proposed Crookwell 2 Wind Farm

Licence Type	Licence Category	Number of Instances
Aeronautical Assigned System	Aeronautical	15
Amateur Repeater	Amateur	88
Broadcast Service	Broadcasting	60
Narrowband Area Service station(s)	Broadcasting	1
Narrowcasting Service station(s)	Broadcasting	31
Point to Multipoint	Fixed	89
Ambulatory System	Land Mobile	15
CBRS Repeater	Land Mobile	14
Land Mobile System - > 30MHz	Land Mobile	399
Paging System - Exterior	Land Mobile	26
Paging System - Interior	Land Mobile	1
PMTS Class B	PTS	370
Radiodetermination	Radiodetermination	15
Scientific Assigned	Scientific	8
1800 MHz Band	Spectrum	110
2 GHz Band	Spectrum	178
2.5 GHz Band	Spectrum	106
700 MHz Band	Spectrum	226
800 MHz Band	Spectrum	278

Table 9 BoM radar sites in the vicinity of the proposed Crookwell 2 Wind Farm

BoM Radar site	Location[1]		Approximate Distance from the Project [km]
Wollongong	E34.26°	S150.87°	120
Canberra	E35.66°	S149.51°	122
Sydney	E33.70°	S151.21°	174
Wagga Wagga	E35.17°	S147.47°	201
Newcastle	E32.73°	S152.03°	301
Yarrawonga	E36.03°	S146.03°	358
Namoi	E31.02°	S150.19°	392
Bairnsdale	E37.89°	S147.56°	411

Note 1. Coordinate system: Lat/Long WGS84 datum

Table 10 Airports in the vicinity of the proposed Crookwell 2 Wind Farm

Airport	Location[1]		Approximate Distance from the Project [km]
Canberra (major)	S35.31°	E149.20°	90
Camden (secondary)	S34.04°	E150.69°	114
Bankstown (secondary)	S33.92°	E150.69°	144
Sydney (major)	S33.94°	E151.17°	158

Note 1. Coordinate system: Lat/Long WGS84 datum

Table 11 Emergency services with radiocommunication assets in the vicinity of the proposed Crookwell 2 Wind Farm

Emergency Service	Contact Details	Distance of closest site from boundary of wind farm [km]
ACT Emergency Services Agency	ACT Emergency Services Agency GPO Box 158 (ICT Support ACTESA) CANBERRA ACT 2601	77
Ambulance Service of NSW	Ambulance Service of NSW The Manager of Telecommunications Locked Bag 105 ROZELLE NSW 2039	16
Australian Federal Police	Australian Federal Police Attn: T&I Eileen Ferber PO Box 401 Eileen Ferber CANBERRA ACT 2601	25
Fire and Rescue NSW	Fire and Rescue NSW Attn: AMO-Comms Level 8, 227 Elizabeth St SYDNEY NSW 2000	9
Laggan and District Bushfire Brigade	Laggan and District Bushfire Brigade PO Box 105 CROOKWELL NSW 2583	11
Mulwaree Goulburn Emergency Repeater Group	Mulwaree Goulburn Emergency Repeater Group 65 Coromandel St GOULBURN NSW 2580	30
NSW Police Force	NSW Police Force Radio Engineering Services Level 4, 151-241 Goulburn St Sydney Police Centre SURRY HILLS NSW 2010	16
NSW Rural Fire Service	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142	16
NSW Volunteer Rescue Association Inc	NSW Volunteer Rescue Association Inc Secretary PO Box 422 NARRANDERA NSW 2700	75
Southern ACT Bushfire Brigade	Southern ACT Bushfire Brigade PO Box 214 SEAFORTH NSW 2092	115
St John Ambulance Australia (ACT) Incorporated	St John Ambulance Australia (ACT) Incorporated Attn: Mr P LeCornu CEO PO Box 292 DEAKIN WEST ACT 2600	94
St John Ambulance Australia (NSW)	St John Ambulance Australia (NSW) 9 Deane Street BURWOOD NSW 2134	25
St John Ambulance Australia Incorporated	St John Ambulance Australia Incorporated Attn: Mr Peter LeCornu CEO PO Box 292 DEAKIN WEST ACT 2600	16
State Emergency Service (NSW)	New South Wales State Emergency Service PO Box 6126 WOLLONGONG NSW 2500	16

Table 11 Emergency services with radiocommunication assets in the vicinity of the proposed Crookwell 2 Wind Farm (concluded)

Emergency Service	Contact Details	Distance of closest site from boundary of wind farm [km]
Tallaganda Shire State Emergency Services Auxilliary	Tallaganda Region Emergency Services Association PO Box 153 BRAIDWOOD NSW 2622	100
Volunteer Marine Rescue NSW	Marine Rescue NSW PO Box 579 CRONULLA NSW 2230	91
Wamboin Rural Fire Brigade	Wamboin Rural Fire Brigade 112 Bingley Way WAMBOIN NSW 2620	78

Table 12 Trigonometrical stations in the vicinity of the proposed Crookwell 2 Wind Farm

Station Name	Datum	Latitude	Longitude	Distance to site [km]
Baw Baw	AGD66 GDA94	S34°42′ 18.97″ S34°42′ 13.34″	E149°38′ 59.19″ E149°39′ 03.48″	16
Butts	AGD66	S34°33′ 06.96″	E149°29′ 49.50″	3
Cameron	AGD66 GDA94	S34°33′ 24.35″ S34°33′ 18.71″	E149°47′ 05.20″ E149°47′ 09.47″	15
Crookwell	GDA94 AGD66	S34°27′ 22.76″ S34°27′ 28.38″	E149°25′ 28.36″ E149°25′ 24.07″	13
Evandale	AGD66 GDA94	S34°42′ 17.75″ S34°42′ 12.12″	E149°32′ 52.19″ E149°32′ 56.48″	16
Fitton	AGD66 GDA94	S34°36′ 23.80″ S34°36′ 18.17″	E149°27′ 13.56″ E149°27′ 17.84″	10
Gap Range	AGD66 GDA94	S34°40′ 17.89″ S34°40′ 12.25″	E149°46′ 00.50″ E149°46′ 04.78″	18
Gurrundah	AGD66	S34°40′ 32.03″	E149°25′ 58.46″	17
Harvey	AGD66	S34°31′ 16.14″	E149°36′ 12.87″	1
Highest Point	GDA94 AGD66	S34°32′ 08.61″ S34°32′ 14.23″	E149°26′ 13.70″ E149°26′ 09.42″	9
Hobbs	AGD66 GDA94	S34°35′ 45.12″ S34°35′ 39.49″	E149°43′ 23.73″ E149°43′ 28.00″	10
Kialla	AGD66 GDA94	S34°35′ 58.40″ S34°35′ 52.77″	E149°32′ 37.13″ E149°32′ 41.42″	5
Kingsdale	AGD66 GDA94	S34°43′ 27.35″ S34°43′ 21.72″	E149°42′ 03.11″ E149°42′ 07.40″	19
Kingsdale North	AGD66 GDA94	S34°38′ 38.70″ S34°38′ 33.07″	E149°42′ 23.70″ E149°42′ 27.98″	12
Laggan	GDA94 AGD66	S34°23′ 05.89″ S34°23′ 11.52″	E149°28′ 22.85″ E149°28′ 18.57″	16
Mary	GDA94 AGD66	S34°38′ 07.92″ S34°38′ 13.54″	E149°20′ 59.00″ E149°20′ 54.71″	19
Maryville	AGD66	S34°28′ 49.68″	E149°35′ 43.59″	4
McAlister	AGD84 AGD66 GDA94	S34°27′ 02.46″ S34°27′ 02.44″ S34°26′ 56.80″	E149°45′ 06.13″ E149°45′ 06.19″ E149°45′ 10.46″	16
Meldrum	AGD66 GDA94	S34°39′ 40.70″ S34°39′ 35.07″	E149°43′ 52.06″ E149°43′ 56.34″	15
Miller	AGD66	S34°30′ 30.10″	E149°44′ 30.26″	12
Peach	AGD66 GDA94	S34°32′ 55.57″ S34°32′ 49.94″	E149°39′ 39.58″ E149°39′ 43.86″	4
Pejar	GDA94 AGD66	S34°32′ 05.69″ S34°32′ 11.32″	E149°32′ 23.95″ E149°32′ 19.67″	0
Podmore	AGD66 GDA94	S34°34′ 29.33″ S34°34′ 23.70″	E149°36′ 06.38″ E149°36′ 10.66″	1
Pomeroy	AGD66 GDA94	S34°37′ 03.28″ S34°36′ 57.65″	E149°30′ 18.69″ E149°30′ 22.97″	8
Redbank	AGD66	S34°25′ 57.82″	E149°33′ 55.20″	9
Rockfield	AGD66 GDA94	S34°40′ 14.01″ S34°40′ 08.38″	E149°32′ 31.31″ E149°32′ 35.60″	13
Sugarloaf	AGD66 GDA94	S34°40′ 30.46″ S34°40′ 24.83″	E149°29′ 12.83″ E149°29′ 17.11″	14

Table 12 Trigonometrical stations in the vicinity of the proposed Crookwell 2 Wind Farm (concluded)

Station Name	Datum	Latitude	Longitude	Distance to site [km]
Tarlo	AGD66 GDA94	S34°36’ 53.80” S34°36’ 48.16”	E149°49’ 10.21” E149°49’ 14.48”	19
Trinity	AGD66	S34°28’ 56.13”	E149°30’ 31.98”	5
Wattman	GDA94 AGD66	S34°29’ 08.73” S34°29’ 14.36”	E149°25’ 03.60” E149°24’ 59.30”	12
Wayo	AGD66 GDA94	S34°37’ 16.18” S34°37’ 10.54”	E149°38’ 22.14” E149°38’ 26.42”	6
Willigam	AGD66	S34°28’ 35.34”	E149°40’ 17.35”	9

Table 13 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	
8	733838	6172296			X	X	X
17	*736692*	*6171234*			*X*		*X*
18	*736232*	*6171276*			*X*		*X*
19	735698	6171835			X	X	X
20	735970	6172727			X	X	X
21	*734279*	*6174723*			*X*	*X*	
22	*733964*	*6173999*			*X*	*X*	*X*
23	*736342*	*6174616*	*X*	*X*	*X*	*X*	*X*
24	*736082*	*6174316*	*X*	*X*	*X*	*X*	*X*
25	*736368*	*6174580*	*X*	*X*	*X*	*X*	*X*
26	*736458*	*6174487*	*X*	*X*	*X*	*X*	*X*
27	*736496*	*6174408*	*X*	*X*	*X*	*X*	*X*
28	736395	6174209		X	X	X	X
31	739448	6167994					X
32	739063	6168245					X
33	739518	6168420					X
34	739270	6168600					X
35	739384	6168786					X
36	739709	6169363					X
37	738567	6169756			X		X
38	738011	6170209			X		X
39	737919	6170298			X		X
40	739452	6169668					X
50	741118	6167758					X
51	740840	6167997					X
52	741178	6167993					X
53	740567	6168992			X		X
54	740557	6169539			X		X
55	741001	6169408			X		X
56	740550	6169310			X		X
57	740578	6170029			X		X
58	741473	6171450			X		
59	741415	6171733			X		
60	740389	6172231			X		X
61	741369	6171908			X		
62	741337	6172055			X		
63	741181	6173622			X		
64	740395	6174100	X		X		
65	740315	6174217	X		X		
68	*739684*	*6175594*	*X*				
69	740191	6175752	X				

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

Table 13 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
70	739339	6175736	X		X		
71	739396	6176926	X				
72	739448	6177340	X				
73	739184	6177867	X				
74	739107	6178738	X				
75	739013	6178876	X				
76	739250	6178840	X				
77	738837	6180318	X				
79	*740830*	*6174323*	*X*		*X*		
80	*741434*	*6172956*			*X*		
81	739537	6178821	X				
82	739732	6178548	X				
84	741184	6168967			X		X
109	740622	6178917	X				
110	740029	6179174	X				
111	739678	6179037	X				
112	739674	6179055	X				
115	739626	6179103	X				
116	739578	6179174	X				
R117	735603	6172925			X	X	X
R118	734952	6173081			X	X	X
R119	734950	6172706			X	X	X
R120	733927	6176267	X	X		X	
R123	731321	6175616		X		X	
R124	731448	6174361				X	
R125	730942	6174100				X	
R130	734250	6177739	X	X			
R131	733732	6178313	X	X			
R132	734771	6178947	X				
R133	733794	6180765		X			

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

Table 14 Summary of responses to consultation undertaken by DNV GL that have been received to date

