Annex K

Electromagnetic Interference (EMI) and Electromagnetic Field (EMF) Assessment Report

DNV·GL

JUPITER WIND FARM

EMI and EMF Assessment

Environmental Resources Management Australia Pty Ltd

Report No.: 170338-AUME-R-02, Rev. F
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Assessment of potential EMI impacts arising from the proposed Jupiter Wind Farm.

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EXECUTIVE SUMMARY

Garrad Hassan Pacific Pty Ltd, now trading as DNV GL, has been commissioned by Environmental Resources Management Australia Pty Ltd ("ERM" or "the Customer") to independently assess the electromagnetic interference (EMI) and electromagnetic field (EMF) related impacts associated with the development and operation of the proposed Jupiter Wind Farm ("the Project"), which is being developed by EPYC ("the Proponent"). This report summarises the results of an EMI and EMF assessment conducted for the Project.

In accordance with the Secretary's Environmental Assessment Requirements (SEARs) [1] and planning guidelines relevant to the Project, this document describes the assessment of potential risks regarding interference with radiocommunication services operating in the vicinity of the Project Area (PA). Consideration is also given to potential EMF related impacts.

"Radiocommunications" is used as a broad term in this report to encompass all services that rely on electromagnetic or radio waves to transfer information. There are many methods of transmitting information via radiocommunication. Radiocommunication services operating in the vicinity of the proposed Project, and their susceptibility to interference with the Project, are discussed in this document. Up to date information relating to nearby telecommunication licences has been obtained from the Australian Communications and Media Authority (ACMA) [2].

Television broadcasting

Wind turbine generators (WTGs) may cause interference to television broadcast signals. Historically, analogue television signals have been more likely to suffer from interference. However, digital television services have recently 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 WTGs distant from the broadcast tower. No television broadcast tower has been identified in close proximity to the PA, with the nearest broadcast tower at least 18 km southeast of the PA, at Mt Gillamatong, servicing the town of Braidwood. Digital television signals from the Black Mountain transmitter near Canberra, currently service the majority of the area around the PA. The Digital TV Switchover Australia website indicates that the digital television signal has "variable coverage" in the vicinity of the PA, with some regions with no coverage. The website also indicates that the northern section of the PA has "variable" digital television coverage from the Knights Hill broadcast tower near Illawarra while the south-eastern section of the PA receives "variable" signal coverage from the Mt Gillamatong broadcast tower near Braidwood. This report highlights the areas around the proposed Project where interference to terrestrial television broadcasts is most likely to occur. A total of 119 dwellings were identified in the potential interference zone for the Black Mountain broadcast tower near Canberra. A total of 111 dwellings and 93 dwellings were identified in the potential interference zones for the Mt Gillamatong and Knights Hill broadcast towers respectively. It is possible that some residents currently experience poor or marginal reception of the digital signals and therefore, they may be susceptible to interference from the Project. For such cases, there are 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.

Fixed point-to-point links

WTGs 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 a fixed point-to-point link crosses the PA, consisting of one fixed licence. An exclusion zone has been established around the point-

to-point link based on a standard industry methodology. Two of the WTGs proposed for the PA are located within the exclusion zone. The owner ofthe link, Transgrid, has been contacted to assess the likely impact of the Project on their services. No formal response has been received to date. However, it is noted that the Proponent has advised that they have received written confirmation from Transgrid that the link will not be affected by the turbines.

Fixed point-to-multipoint links

WTGs can also cause interference with fixed point-to-multipoint links; however it is not possible to identify the locations of paths for point-to-multipoint links as only the base-station is licensed and contained in the ACMA Radiocommunications Database [2]. There is one point-to-multipoint base station listed in the ACMA database within 20km of the PA, owned by the former Palerang Council. The former Palerang Council has been contacted by DNV GL to seek feedback regarding the likely impact of the Project on their services. No formal response has been received to date.

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the PA. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the PA, a consultation process is currently underway with the operators of these stations to seek feedback on any potential impact that the Project could have on their services. To date, feedback has been received from one of the operators, namely Essential Energy, indicating that the Project will not impact their existing services.

CB Radio and mobile phones

In general, Very High Frequency (VHF) and Ultra High Frequency (UHF) frequency band radio signals, and digital voice based technologies such as mobile phones (often called Global System for Mobile Communications, or GSM phones), third generation phones (often called 3G or NextG mobiles), and fourth generation phones (often called 4G mobiles) are unaffected by wind farm development. Some interference is theoretically possible in areas where coverage is marginal and a WTG 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. As part of the consultation process, mobile phone network operators have been contacted to seek feedback on any potential impact that the Project could have on their services. To date, feedback has been received from Telstra and Optus, who have both indicated that the Project will have no impact on their services.

Emergency services

Emergency services operating radiocommunications assets in the vicinity of the PA have also been identified. The majority 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 stations have been notified of the Project as part of a consultation process and their feedback sought on any potential impact that the Project could have on their services. To date, feedback has been received from a number of operators and no significant impacts from the Project have been identified.

Satellite television and internet

It is possible that WTGs could cause interference to satellite television and internet services if a WTG intercepts the signal between a satellite and a ground based receptor. However, it is expected that interference to satellite television or internet services resulting from the development and operation of the Project is unlikely based on the proposed WTG locations and locations of existing dwellings.

Radio broadcasting

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

Aviation and meteorological radar

WTGs have the potential to interfere with meteorological and aviation radars. Reflection of radar signals by WTG blades may give false readings or create a radar "shadow" behind the WTGs. Due to the distance from radar assets, and the high probability that the WTGs 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. Feedback has been sought from the operators of the meteorological stations to assess whether the Project is likely to adversely impact their services. DNV GL understands that an Aviation Impact Assessment has been prepared for the project and includes an assessment of any potential impacts of the Project on aviation systems.

Trigonometrical stations

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 PA has been conducted and there are five stations that are located within the PA. DNV GL has contacted Geoscience Australia and the New South Wales Government Land and Property Information (LPI) to determine the potential for interference from the Project.

Cumulative impacts

Possible cumulative EMI impacts from the Project and nearby wind farms have also been considered and are presented in *Section 4.16*. Cumulative impacts are not expected to occur for most services considered, however the possibility exists for cumulative impacts to point-to-multipoint stations, mobile phones, wireless internet, Citizens Band (CB) radio and television services. Options exist to mitigate most interference issues should they occur.

Electromagnetic emissions from WTGs

Electromagnetic waves surround us and are caused by both natural sources (e.g., the sun, thunderstorms) and artificial sources. Low frequency electromagnetic waves (less than approximately 3 kHz) are often termed electromagnetic fields (EMF), while higher frequency electromagnetic waves are often termed electromagnetic radiation (EMR). All electrical devices emit electromagnetic waves. *Section 5* discusses the electromagnetic emissions from WTGs and covers both EMF and EMR. DNV GL has deemed that EMF strengths and EMR levels are likely to be within limits imposed by applicable guidelines and no adverse impacts are expected. Emissions from other components that may be present in a wind farm have not been assessed, unless specifically stated.

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

1 INTRODUCTION

Environmental Resources Management Australia Pty Ltd ("ERM" or "the Customer") has requested that Garrad Hassan Pacific Pty Ltd, now trading as DNV GL, carry out an independent assessment of electromagnetic interference (EMI) and electromagnetic field (EMF) related impacts associated with the proposed Jupiter Wind Farm ("the Project"). The results of the work are reported here.

In accordance with relevant planning guidelines, as discussed in *Section 3*, this assessment investigates the impact of the Project on:

- fixed point-to-point links;
- fixed point-to-multipoint links;
- radiocommunication assets belonging to emergency services;
- meteorological radars;
- trigonometrical stations;
- Citizens Band (CB) radio and mobile phones;
- wireless internet;
- broadcast radio;
- satellite television and internet; and
- broadcast television.

The assessment also considers potential impacts due to electromagnetic emissions (including electromagnetic fields and electromagnetic radiation) from the Project.

In order to conduct the EMI assessment, information regarding radiocommunication licences in the vicinity of the Project have been obtained from the Australian Communication and Media Authority (ACMA) database [2].

A description of the proposed Project considered in this analysis, as provided by the Customer [3, 4], is detailed in the following sections.

2 PROJECT SITE

2.1 Site description

The proposed development involves the construction and operation of the Jupiter Wind Farm ("the Project") within the Southern Tablelands Region of New South Wales (NSW). The Project Area (PA) covers an area of approximately 4,999 hectares (ha) spanning across the Goulburn Mulwaree and former Palerang Local Government Areas (LGAs), and is situated approximately 5 kilometres (km) south east of the township of Tarago and approximately 18 km east of Bungendore.

The PA is characterised by open, undulating terrain, however there are scattered trees, areas of dense forestry and wind breaks located throughout the region. Large areas of bushland are located to the south and east of the PA. Complex terrain characterised by steep hills and ridges is located to the south, west and east of the PA. The PA and surrounding land is primarily used for grazing sheep and cattle.

The PA is located in a region of high wind farm activity, with the pre-existing Capital 1 and Woodlawn wind farms located approximately 13 km to the west and 6 km west-north west of the PA, respectively. The approved Capital 2 Wind Farm is located at approximately 14 km west of the PA, with 41 WTGs proposed amongst the Capital 1 Wind Farm WTGs. The approved Capital Solar Farm is located at approximately 11 km west of the PA, adjacent to the Capital 1 and 2 wind farms. It is also noted that the Collector Wind Farm is located at approximately 31.3 km northwest of the PA. An assessment of the potential cumulative EMI impacts of the Project and the neighbouring wind farms and solar farm has been undertaken and is described in *Section 4.16*.

2.2 Project description

The Project will involve construction of up to 88 wind turbine generators (WTGs) within two distinct precincts. The northern precinct will consist of up to 75 WTGs, and the southern precinct up to 13 WTGs, with a maximum height of 173 m above ground level (AGL). The Project will also involve construction of a series of internal access roads and 33 kV reticulation network connecting the WTGs; an electrical substation and 330 kV transmission line connection to the existing TransGrid 330 kV transmission line that passes through the PA; and other associated buildings and ancillary structures and equipment.

The 33 kV transmission line alignment, connecting the underground 33 kV electrical reticulation networks from the southern and northern WTG precincts to the substation, is yet to be confirmed in detail. At this stage, the 33 kV transmission line is proposed to be constructed within the road reserve of Goulburn Road, the Kings Highway and the proposed access road into the southern precinct. The 33 kV transmission line will be built as either an above ground line consisting of poles and wires, or a buried underground cable. The transmission line alignment and overall construction type will be determined during detailed Project design, in consultation with relevant electrical suppliers and regulatory authorities.

A WTG layout has been provided by ERM [3] and has been used for the purpose of the EMI study. *Figure 1* below shows a map of the PA with the proposed WTG layout, and the WTG coordinates are listed in *0*. The map also shows the PA (in red) which includes only involved landowners. A list of dwellings neighbouring the Project was also supplied to DNV GL by the Customer [4].

To assess potential EMI impacts that are dependent on WTG geometry, DNV GL has considered a WTG geometry having a rotor diameter of 126 m or less and an upper tip height of 173 m or less.

As detailed further in *Section 4*, a radial distance of 75 km from the PA was taken into consideration to capture all of the potentially affected radiocommunication services in the area.

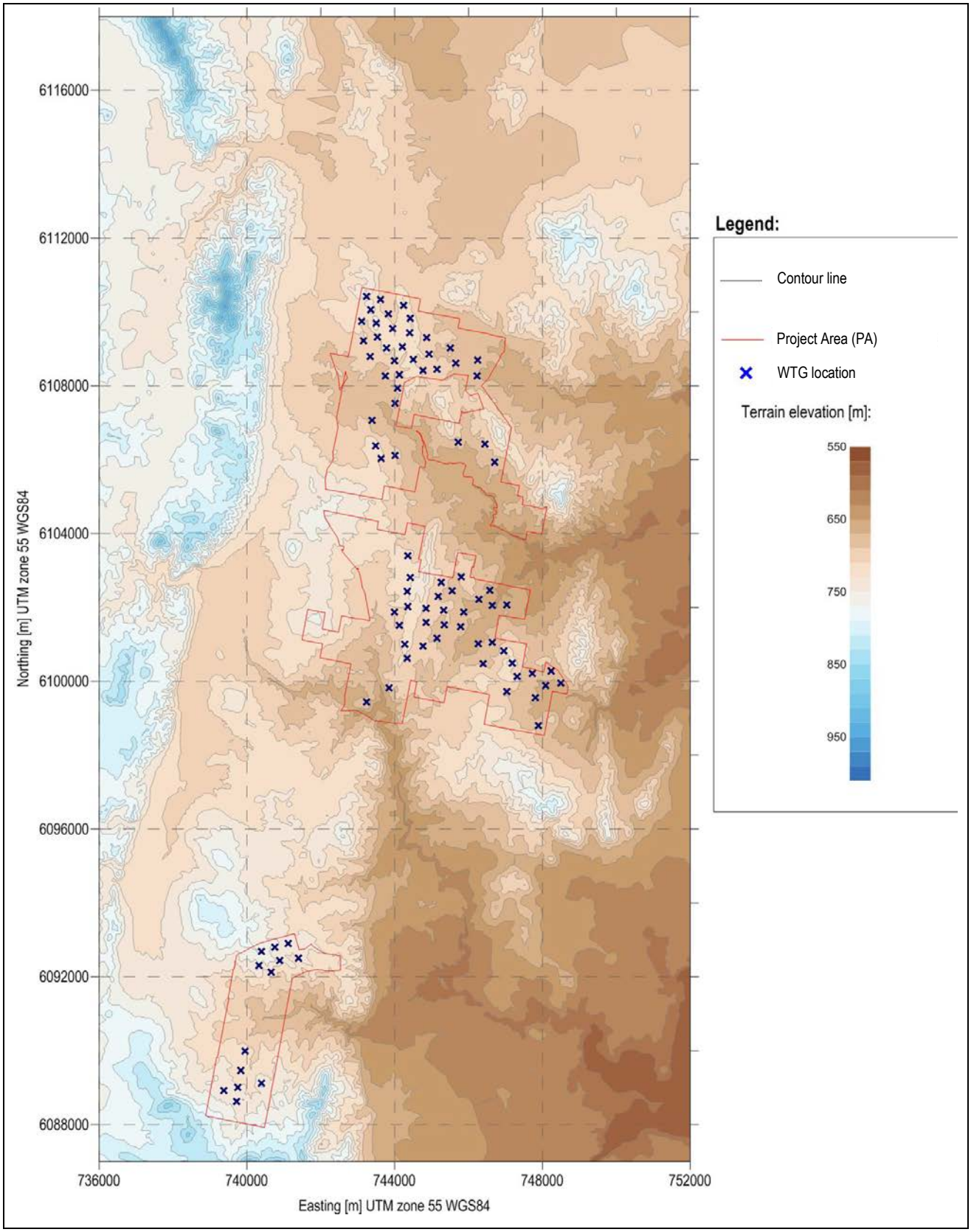

Figure 1: Layout of the PA

3 PLANNING GUIDELINES

3.1 Secretary's Environmental Assessment Requirements (SEARs)

Regarding interference to telecommunication services, the Secretary's Environmental Assessment Requirements for the Jupiter Wind Farm (SEARs) [1] outline the following requirements for the Project:

> *"Telecommunications: identify possible effects on telecommunications systems, assess impacts and mitigation measures including undertaking a full engineering assessment to examine the potential impacts as well as analysis and agreement on the implementation of suitable options to avoid potential disruptions to radio communication services which may include the installation and maintenance of alternative sites."*

3.2 Planning guidelines

The Draft NSW Planning Guidelines for Wind Farms (Draft NSW Guidelines) [5] 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."*

A consultation process has been carried out as part of the current assessment, which has involved providing information describing the Project to organisations, and seeking feedback regarding whether their services have the potential to experience interference due to the Project. Approximately 24 organisations have been contacted, and feedback provided to date is summarised throughout the report and in *Appendix C*.

Regarding electromagnetic fields, the SEARs provide the following requirements for the Project:

> *"Health: … Identify potential hazards and risks associated with electric and magnetic fields and demonstrate the application of the principles of Prudence Avoidance."*

In addition, the Draft NSW guidelines currently state:

> *"The assessment should consider the potential for the proposed wind farm and associated transmission line network to generate electromagnetic fields (EMFs).*
>
> *Wherever electrical equipment operates, electric and magnetic fields (EMFs) are created in the surrounding environment. The main sources of EMFs typically associated with a proposed wind*

farm is the electrical equipment within the turbine structures, the substation and the interconnecting underground and overhead wiring. The fields associated with these are typically localised.

Despite extensive research and numerous public inquiries, adverse health effects have not been established, but the possibility has not been ruled out. A prudent approach should be applied in designing and siting wind farm facilities. All equipment should be constructed according to industry accepted practices. Provided this occurs, the EMFs associated with the proposed wind farm will typically be well within the relevant health standards (including ARPANSA standards) and, in many cases, will be localised to areas not often frequented by people. "

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

However, the Environment Protection and Heritage Council (EPHC), in conjunction with the Local Government and Planning Ministers' Council released a draft version of the National guidelines for wind farm development in July 2010 (Draft National Guidelines) [6]. The Draft National Guidelines cover a range of issues spanning over the different stages of wind farm development.

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

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

4 ELECTROMAGNETIC INTERFERENCE (EMI)

If not properly designed, wind farms have the potential to interfere with radiocommunication 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 to 60 km from the centre of the wind farm would normally capture all of the potentially affected services in the area. However, in order to reduce the potential for telecommunication links crossing the site being inadvertently excluded from assessment, this assessment has adopted a larger study area extending approximately 75km from the centre of the precincts. The assessment methodology has incorporated identification of telecommunication towers located within this study area and assessment of the telecommunication licences attached to each of these towers.

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

4.1 Telecommunication towers

An image of the ACMA database dated January 2015 was used for this assessment [2]. From the database, there are 966 telecommunication towers within a nominal 75 km of the Project. The locations of these telecommunication towers relative to the PA are shown in *Appendix B*. The following sections contain an assessment of potential impacts to services identified within the database, as well as other services that are not registered in the database.

4.2 Fixed licences of point-to-point (microwave) type

4.2.1 Diffraction

WTGs can potentially cause interference, or diffraction, of point-to-point microwave signals and in some cases, point-to-point Ultra High Frequency (UHF) signals. It is possible to design the wind farm to avoid 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) [6] [7] [8]. 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, WTGs, 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 receptor

D is the distance from the transmitter to receptor, 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 licence links that may experience interference from WTGs. Each individual link is given an "Assignment ID" by the ACMA so it can be readily identified. The paths resulting from the towers analysed are shown in *Appendix B*. 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 is one link passing over the PA. The link is shown in greater detail in *Figure B-3* of *Appendix B*.

Several references [9] [10] [8] state that WTGs should be located outside of either the first or second Fresnel zone in order to avoid interference to that link. For the identified link crossing the PA, an exclusion zone has been established based on their operating frequencies, the second Fresnel zone plus the blade length for WTGs with a 126 m rotor diameter. The potential exclusion zones are also shown in *Figure B-3*.

It is common practice to have multiple assignment IDs 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 below.

Assignment ID	Licence number	Frequency (Hz)	Postal address
1207514 – 1205052	1206361	44690000	Transgrid PO Box 93 (Michael Freeburn) Waratah West 2298
1207515 – 1205050	1206361	42690000	

Table 1: Details of point-to-point links crossing the PA

As shown in *Figure B-3*, there is one link crossing the PA, and two WTGs which lie within the second Fresnel zone.

An assessment was carried out to determine if the link passes over the proposed Project at a height that was well above the highest point of the WTGs (hub height + blade length = 173 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 PA over which the links cross. It was determined that the links do cross the PA at a height which has the potential to intersect with WTG blades.

It is possible that the WTGs located within the established exclusion zone will cause interference to the telecommunications link. The operator of the link, Transgrid, has been contacted by DNV GL to assess any potential impact as part of a rigorous consultation process. To date, no formal response has been

received by DNV GL. However, it is noted that the Proponent has advised that they have received written confirmation from Transgrid that the link will not be affected by the turbines.

