PALING YARDS WIND FARM

EMI Assessment

Paling Yards Development Pty Ltd

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EXECUTIVE SUMMARY

DNV has been commissioned by Paling Yards Development Pty Ltd ("Paling Yards Development" or "the Customer") to independently assess potential electromagnetic interference (EMI) impacts associated with the development and operation of the proposed Paling Yards Wind Farm ("PYWF" or "the Project") in New South Wales. The results of the EMI assessment are described in this document.

Background and methodology

DNV has assessed the potential EMI impacts for the Project in accordance with the Secretary's Environmental Assessment Requirements for the Paling Yards Wind Farm [1], NSW Wind Energy Guideline [2], and Draft National Wind Farm Development Guidelines [3]. The methodology used in this study has been informed by these guidelines and various standard industry practices.

A Project layout consisting of 47 wind turbines with a rotor diameter of 158 m and tip height of 240 m has been considered. These dimensions represent the maximum overall tip height within the maximum rotor and tower hub height dimensions.

There are 38 identified dwellings within 5 km of the Project, nine of which are involved dwellings.

Outcomes of the assessment

The results of the EMI assessment, including feedback obtained from relevant stakeholders, are summarised in the table at the end of this section.

In its current configuration, the Project has the potential to interfere with several point-to-point links crossing the proposed Project boundary and point-to-area style communications hosted by radiocommunication towers located within 2 km of the proposed turbine locations.

To avoid the potential for impact to their point-to-point links and point-to-area style communications used for emergency services mobile radio and paging systems, the NSW Government Telecommunications Authority (NSW Telco Authority) has asked that four turbines be relocated to be outside a 1 km radius around the tower hosting their services. The NSW Police Force has also raised concerns about the potential for impact to their operations, and has asked that five turbines (including the four turbines identified by the NSW Telco Authority) be relocated to be outside both a 1 km radius around the relevant tower and a 1 km clearance zone on either side of the link path for their point-to-point link crossing the Project boundary.

Although feedback has not yet been received from either Telstra or the NSW Rural Fire Service regarding potential impacts to their point-to-point links crossing the Project boundary, DNV recommends that a further two turbines be relocated to be outside the diffraction exclusion zone established in this assessment for a point-to-point link operated by NSW Rural Fire Service in order to avoid the potential for impact to that link. Additionally, a preliminary response from Telstra regarding potential impacts to their mobile phone services operated from a tower located within 2 km of the proposed turbine locations has asked that one turbine (which is also located within the clearance zones requested by the NSW Telco Authority and NSW Police Force) be relocated by at least 50 m from its current proposed location. Consultation with both Telstra and the NSW Rural Fire Service is ongoing to confirm the potential for impact to their assets and any required clearances.

Feedback received from the Bureau of Meteorology (BoM) indicates that there is potential for the Project to materially impact on the operation of their Wollongong radar facility and the associated weather monitoring and prediction services. To avoid the potential for impact to their operations, the BoM has asked that 10 turbines be relocated to be outside of a defined exclusion zone. Alternatively, the Customer may formally commit to advising the BoM of the final turbine layout and any changes to the Project design, notifying the BoM prior to any planned shutdown of the Project to allow calibration of their systems, and cooperating with any requests from the BoM to temporarily shut down the identified turbines for an agreed maximum period per year in the event of severe weather conditions.

Turbines at the Project may also interfere with public point-to-area style services such as mobile phone signals from towers outside the Project boundary, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings in the vicinity of the Project may experience interference to digital television broadcast signals from the Central Tablelands, Illawarra, and Canberra transmitters. Coverage maps for these transmitters indicate that most of the identified dwellings are unlikely to be receiving signals from the affected transmitter. However, if any dwellings are currently receiving signals from these transmitters there may be potential for those dwellings to receive a stronger reflected signal from a turbine and therefore to experience interference. If interference to these types of services is experienced, a range of options are available to rectify difficulties.