Licence type	Distance of closest site [km]	Operator	DNV GL reference	Response received
Fixed point-to-point, land mobile system	Fixed point-to-point: Two turbines (F19, F26) in second Fresnel zone set by DNV GL Land mobile system: 7 km	NSW Rural Fire Service	170691-AUME-L-04	<u>Response received by email on 12/01/16:</u> *"[we] confirm your findings that two turbines F19 and F26 will be located within the above exclusion zone… and will almost certainly cause interference to the link which already has marginal performance. The options available… are: Relocate the F19 and F26 turbines so that they are outside the RFS recommended exclusion zone of 150m… or fund the relocation of the link...the cost of this would be in the order of $40k."*
Fixed point-to-point, fixed point-to-multipoint	Fixed point-to-point: No turbines in exclusion zone set by Vertical Telecoms Pty Limited; one turbine (F9) near second Fresnel zone set by DNV GL Fixed point-to-multipoint: 75 km	Vertical Telecoms Pty Limited	170691-AUME-L-06	<u>Initial response received by email on 02/02/16:</u> *"Our design engineers have advised there will not be any interference to our link."* <u>Further information received by email on 4/02/16:</u> *"…considering Wind Turbine (WT) F9…:* *Based on the calculations, we have first Fresnel zone F1 =19.6m; second Fresnel zone F2 =27.7m for the point to point link…* *On analysing WT F9 location with respect to the point to point ray line, we have vertical clearance. Considering the horizontal plane, distance between WT F9 and ray line is about 115m. By taking into account the turbine blade length of 65m… with an additional buffer number of 15m, we have clearance of approx. 7.3m (115m – 27.7m – 65m – 15m) with respect to second Fresnel zone in horizontal plane.* *In practice, the second Fresnel zone clearance requirement is very conservative. …Vertel would like to have an exclusion zone based on the first Fresnel zone and comment that the position of WT F9 is on the edge of the required exclusion zone."*
Fixed point-to-point	No turbines in second Fresnel zone set by DNV GL	Airservices Australia	170691-AUME-L-08	<u>Response received by email on 02/02/2016:</u> *"This proposal for a wind farm… will not adversely impact the performance of any Airservices Precision/Non-Precision Nav Aids, Anemometers, HF/VHF/UHF Comms, A-SMGCS, Radar, PRM, ADS-B, WAM or Satellite/Links."*

Table 14 Summary of responses to consultation undertaken by DNV GL that have been received to date (continued)

Licence type	Distance of closest site [km]	Operator	DNV GL reference	Response received
Fixed point-to-multipoint	60	Ace Internet Services Pty Ltd	170691-AUME-L-09	Response received by email on 22/12/2015: *"We would not expect any interference to our network from the location described."*
Fixed point-to-multipoint	38	Australian Rail Track Corporation Limited	170691-AUME-L-10	Response received by email on 05/02/2016: *"We have reviewed the location of the proposed wind farm and believe that they will not impact on any communication equipment that ARTC has in the area."*
Fixed point-to-multipoint, meteorological radar	Fixed point-to-multipoint: 23 km Meteorological radar: 120 km	Bureau of Meteorology	170691-AUME-L-12	Response received by email on 05/02/2016: *"Noting that: No Bureau radar is within 20-30 kms of the proposed Crookwell wind farm. The closest radar to the proposed wind farm is approximately 140 km away… Recommendation: That the Bureau radars currently in place will not be measurably affected by the proposed Crookwell wind farm."*
Fixed point-to-multipoint	49	Endeavour Energy	170691-AUME-L-13	Response received by email on 24/12/2015: *"…we do not believe the Crookwell 1 and 2 wind farms will have any impact on our radio network given the distance from our closest asset… is 42km distant to the closest boundary."*
Fixed point-to-multipoint	25	Essential Energy	170691-AUME-L-14	Response received by email on 02/02/2016: *"Our communications team has confirmed the proposed wind farm will have no impact on Essential Energy's existing infrastructure."*
Fixed point-to-multipoint	20	Goulburn Mulwaree Council (Goulburn City Council)	170691-AUME-L-16	Response received by email on 10/02/2016: *"The relevant staff have reviewed the documentation provided and have advised that they cannot foresee any issues with the proposal."*

Table 14 Summary of responses to consultation undertaken by DNV GL that have been received to date (continued)

Licence type	Distance of closest site [km]	Operator	DNV GL reference	Response received
Fixed point-to-multipoint, PMTS/spectrum	Fixed point-to-multipoint: 44 km PMTS/spectrum: 12 km	Telstra Corporation Limited	170691-AUME-L-18	<u>Response received by email on 22/01/2016:</u> *"There are no radio paths or fibre paths that will be impacted by this Windfarm/s. There are copper cables within the boundaries and it is suggested that Dial Before You Dig information be sourced before any construction occurs."*
Fixed point-to-multipoint	9	Upper Lachlan Shire Council	170691-AUME-L-19	<u>Response received by email on 03/02/2016:</u> *"The information that you have sent appears ok except that there is one omission… Council's new TV translator station at Wades Hill, west of Crookwell… The translator receives signals from Mount Gray in Goulburn and retransmits them to Crookwell. …my concern is that the transmission line of sight may cross the Crookwell 2 and Crookwell 3 sites.* *…Council will be taking every step necessary to protect the signal from Mount Gray to Wades Hill… Council will require undertakings from your client (that will include conditions of consent) to protect the service. Council will also be seeking to finalise whatever arrangements are necessary to protect the service before work commences…"*
Fixed point-to-multipoint	22	YLESS4U Pty Ltd	170691-AUME-L-23	<u>Response received by telephone 03/02/2016:</u> No concerns noted; may take lack of formal response as an indication of no issues.
Land mobile system	25	Australian Federal Police	170691-AUME-L-24	<u>Response received by email on 04/02/2016:</u> *"We do not believe the towers or rotating blades… [will] have a measurable effect on our radio network…"*
Land mobile system	9	Fire and Rescue NSW	170691-AUME-L-25	<u>Response received by email 11/01/2016:</u> Consultation letter forwarded by Fire and Rescue NSW to NSW Telco Authority, in order to assess the impact on Government owned radio networks: *"The development of the wind farm poses a threat to 2 (two) government agency owned point to point links… [belonging to] NSW Rural Fire Service and Ambulance Service of NSW… There are no threats posed to the other agency links that transmit close to the wind farm area."*

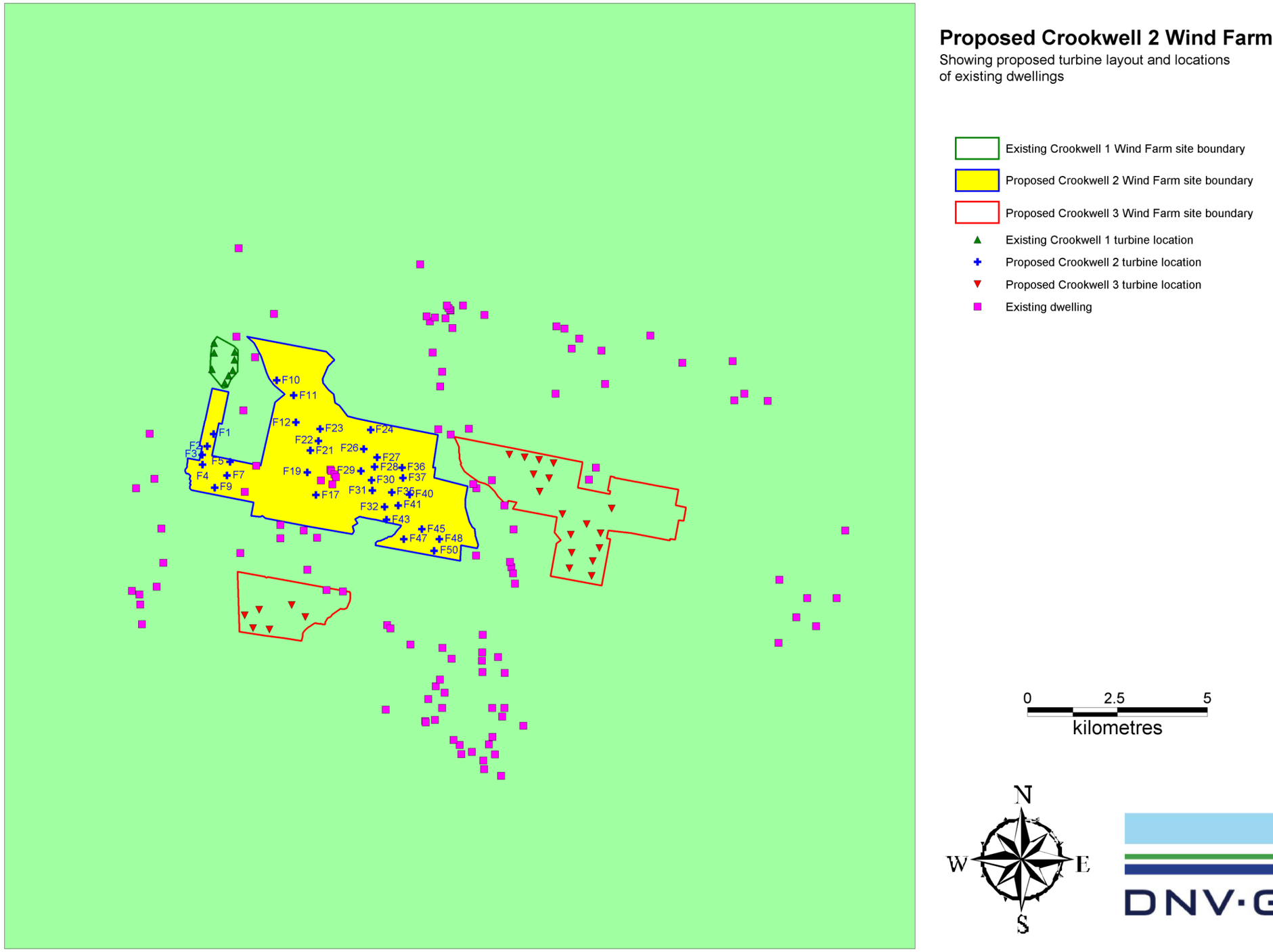
Table 14 Summary of responses to consultation undertaken by DNV GL that have been received to date (continued)

Licence type	Distance of closest site [km]	Operator	DNV GL reference	Response received
Land mobile system	30	Mulwaree Goulburn Emergency Repeater Group	170691-AUME-L-27	Response received by telephone on 22/01/2016: Do not think that the wind farm(s) will affect the repeater; noted that no issues have been encountered due to other turbines in the area.
Land mobile system	25	NSW Police Force	170691-AUME-L-28	Response received by email on 08/02/2016: *"The Wind Farm facility does not obstruct any NSWPF radio links. Furthermore, approximate distance to nearest NSWPF sites are as follows. Red Ground - 25km; Gray Mt. - 25km; Bannaby - 30km… Based on the above information, the proposed development would have no impact on NSW Police Radiocommunications."*
Land mobile system	6	St John Ambulance Australia (NSW)	170691-AUME-L-29	Response received by email on 05/02/2016: *"St John (NSW) has no objection to the proposal of a windfarm at Crookwell."*
Trigonometrical stations, Global Navigational Satellite System stations	One trigonometrical station within wind farm boundaries	Geoscience Australia	170691-AUME-L-32	Response received by email on 11/01/2016: *"Geoscience Australia does not see foresee any impact to our trigonometrical stations, Global Navigational Satellite System stations, equipment, facilities or services associated with the proposed Crookwell Wind Farms."*

Table 14 Summary of responses to consultation undertaken by DNV GL that have been received to date (concluded)

Licence type	Distance of closest site [km]	Operator	DNV GL reference	Response received
Trigonometrical stations	One trigonometrical station within wind farm boundaries	NSW Land and Property Information	170691-AUME-L-33	<u>Response received by email on 29/01/2016:</u> *"I have examined the proposed turbine positions… LPI geodetic asset TS3695 "Pejar" is in very close proximity to the proposed turbine position… "F1" within the proposed "Crookwell 2" wind farm. The distance between… "F1" and TS3695 is approximately 13 metres. Construction of turbine "F1" at this proposed position would be highly likely to disturb the position of TS3695 and affect survey observations taken at TS3695. TS3695 is a trigonometrical station of high class and order… I therefore require the proposed position of turbine "F1" to be moved to at least 100 metres distant from TS3695 "Pejar".* *I raise no further objection to construction of the proposed wind farms "Crookwell 2" & "Crookwell 3"… subject to the following conditions:* *1. The proposed position of turbine "F1" is be moved to at least 100 metres distant from TS3695 "Pejar".* *2. Should the amended proposed position of turbine "F1" or any construction access road be within 200 metres of TS3695 "Pejar", then:* *(i) Prior to commencement of construction TS3695 "Pejar" is located by your site surveyor and protected by erection of an appropriate physical barrier… to prevent disturbance… Any Trigonometrical Station rock cairn unpiled in verifying the location of TS3695 "Pejar" must be repiled…* *(ii) Photographs of TS3695 "Pejar" are taken prior to the commencement of construction and those photographs emailed… to [LPI].* *(iii) Photographs of TS3695 "Pejar" are taken after construction has been completed and those photographs emailed to [LPI].* *3. Any Survey Marks… are not disturbed during the construction or maintenance of the proposed "Crookwell 2" & "Crookwell 3" wind farms. …it is noted that TS3683 "Peach" is approximately 430 metres from proposed turbine position "A15". Also of particular concern are the Survey Marks of vertical class LB and order L2 along the Goulburn Road as they comprise part of New South Wales' second order level network…* *4. The construction site foreman is informed of the importance of protecting… [all] Survey Marks from disturbance and destruction.* *Please note that TS3695 "Pejar" as well as all other Survey Marks are… protected marks under the Surveying and Spatial Information Act 2002 which has penalties for disturbance of such marks.*