4.2.2 Near-field effects and scattering

The Draft National Guidelines [6] mention the possibility of interference to point-to-point microwave 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 WTG is within 1 km of a telecommunication site. The Draft National Guidelines also state that scattering is best avoided by placing WTGs more than 2 km from a communication tower.

All communication towers are greater than 2 km from the PA, with the closest telecommunication tower located approximately 3.9 km west of the PA (Mt Fairy Road Boro, Site ID 136014). It is not expected that the neighbouring communication towers will experience interference due to near field effects or scattering.

It is also noted that there is a communication tower located 6 km north of the PA (Telstra site Tarago Roadbase quarry near Braidwood & Lumley Roads, Site ID 133671). While it is expected that the Telstra communication tower will not experience any interference due to near field effects or scattering, due to the significant distance between the tower and the PA, the operator of links attached to this tower (Telstra Corporation) has been contacted to seek feedback regarding potential impacts to their services and operations. Telstra have indicated that there are no links crossing the PA.

4.3 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 119 Assignment ID's were identified within approximately 75 km of the PA. These licences are shown in *Figure B-4*. The details of the licence holders as per the ACMA database are provided in *Table B-1*.

There is one point-to-multipoint base station listed in the ACMA database within 20 km of the PA, at Transfer pump station, Gundaroo Road, Bungendore. The station is operated by the former Palerang Council. As part of the current consultation process, the link owner has been contacted to assess any potential interference issues that may arise from the development and operation of the Project. No formal response has been received to date.

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the PA. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the PA, as part of an extensive consultation process, feedback has been sought from operators of stations within 40 km of the centre of the PA that were deemed to have the potential to experience interference. Eight organisations have been contacted, and to date, feedback has been received from one of these organisations, namely Essential Energy, who have indicated that the Project will not impact their existing services.

4.4 Other licence types

A review of the ACMA database for other licences was conducted. These licences are shown in the table below and *Figure B-5*.

Many of the licences identified can be broadly described as base to mobile station style communications, including radio broadcasting, commercial and private mobile telephony. These licence types are generally not affected by the presence of WTGs 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 4.14* and *4.15*.

A number of aeronautical licences, and radiodetermination licences which may be used for aircraft navigation, have been identified. It is assumed that potential impacts to these services will be considered as part of an Aviation Impact Assessment.

It is noted that the number of other licences is significant. However, this is primarily because the search area used to identify licences in the ACMA RADCOM database extends 75 km from the PA, and has therefore captured a significant number of licences that are registered in the area around Canberra. The number of licences in close proximity to the PA is small, with only 159 licences identified within 20 km of the PA.

Licence type	Licence category	Number of instances
1800 MHz Band	Spectrum	905
2 GHz Band	Spectrum	3875
2.3 GHz Band	Spectrum	446
2.5 GHz Band	Spectrum	172
2.5 GHz Mid Band	Spectrum	60
27 GHz Band	Spectrum	2
3.4 GHz Band	Spectrum	12
700 MHz Band	Spectrum	378
800 MHz Band	Spectrum	1338
ACA Assigned	ACA	122
Aeronautical Assigned System	Aeronautical	37
Amateur Beacon	Amateur	5
Amateur Repeater	Amateur	41
Ambulatory – Copy	Land Mobile	6
Ambulatory – Initial	Land Mobile	15
Ambulatory System	Land Mobile	55
Broadcast Service	Broadcasting	211
CBRS Repeater	Land Mobile	18
Earth Receive	Earth Receive	37
Fixed Earth	Earth	50
Fixed Receive	Fixed Receive	17
Land Mobile System - > 30MHz	Land Mobile	1578
Land Mobile System 0-30MHz	Land Mobile	16
Limited Coast Assigned System	Maritime Coast	25
Limited Coast Marine Rescue	Maritime Coast	12
Major Coast A	Maritime Coast	12
Narrowband Area Service station(s)	Broadcasting	14
Narrowcasting Service station(s)	Broadcasting	70
Narrowcasting Service stations (HPON)	Broadcasting	9
PABX Cordless Telephone Service	Land Mobile	2
Paging System – Exterior	Land Mobile	54
Paging System – Interior	Land Mobile	23
PMTS Class B (18005-1880 MHz)	PTS	2
PMTS Class B (2110-2170 MHz)	PTS	116
PMTS Class B (935-960 MHz)	PTS	1164
Radiodetermination	Radiodetermination	33
Scientific Assigned	Scientific	8
Sound Outside Broadcast	Fixed	13
Television Outside Broadcast system	Fixed	1

Table 2: Details of other licences identified within 75 km of the PA

4.5 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 PA. The groups identified are listed in the following table along with their contact details. While no direct interference to services have been determined, each service with a site located within 40 km from the centre of the PA has contacted as part of the formal consultation process. To date, feedback has been received from Fire and Rescue NSW, St John Ambulance and the Wamboin Rural Fire Brigade.

Fire and Rescue NSW have indicated that the Project will have no adverse effects on their services

St John Ambulance have also raised no objections to the Project. Although they intend to install a repeater at Mt Gray near Goulburn in the future, this will be on the fringe of the EMI assessment area.

The Wamboin Rural Fire Brigade have requested that any personnel on the PA should avoid using CB channel 36 (477.3 MHz) as this will cause congestion with their UHF repeater.

Emergency service	Contact details	Distance of closest site from centre of PA [km]
ACT Emergency Services Agency	Shared Services ICT GPO Box 158 (ICT support ACTESA) Canberra ACT 2601	39.1
Ambulance Service of NSW	Locked bag 105 Rozelle NSW 2039	6.9
Australian Federal Police	Attn Radio and Electronic support PO Box 401 Canberra ACT 2601	21.3
Fire and Rescue NSW	Attn AMO Comms Level 8 227 Elizabeth St Sydney NSW 2000	18.9
Mulwaree Goulburn Emergency Repeater Group	65 Coromandel St Goulburn NSW 2580	25.7
NSW Police Force	Engineering Services Level 4 151-241 Goulburn St Sydney Police centre Surry Hills NSW 2010	6.9
NSW Rural Fire Service	Locked mail bag 17 Granville NSW 2142	6.8
St John Ambulance Australia (NSW)	9 Deanne Street Burwood NSW 2134	20.8
St John Ambulance Australia Incorporated	Attn Mr P LeCornu CEO PO Box 3895 Manuka ACT 2603	20.8
State Emergency Service (NSW)	PO Box 6126 Wollongong NSW 2500	33.6
Tallaganda Shire State Emergency Services Auxiliary	PO Box 153 Braidwood NSW 2622	18.6
Wamboin Rural Fire Brigade	112 Bingley Way Wamboin NSW 2620	28.2

Table 3: Emergency services with radiocommunication assets in the vicinity of the PA

4.6 Aircraft navigation systems

DNV GL understands that an Aviation Impact Assessment has been prepared for the project and includes an assessment of any potential impacts of the Project on aircraft navigation systems.

4.7 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 WTG 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, WTGs may create a radar obstruction or "shadow" where aircrafts 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 WTGs 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 [6]. Radar installations are typically located at major airports. As shown in *Figure B-6*, the Project is located approximately 40 km from Canberra airport and 185 km from the Sydney international airport. DNV GL understands that there is no radar installation at Goulburn airport, which is located approximately 35 km north of the PA.

Due to the significant distance from major airports, and the high probability that the WTGs will lie below the radar line-of-sight, it is unlikely that the Project will cause interference with aviation radar, however DNV GL understands that an Aviation Impact Assessment has been prepared for the Project and includes an assessment of any potential impacts on aviation radar due to the Project development and operation.

Airport	Location (WGS84)	Approximate distance from the PA [km]
Canberra	S35.30° E149.19°	39
Sydney	S33.94° E151.18°	185
Bankstown	S33.92° E150.99°	174
Camden	S34.04° E150.69°	146

Table 4: Airports in the vicinity of the PA

4.8 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 field station are unlikely to affect wind finding operations [6]. However, wind farms can impact upon weather watch radar when located within several hundred kilometres of a radar station. Generally, the optimal coverage area for "weather watch" radar extends approximately 200 km from the radar installation at a height of approximately 3000 m [11] [12] and approximately 100 km at a height of 1000 m [12]. 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 Guidelines, consultations with operators of weather stations within 463 km (250 nautical miles) of the PA should be undertaken [6]. It has been identified that the BoM operates eight weather stations within that range with the closest station "Canberra" located approximately 39 km south of the PA. The locations of these stations are shown in *Figure B-6* and the details of each station can be found below.

BoM radar site	Location (WGS84)	Approximate distance from the PA [km]
Yarrawonga	S36.03° E146.03°	334
Wollongong	S34.264° E150.874°	140
Sydney	S33.701° E151.21°	206
Namoi	S31.024° E150.191°	451
Newcastle	S32.73° E152.027°	338
Canberra	S35.66° E149.51°	39
Bairnsdale	S37.89° E147.56°	340
Wagga Wagga	S35.17° E147.47°	196

Table 5: BoM radar sites in the vicinity of the PA

In order to determine if interference to any of the BoM radar installations is possible, and in accordance with the recommendations of the Draft National Guidelines, the BoM has been contacted regarding the potential for interference from the Project. To date no formal response has been received.

4.9 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 [13].

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) [14] [15]. The AFN stations are equipped with EDM devices and GPS receptors and transmit data to GeoScience Australia via phone lines, internet and/or satellite [14].

The closest GNSS station is located at approximately 61 km southwest of the PA, at Mt Stromlo near Canberra. Due to the significant distance between the PA 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 [16] and it has been observed that the PA is located in the region of first-order triangulation. 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 will then be used for second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

According to the National Geospatial Reference system database from Geoscience Australia [17], there are 95 trig points within 20 km of the PA, with 5 points within the boundaries of the PA. The details of all 95 trig points are provided in *Appendix B* and illustrated in *Figure B-7*. Two Trig points, 'Wilson' and 'Barnet', are located within the PA.

Although it is unlikely that the trig points in close proximity to the PA host EDM devices or other equipment that is likely to be subject to electromagnetic interference, Geoscience Australia and the New South Wales Land and Property Information (LPI) have been contacted regarding the potential for interference from the development and operation of the Project. No formal response has been received to date.

4.10 Citizens Band radio

Citizens 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 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 the UHF CB over the following years. 27 MHz CB transmit signals in either AM (Amplitude Modulation) 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 (Frequency Modulation) 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 WTGs, simple steps such as moving a short distance until the signal strength improves would help to mitigate the impact.

4.11 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 WTGs. However, mobile phone networks are designed to operate in such conditions and in most cases, there is sufficient mobile network coverage and signal strength, the presence of WTGs is unlikely to cause 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 WTGs 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 PA has been carried out. The nearest mobile phone tower is located approximately 5 km from the PA.

Mobile phone network coverage maps have been obtained for Optus [18], Telstra [19], and Vodafone [20]. *Figure B-8* shows the Optus network coverage for the PA. The map shows good coverage in most locations in the vicinity of the PA, although some areas with coverage require an external antenna to receive 3G coverage. *Figure B-9* shows the Telstra 2G network coverage, *Figure B-10* shows the 3G (or NextG) coverage and *Figure B-11* shows the 4G coverage. There is coverage for both bands in the vicinity of the PA; with marginal coverage in the northern and southern sections of the PA while the centre of the PA requires an external antenna to receive 2G coverage. For the Vodafone network, the nearest tower is approximately 19 km south east of the PA, near the town of Braidwood. *Figure B-12* shows the network coverage for the Vodafone network in the vicinity of the PA.

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 WTG intercepts the signal between a mobile phone and the tower.

In case 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.

As part of the consultation process, Telstra, Optus and Vodafone have been contacted to seek feedback on any potential impact that the Project development and operation could have on their operations and services. To date, Telstra and Optus have both indicated that the Project will have no impact on their operations and services.

4.12 Wireless internet

Yless4U Pty Ltd hold point-to-multipoint licences in the vicinity of the PA with one base station located near the town of Goulburn, 48 km from the PA. As the locations of Yless4U customers are not known, it is not possible to determine whether there is the potential for interference to Yless4U's service. It is unlikely that a station at this distance is servicing customers in the vicinity of the PA. However, Yless4U Pty Ltd has been contacted to determine whether their services will be impacted by the Project. No formal response has been received to date.

Additionally, a review of the Australian ISP directory has been undertaken and there are four internet providers which operate in the area surrounding the PA and Yless4U is not included in the list of internet providers. According to the directory [21], NBNSP, Internode, AusBBS and iPrimus offer internet services based on the National Broadband Network (NBN) of Australia. However, according to the NBN Co Ltd website, the network is not available yet for the PA and is not expected for the next six months [22].

Consequently, residents in the vicinity of the PA are likely to utilise Telstra NextG wireless broadband services. The NextG wireless broadband service utilises the same network as the NextG mobile phone service and therefore, the comments made in *Section 4.11* are applicable here.

Specifically, the presence of WTGs is unlikely to cause any interference. However should interference occur, the simple mitigation options given in *Section 4.11* may be applicable.

4.13 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.

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.

Figure 2: Two way connection to the Internet via Satellite [23]

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

A number of satellite internet service providers (ISPs) service rural areas across Australia. Considering the line of sight from satellites that commonly provide internet access in Australia (e.g., IPSTAR) to the dwellings in the vicinity of the Project, it is unlikely that the signals from these satellites will be intercepted by WTGs in the Project.

The main satellite for pay TV and free-to-air TV in Australia is the Optus C1 satellite. From the PA, the Optus-C1 satellite has an elevation of approximately 48.5° [24]. As above, it is unlikely that the Project will impact upon the line-of-sight from this satellite to any dwelling.

4.14 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 PA are shown in *Figure B-13*.

4.14.1 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 WTGs), 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 receptor. 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 WTGs, it is expected that a wind farm would not cause significant interference for a receptor. Additionally, due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a WTG [25]. Any interference problems are likely to be easily resolved through the installation of a high quality antenna and/or amplifier.

4.14.2 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 WTG [25], and should be easily rectified through the installation of a high quality antenna and/or amplifier.

4.14.3 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 [26]. According to the digital radio coverage map available on the ABC website [27], digital radio is not yet available in the PA.

4.15 Terrestrial television broadcasting

Terrestrial television (TV) 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 [28]. Digital television (DTV) signals are typically more robust in the presence of interference than analogue television signals, and are generally unaffected by interference from WTGs. DNV GL has experience in situations where dwellings 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 [29], 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 WTGs.

The Broadcast Transmitter Database [28] was examined to identify broadcasters nearby to the PA, with those found shown in *Figure B-13*. The main television transmitter used by residents in the vicinity of the Project is the Black Mountain transmitter near Canberra [30]. However, some sections of the PA receive television signals from the Mt Gillamatong and Knights Hill broadcast towers located near Braidwood and Illawarra respectively.

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

- proximity of WTGs to television broadcast tower;
- proximity of WTGs to receptors (dwellings);
- location of WTGs in relation to dwellings 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 receptor in relation to terrain and other obstacles; and

- frequency and power of the television broadcast signal.

4.15.1 Large scale interference

For broadcast signals, large scale interference can generally be avoided by placing the WTGs 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 [7].

No television broadcast tower has been identified in close proximity to the PA, with the nearest broadcast tower at least 18 km southeast of the PA, at Mt Gillamatong, servicing the town of Braidwood, therefore the Project is not expected to cause large scale interference.

4.15.2 Forward and back scatter

WTGs 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. This causes multipath errors, and can have different impacts for analogue and digital television signals. A WTG has the potential to scatter electromagnetic waves carrying television signals both forward and back.

Forward scatter can occur when the transmitter, one or more WTGs, and receptor 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 WTG, where direct and scattered signals can be received, with the blade rotation introducing a rapid variation in the scattered signal [31]. Both of these effects can potentially degrade the DTV signal quality.

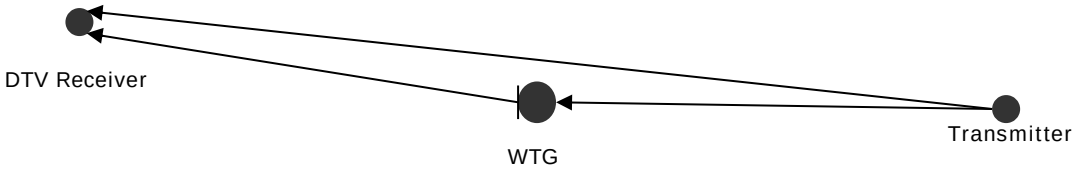

Figure 3: Forward scatter signal path

Backscatter from WTGs occurs when DTV signals are reflected from WTG towers and blades onto a DTV receptor as shown below. The reflected signals are attenuated, time-delayed and phase-shifted (due to a longer path from transmitter to receptor) 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 receptor includes the original signal (transmitter to receptor) and a series of time-varying multipath signals (transmitter-turbine-receptor).

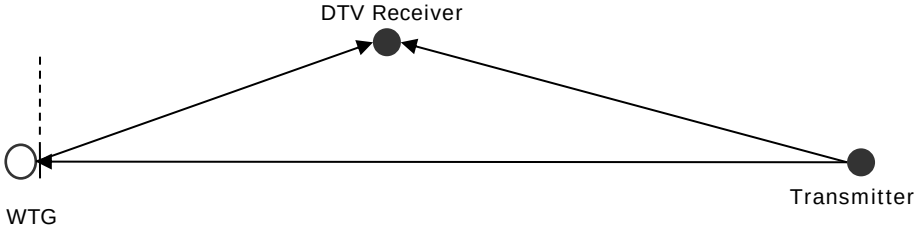

Figure 4: Backscatter signal path

Interference to DTV signals from WTG developments can potentially occur in both the forward and backward scatter region. The effect of a WTG on a DTV signal can be different depending on the scattering region where the receptor is located [31].

According to Ofcom [29], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [7] [32] [33]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast tower, but do have line-of-sight to the WTGs [33]. The shape of this region assumes a relatively high gain, directional antenna that has a beam width (or directional range) of approximately ±15° to ±20°. If a lower gain or omni-directional antenna is being used, this region is likely to be larger.

Back scattered signals arrive at the dwelling delayed relative to the source signal from the broadcast tower. The back scatter region generally does not extend further than 500 m [7] [30], 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.

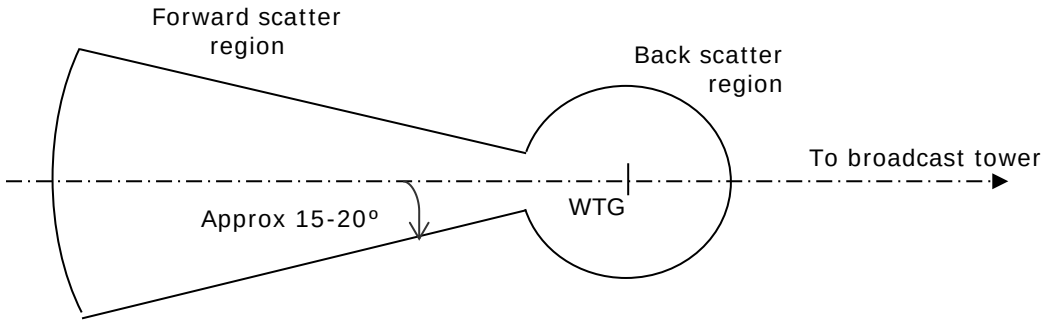

Figure 5: Potential television interference zones around a WTG

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 Project 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 [32] 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 analysed, the threshold carrier-to-noise (C/N) ratios obtained were similar to those expected in environments with the absence of wind farms. More precisely, the DVB-T reception quality does not seem to be affected in the forward scattering region of the wind turbines."*

In other words, WTGs do not usually affect DVB-T DTV signals in the forward scatter region. However, ITU [34] also highlight that in the case where there is significant blockage of the direct signal, but clear line-of-sight to one or more WTGs, interference to the reception of the DTV signal is possible.

With regards to back scattering, 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 backscatter to achieve the same QEF condition as is the case without the presence of WTGs.

4.15.3 Theoretical models for WTG 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 [35]. 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 [32], 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 WTG rather that 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. This is often referred to as the 'keyhole' approach, and is an established technique for predicting 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 [29]. The union of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

4.15.4 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 above analysis can be seen in *Figure B-14*, *Figure B-15* and *Figure B-16*. The dwellings that are most likely to be susceptible to interference include those within the possible interference zone. A total of 119 dwellings were identified in the potential interference zone for the Black Mountain broadcast tower near Canberra. A total of 111 dwellings and 93 dwellings were identified in the potential interference zone for the Mt Gillamatong and Knights Hill towers located near Braidwood and Illawarra respectively. However, 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 [30], the area around the PA is able to receive a digital television signal from either the Black Mountain broadcast tower located near Canberra, the Knights Hill tower near Illawarra or from the Mt Gillamatong broadcast tower near Braidwood. The

coverage maps suggest that the majority of the area surrounding the PA should receive variable coverage with areas of poor coverage from each tower. It is also possible that areas of poor coverage from two out of the three towers might receive a reasonable level of television signals from the third tower.

Thus, although digital television signals are generally unlikely to be susceptible to interference from WTGs 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 WTG that is of sufficient power to interfere with the signal received directly from the transmitter. If reception difficulties are encountered, there are a number of mitigations options available, and these are discussed in further detail in *Section 4.15.5*.

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.

4.15.5 Mitigation options

In the event that TV interference is an issue during Project construction or after Project 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 dwelling;
4. relocating the antenna to a less affected position;
5. the installation of cable/satellite TV at the affected dwelling; 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 [31] DVB-T reception quality may not be substantially affected in the forward scatter region.

ITU [34] also 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. 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. As discussed in *Section 4.15.4*, the majority of areas around the Project that are expected to have variable coverage (as shown in *Figure B-15*), which may be able to access the Viewer Access Satellite Television (VAST) service [36].

4.16 Cumulative EMI impacts

As mentioned in *Section 2.1*, the PA is located in an area of high wind farm development activity, with the existing Capital 1 and Woodlawn wind farms as well as the approved Capital 2 Wind Farm and Capital Solar Farm, located west of the PA. The approved Collector Wind Farm is proposed at approximately 33 km north west of the PA. The locations of the surrounding wind farms and solar farm are shown in *Figure B-17*.

Based on publicly available information, it is understood that the Capital 1 Wind Farm consists of 67 WTGs while the Woodlawn Wind Farm consists of 23 WTGs, and the WTG locations have been obtained from satellite and aerial imagery. The proposed WTG locations for the Capital 2 Wind Farm and Collector Wind Farm have been obtained from publicly available information [37], [38]. The proposed Capital Solar Farm development envelope has also been obtained from publicly available sources [39].

As per the recommendation set in the SEARs, all five projects have been considered in the cumulative impact assessment described below.

4.16.1 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 4.2*, one point-to-point link passes through the PA and two WTGs proposed for the Project fall within the second Fresnel Zone of the link. The link also passes near the approved Capital Solar Farm as well as the Capital 1 and Capital 2 wind farms.

The proposed PA for the solar farm is at approximately 1.2 km north of the second Fresnel zone. The nearest WTG from the existing Capital 1 Wind Farm is located at approximately 3.8 km north-northwest of the second Fresnel zone of the link while the closest WTG from the approved Capital 2 Wind Farm is located at approximately 5.5 km northwest of the second Fresnel zone.

It is therefore deemed unlikely that cumulative impacts to the link will occur as the link exclusion zone does not intersect WTGs from the neighbouring wind farms, nor does it cross the proposed PA of the solar farm.

4.16.2 Point-to-multipoint microwave links

As noted earlier, there is one point-to-multipoint base station located within 20 km of the PA, with the closest station located at approximately 18 km west of the PA, at Transfer pump station, Gundaroo Road, Bungendore and is operated by the former Palerang Council.

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. The consultation process with the station operators will help determine the links paths and thus assess the likely cumulative EMI impacts arising from the Project. At this stage, no issues have been raised through the consultation process.

4.16.3 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.

4.16.4 Emergency services

As discussed in *Section 4.5*, DNV GL does not expect any direct interference to emergency services from the Project, and hence, there are not expected to be any cumulative impacts from the Project. Nevertheless, the consultation process described in *Section 4.5* should capture any adverse impacts not identified. At this stage, no issues have been raised through the consultation process.

4.16.5 Aviation radar

DNV GL understands that an Aviation Impact Assessment has been prepared for the project and includes an assessment of any potential cumulative impacts to aviation radar from the Project.

4.16.6 Meteorological radar

It is not expected that the Project will result in any adverse impact on BoM radar installations and therefore, it is expected that there will be no cumulative impacts to BoM radars.

4.16.7 Trigonometrical stations

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

4.16.8 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.

4.16.9 Mobile phones

Although mobile phone signals are generally not susceptible to interference from WTGs, 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 WTGs 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.

4.16.10 Wireless internet

As noted in *Section 4.12*, it is most likely that residents utilise the Telstra NextG wireless broadband services. Consequently, the comments made in *Section 4.16.9* are also applicable here.

4.16.11 Satellite television and internet

As discussed previously, it is unlikely that satellite television signals will experience interference from the Project, and therefore it is unlikely that there will be any cumulative impacts from the Project.

According to the Australian ISP directory [21], there is currently no satellite ISP providing internet in the vicinity of the PA. Therefore, it is unlikely that there will be any cumulative impacts from the Project.

4.16.12 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 at the affected dwelling. As such, cumulative impacts from the Project are not expected to be significant.

4.16.13 Terrestrial television

The areas that are most likely to experience interference to terrestrial television reception are presented in *Section 4.15* for the Project in isolation. A similar analysis, repeated to include the neighbouring Capital 1, Capital 2 and Woodlawn wind farms, adds to these potential interference zones and is shown in *Figure B-18*.

Due to the significant distance between the PA and the approved Collector Wind Farm (over 30 km), DNV GL considers that the potential interference zones arising from the Collector Wind Farm are unlikely to affect the residents surrounding the PA.

DNV GL have not been provided with information regarding potential residences located in the area between the wind farms and there may be cumulative impacts on terrestrial television signals for those residences, particularly for dwellings which have a non-directional or low-gain antenna and therefore, may receive a reflected signal from the surrounding turbines.

Therefore, it is expected that those dwellings located between the surrounding wind farms and the PA, where the signal passes through the WTGs at the existing Capital 1 and Woodlawn wind farms are most likely to be susceptible to cumulative impact from the three wind farms. However, it is expected that any interference to terrestrial television can be mitigated by improving the equipment at a dwelling location or other options as listed in *Section 4.15.5*.

5 ELECTROMAGNETIC EMISSIONS FROM WTGS

Electromagnetic waves surround us and are caused by both natural (e.g., the sun, thunderstorms) and artificial sources. Low frequency electromagnetic waves (less than approximately 3 kHz) are often termed electromagnetic fields (EMF), while higher frequency electromagnetic waves are often termed electromagnetic radiation (EMR).

All electrical devices emit electromagnetic waves. This section discusses the electromagnetic emissions from WTGs, it covers both EMF and EMR. It does not cover emissions from other components that may be present in a wind farm, unless specifically stated.

5.1 EMF

Electric and magnetic fields are produced by both natural and artificial sources. However, artificial sources are the dominant sources of EMF and are usually associated with the generation, distribution and use of electricity at the frequency of 50 Hz. The electric field is proportional to the voltage. The magnetic field is proportional to the current.

Electric fields can be shielded by earthed conductive materials and the earth itself but the shielding of magnetic fields is often not practicable.

There are currently no Australian standards regulating exposure to these fields. The National Health and Medical Research Council (NHMRC) has issued Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields [40]. These guidelines are aimed at preventing immediate health effects resulting from exposure to these fields. The recommended magnetic field exposure limit for members of the public (24 hour exposure) is 100 microtesla (1,000 mG - milligauss), while the recommended electric field exposure limit is 5000 V/m.

In Australia, The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), is the Federal Government agency charged with responsibility for protecting the health and safety of people, and the environment, from the harmful effects of ionising and non-ionising radiation. ARPANSA published a draft standard for Exposure Limits for Electric and Magnetic Fields in 2006. According to the ARPANSA website, the Radiation Health Committee (RHC) decided in 2011 to redraft the proposed standard as guidelines, and the draft is currently in preparation [41].

The exposure limits in the draft standard include significant safety factors and margins. The relevant limits for general exposure to 50 Hz in the draft standard [42] are:

- 100 microtesla magnetic field (1000 mG); and
- 5000 V/m electric field.

It is noted that the exposure limits in the ARPANSA draft standard are the same as those recommended by the NHMRC.

In a WTG, the electrical fields will be shielded by the WTG tower which is earthed, but the nacelle may not be completely shielded. However voltages in the nacelle are most often low, and even when high voltage is used, the high voltage cables for the different phases will be in close proximity and balanced and so will act to cancel each other out. Thus the electric fields from a WTG will be well below that of a typical power line operating at the same voltage.

Magnetic fields decrease with distance and this happens more quickly when the individual wires are close together and the currents flow in opposite direction cause the fields to cancel each other out. In the case of WTGs this is the case and thus magnetic fields can be expected to be low.

This expectation has been verified by measurements conducted in the vicinity of a WTG in Canada [43]. This measured a maximum of 0.4 milligauss (at the tower door) in the vicinity of the WTG, which is less than 1/1000th of the recommended limit (which already includes safety margins). Another study [44] has obtained similar findings.

It can be concluded that EMF from WTGs are well within the applicable guidelines and no adverse health effects can be expected.

As per the SEARs and the Draft NSW Guidelines, demonstration of the application of the principles of Prudence Avoidance is required. Prudence Avoidance, as described by the Energy Networks Association (ENA) [45] involves reducing magnetic field exposure where this is practicable and can be done at a modest cost. The proposed electrical collector group for the Project will consist of 33 kV cables connecting the WTGs and precincts, and a 330 kV cable connecting the substation to the existing 330 kV network. The 33 kV cables from the southern precinct to the substation may include a combination of both overhead and underground lines, with the final design to be determined during the detailed design phase of the Project. The underground cabling network is likely to be compromised of three-core cables, where the conductors of the cables are laid close together in a trefoil phase arrangement. This arrangement of cables can help to reduce EMF levels [46]. The EMF from the collector group network (cables and transmission line) therefore does not pose a particular risk and could be said to demonstrate the principles of Prudence Avoidance.

The EMFs from other components (transformers, underground cables, substation and transmission lines) in a wind farm are typical of similar installations that are used elsewhere, and therefore do not pose a particular risk.

5.2 EMR

All electrically-powered equipment produces electromagnetic radiation (radio waves). For most equipment this effect is unwanted (unintended radiation) and is limited by design to comply with mandatory standards. For other equipment (transmitters) the radiation is intentional and necessary (for example telecommunications systems).

Some common sources of unwanted electromagnetic radiation which may be found in WTGs include switch mode power supplies, microprocessors and variable speed drives. These types of devices are commonly found in homes, offices and factories. Switch mode power supplies are used in computers, phone chargers, TVs, energy saving lights. Microprocessors are almost ubiquitous. Variable speed drives are used for lifts, water pumping, industrial equipment, and in "inverter" air conditioning units.

WTGs are constructed to stringent standards to ensure electrical compatibility. Under the IEC standard for WTGs IEC 61400-1, there are a number of other standards referenced. Among these are standards related to electromagnetic compatibility (EMC) [47]. These include standards both with respect to immunity and emission of electromagnetic waves. The standard to which emissions must be limited is IEC 61000-6-4 "Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 4: Emission standard for industrial environments".

Electrical equipment sold in Australia and New Zealand must meet certain requirements with respect to EMC. IEC 61400-6-4 is one of the recognised standards under the regulations to demonstrate compliance with the regulations [48]. In addition WTGs are internationally traded, and so will be designed to meet the EMC standards in areas which they are sold, such as European Directives on EMC, which are required for installation in Europe and to display the EC mark.

DNV GL has performed measurements of electromagnetic emissions of WTGs in Denmark and the UK [49]. The measurements were performed due to a proposed wind farm in the vicinity of a British Telecom satellite receiving station, where there was some concern that the installation could be affected even though the WTGs complied with proven EMC emissions standards. The measurements were conducted on pitch controlled, fixed speed WTGs of the type proposed for the wind farm next to the satellite station, which were manufactured by Vestas. The only emissions that were able to be detected were detected when the measurement equipment was located inside the WTG tower. The emissions that were detected were thought to emanate from switch mode power supplies. No emissions were able to be detected from outside the WTG. Prior to the study being performed it was thought that the tower may act as an antenna, however the study demonstrated that the tower in fact acts as a shield. It should also be noted that the study was conducted some time ago, and since that time, WTGs have evolved to include other technologies, such as variable speed drives, which have the potential to cause emissions, however EMC standards have also evolved during that time, meaning that any emissions from these technological developments are likely to be controlled.

From a practical perspective, the following is noted:

- Devices which are likely to cause electromagnetic emissions (microprocessors, switched mode power supplies, variable speed drives) are located within metallic panels, which will act as shields. The outputs from variable speed drives are also filtered.
- Many such components are located within the WTG tower or metallic components such as the hub, which will provide a further degree of shielding.
- There is a strong incentive on WTG manufacturers to control electromagnetic emissions at source, due to WTGs themselves containing sensitive electronic components which may themselves be affected by electromagnetic emissions.
- Despite large numbers of WTGs being installed, DNV GL is not aware of any issues in the public domain, where problems have been caused by electromagnetic emissions from WTGs.

Given that WTGs are constructed to standards that are recognised EMC regulations in Australia, New Zealand, and many other markets, and the nature of the design of WTGs means that the components likely to cause emissions are effectively shielded, it is considered unlikely that electromagnetic emissions from WTGs will have an adverse effect.

6 CONCLUSIONS

Broadcast towers and transmission paths around the PA were investigated to see if EMI would be experienced as a result of the development and operation of the Project. The Project will involve the installation of 88 WTGs. To assess potential EMI impacts that are dependent on WTG geometry, DNV GL has considered a WTG geometry having a rotor diameter of 126 m or less and an upper tip height of 173 m or less.

6.1 Fixed point-to-point links

Several point-to-point microwave links were identified with a path over, or near to the PA. Of these links, one link (involving two fixed licences in total) was identified passing within the PA. Further analysis showed that the link passed close enough to the ground over the PA such that WTGs could potentially interfere with the signal. The interference zones around this point-to-point link has been identified and it has been found that two WTGs from the Project have the potential to cause interference to the link based on the current WTG coordinates and microwave tower coordinates presented in the ACMA database. The owner of the link, Transgrid, has been contacted to assess the potential impact of the Project on their services and operations. No formal response has been received by DNV GL to date. However, it is noted that the Proponent has advised that they have received written confirmation from Transgrid that the link will not be affected by the turbines.

6.2 Fixed point-to-multipoint licences

There is one point-to-multipoint base station listed in the ACMA database within 20km of the PA, owned by the former Palerang Council. It is not possible to determine if there are any potential impacts without knowing the locations of each station in the multipoint network, however the former Palerang Council has been contacted to assess the impact of the Project on their services and operations. No formal response has been received to date. There are a number of point-to-multipoint stations at a distance of greater than 20 km from the PA. Again, it is not possible to determine if there are any potential impacts without knowing the locations of each station in the multipoint network. However, it is unlikely that stations at this distance will be servicing customers in the vicinity of the PA. DNV GL has undertaken an extensive consultation process where the operators of these stations have been notified of the Project and their feedback has been sought on any potential impact that the Project could have on their services. To date, feedback has been received from Essential Energy, who have indicated that the Project will not impact existing services.

6.3 Other licence types

A review of other licences within 75 km of the PA 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 WTGs 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.

6.4 Emergency services

Emergency services with radiocommunications assets in the vicinity of the PA have been identified and have been contacted to seek feedback on the potential for adverse impacts to their services.

To date, feedback has been received from Fire and Rescue NSW, St John Ambulance and the Wamboin Rural Fire Brigade. No impacts from the Project have been identified, with the exception of the Wamboin

Rural Fire Brigade indicating that any communication by personnel involved in the Project, on CB channel 36 (477.3 MHz), will cause interference to their UHF repeater.

6.5 Aircraft navigation systems

It is recommended that an Aviation Impact Assessment is carried out to assess any adverse impacts of the Project on aviation navigation systems.

6.6 Aviation radar

The PA is located approximately 40 km from Canberra Airport. Due to the significant distance of major airports from the Project and the high probability that the WTGs will lie below the aviation radar line-of-sight, it is unlikely that the Project will have an impact on aviation radar.

It is also recommended that an Aviation Impact Assessment is undertaken to assess the impacts of the Project on aviation radars.

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 PA and the closest station is located at approximately 39 km west of the PA, at Canberra. In order to determine if interference to any of the BoM radar installations is possible, and in accordance with the Draft National Wind Farm Development Guidelines, the BoM has been contacted to seek feedback regarding to the potential for interference to its radar installations. No formal response has been received to date.

6.8 Trigonometrical stations

A total of 95 trigonometrical stations have been identified within 20 km of the PA, and two trig points, 'Wilson' and 'Barnet', are located within the PA. Although they are unlikely to host equipment that is susceptible to electromagnetic interference, Geoscience Australia and the New South Wales Land and Property Information (LPI) have been notified of the Project. No formal response has been received to date.

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 shall be minimal.

6.10 Mobile phones

In general, mobile phone signals are not susceptible to interference from WTGs. The nearest mobile phone base station is approximately 5 km from the PA. Published mobile GSM and 3G network coverage has been reviewed for the area around PA. In areas with good network coverage, mobile signals are unlikely to be affected. However there are some areas around the PA where coverage may be marginal and therefore mobile signals may be susceptible to interference from the Project. Optus, Telstra and Vodafone have been contacted by DNV GL to seek feedback on any potential impact that the Project could have on their services. To date, Telstra and Optus have both indicated that the Project will have no impact on their operations and services.

DNV GL also 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.

6.11 Wireless internet

Yless4U Pty Ltd may provide wireless internet services to dwellings in the vicinity of the PA; however it is not possible to identify customers who are using the Yless4U Broadband service. As part of an extensive consultation process, the broadband service provider has been contacted to assess any adverse impacts on their services, arising from the Project development and operation. No formal response has been received to date.

6.12 Satellite television and internet

Residents in the vicinity of the PA may also have access to satellite television. DNV GL has reviewed the line-of-sight from commonly used satellites to dwellings, and it is unlikely that signals from these satellites will be intercepted by WTGs in the Project.

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 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 WTGs, 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 vicinity of the PA.

6.14 Television broadcasting

Broadcast towers around the Project were investigated to see if television interference would be an issue for the Project. Television interference mechanisms are complex to calculate and can have limited predictive accuracy. Television interference around WTGs 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 recently 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.

Work presented here highlights the areas around the PA where interference to terrestrial television broadcasts is more likely occur. A total of 119 dwellings were identified in the potential interference zone for the Black Mountain broadcast tower near Canberra. A total of 111 and 93 dwellings have been identified in the potential interference zones from the Mt Gillamatong and Knights Hill broadcast towers respectively.

The PA is in a location for which there is variable predicted digital terrestrial television coverage across most of the PA according to the Australian Government Digital Ready MySwitch website. However, in the areas where digital reception is marginal, residents in the vicinity of the PA 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 receptor at the affected dwelling; and
7. installation of a TV relay station.

6.15 Cumulative impacts

Possible cumulative EMI impacts from the Project and nearby wind farms have been considered in *Section 04.16*. Cumulative impacts are not expected to occur for most services considered, however the possibility exists for cumulative impacts to point-to-multipoint stations, mobile phones, wireless internet, CB radio and television services. Options exist to mitigate most interference issues should they occur.

6.16 Electromagnetic emissions from WTGs

Consideration has been given to potential electromagnetic fields (EMF) and electromagnetic radiation (EMR) in the vicinity of WTGs. DNV GL has deemed that EMF strengths and EMR levels are likely to be within limits imposed by applicable guidelines and no adverse impacts are expected.