LIST OF FIGURES



Proposed Crookwell 2 Wind Farm

Showing proposed turbine layout and locations of existing dwellings

- 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

0 2.5 5
kilometres

N
W E
S

DNV·GL

Figure 1 **Map of the proposed Crookwell 2 Wind Farm and neighbouring wind farms**

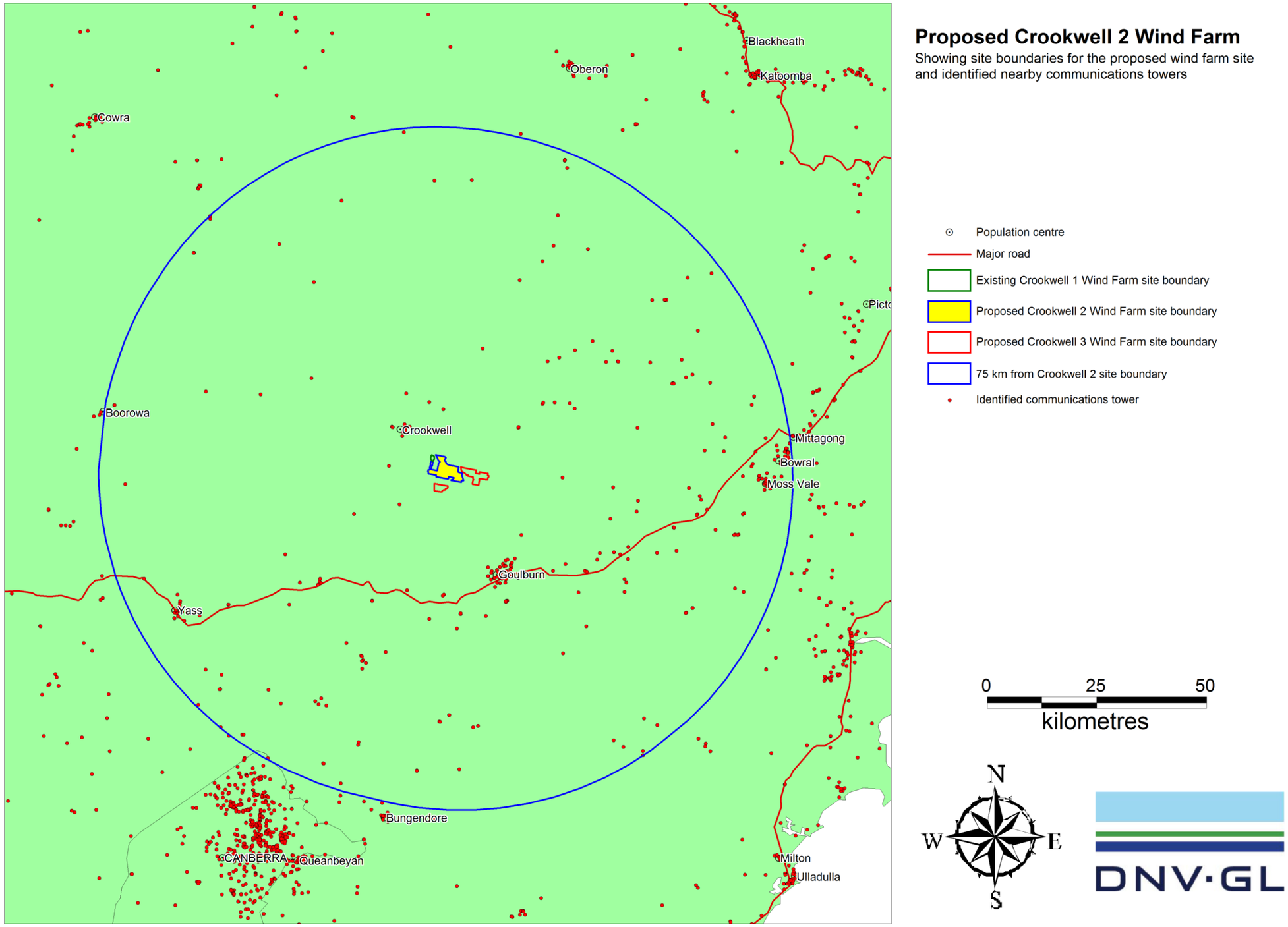
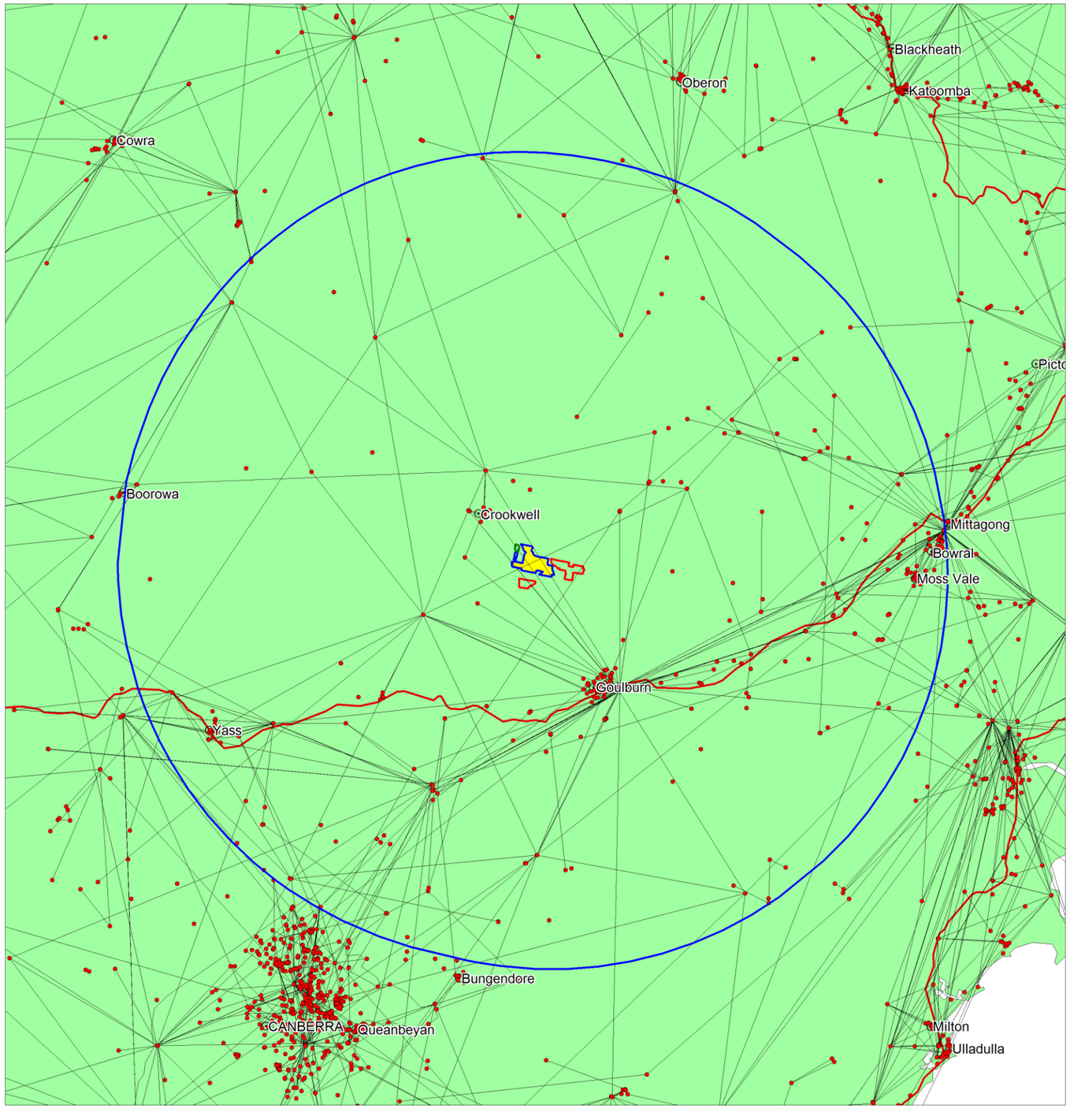


Figure 2 Location of the proposed Crookwell 2 Wind Farm and identified proximate radiocommunication sites



Proposed Crookwell 2 Wind Farm

Showing site boundaries for the proposed wind farm site and identified fixed point-to-point licences

- Population centre
- Major road
- Existing Crookwell 1 Wind Farm site boundary
- Proposed Crookwell 2 Wind Farm site boundary
- Proposed Crookwell 3 Wind Farm site boundary
- 75 km from Crookwell 2 site boundary
- Identified communications tower
- Identified fixed (point-to-point) licences

0 25 50
kilometres

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DNV·GL

Figure 3 **Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Crookwell 2 Wind Farm**

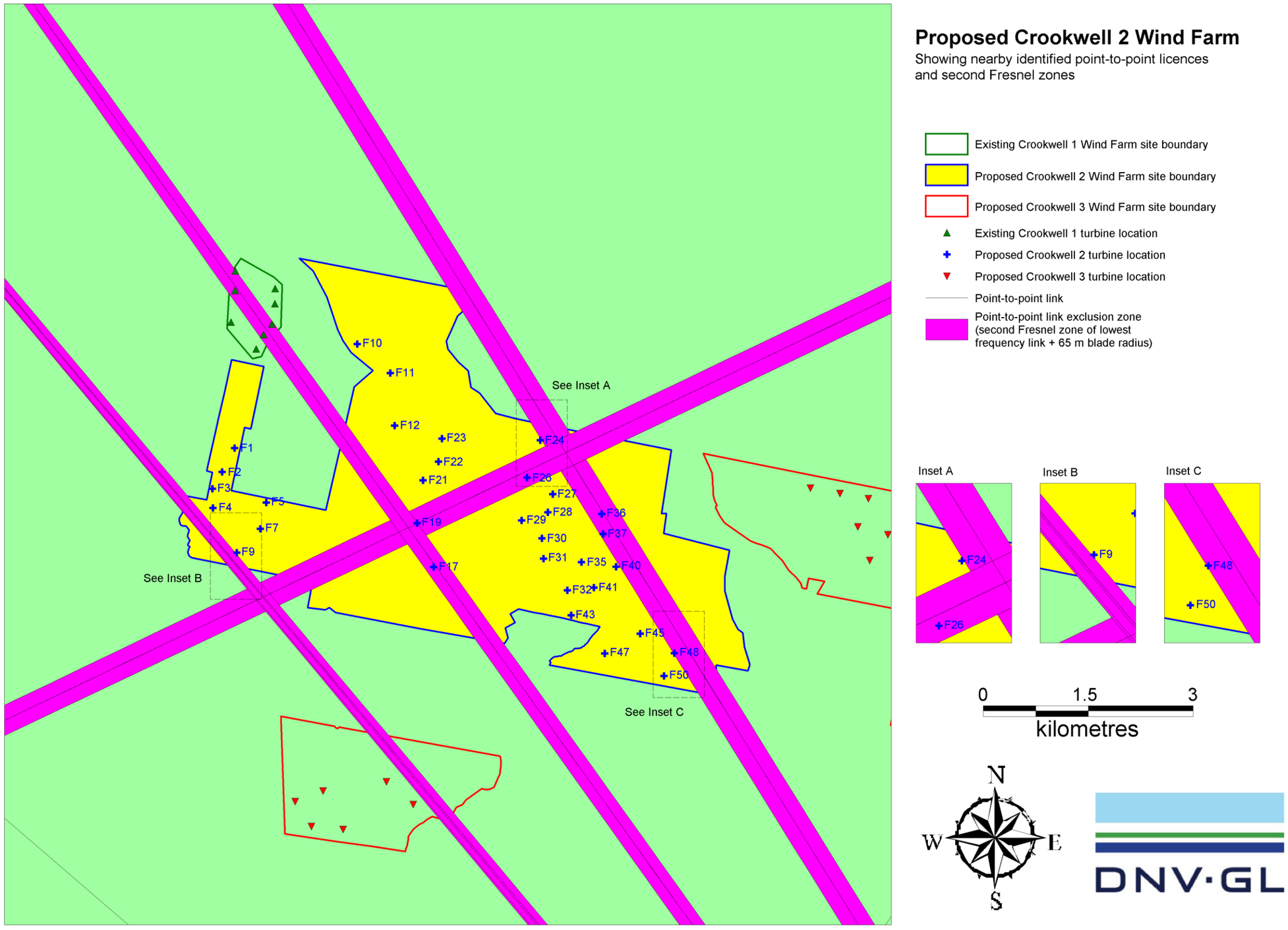


Figure 4 Identified telecommunication vectors and second Fresnel zones plus 65 m buffer for the proposed Crookwell 2 Wind Farm