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APPENDIX A PROJECT INFORMATION

WTG parameter	Value
No of WTGs	88
Hub height option [m]	110
Rotor blade length [m]	63
Rotor diameter [m]	126
Total height to tip [m]	173

Table A-1: WTG configuration considered for the Project

WTG ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]	WTG ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]
1	744406	6109438	724	45	747883	6098802	681
2	744346	6102432	724	46	746955	6100823	701
3	747323	6100126	699	47	739725	6088632	744
4	745727	6106483	680	48	744924	6108865	695
5	743945	6109545	713	49	743832	6109942	707
6	746442	6106428	690	50	743529	6109312	710
7	744212	6109049	718	51	745152	6108446	699
8	745556	6102445	684	52	746223	6108273	671
9	744118	6101506	704	53	744009	6107522	680
10	744847	6101969	708	54	747035	6102064	663
11	744355	6102014	712	55	745786	6101474	675
12	744134	6108304	701	56	747726	6100214	675
13	744765	6108412	708	57	747190	6100490	726
14	748237	6100284	680	58	746645	6101051	679
15	740388	6092679	767	59	745180	6102300	692
16	743099	6109744	712	60	743855	6099811	686
17	743236	6099443	677	61	740751	6092804	745
18	741121	6092899	743	62	739380	6088927	739
19	741400	6092501	734	63	739751	6089012	732
20	745805	6102824	691	64	739842	6089457	721
21	744416	6109825	730	65	740659	6092128	726
22	743337	6108799	700	66	744347	6100627	702
23	743494	6109695	739	67	743999	6101878	701
24	744430	6102811	720	68	744364	6103396	713
25	743240	6110426	736	69	745147	6101171	687
26	747802	6099561	670	70	745874	6101867	673
27	744071	6107931	698	71	745340	6101530	684
28	745255	6102680	701	72	746284	6102215	670
29	740402	6089116	750	73	743389	6107071	683
30	748085	6099883	666	74	743994	6108684	708
31	744857	6101587	697	75	744014	6106122	700
32	746701	6105940	680	76	746242	6108688	680
33	743359	6110062	737	77	743615	6110341	707
34	743780	6109027	724	78	745515	6109026	685
35	739943	6089987	720	79	743151	6109226	705
36	740321	6092305	748	80	743755	6108268	692
37	744772	6100957	695	81	744871	6109301	698
38	745332	6101919	694	82	746574	6102462	666
39	748502	6099956	671	83	746635	6102051	656
40	744282	6101002	725	84	746268	6101014	670
41	744510	6108708	714	85	746390	6100471	688
42	744240	6110170	727	86	747039	6099715	687
43	745649	6108613	690	87	743632	6106026	709
44	743477	6106380	725	88	740884	6092435	736

[1] Coordinate system: MGA zone 55, GDA94 datum

Table A-2: Proposed layout for the Project

APPENDIX B EMI ASSESSMENT RESULTS

Assignment ID	Site ID	Licence no.	Location (AGD66)	Distance to PA (km)	Licence owner
1100978-6564	9580	1101113	690683E 6094201N Zone 55	48.8	ACTEW Distribution Ltd and Jemena Networks (ACT) Pty Ltd Attn Radio workshop GPO Box 366 Canberra ACT 2601
1100979-6564	9580	1101113	690683E 6094201N Zone 55	48.8	
1103849-1103642	9619	1105832	692837E 6082775N Zone 55	46.7	
1103850-1103642	9619	1105832	692837E 6082775N Zone 55	46.7	
1104783-1104601	9580	1106423	690683E 6094201N Zone 55	48.8	
1104889-1104601	9580	1106423	690683E 6094201N Zone 55	48.8	
1109597-1109193	9619	1108754	692837E 6082775N Zone 55	46.7	
1109598-1109193	9619	1108754	692837E 6082775N Zone 55	46.7	
1109599-1109194	9619	1108755	692837E 6082775N Zone 55	46.7	
1109600-1109194	9619	1108755	692837E 6082775N Zone 55	46.7	
1109601-1109195	9619	1108756	692837E 6082775N Zone 55	46.7	
1109602-1109195	9619	1108756	692837E 6082775N Zone 55	46.7	
1109603-1109196	9580	1108757	690683E 6094201N Zone 55	48.8	
1109604-1109196	9580	1108757	690683E 6094201N Zone 55	48.8	
1109605-1109197	9580	1108758	690683E 6094201N Zone 55	48.8	
1109606-1109197	9580	1108758	690683E 6094201N Zone 55	48.8	
1109607-1109198	9580	1108759	690683E 6094201N Zone 55	48.8	
1109608-1109198	9580	1108759	690683E 6094201N Zone 55	48.8	
1109609-1109199	11543	1108760	664560E 6082480N Zone 55	74.8	
1109610-1109199	11543	1108760	664560E 6082480N Zone 55	74.8	
1140802-2214012	9685	1105544	697250E 6061670N Zone 55	49.9	
1140803-2214012	9685	1105544	697250E 6061670N Zone 55	49.9	
1145763-2219175	11543	1139632	664560E 6082480N Zone 55	74.8	
1145764-2219175	11543	1139632	664560E 6082480N Zone 55	74.8	
1229456-1222959	9676	1225908	685186E 6063905N Zone 55	59.4	
1229457-1222959	9676	1225908	685186E 6063905N Zone 55	59.4	
1234252-1227467	9580	1230472	690683E 6094201N Zone 55	48.8	
1234253-1227467	9580	1230472	690683E 6094201N Zone 55	48.8	
8176720-8176199	9580	1185877	690683E 6094201N Zone 55	48.8	Aerial Capital Enterprises Pty Ltd PO Box 1233 Fyshwick ACT 2609
8176732-8176213	9580	1185877	690683E 6094201N Zone 55	48.8	
1234315-1227515	100964	1230492	682602E 6089863N Zone 55	56.5	Australian National University Leonard Huxley Building Mills Rd Canberra ACT 0200
1217653-1213351	202399	1234158	703000E 6149000N Zone 55	55.8	Australian Rail Track Corporation PO Box 10343 Gouger St Adelaide SA 5000
1217654-1213351	202399	1234158	703000E 6149000N Zone 55	55.8	
8276008-8303572	9012278	1928304	683605E 6100487N Zone 55	56.8	Belconnen Magpies Sport Club Ltd PO Box 144 Kippax ACT 2615
8276009-8303573	9012278	1928304	683605E 6100487N Zone 55	56.8	

Table B-1: Details of point-to-multipoint licences within 75 km of the PA

Assignment ID	Site ID	Licence no.	Location (AGD66)	Distance to PA (km)	Licence owner
1235564-1228610	9480	1231599	224000E 6170700N Zone 56	68.0	Bureau of meteorology GPO Box 1289 (Comms Section) Melbourne VIC 3001
1235565-1228611	205697	1231600	762941E 6172939N Zone 55	65.8	
1235571-1228617	205700	1231606	702812E 6071028N Zone 55	40.5	
1235572-1228618	205701	1231607	752927E 6150092N Zone 55	41.1	
1235580-1228626	205706	1231615	748451E 6060628N Zone 55	29.3	
1235587-1228633	205710	1231622	726387E 6054088N Zone 55	36.9	
1235591-1228637	205716	1231626	243747E 6144260N Zone 56	57.9	
137206-879	9728	433708	771660E 6069420N Zone 55	36.9	
1806055-2223289	204400	1146699	727632E 6050557N Zone 55	39.8	
1813007-2229837	136620	1190158	699040E 6089745N Zone 55	40.1	Capital Airport Group Ltd 2 Brindabella Circuit Brindabella Business Park ACT 2609
1813008-2229837	136620	1190158	699040E 6089745N Zone 55	40.1	
1137361-2208299	136234	1135737	697501E 6088586N Zone 55	41.7	Department of defence Attn David Murray Defence Spectrum Office CP1-4-019 Campbell Park Canberra ACT 2600
158122-11772	9605	493181	697100E 6097000N Zone 55	42.9	
8237414-8255750	9010107	1914017	702639E 6070890N Zone 55	40.7	Ecowise Environmental (Victoria) Ltd PO Box 1834 Fyshwick ACT 2609
8237420-8255757	9010107	1914017	702639E 6070890N Zone 55	40.7	
1144478-2217825	9570	1138925	692320E 6090740N Zone 55	46.9	Embassy of the United States of America Moonah Place Yarralumla ACT 2600
1223656-1217847	9008	1219096	259360E 6084330N Zone 56	58.7	Endeavour Energy PO Box 6366 Blacktown DC NSW 2148
1223658-1217860	9012	1219098	256718E 6073288N Zone 56	59.8	
1223698-1217847	9008	1219096	259360E 6084330N Zone 56	58.7	
1223722-1217860	9012	1219098	256718E 6073288N Zone 56	59.8	
8175591-8174651	9002254	1184813	238331E 6162368N Zone 56	67.8	
8175597-8174659	9002254	1184813	238331E 6162368N Zone 56	67.8	
8188498-8193563	201625	1563035	266778E 6096569N Zone 56	64.4	
8188509-8193574	201625	1563035	266778E 6096569N Zone 56	64.4	
1423200-1418359	404074	1427988	749890E 6148994N Zone 55	39.4	Essential Energy PO Box 718 QUEANBEYAN NSW 2620
1423201-1418359	404074	1427988	749890E 6148994N Zone 55	39.4	
1424260-1419213	404074	1429638	749890E 6148994N Zone 55	39.4	
1424261-1419213	404074	1429638	749890E 6148994N Zone 55	39.4	
8385700-8437691	403848	1965539	229290E 6034380N Zone 56	62.9	
8385701-8437692	403848	1965539	229290E 6034380N Zone 56	62.9	
1423200-1418359	404074	1427988	749890E 6148994N Zone 55	39.4	
1224603-1218541	402066	1220402	246049E 6040332N Zone 56	69.3	Eurobodalla Shire Council PO Box 99 MORUYA NSW 2537
1224604-1218551	204010	1220403	248854E 6034550N Zone 56	75.3	
1224605-1218541	402066	1220402	246049E 6040332N Zone 56	69.3	
1224615-1218551	204010	1220403	248854E 6034550N Zone 56	75.3	
1230121-1223656	204831	1226700	244240E 6031325N Zone 56	74.4	
1230122-1223656	204831	1226700	244240E 6031325N Zone 56	74.4	
1231717-1225220	8965	1228054	244360E 6043160N Zone 56	66.1	
1231718-1225220	8965	1228054	244360E 6043160N Zone 56	66.1	

Table B-1: Details of point-to-multipoint licences within 75 km of the PA - continued

Assignment ID	Site ID	Licence no.	Location (AGD66)	Distance to PA (km)	Licence owner
314882-27329	35237	26488	745950E 6152490N Zone 55	42.4	Goulburn City Council Locked Bag 22 GOULBURN DC NSW 2580
7938-27329	35237	26488	745950E 6152490N Zone 55	42.4	
1102936-1102855	100872	1105029	774650E 6155890N Zone 55	55.2	Goulburn Mulwaree Council Locked Bag 22 GOULBURN NSW 2580
1102937-1102855	100872	1105029	774650E 6155890N Zone 55	55.2	
1232921-1226293	205249	1229107	269200E 6086980N Zone 56	67.8	Mollymook Golf Club Ltd PO Box 315 ULLADULLA NSW 2539
1232922-1226293	205249	1229107	269200E 6086980N Zone 56	67.8	
8299592-8332186	9013659	1936643	263368E 6134144N Zone 56	69.4	OFFICE OF ENVIRONMENT AND HERITAGE Asset Management Unit level 3 PO Box 1967 HURSTVILLE BC NSW 1481
8299593-8332187	9013659	1936643	263368E 6134144N Zone 56	69.4	
1105023-1104710	101195	1106560	721540E 6095920N Zone 55	19.0	Former Palerang Council PO Box 348 BUNGENDORE NSW 2621
1105024-1104710	101195	1106560	721540E 6095920N Zone 55	19.0	
1225981-1219592	100406	1221986	728180E 6065010N Zone 55	26.1	
1225982-1219592	100406	1221986	728180E 6065010N Zone 55	26.1	
1106282-1105926	9702	1107238	705840E 6086580N Zone 55	33.4	QUEANBEYAN CITY COUNCIL PO Box 90 QUEANBEYAN NSW 2620
1106283-1105926	9702	1107238	705840E 6086580N Zone 55	33.4	
1841081-2255830	141384	1964316	701610E 6077934N Zone 55	39.1	
1841082-2255830	141384	1964316	701610E 6077934N Zone 55	39.1	
1465206-1474580	49191	1192693	689900E 6091100N Zone 55	49.3	Royal Canberra Golf Club West Bourne Woods YARRALUMLA ACT 2600
1217485-1213217	9009834	1213539	268323E 6082764N Zone 56	67.7	Shoalhaven City Council PO Box 42 NOWRA NSW 2541
1217486-1213218	202372	1213540	271300E 6088200N Zone 56	69.6	
1217488-1213219	202373	1213541	268500E 6081500N Zone 56	68.2	
1217511-1213217	9009834	1213539	268323E 6082764N Zone 56	67.7	
1217512-1213218	202372	1213540	271300E 6088200N Zone 56	69.6	
1217513-1213219	202373	1213541	268500E 6081500N Zone 56	68.2	
17259-27351	9008	55946	259360E 6084330N Zone 56	58.7	
1810857-2227749	201625	1187830	266778E 6096569N Zone 56	64.4	
1810858-2227749	201625	1187830	266778E 6096569N Zone 56	64.4	
319527-27351	9008	55946	259360E 6084330N Zone 56	58.7	
1202756-1202032	200490	1202370	255150E 6148650N Zone 56	69.6	Sydney Catchment Authority PO Box 323 PENRITH NSW 2751
1202757-1202032	200490	1202370	255150E 6148650N Zone 56	69.6	

Table B-1: Details of point-to-multipoint licences within 75 km of the PA - continued

Assignment ID	Site ID	Licence no.	Location (AGD66)	Distance to PA (km)	Licence owner
1504464-1503561	501190	1209756	765960E 6036800N Zone 55	58.0	Telstra Corporation Limited Attn: Tom Fairbrother (Radio Engineering), Transport Engineering Locked Bag 810 ADELAIDE SA 5000
1504465-1503561	501190	1209756	765960E 6036800N Zone 55	58.0	
1504475-1503571	501197	1209749	240900E 6076200N Zone 56	44.4	
1504476-1503571	501197	1209749	240900E 6076200N Zone 56	44.4	
1504478-1503573	8979	1209752	229280E 6034340N Zone 56	62.9	
1504479-1503573	8979	1209752	229280E 6034340N Zone 56	62.9	
1504489-1503580	501189	1209755	229895E 6053202N Zone 56	48.7	
1504490-1503580	501189	1209755	229895E 6053202N Zone 56	48.7	
358979-27327	41454	178455	728075E 6184610N Zone 55	76.0	Upper Lachlan Shire Council Upper Lachlan Council PO Box 42 GUNNING NSW 2581
81689-27327	41454	178455	728075E 6184610N Zone 55	76.0	
8391722-8445825	9019481	1968122	707586E 6149840N Zone 55	53.2	
8391723-8445826	9019481	1968122	707586E 6149840N Zone 55	53.2	
1824200-2240090	138680	1918930	253024E 6161558N Zone 56	76.5	Wingecarribee Shire Council Water and Sewer PO Box 141 MOSS VALE NSW 2577
1824201-2240090	138680	1918930	253024E 6161558N Zone 56	76.5	
1231198-1224733	9529	1227638	680050E 6141725N Zone 55	70.4	Yass Valley Council PO Box 6 YASS NSW 2582
1231202-1224733	9529	1227638	680050E 6141725N Zone 55	70.4	
8408295-8469229	9484	1977109	745960E 6150500N Zone 55	40.4	YLESS4U Pty Ltd 62 Newington Road BYWONG NSW 2621

Table B-1: Details of point-to-multipoint licences within 75 km of the PA - concluded

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J103A	742505.0	6107961.0	✓		✓
J103B	742583.0	6107895.0	✓		✓
J119	742009.0	6092676.0		✓	
J12A	743409.0	6103064.0	✓		✓
J12B	743588.0	6103119.0	✓		✓
J140	743131.7	6101005.7	✓		✓
J151	740388.0	6090540.0			
J163	745543.0	6100089.0		✓	✓
J165	743165.0	6102466.0	✓		✓
J44	744067.1	6106726.0	✓	✓	✓
J53	744981.7	6106579.0	✓	✓	
J79	742677.8	6099519.3			✓
J89	742923.4	6106135.1	✓		✓
J96A	742667.0	6105528.0	✓		✓
J96B	742750.0	6105322.0	✓		✓
J105	738940.0	6092132.0	✓		✓
J115	738440.0	6092661.0	✓		
J120	738906.0	6091824.0	✓		✓
J126B	741615.0	6111462.0	✓		
J130	741215.3	6110328.2	✓		
J134	741536.0	6110624.0	✓		
J135	741319.0	6110705.5	✓		
J138	742295.0	6107519.0	✓		✓
J141	746551.0	6103871.0	✓	✓	
J142	746010.0	6104388.0	✓		
J144	746494.0	6104799.0	✓		
J145	745725.7	6105137.6	✓		✓
J146	746184.0	6104994.0	✓		
J147	746447.0	6104325.0	✓	✓	
J148	746014.0	6104219.0	✓	✓	
J152	746501.0	6110413.0	✓	✓	
J153	746929.0	6110488.0	✓	✓	
J16	743867.0	6104375.0	✓		✓
J162_TB[3]	748557.0	6101408.0	✓	✓	
J174A	748193.0	6102321.0	✓	✓	
J174B	748387.0	6102234.0	✓	✓	

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J178	742061.0	6099366.0			✓
J181	742108.0	6102518.0	✓		✓
J184	741451.0	6100095.0			✓
J194	740800.0	6087598.0			
J197	738848.0	6090268.0	✓		✓
J116A	742069.0	6102101.0	✓		✓
J116B	742116.0	6101885.0	✓		✓
J20	742740.0	6102263.0	✓		✓
J208	745869.0	6099526.0		✓	✓
J216	744854.0	6099403.0		✓	✓
J217	745680.0	6099319.0		✓	✓
J224	738743.0	6092769.0	✓		
J226	745401.0	6099419.0		✓	✓
J227	741806.0	6089667.0		✓	
J230A	747497.0	6110096.0	✓	✓	
J230B	747576.0	6110176.0		✓	
J234A	747774.0	6103681.0	✓	✓	
J234B	747601.0	6103861.0	✓	✓	
J235	745302.0	6099055.0		✓	✓
J237	741499.0	6091426.0			
J241	739229.0	6091823.0	✓		✓
J247	745265.0	6098403.0			✓
J255	741085.0	6090116.0		✓	
J257	741556.0	6110433.0	✓		
J269	746899.0	6097757.0			✓
J3	745692.0	6110374.0	✓	✓	
J392	742308.0	6107841.0	✓		✓
J393	738904.0	6091486.0	✓		✓
J40	744089.0	6104771.0	✓		✓
J422_TB[3]	741808.0	6098273.0			✓
J424	741606.0	6098909.0			✓
J425	741737.0	6098901.0			✓
J5	742375.0	6102772.0	✓		✓
J60	744900.0	6111980.0	✓		
J70	739472.0	6091650.0	✓		✓
J75A	742333.0	6104756.0	✓		✓

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J75B	742283.0	6104697.0	✓		✓
J76A	745945.0	6110174.0	✓	✓	
J76b	745980.0	6110265.0	✓	✓	
J85	742574.0	6102275.0	✓		✓
J87	742702.0	6105043.0	✓		✓
J88	738838.0	6092449.0	✓		
J72_DAA[2]	740061.0	6108313.0			✓
J250	745235.0	6093515.0		✓	
J248	745262.0	6093118.0		✓	
J210	744347.0	6095209.0			
J58A	741335.0	6103449.0	✓		✓
J419_DAA[2]	743699.0	6088832.0		✓	
J107A	740684.0	6096043.0	✓		✓
J150A	750355.0	6104633.0		✓	
J111	740783.0	6103613.0	✓		✓
J117	740652.0	6096784.0	✓		✓
J13	739337.0	6107891.0			✓
J150B	749374.0	6107643.0		✓	
J173	749272.0	6110391.0		✓	
J179	739624.0	6107513.0			✓
J191B	749279.0	6095333.0			
J191C	744438.0	6095722.0			✓
J192	741355.0	6113099.0	✓		
J198A	740480.0	6112385.0			
J204	751074.0	6101923.0		✓	
J209	743796.0	6096175.0			✓
J212	745096.0	6092983.0		✓	
J215	744748.0	6093675.0		✓	
J219	744095.0	6096276.0			✓
J222	744054.0	6095916.0			✓
J223	744994.0	6093138.0		✓	
J225	749681.0	6103552.0		✓	
J228	743137.0	6087352.0		✓	
J229D	744020.0	6090844.0		✓	
J229C	743889.0	6090358.0		✓	
J229B	743759.0	6090202.0		✓	

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J231	744723.0	6093237.0		✓	
J232A	744329.0	6093936.0		✓	
J236	744535.0	6090526.0		✓	
J240	744878.0	6093302.0		✓	
J245	744998.0	6093274.0		✓	
J249	750660.0	6103580.0		✓	
J25	739355.0	6107521.0			✓
J253A	744409.0	6094311.0			
J253B	744352.0	6094167.0			
J254	744604.0	6093372.0		✓	
J262	747843.0	6112013.0		✓	
J27	745048.0	6093754.0		✓	
J278	750009.0	6108641.0		✓	
J28A	739209.0	6095888.0	✓		
J297	748657.0	6110826.0		✓	
J299	749973.0	6108948.0		✓	
J308	749325.0	6109688.0		✓	
J319	750596.0	6106101.0		✓	
J351	743898.0	6089537.0		✓	
J356	748952.0	6110604.0		✓	
J369	743310.0	6090062.0		✓	
J371	736555.0	6090653.0			✓
J379	749799.0	6109066.0		✓	
J386	750023.0	6106767.0		✓	
J402	741159.0	6085134.0			
J41A	745045.0	6113665.0	✓		
J411	741034.0	6085350.0			
J412	750027.0	6106193.0		✓	
J415	744274.0	6088715.0		✓	
J417	743734.0	6089222.0		✓	
J45	740322.0	6101423.0			✓
J63	741203.0	6103106.0	✓		✓
J67	742969.0	6113810.0	✓		
J7	740535.0	6101770.0			✓
J71	740397.0	6096216.0	✓		✓
J74	744317.0	6113407.0	✓		

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J72_DAA[2]	738932.0	6108373.0			✓
J64_DAA[2]	738517.0	6107086.0			
J159_DASD[4]	746999.0	6113614.0	✓		
J183_DAA[2]	745275.0	6114197.0	✓		
J128_DAA[2]	745306.0	6114919.0			
J131	738825.0	6108017.0			✓
J137	738549.0	6106689.0			
J143A	750590.0	6104195.0		✓	
J143B	751026.0	6105410.0		✓	
J195	736962.0	6095006.0			
J200	745800.0	6092652.0		✓	
J201	745845.0	6093551.0		✓	
J202	745724.0	6093442.0		✓	
J206	745634.0	6093258.0		✓	
J207	745378.0	6093130.0		✓	
J211	745354.0	6091707.0		✓	
J220	744888.0	6094661.0			
J232B	745589.0	6094298.0		✓	
J251	745460.0	6093717.0		✓	
J252	745583.0	6093823.0		✓	
J263	745965.0	6094559.0			
J264	737450.0	6096145.0	✓		
J265	747689.0	6112445.0		✓	
J266	747874.0	6113233.0			
J268	745810.0	6093393.0		✓	
J273	750913.0	6106706.0		✓	
J28B	738378.0	6109335.0			✓
J283	749703.0	6094328.0			
J289	750355.0	6108308.0		✓	
J313	744489.0	6089702.0		✓	
J322	735426.0	6089981.0			
J354	745504.0	6091281.0		✓	
J367	750283.0	6108112.0		✓	
J380	749786.0	6110615.0		✓	
J397	746044.0	6093993.0		✓	
J398	751384.0	6106628.0		✓	

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J399	745915.0	6093844.0		✓	
J400	751478.0	6095436.0			
J401	736770.0	6095276.0	✓		
J403	750465.0	6107403.0		✓	
J405A	740303.0	6084038.0			
J405B	740542.0	6084086.0			
J406	736866.0	6095530.0	✓		
J407	745320.0	6090280.0			
J408	750807.0	6106922.0		✓	
J409	751884.0	6096047.0			
J41B	741839.0	6114999.0	✓		
J413	736725.0	6094824.0			
J414	750783.0	6107361.0		✓	
J48	745818.0	6094783.0			
J52	743079.0	6114991.0	✓		
J62	744752.0	6114680.0	✓		
J72	738357.0	6109105.0			
J8A	735301.0	6091638.0	✓		
J8B	735462.0	6091466.0	✓		
J82	738904.0	6106214.0			✓
DAA_1[2]	744946.0	6087633.0		✓	
DAA_3[2]	744706.0	6087224.0		✓	
D202	751135.0	6108887.0		✓	
J54	742816.0	6115405.0	✓		
J84	738827.0	6106742.0			✓
D205	745210.0	6087869.0		✓	
D206	744581.0	6087186.0		✓	
DAA_2[2]	745055.0	6087687.0		✓	
J97D	735493.0	6086938.0			✓
J97E	739444.0	6097848.0			✓
J99	745015.0	6114313.0	✓		
J275	737992.0	6093419.0	✓		
J10	740571.0	6109368.0			✓
J101	741845.0	6103423.0	✓		✓
J107B	740958.0	6095052.0	✓		
J116	740672.0	6100974.0			✓

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J117A	741257.0	6095174.0			
J117B	742025.0	6095719.0			
J117C	742146.0	6095797.0			
J126	740993.0	6111981.0			
J127	741047.0	6106970.0			✓
J129A	743758.0	6094060.0			
J129B	743973.0	6093846.0		✓	
J15	741405.0	6101319.0			✓
J154_DAA[2]	747123.0	6111182.0	✓	✓	
J155	746531.0	6111097.0	✓	✓	
J156	741703.0	6112262.0	✓		
J157	741685.0	6111844.0	✓		
J158	741673.0	6112940.0	✓		
J180	740996.0	6100757.0			✓
J182	741088.0	6100167.0			✓
J185	741591.0	6100736.0			✓
J186	742063.0	6102778.0	✓		✓
J186A	742040.0	6102828.0	✓		✓
J188	741550.0	6102968.0	✓		
J19	740894.0	6109882.0			✓
J190	748027.0	6103988.0	✓	✓	
J191A	746118.0	6096795.0			✓
J193	749399.0	6103723.0	✓	✓	
J196	749286.0	6103448.0	✓	✓	
J198B	741265.0	6112270.0	✓		
J199	746012.0	6097947.0			✓
J213	738312.0	6093187.0	✓		
J214	749543.0	6103681.0		✓	
J218_DTB[3]	741974.0	6090465.0		✓	
J218A	741992.0	6090396.0		✓	
J221	747589.0	6110421.0	✓	✓	
J229A	743290.0	6090453.0		✓	
J23	741018.0	6101963.0			✓
J239	747310.0	6111056.0	✓	✓	
J242	748511.0	6103740.0	✓	✓	
J243	745411.0	6098303.0			✓

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - continued

Dwelling ID	Eastings[1] [m]	Northing[1] [m]	Located in potential interference zone		
			Mt Gillamataong (Braidwood)	Black Mountain (Canberra)	Knights Hill (Illawarra)
J243A	745358.0	6098308.0			✓
J244	747474.0	6110737.0	✓	✓	
J246	750199.0	6102261.0		✓	
J258	748378.0	6110125.0		✓	
J259	748543.0	6109461.0		✓	
J26	741183.0	6107638.0			✓
J260	748830.0	6109539.0		✓	
J261	748934.0	6109094.0		✓	
J272	740583.0	6110244.0			
J275A	737976.0	6093431.0	✓		
J31	739764.0	6095613.0	✓		
J323	743150.0	6087949.0		✓	
J325	748072.0	6110022.0		✓	
J339	748099.0	6110871.0		✓	
J33_DAA[2]	740791.0	6110997.0			
J388	737837.0	6093453.0	✓		
J389	738200.0	6093403.0	✓		
J39	738244.0	6091869.0	✓		✓
J391	749662.0	6102960.0		✓	
J394	740575.0	6111681.0			
J396	750518.0	6102128.0		✓	
J416	742930.0	6096592.0			
J423	741244.1	6098127.9			✓
J429_DAA[2]	749464.0	6106005.0		✓	
J43	741925.0	6103019.0	✓		
J46	741729.0	6102476.0	✓		✓
J51	737495.0	6092032.0	✓		
J58B	741388.0	6103527.0	✓		✓
J65	740496.0	6110573.0			
J83A	742663.0	6096728.0			
J91	740881.0	6108236.0			✓
J93	740797.0	6110817.0			
J94	737890.0	6093189.0	✓		
J97A	741336.0	6105789.0	✓		✓
J97B	737487.0	6086813.0			✓
J97C	741204.0	6105879.0			✓

[1] Coordinate system: MGA zone 55, GDA94 datum
[2] Location with development approval for dwelling
[3] Dwelling not yet built
[4] DA approved from shed to dwelling

Table B-2: Details of dwellings falling within potential TV interference zones - concluded

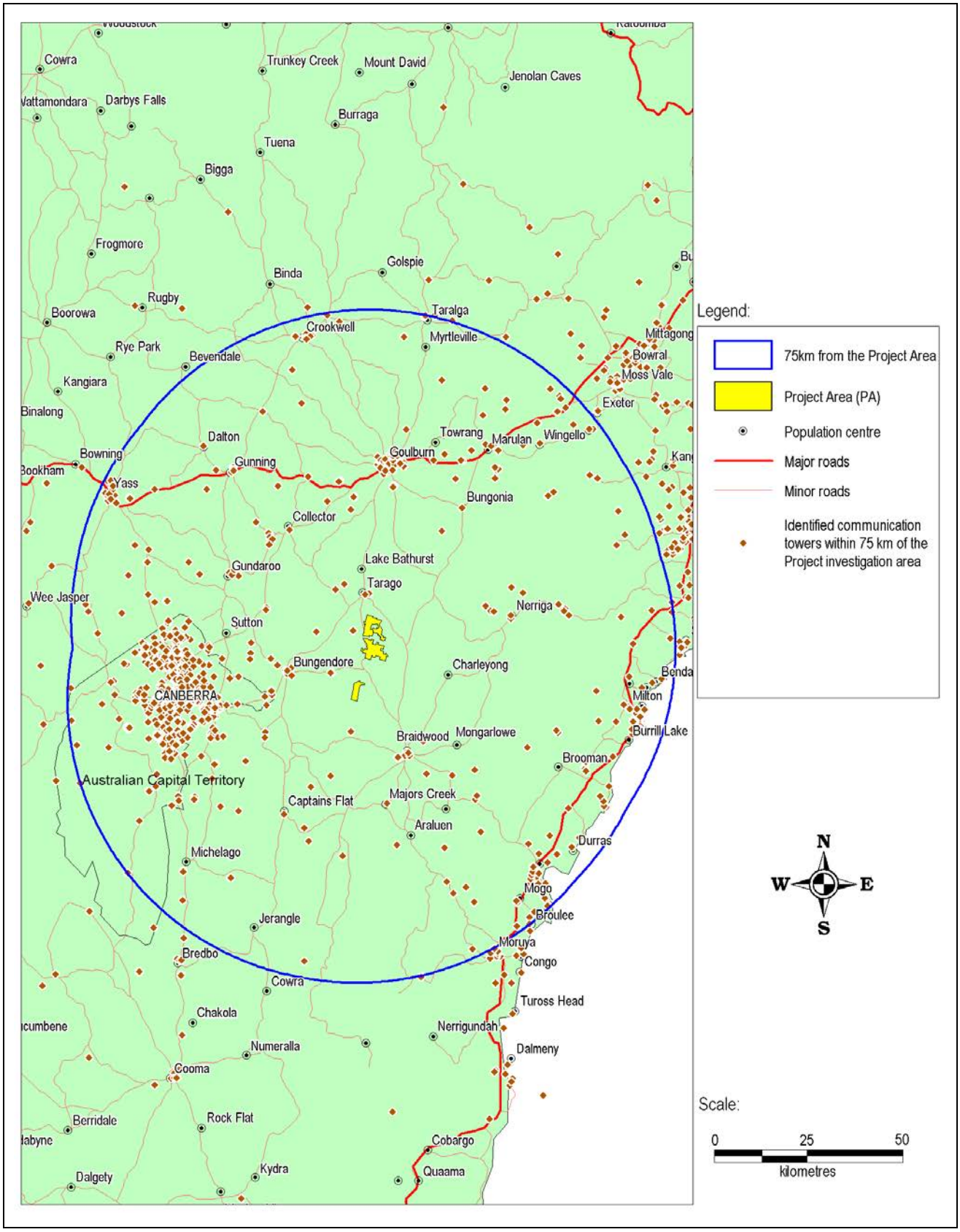

Figure B-1: Location of the PA and identified proximate radiocommunication sites

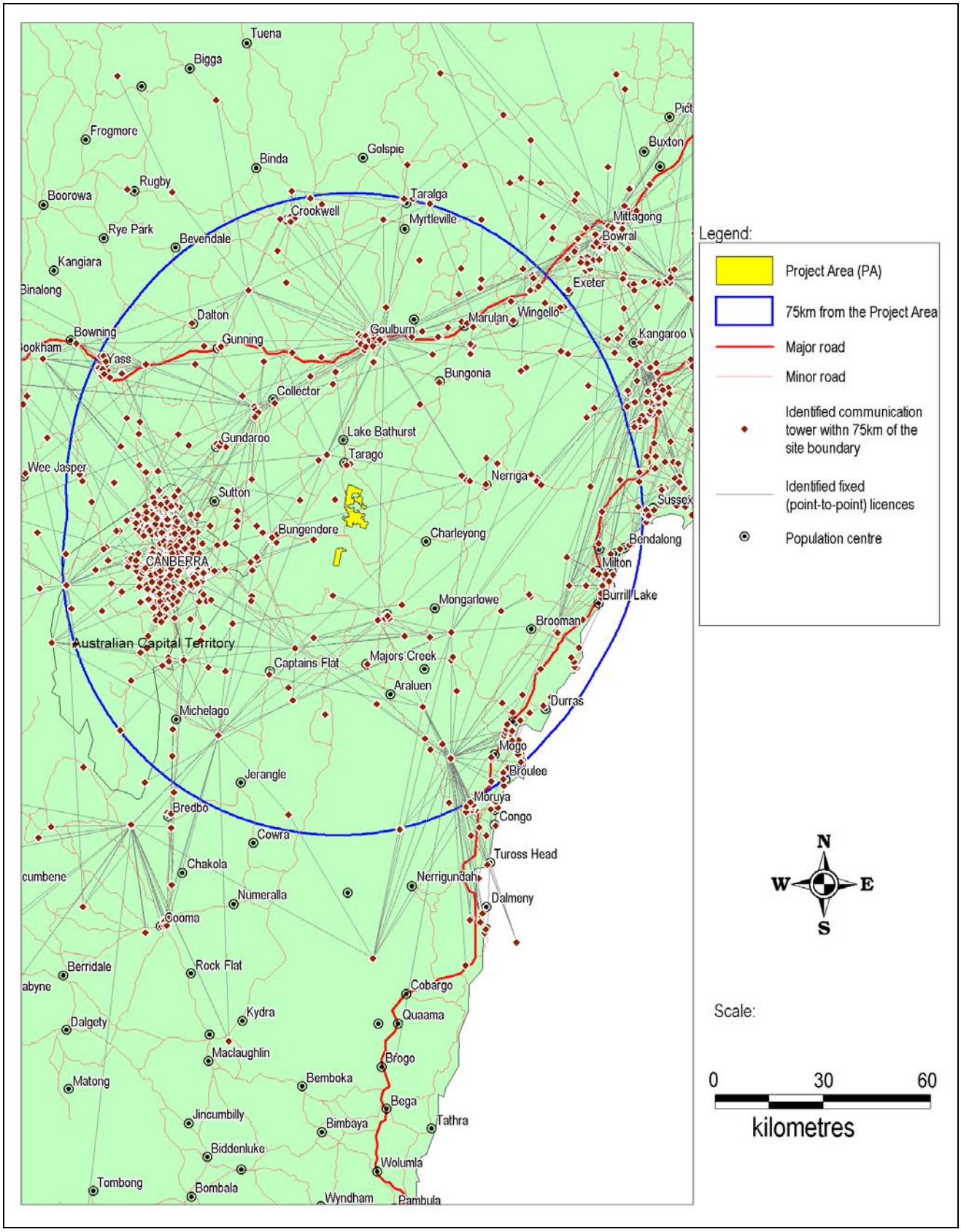

Figure B-2: Identified transmission vectors for fixed licences of point-to-point type proximate to the PA

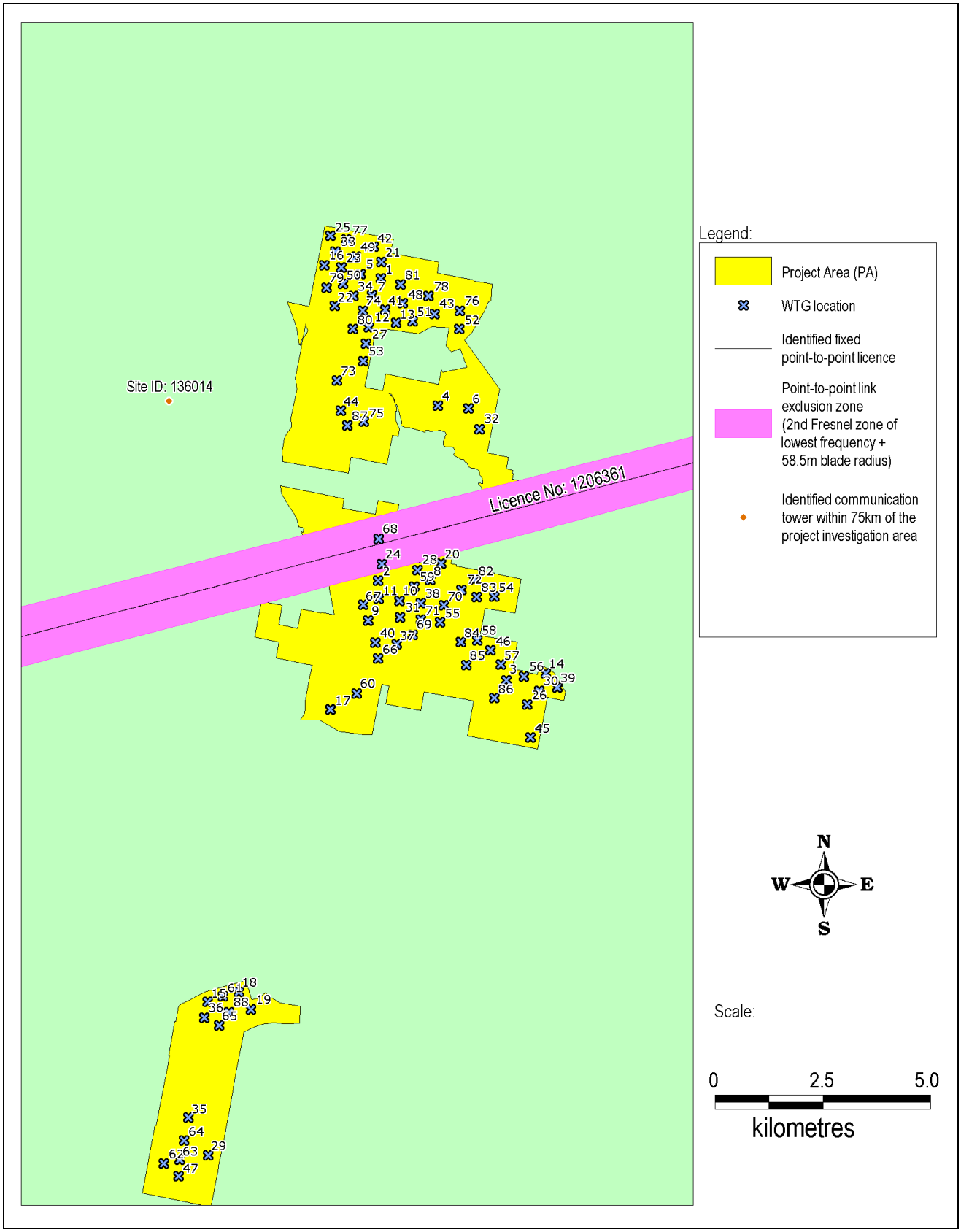

Figure B-3: Identified telecommunication vector and second Fresnel zone plus 58.5 m buffer for the proposed PA