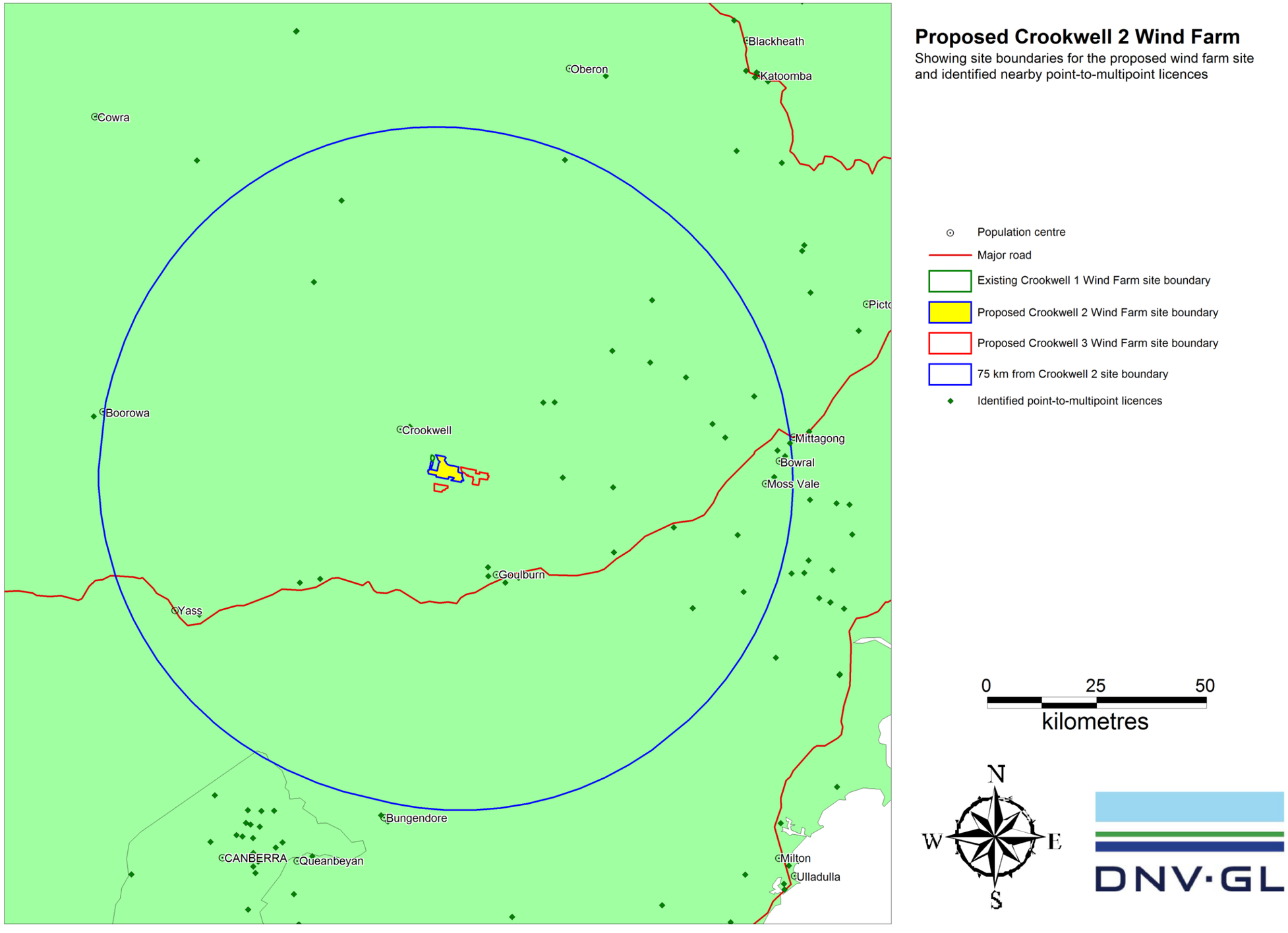


Figure 5 Location of point-to-multipoint licences in the vicinity of the proposed Crookwell 2 Wind Farm

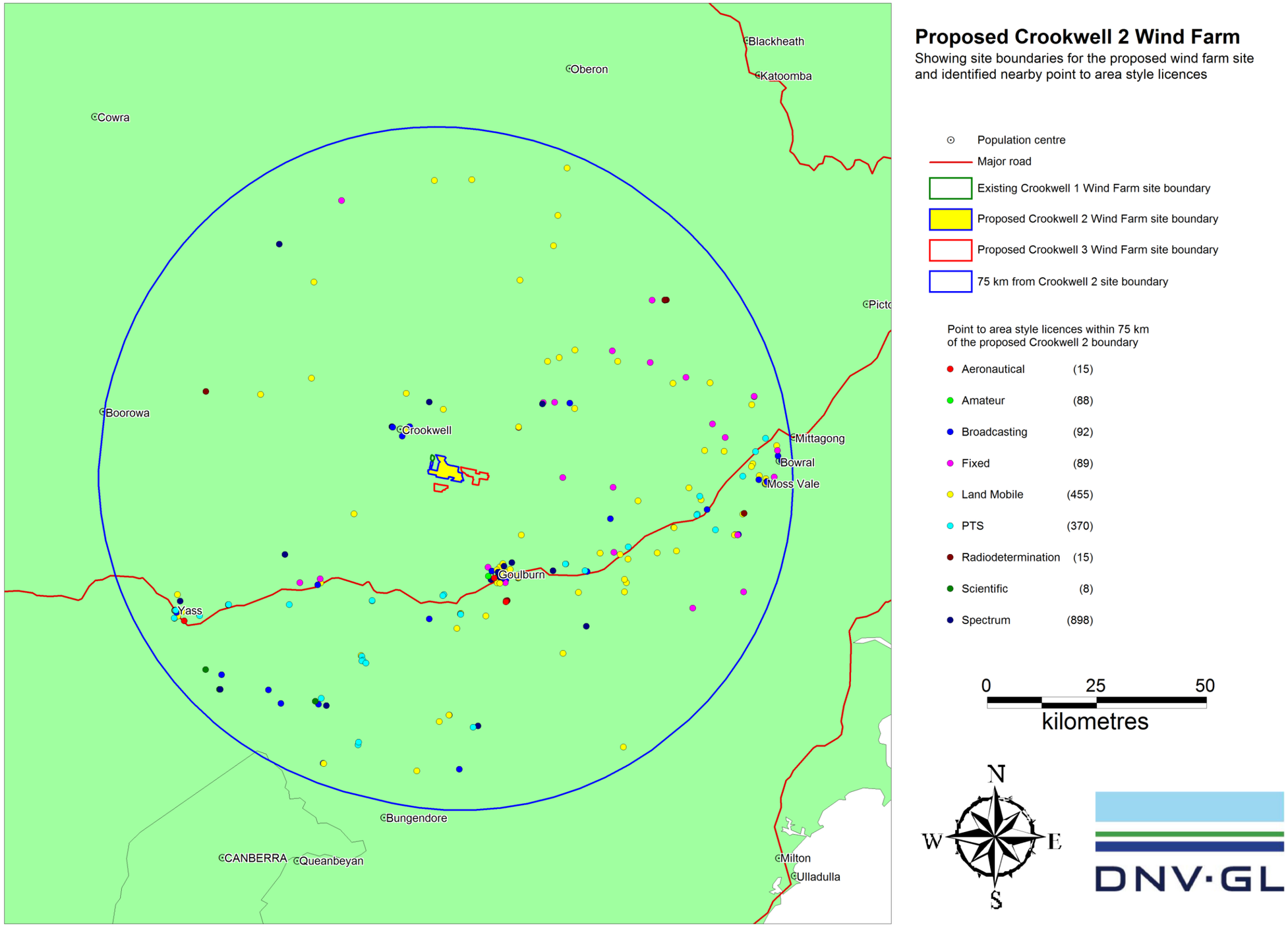


Figure 6 **Location of general point to area style licences within 75km of the proposed Crookwell 2 Wind Farm**

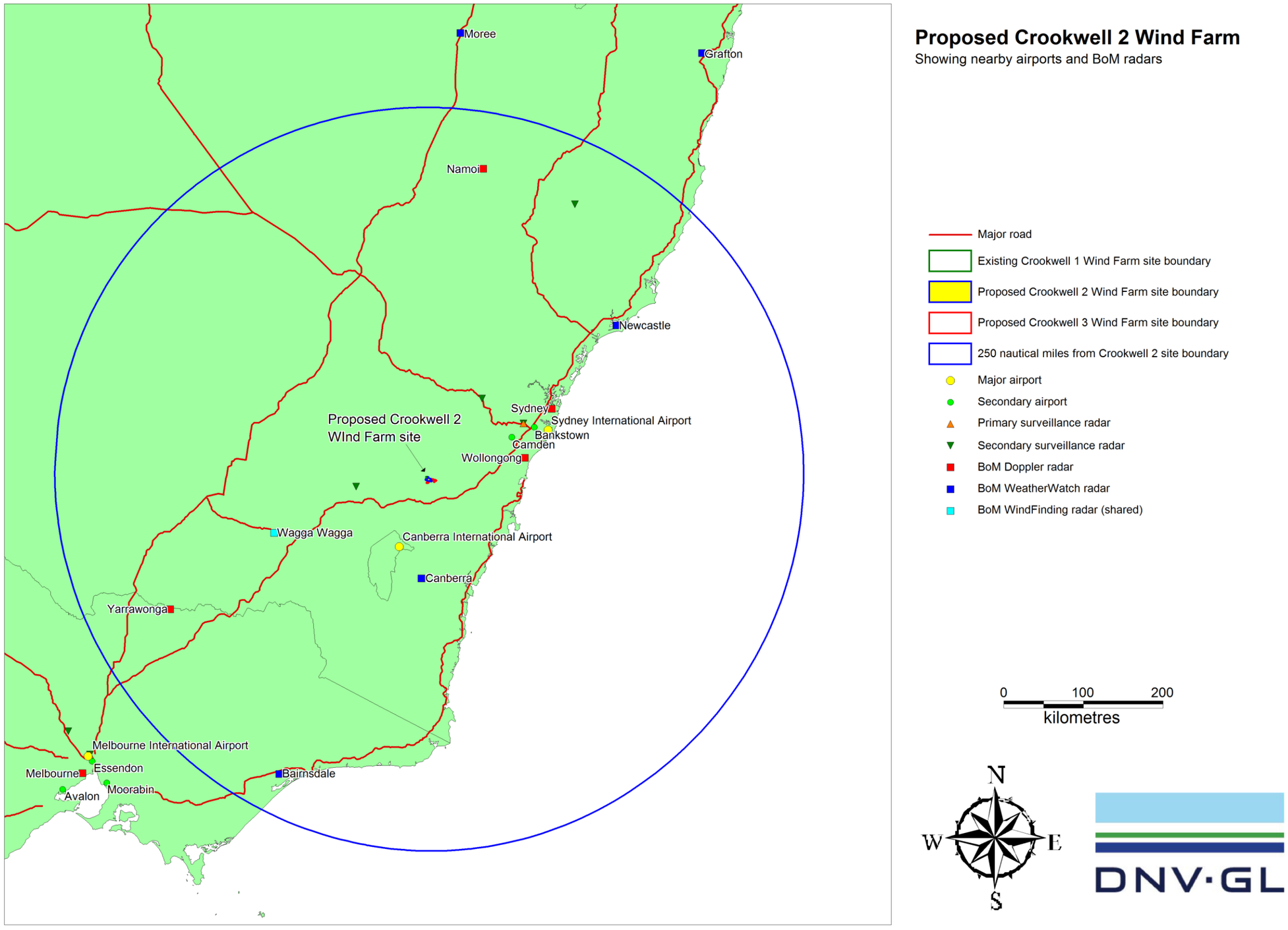


Figure 7 Location of major airports and meteorological radar sites within 250 nautical miles of the proposed Crookwell 2 Wind Farm