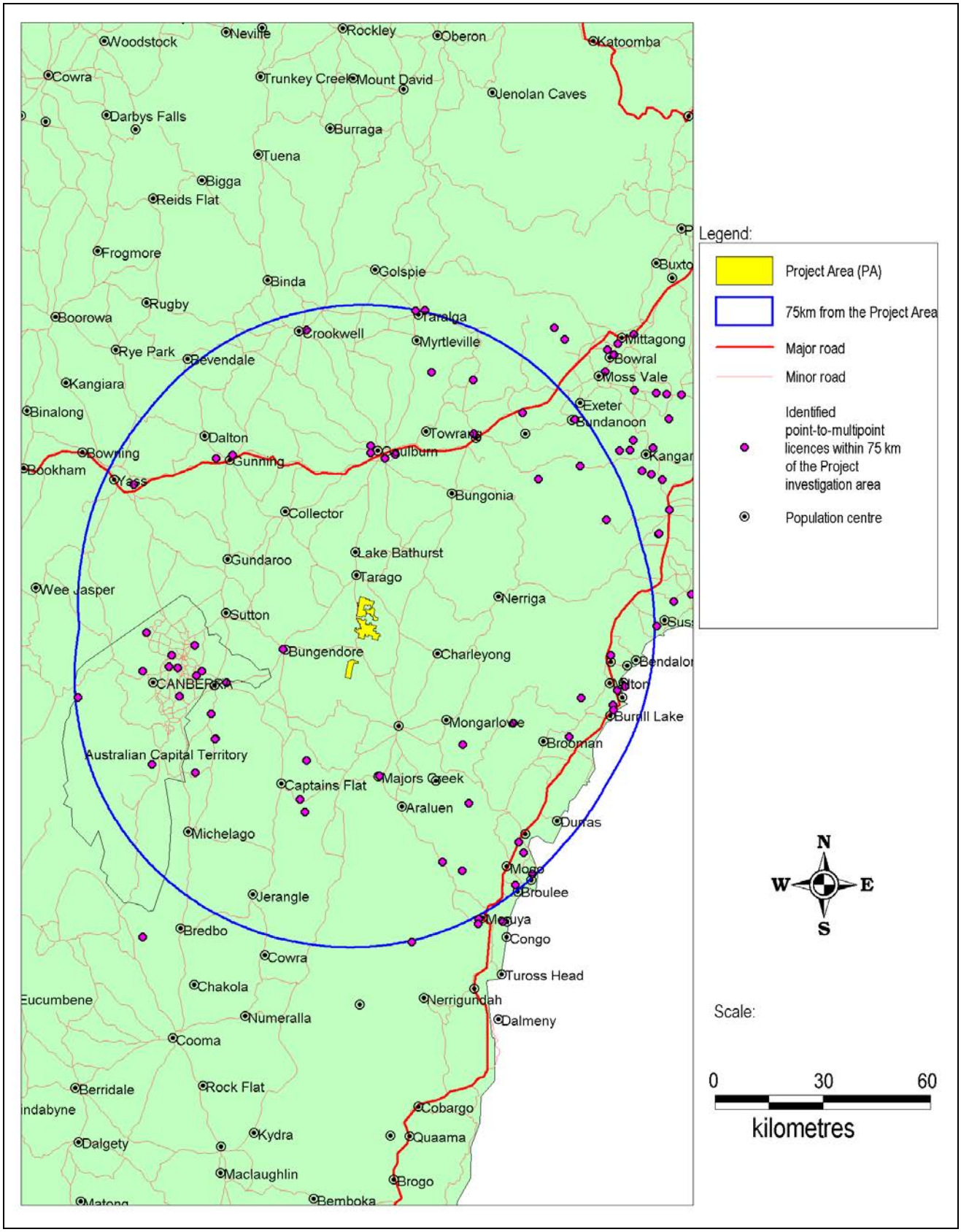

Figure B-4: Location of point-to-multipoint licences within 75 km of the PA

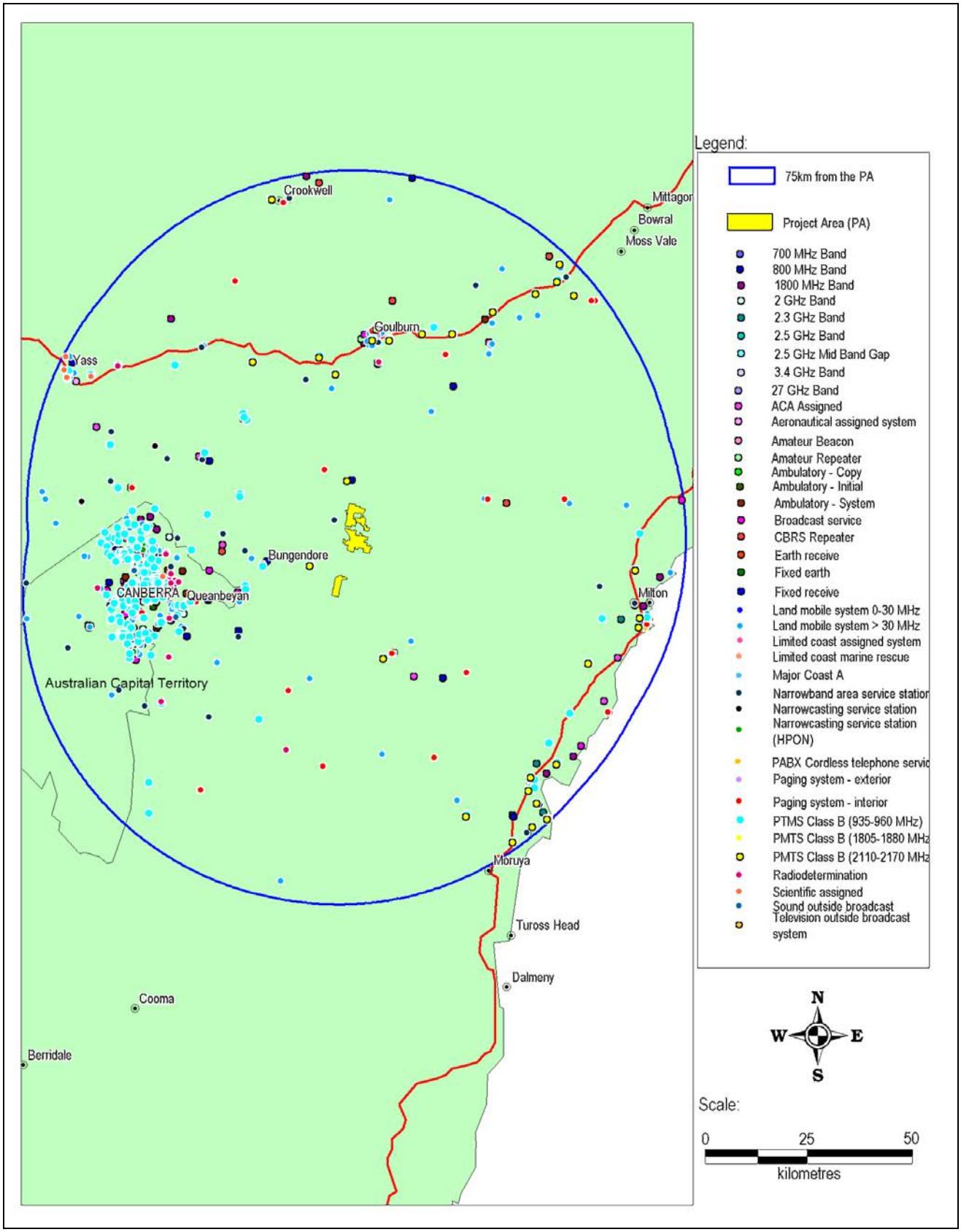

Figure B-5: Location of general point to area licences within 75 km of the PA

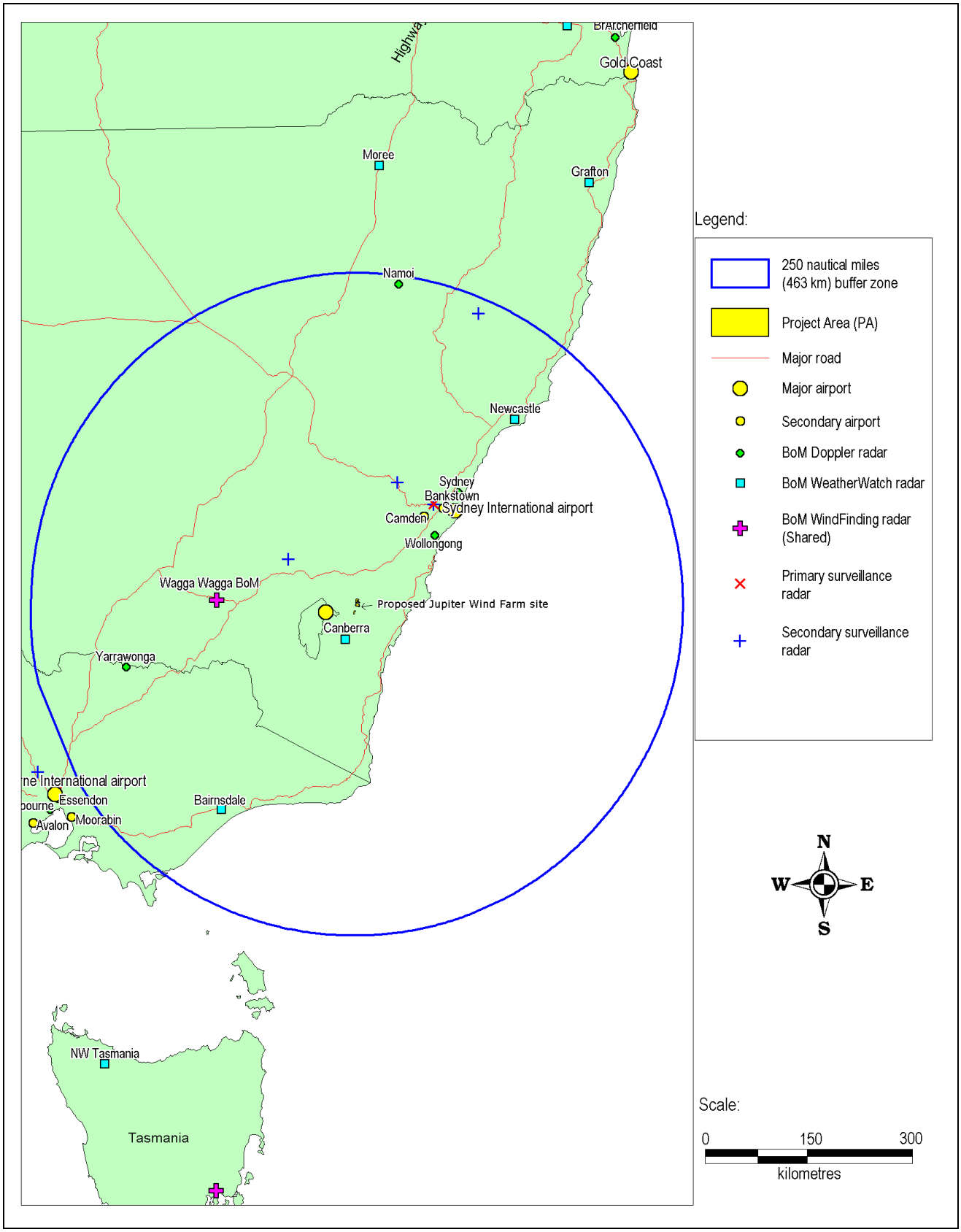

Figure B-6: Location of major airports and Bureau of Meteorology weather watch radar sites within 250 nautical miles of the PA