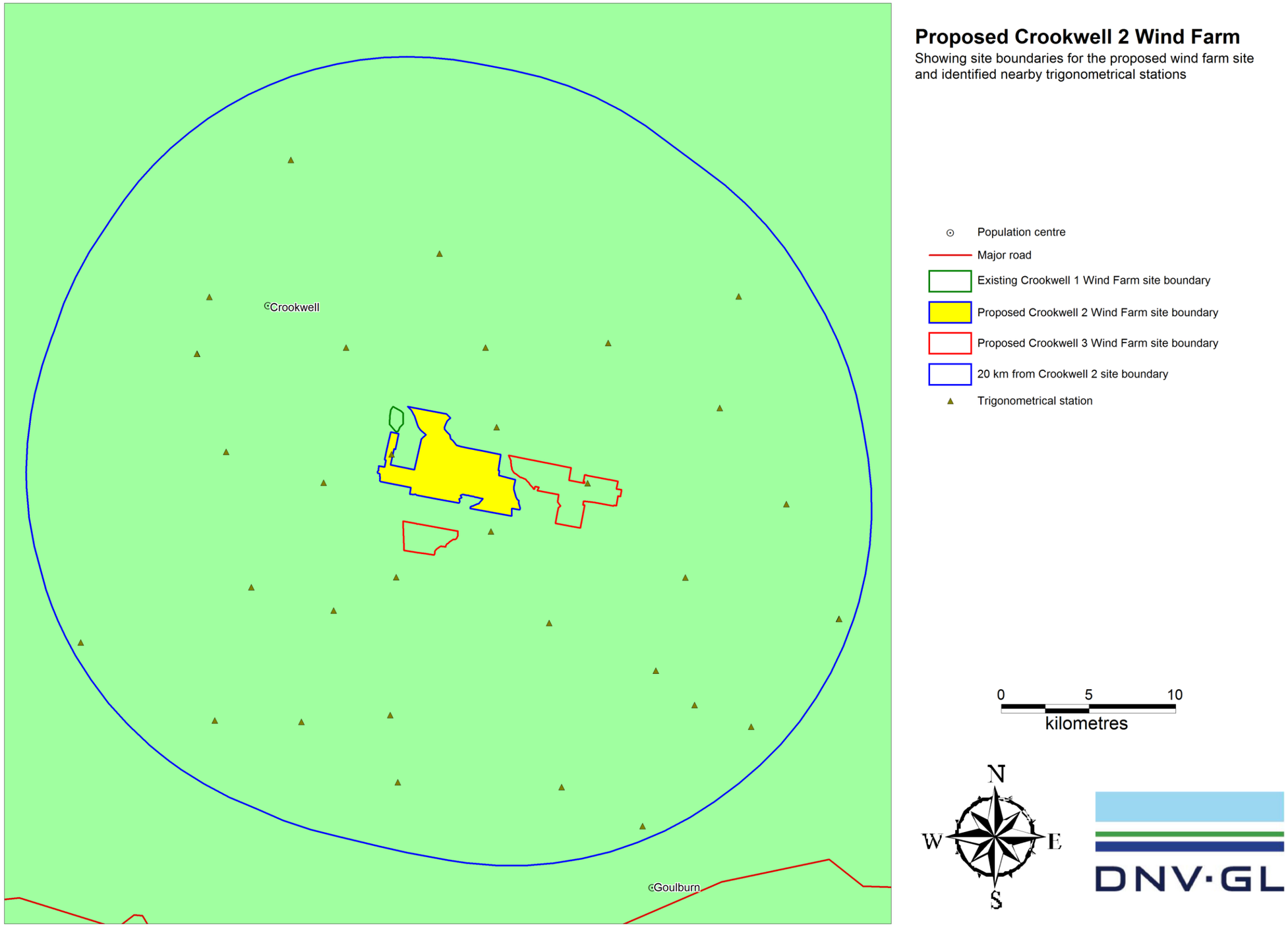


Figure 8 Location of trigonometrical stations within 20 km of the proposed Crookwell 2 Wind Farm

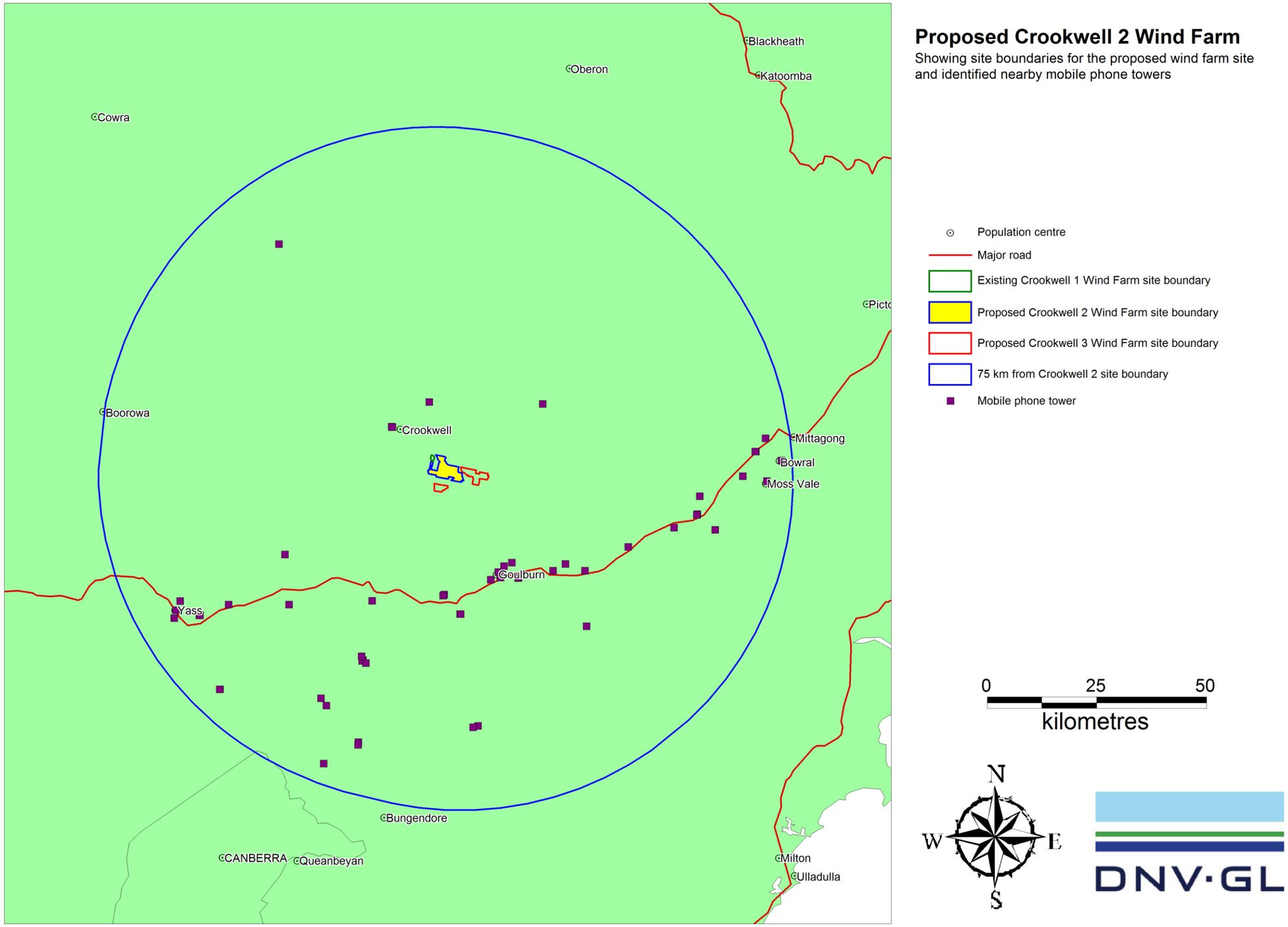


Figure 9 Location of mobile phone towers within 75 km of the proposed Crookwell 2 Wind Farm

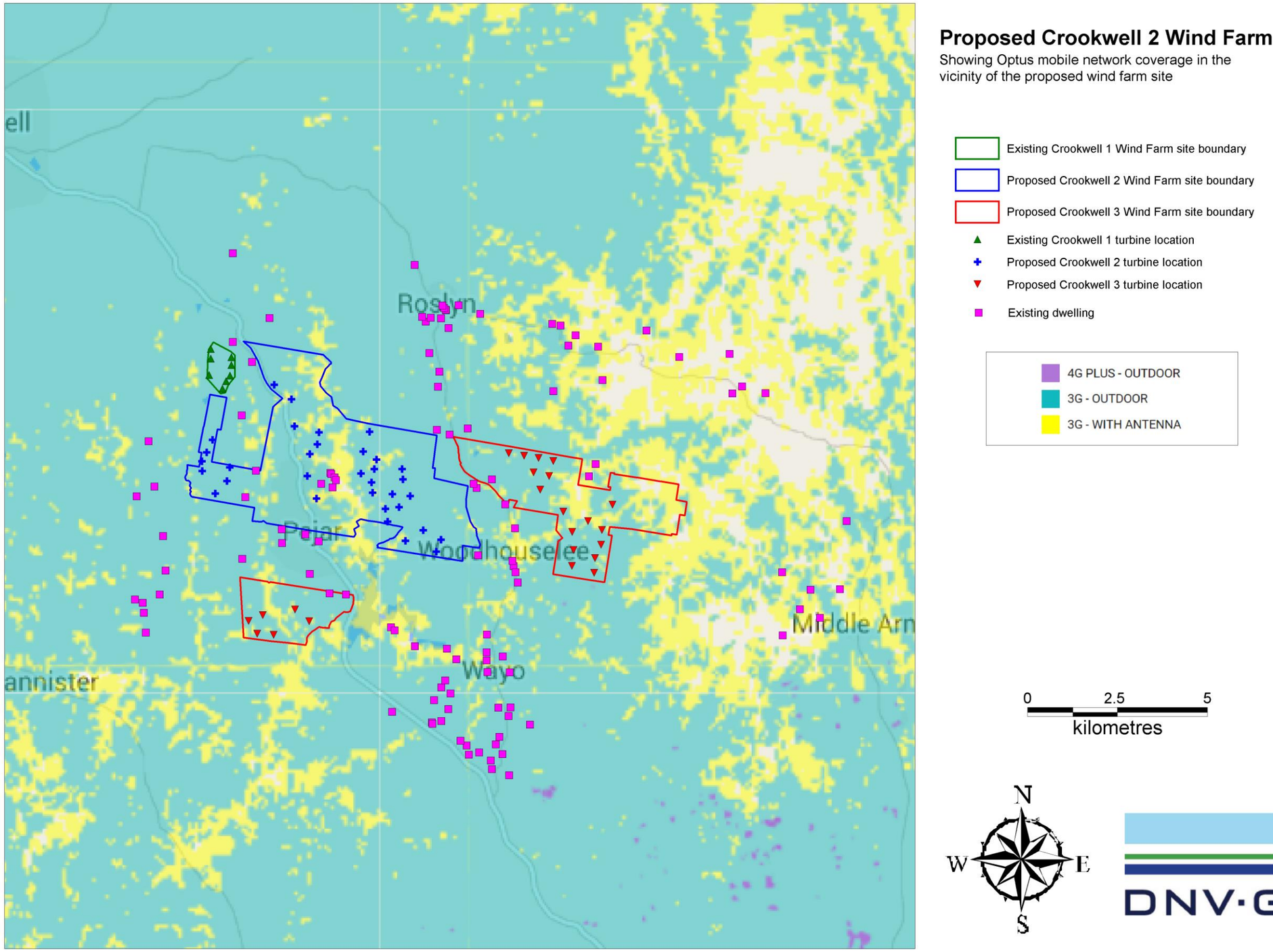


Figure 10 Optus Mobile network coverage (Samsung Galaxy S6 handset) for the proposed Crookwell 2 Wind Farm

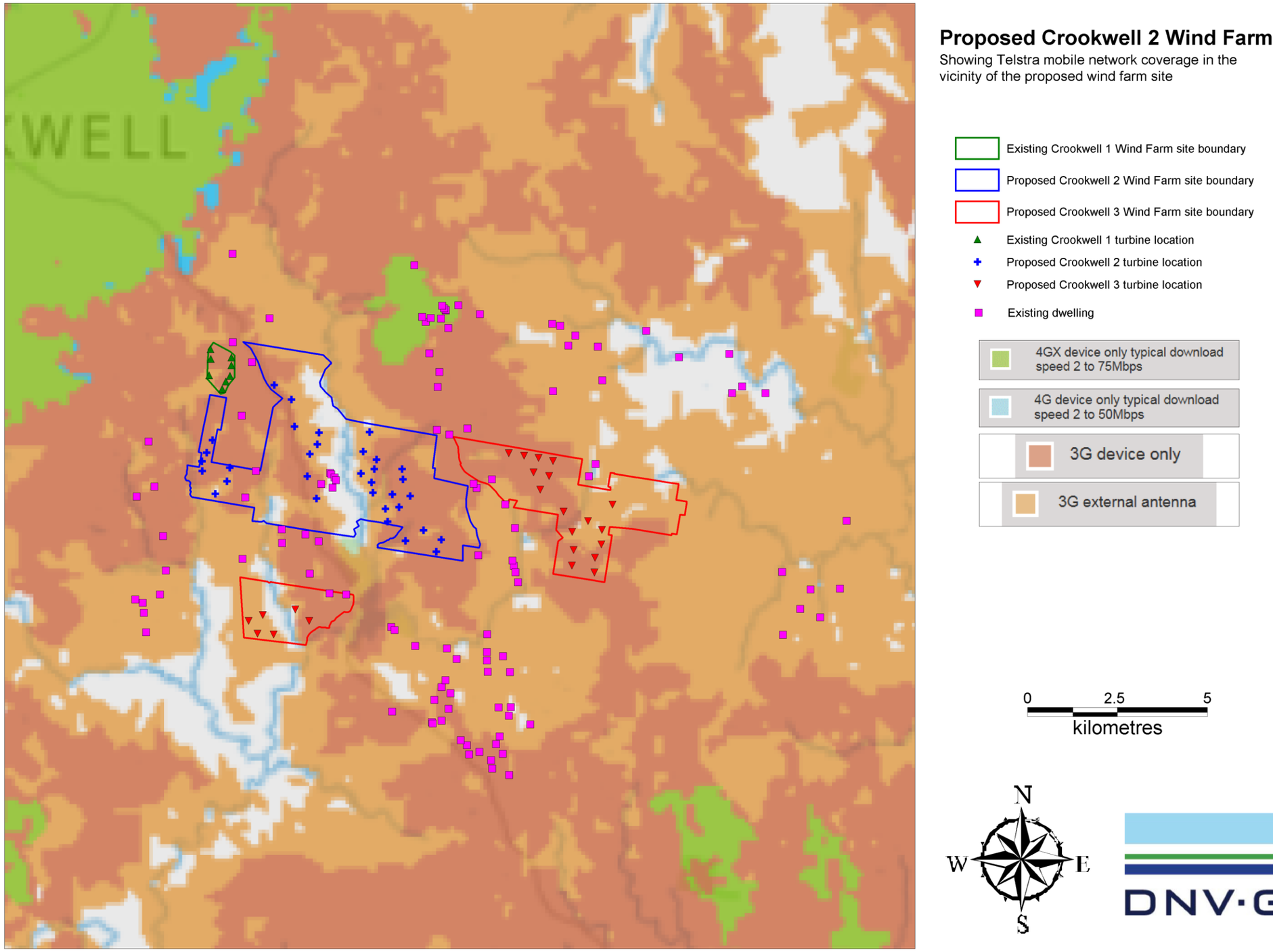


Figure 11 Telstra network coverage for the proposed Crookwell 2 Wind Farm

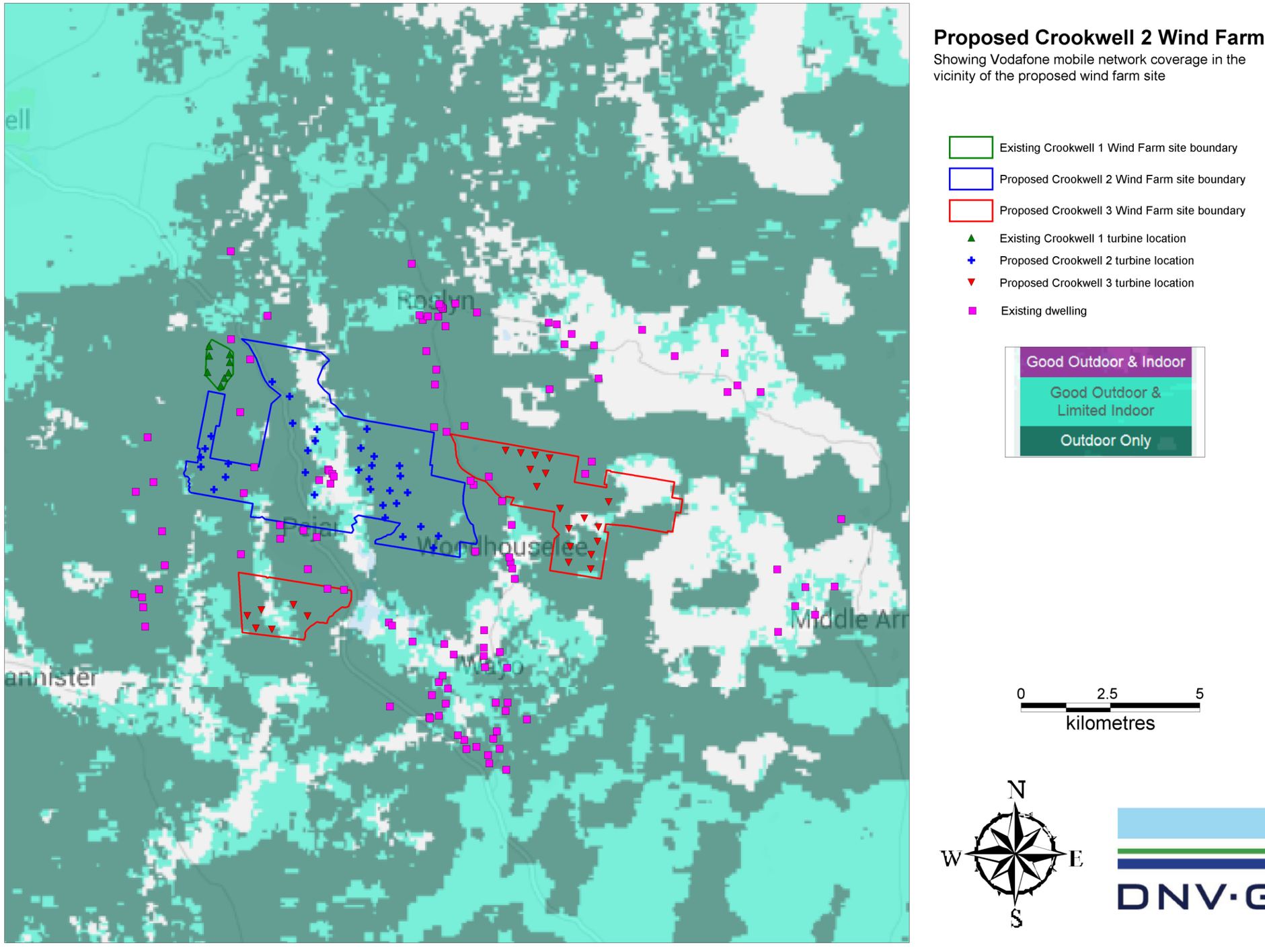


Figure 12 Vodafone network coverage for the proposed Crookwell 2 Wind Farm

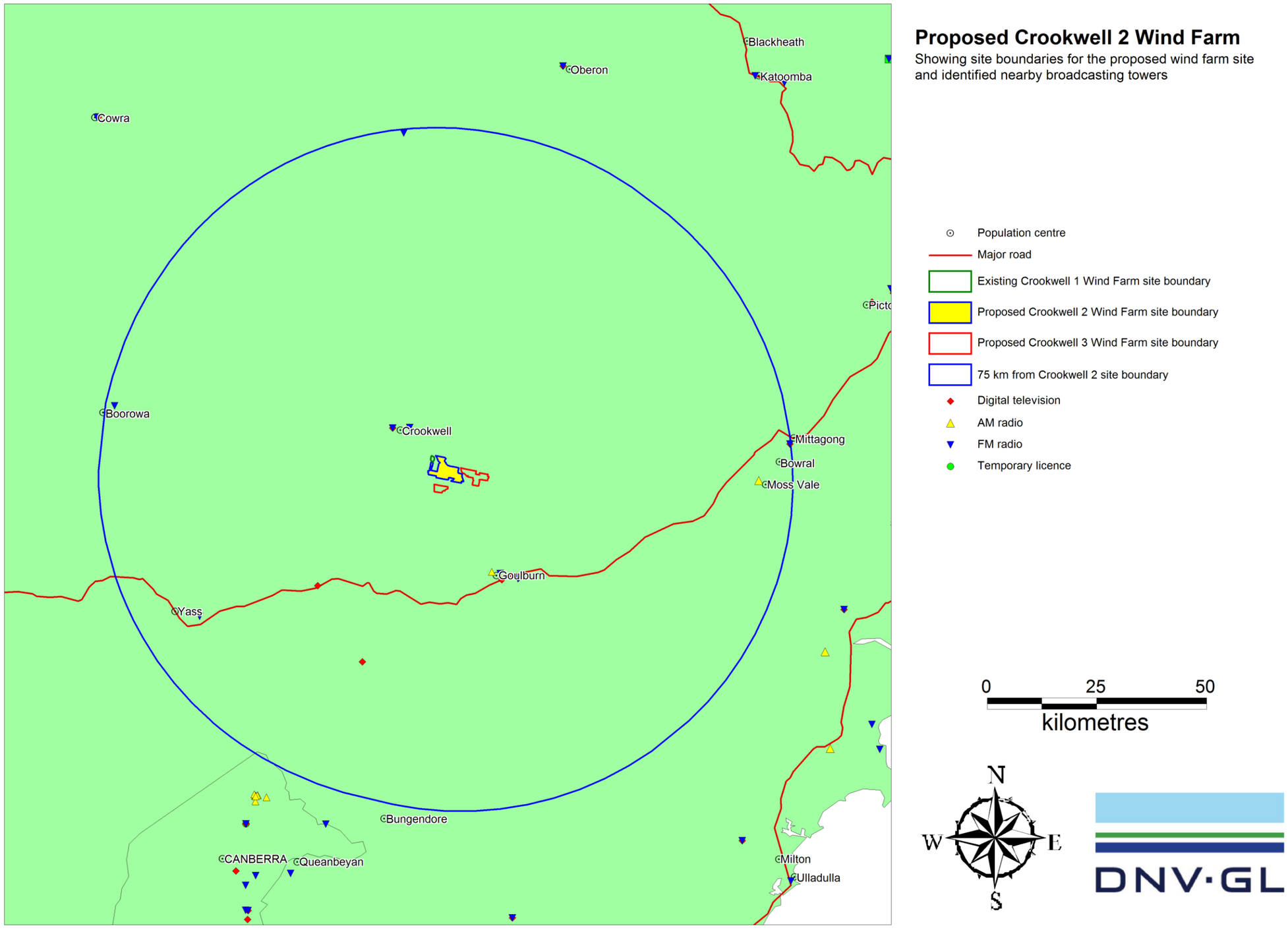


Figure 13 Location of broadcast transmitters in the vicinity of the proposed Crookwell 2 Wind Farm