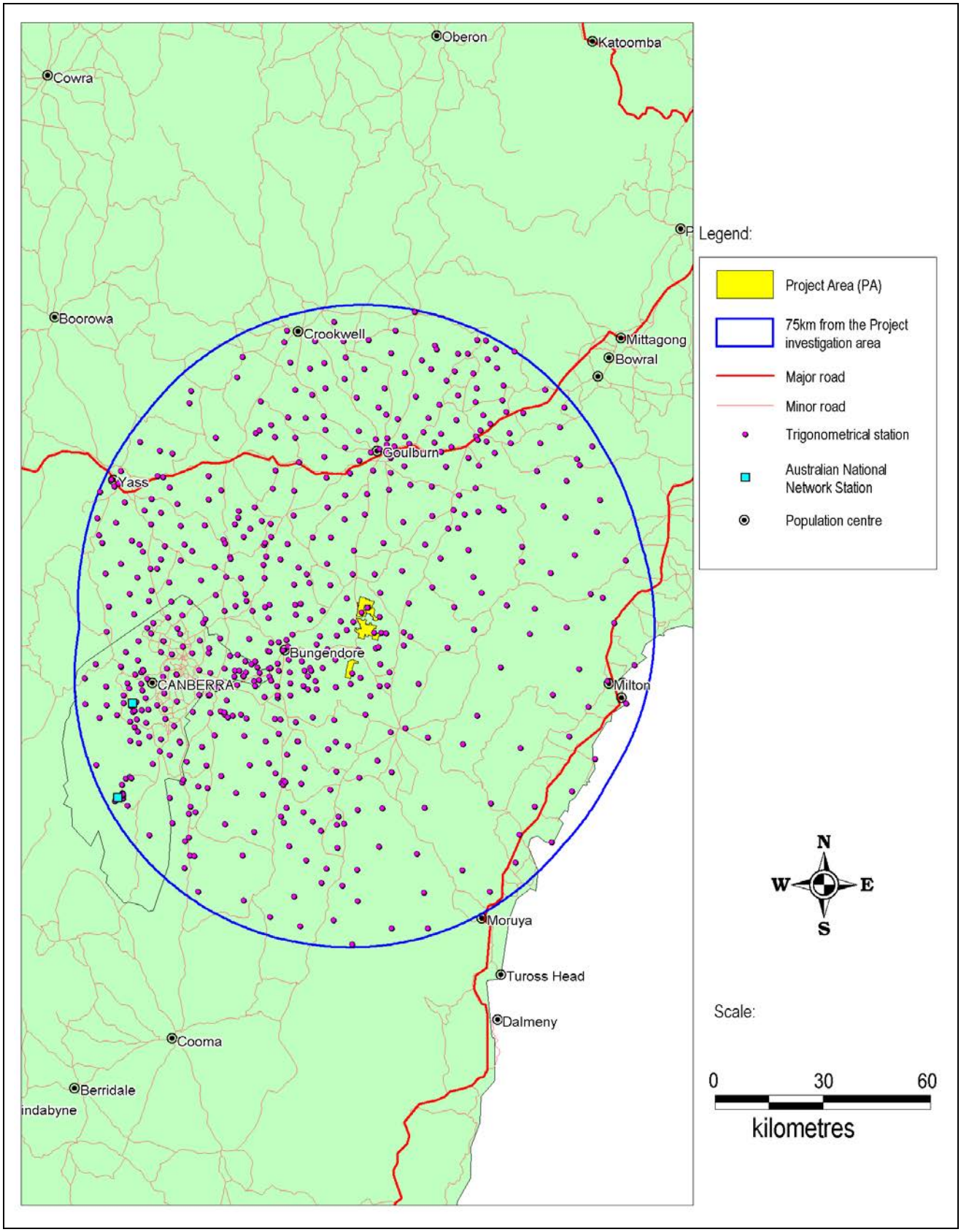

Figure B-7: Location of trigonometrical stations within 20 km of the PA

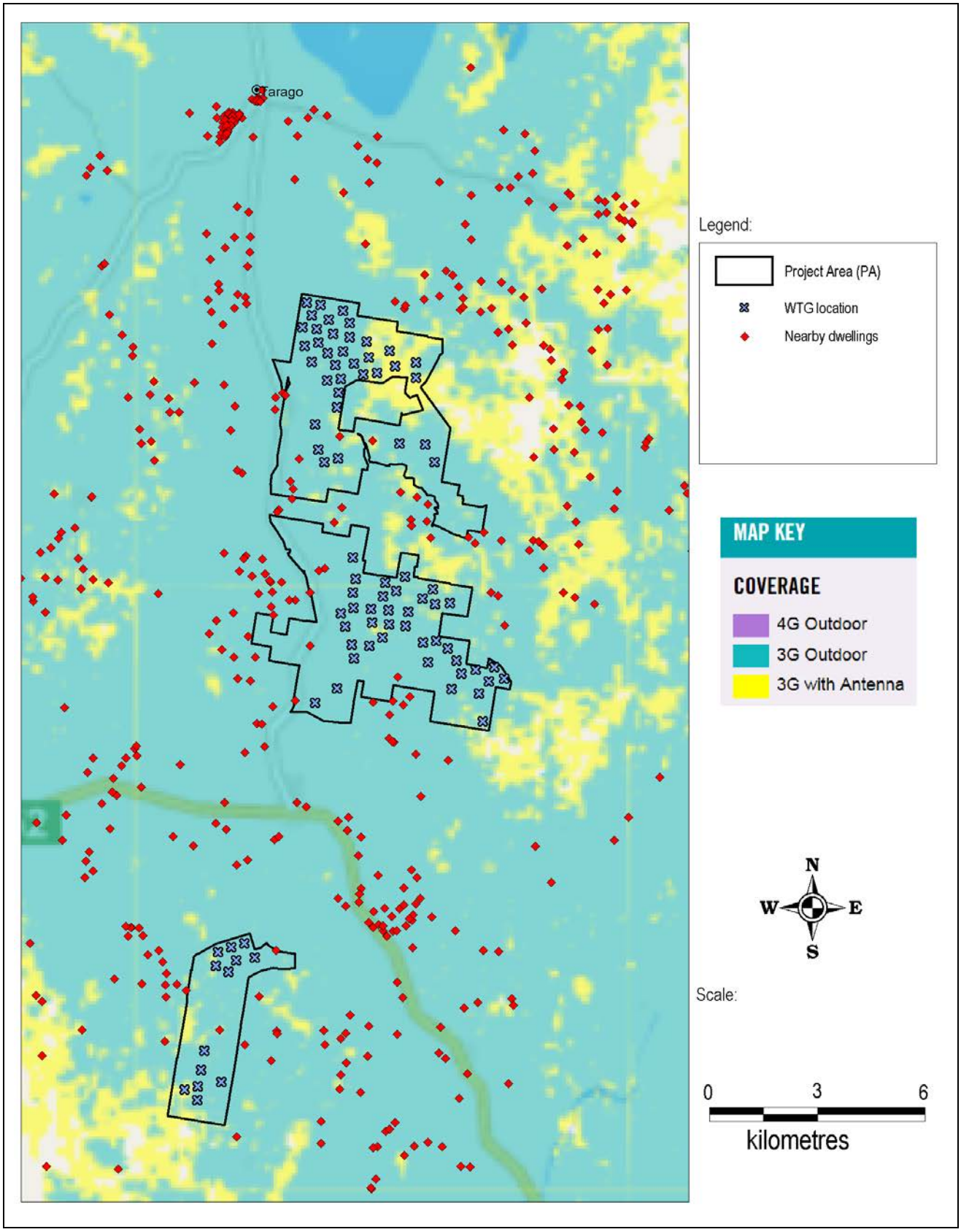

Figure B-8: Optus mobile network coverage for the PA

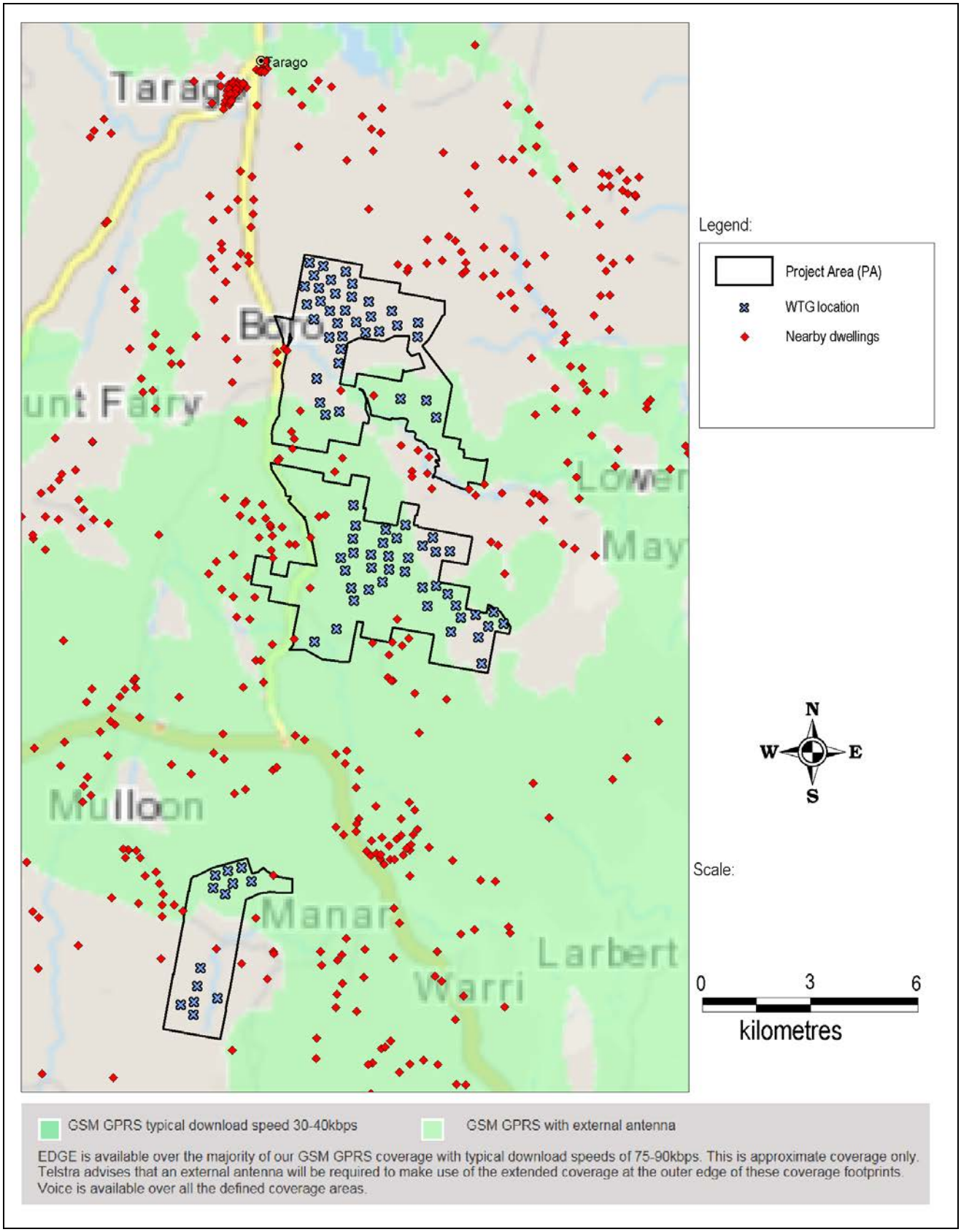

Figure B-9: Telstra 2G mobile network coverage for the PA

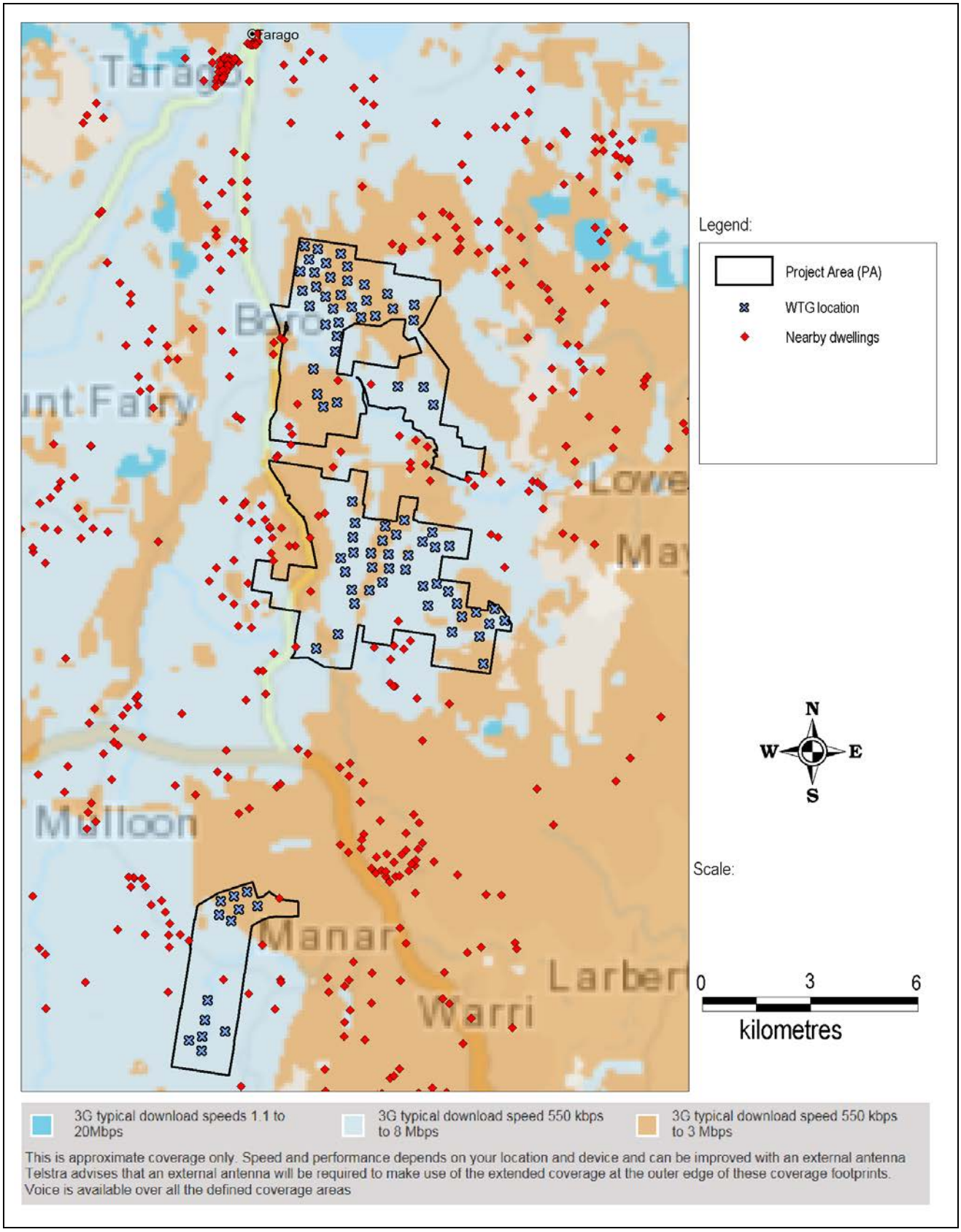

Figure B-10: Telstra 3G (NextG) mobile network coverage for the PA

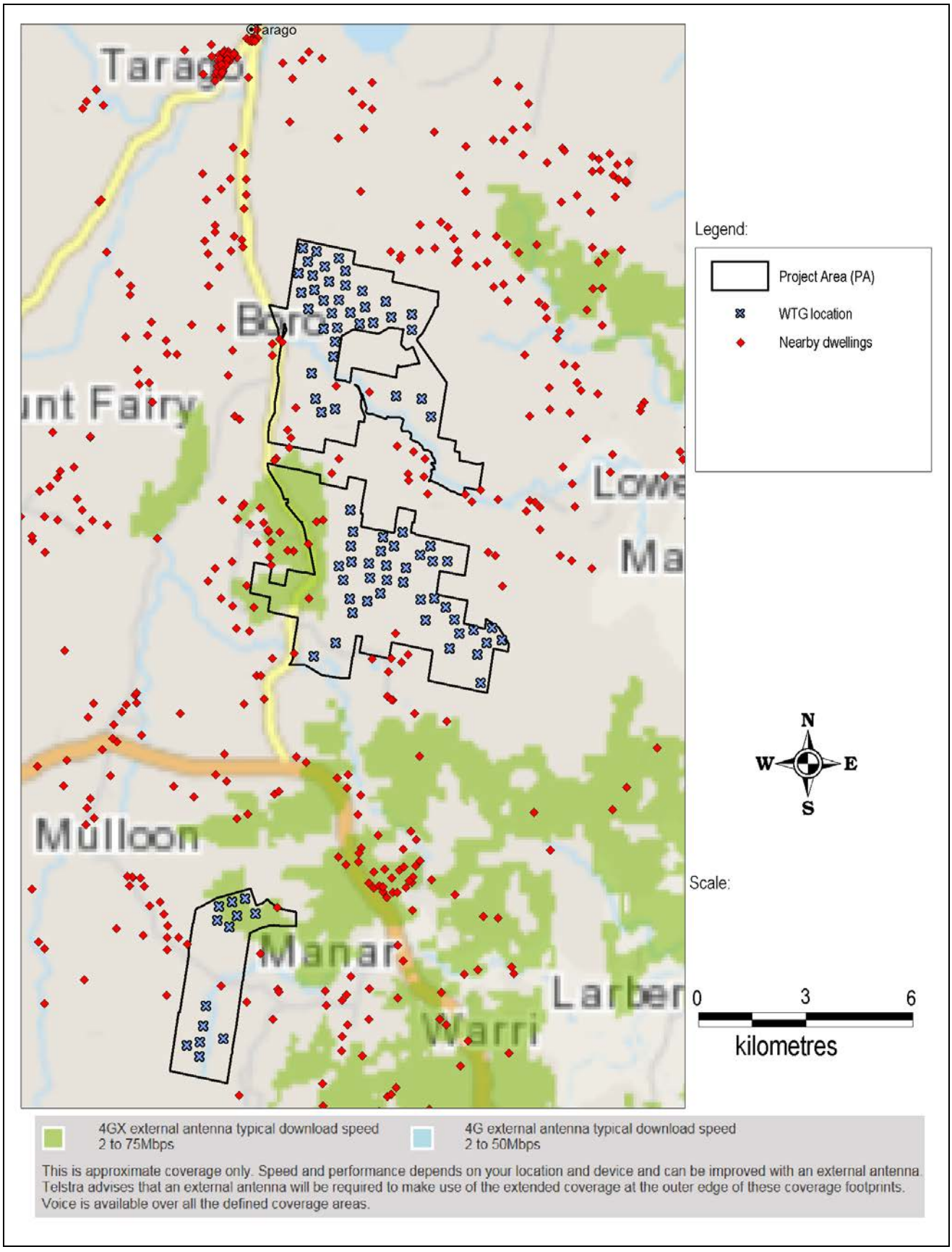

Figure B-11: Telstra 4G mobile network coverage for the PA

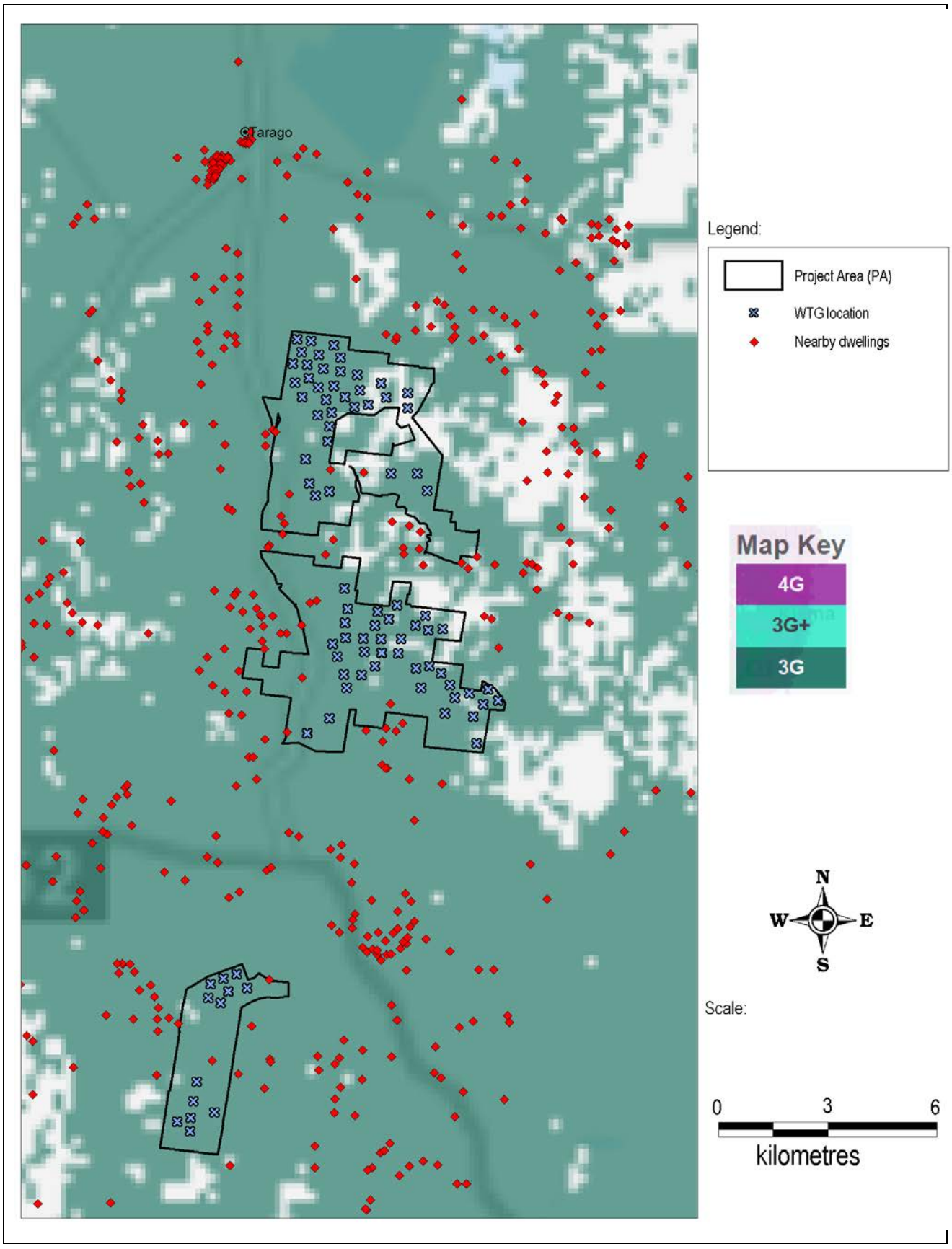

Figure B-12: Vodafone mobile network coverage for the PA

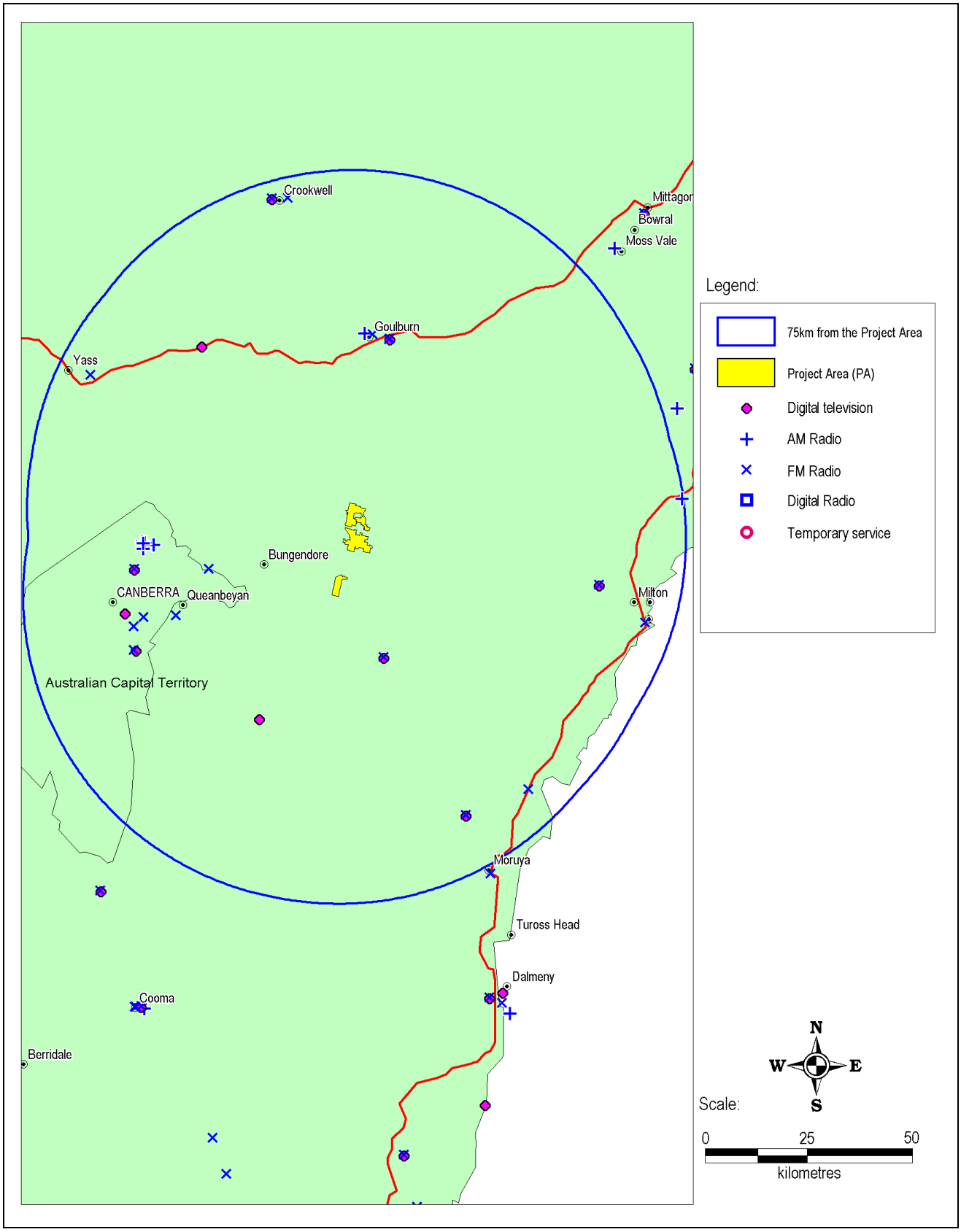

Figure B-13: Location of broadcast transmitters in the vicinity of the PA

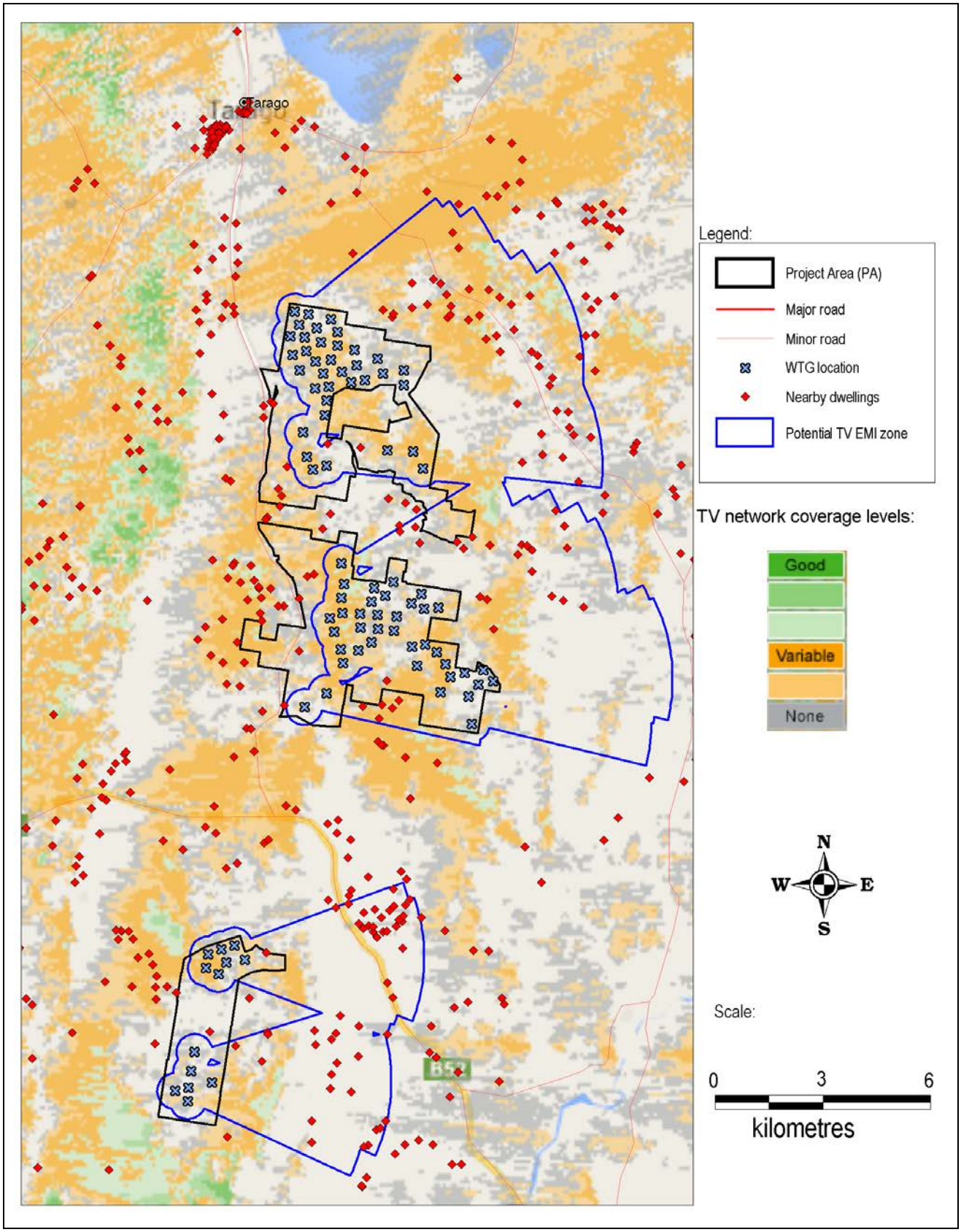

Figure B-14: Potential TV EMI zones and network coverage levels from the Canberra broadcast tower