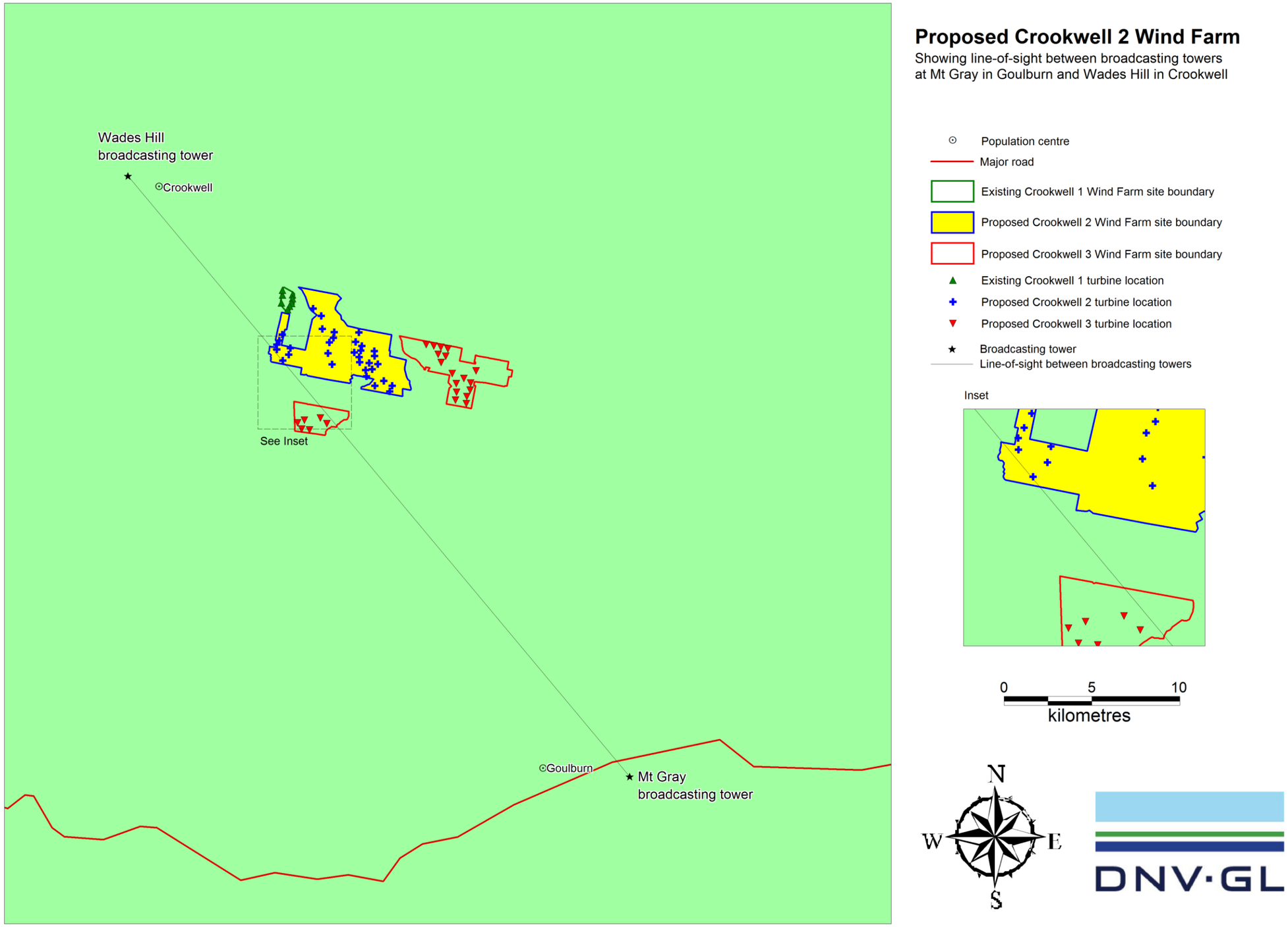
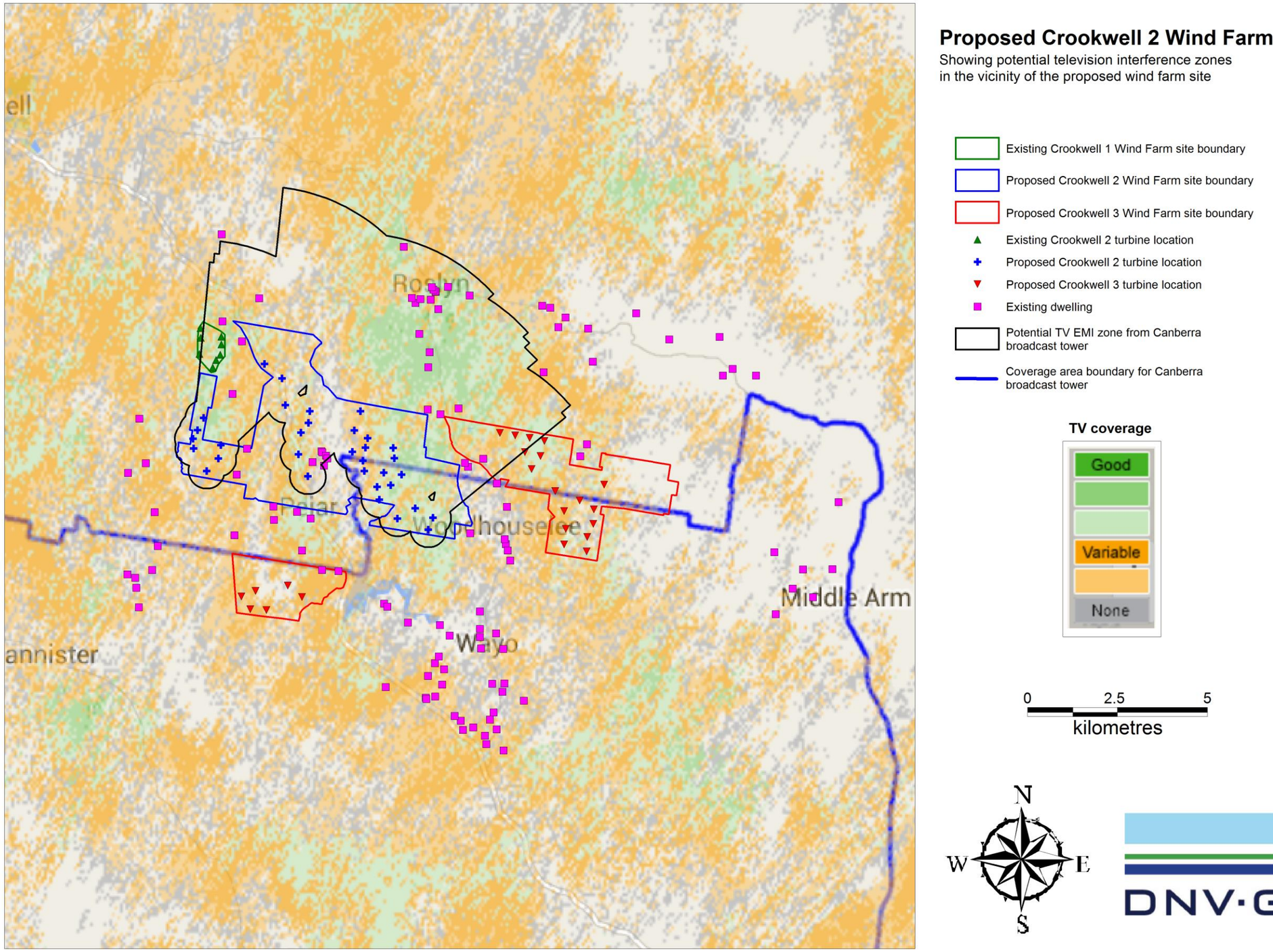


Figure 14 **Line-of-sight from Goulburn broadcast tower at Mt Gray to Crookwell broadcast tower at Wades Hill, relative to the proposed Crookwell 2 Wind Farm**



Proposed Crookwell 2 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 2 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

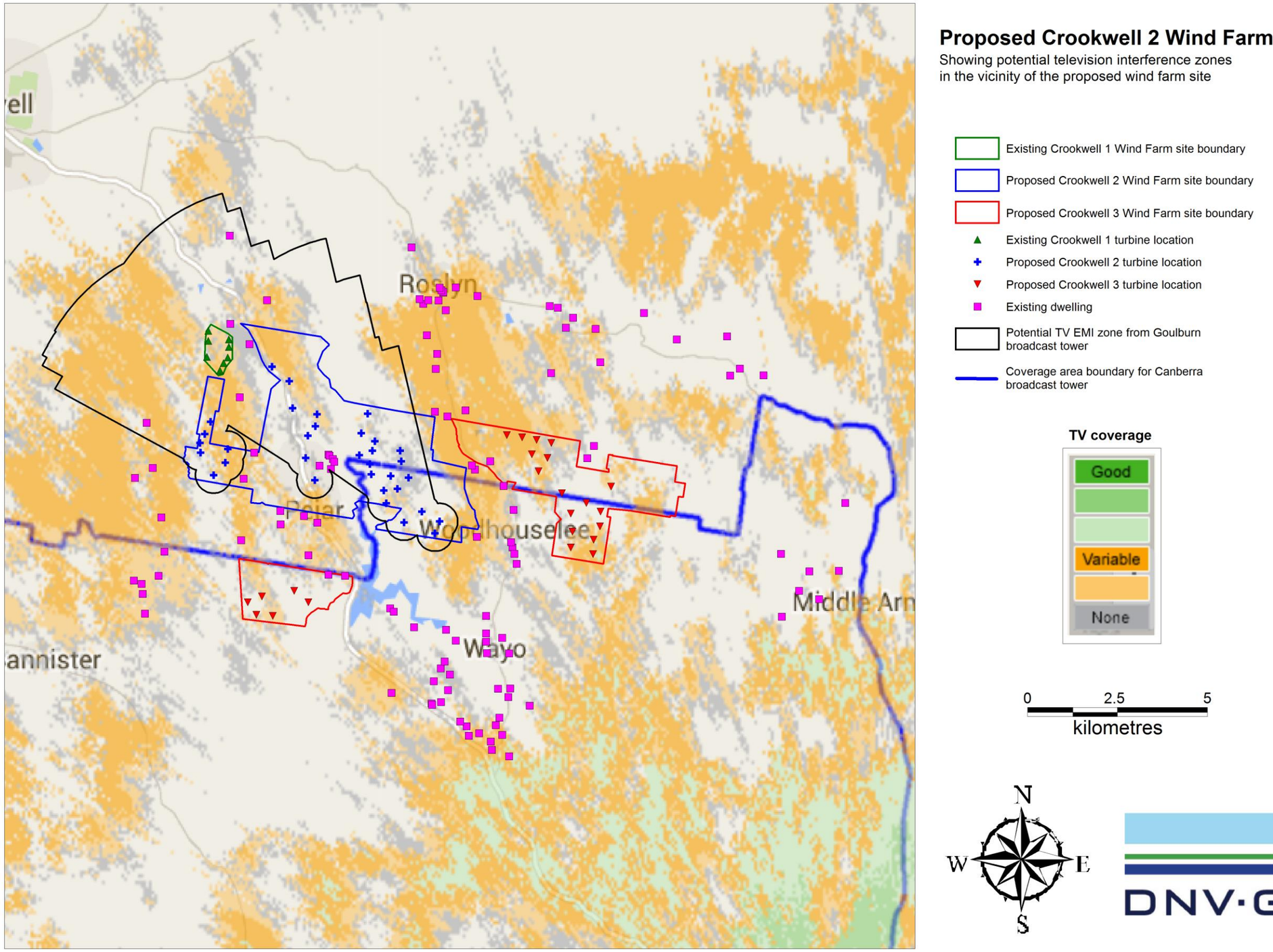
Good
Variable
None

0 2.5 5
kilometres

N
W E
S

DNV·GL

Figure 15 Potential TV EMI zones from the Canberra broadcast tower



Proposed Crookwell 2 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 Goulburn 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 16 Potential TV EMI zones from the Goulburn broadcast tower