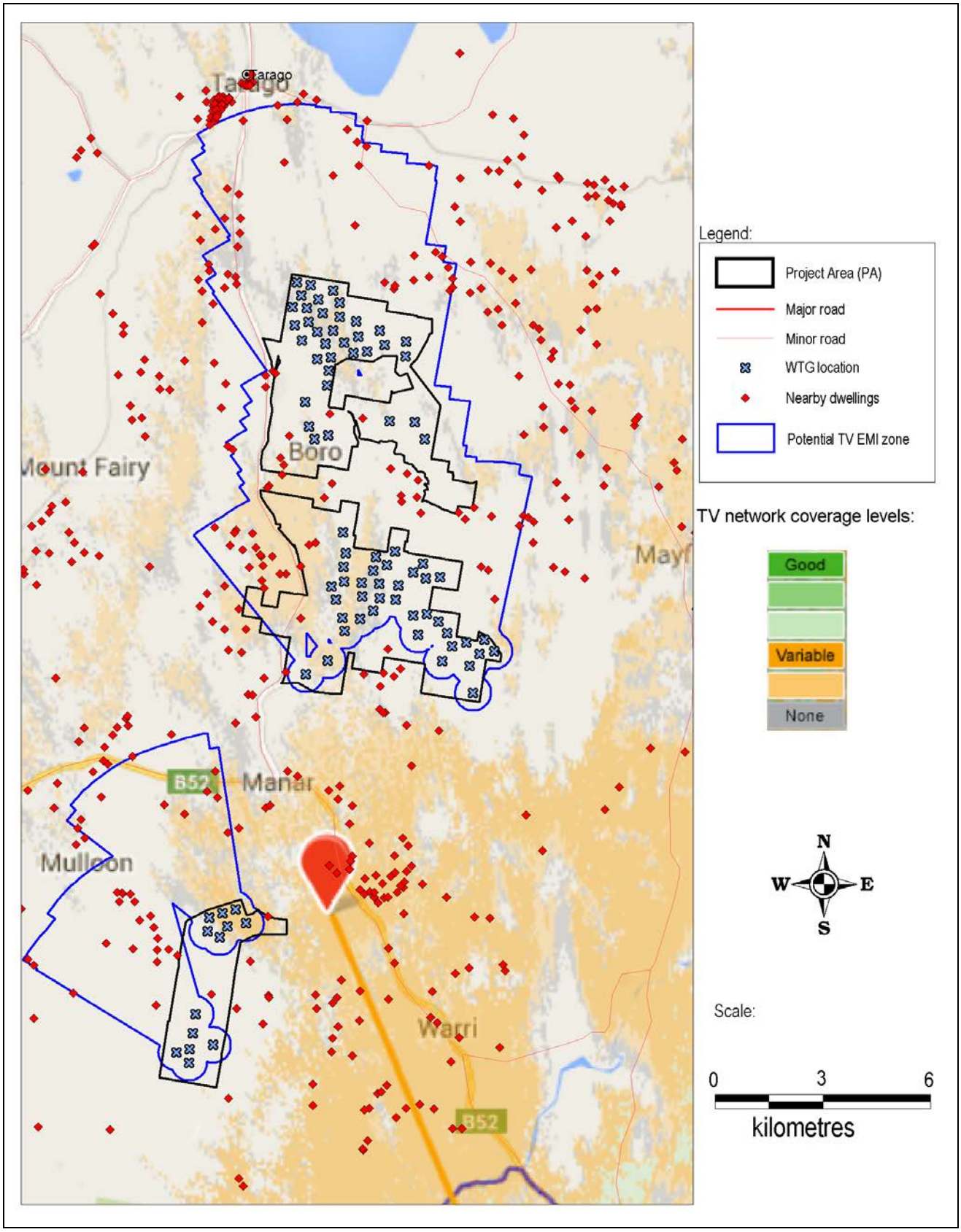

Figure B-15: Potential TV EMI zones and network coverage levels from the Braidwood broadcast tower

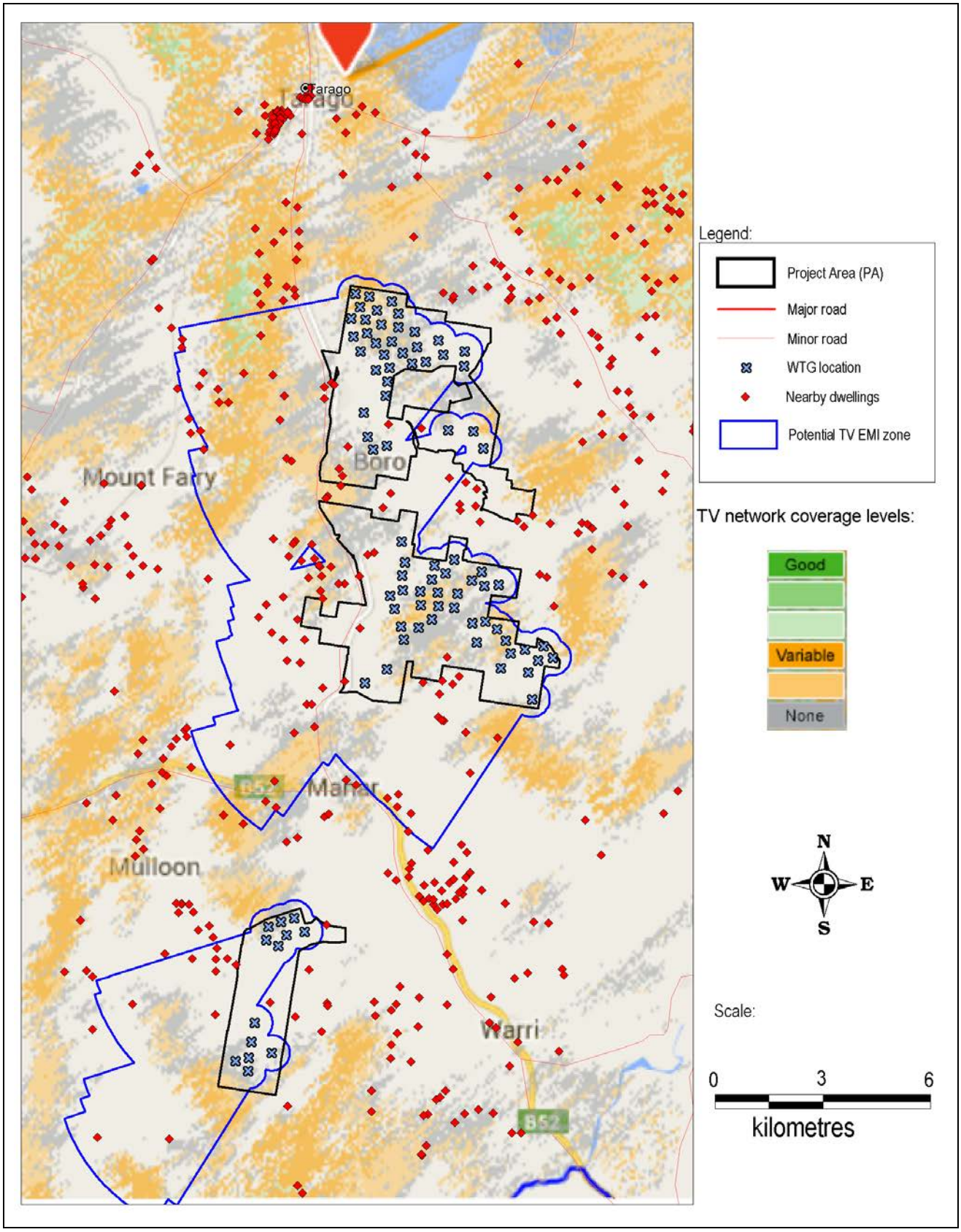

Figure B-16: Potential TV EMI zones and network coverage levels from the Illawarra broadcast tower

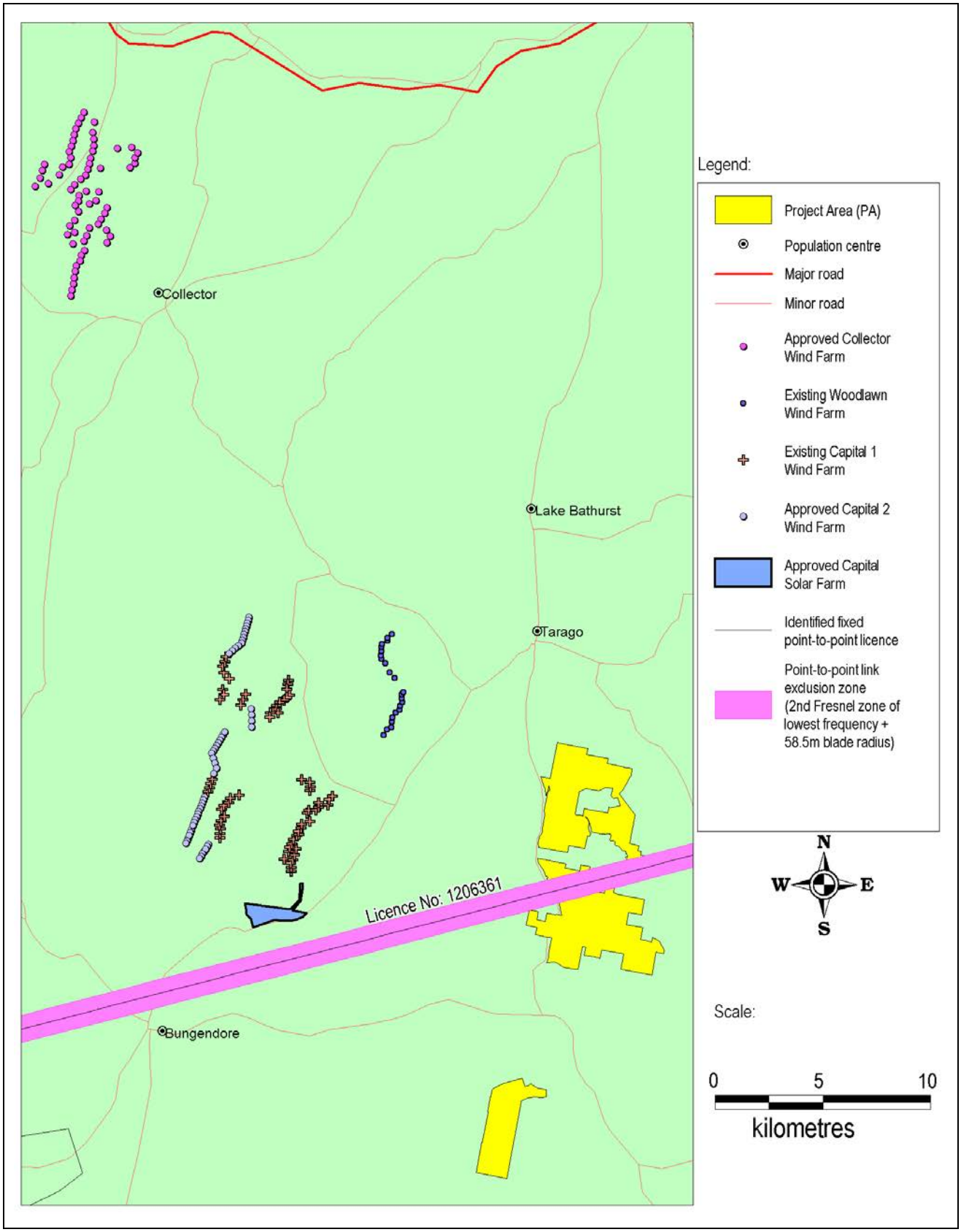

Figure B-17: Location of surrounding wind farms and solar farm in the vicinity of the PA

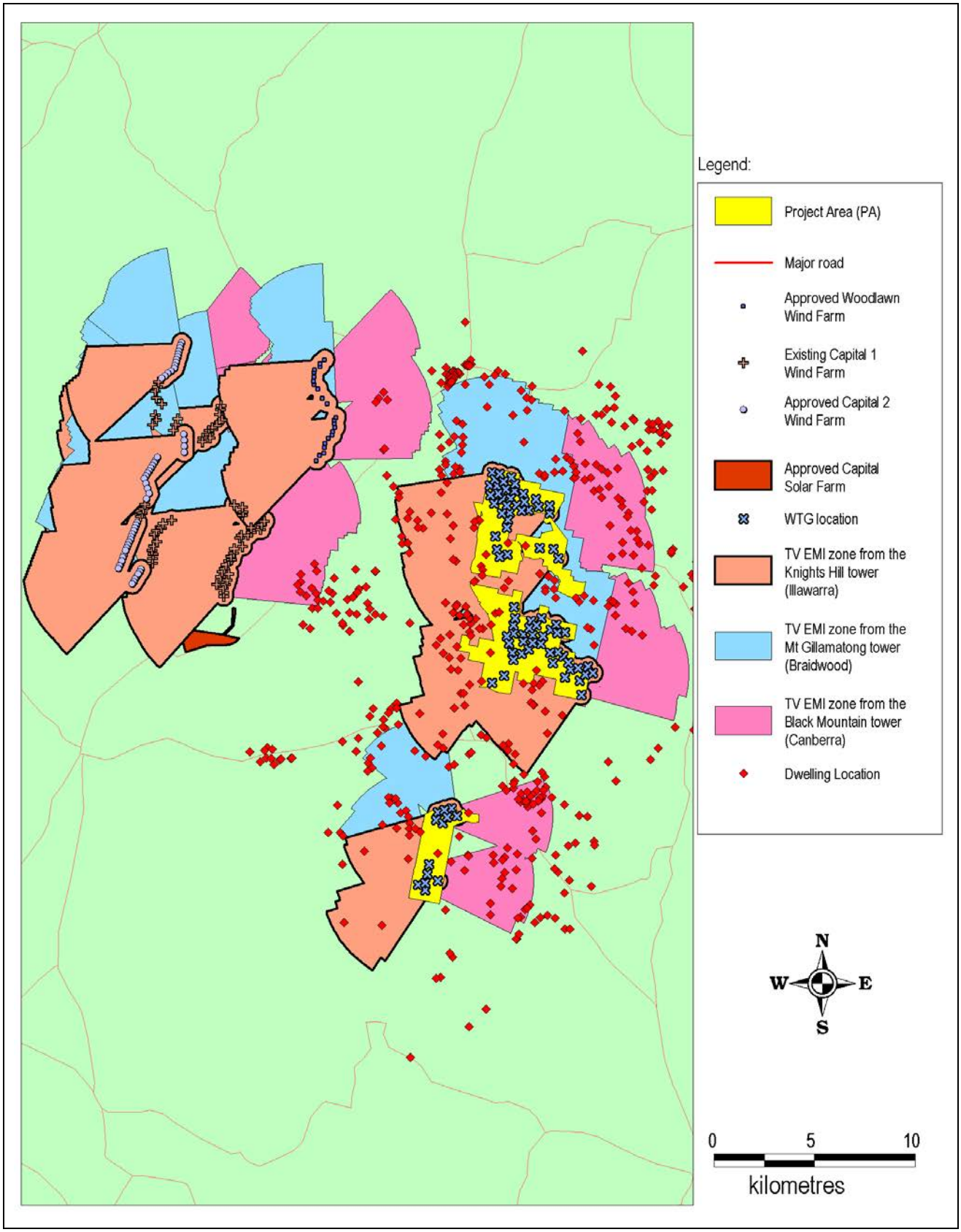

Figure B-18: Potential TV EMI zones from the Black Mountain, Mt Gillamatong and Knights Hill broadcast towers, resulting from the Project, Capital 1, Capital 2 and Woodlawn wind farms

APPENDIX C CONSULTATION PROCESS

Below is a summary of the responses received to-date following the consultation process undertaken by DNV GL.

	Licence type	Closest distance to PA [km]	Operator	DNV GL reference	Response received
1	Fixed point-to-multipoint	39.4	Essential Energy	170338-AUME-L-05	Response received on 22-09-2015: The relevant Communications Manager has confirmed the proposal as outlined below will have no effect on existing Essential Energy communications links.
2	Fixed point-to-point, paging system, land mobile system	18.9	Fire and Rescue NSW	170338-AUME-L-10	Response received on 17-09-2015: The information provided indicates the proposed Jupiter Wind Farm will have no adverse effects on the telecommunications services in use by FRNSW in the area.
3	Land mobile system, ambulatory system	20.8	St John Ambulance Australia	170338-AUME-L-14	Response received on 28-09-2015: I […] have no objections with the planned wind farm assessment. We currently have no equipment in the area, but in the future will be putting a repeater at Mt Gray (near Goulburn) which is only on the fringe of this EMI assessment area.
4	Land mobile – CBRS repeater	28.2	Wamboin Rural Fire Brigade	170338-AUME-L-16	Letter received on 22-09-2015: It would be appreciated if you could bring to the attention of any construction workers on your site that they should not use [CB] channel 36 [477.3 MHz].
5	PTMS Class B (Mobile phone)	> 30	Telstra	170338-AUME-L-22	Response received on 23-09-2015: There are no Telstra radio link ray lines crossing [the] proposed Jupiter Wind Farm areas.
6	PTMS Class B (Mobile phone)	> 5	Optus	170338-AUME-L-23	Response received on 18-09-2015: I wish to inform that the proposed Jupiter wind farm has no impact on the existing and planned microwave radio links in [the] Optus Network in the area.

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.