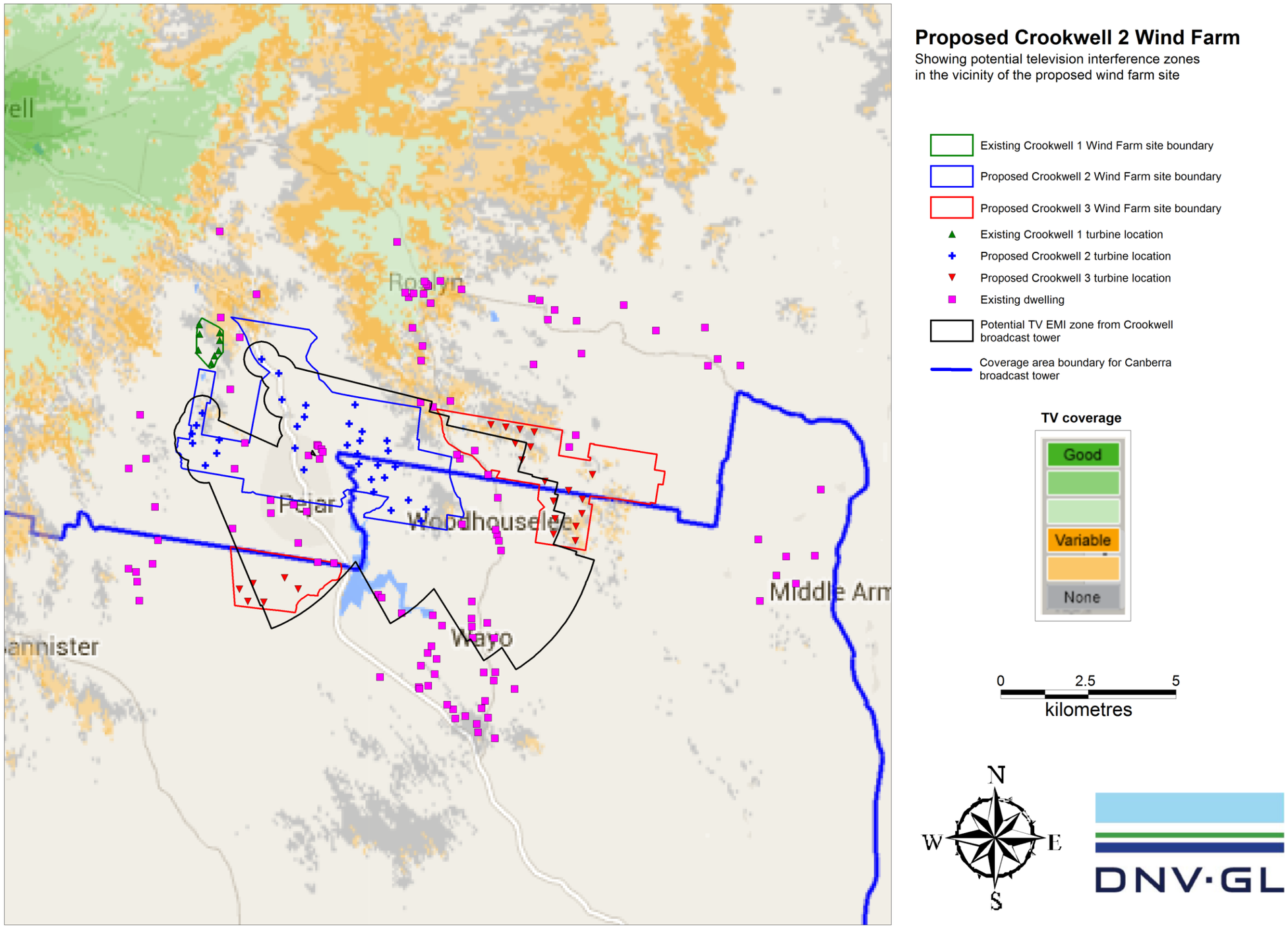


Figure 17 Potential TV EMI zones from the Crookwell broadcast tower

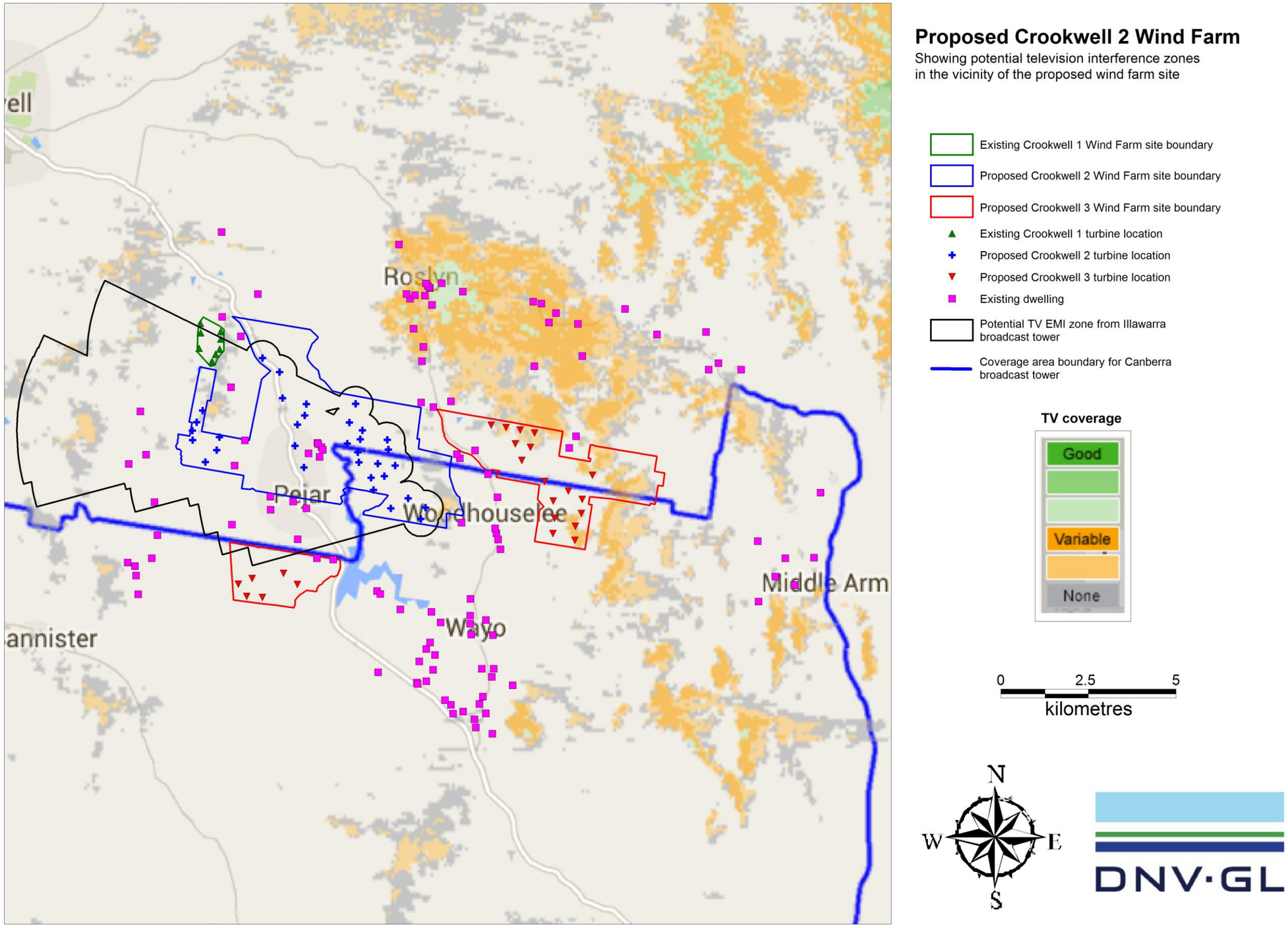


Figure 18 **Potential TV EMI zones from the Illawarra broadcast tower**

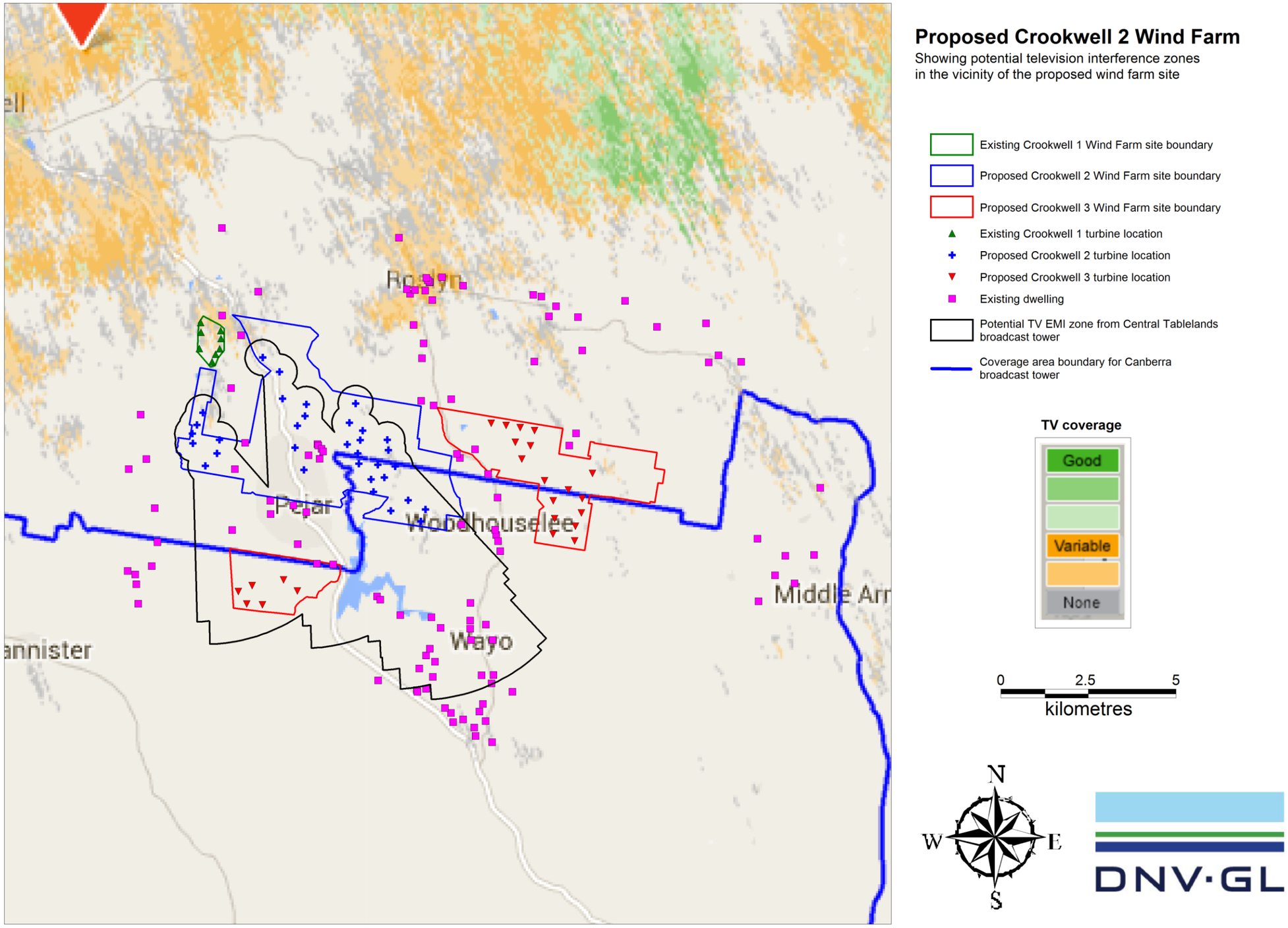


Figure 19 **Potential TV EMI zones from the Central Tablelands broadcast tower**

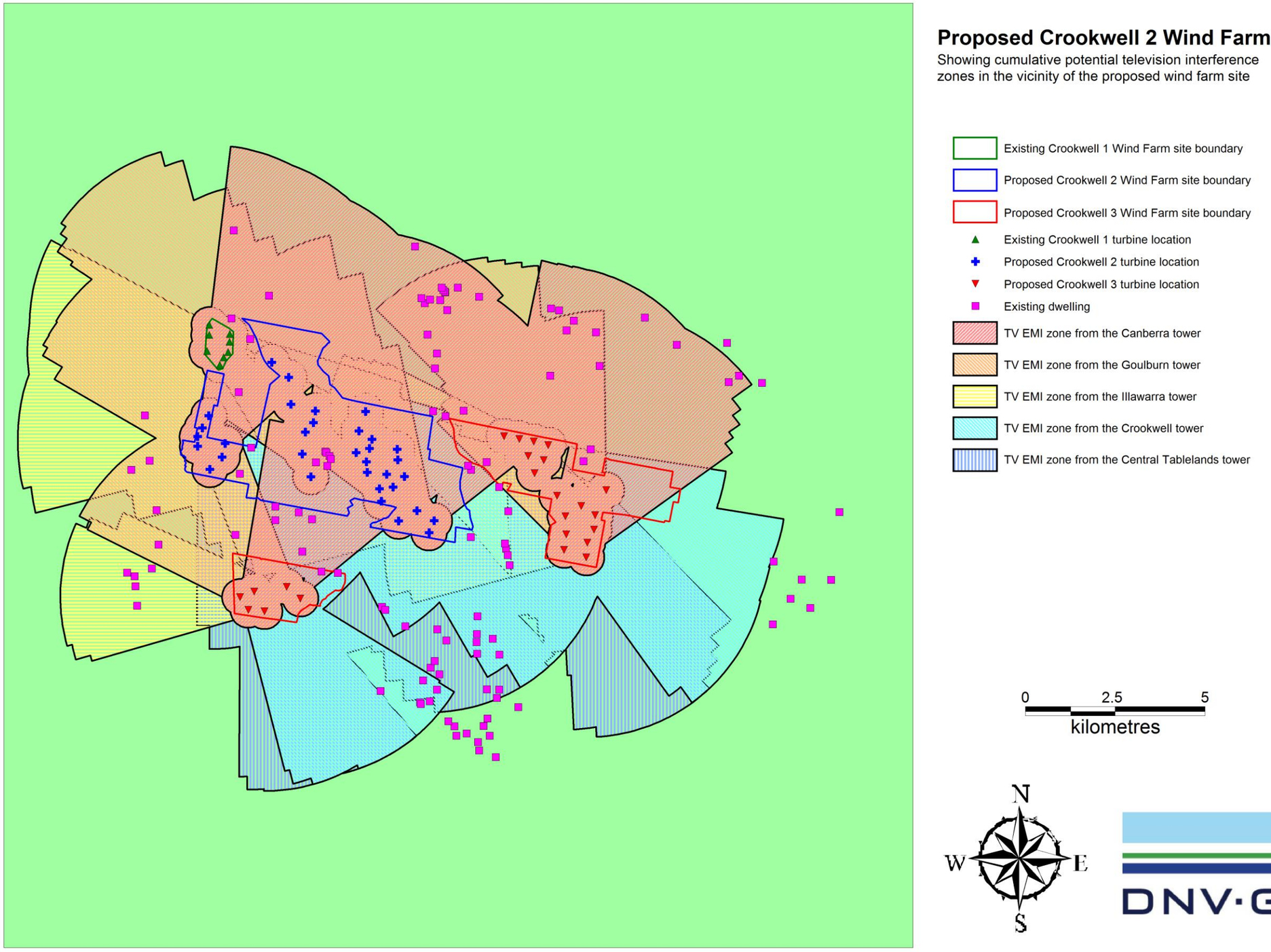


Figure 20 **Cumulative potential TV EMI zones from the Canberra, Goulburn, Crookwell, Illawarra, and Central Tablelands broadcast towers resulting from the Crookwell 1, Crookwell 2, and Crookwell 3 wind farms**

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.