Impacts to satellite television and internet signals that may be received at dwellings in the vicinity of the Project are considered unlikely. The proposed turbines are not expected to interfere with any satellite television or internet services intended for Australian audiences. Interference is possible for signals from satellites that do not provide services designed for Australian audiences, however these are unlikely to be used by nearby residents.

While the Project may cause interference to other radiocommunication services in the surrounding area, such as point-to-multipoint links, further information from the operators of those services is required to determine the likely impacts. DNV has contacted other organisations operating services that may be affected by the Project, besides those discussed above, to seek feedback regarding any potential for EMI-related impact and no concerns have been raised to date.

Summary of EMI assessment results for the proposed Project

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio-communication towers	3 towers within 2 km of proposed turbine locations, hosting point-to-point links and point-to-area style communications operated by: New South Wales Government Telecommunications Authority (NSW Telco Authority) NSW Police Force NSW Rural Fire Service Telstra Corporation Limited (Telstra)	**NSW Telco Authority, NSW Police Force:** potential for interference raised (see feedback for point-to-point links and emergency services) **Telstra:** potential for interference raised (see feedback for mobile phones) **NSW Rural Fire Service:** no response received	**Point-to-point links:** see findings for point-to-point links **Point-to-area style communications:** see findings for emergency services and mobile phones	**Point-to-point links:** see mitigation for point-to-point links below **Point-to-area style communications:** see mitigation for emergency services and mobile phones
Fixed point-to-point links	9 links crossing Project boundary, operated by: NSW Telco Authority NSW Police Force NSW Rural Fire Service Telstra **NSW Telco Authority links:** no turbines in diffraction or near-field zones, 15 turbines in potential reflection/scattering zones **NSW Police Force link:** no turbines in diffraction or near-field zones, 6 turbines in potential reflection/scattering zones **NSW Rural Fire Service links:** 2 turbines in diffraction zone for one link, 7 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **Telstra links:** no turbines in diffraction or near-field zones, 12 turbines in potential reflection/scattering zones	**NSW Telco Authority:** potential for interference raised, 1 km clearance around tower requested – *4 turbines in requested clearance zone* **NSW Police Force:** potential for interference raised, 1 km clearance around tower and link path requested – *5 turbines in requested clearance zone* **Other operators:** no response received	**NSW Telco Authority, NSW Police Force, NSW Rural Fire Service links:** high likelihood of interference **Other links:** low likelihood of interference	**NSW Telco Authority and NSW Police Force links:** relocate turbines to be outside clearance zones requested by operators **NSW Rural Fire Service link:** relocate turbines to be outside diffraction exclusion zone established by DNV **Other links:** if required - relocate turbines to be outside any requested clearance zones, reroute affected links, replace affected links with alternative technologies

Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Fixed point-to-multipoint links	156 assignments within 75 km of Project boundary No base stations within 20 km of Project boundary	**Ace Internet Services, Bureau of Meteorology (BoM), Water NSW:** no concerns raised **Other operators:** no response received	**Ace Internet services, BoM, Water NSW licences:** none **Other licences:** potential for interference if link paths cross the Project near turbines	If required – relocate turbines to be outside any interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies
Other licence types	**Point-to-area style communications:** see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting	-	-	-
Emergency services	**Point-to-point links:** NSW Telco Authority, NSW Police Force, and NSW Rural Fire Service links crossing boundary (see findings for point-to-point links) **Point-to-area style communications:** NSW Telco Authority and NSW Police Force towers within 2 km of turbines	**NSW Telco Authority:** potential for interference raised, 1 km clearance around tower requested – *4 turbines in requested clearance zone* **NSW Police Force:** potential for interference raised, 1 km clearance around tower and link path requested – *5 turbines in requested clearance zone* **St John Ambulance:** no concerns raised **Other operators:** no response received	**Point-to-point links:** see findings for point-to-point links **Services from towers within 2 km of turbines:** high likelihood of interference **Other services:** unlikely to cause interference	**Point-to-point links:** as for point-to-point links **Services from towers within 2 km of turbines:** relocate turbines to be outside clearance zones requested by operators **Other services:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower

Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Meteorological radar	Nearest radar: 78 km from Project	Concerns raised regarding potential for interference to Wollongong radar, necessary exclusion zone identified – *10 turbines in requested exclusion zone*	High likelihood of interference	Relocate turbines to be outside exclusion zone requested by BoM Alternatively, enter into formal agreement to advise the BoM of the final turbine layout and any changes to the Project design, notify the BoM prior to any planned shutdown of the Project to allow calibration of systems, collaborate with the BoM in the event of severe weather conditions
Trigonometrical stations	Unlikely to be affected	**Geoscience Australia:** no concerns raised **NSW Spatial Services:** no concerns raised, provided assets are protected from physical disturbance during construction	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phones	**Telstra:** 1 tower within 2 km of turbines, fair to good coverage across Project **Optus and Vodafone:** limited to no coverage across Project Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	**Telstra:** potential for interference raised, *relocation of one turbine by at least 50 m requested* **Other operators:** no concerns raised	**Telstra services from towers within 2 km of turbines:** high likelihood of interference **Telstra services from other towers:** low likelihood of interference **Other services:** unlikely to cause interference	**Telstra services from towers within 2 km of turbines:** relocate turbine as requested by Telstra **Other services:** if required – increase signal strength from affected tower or alternative towers, install additional tower

Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Wireless internet	**Mobile broadband service providers:** Ace Internet Services Pty Ltd, Telstra, NBN Co **NBN:** available as a satellite service only	**Telstra:** potential for interference raised (see feedback for mobile phones) **Other operators:** no concerns raised	**Mobile broadband services:** see findings for mobile phones **NBN:** none	**Mobile broadband services:** as for mobile phones **NBN:** none required
Satellite television and internet	**Services intended for Australian audiences:** unlikely to be affected **Services intended for international audiences:** signals from 53 satellites intercepted at 13 dwellings	Consultation with operators not considered necessary	Unlikely to cause interference	If required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** Project is outside the intended coverage area	Consultation not considered necessary	**AM and FM signals:** low likelihood of interference **Digital radio signals:** none	**AM and FM signals:** if required – install higher-quality antenna at affected location **Digital radio signals:** none required

Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Television broadcasting	May experience interference in areas with poor or marginal reception **Central Tablelands transmitter:** patchy coverage with 'variable' to 'good' coverage in small areas close to turbines in west of Project and small areas to north, south, and southwest, 'poor' to no coverage elsewhere 13 dwellings in potential interference zone	No response received	Low likelihood of interference – most identified dwellings are unlikely to be receiving signals from the corresponding transmitter, but dwellings that are receiving signals may experience interference	If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter
	Illawarra transmitter: patchy coverage with 'variable' to 'good' coverage in areas to northeast and east, 'poor' to 'variable' coverage in small areas within Project boundary and small areas to north, south, and southeast, no coverage elsewhere 6 dwellings in potential interference zone	No response received		
	Canberra transmitter: patchy coverage with 'poor' to 'variable' coverage in small areas within Project boundary and small areas to northeast, east and south, no coverage elsewhere 10 dwellings in potential interference zone	No response received		

1 INTRODUCTION

Paling Yards Development Pty Ltd ("Paling Yards Development" or "the Customer") has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the proposed Paling Yards Wind Farm ("PYWF" or "the Project") in New South Wales. The results of this work are reported here. This document has been prepared in accordance with DNV proposal L2C-208538-AUME-P-01 Issue B, dated 13 November 2020, and DNV variation order L2C-208538-AUMEL-VO-02 Issue A, dated 22 May 2022, and is subject to the terms and conditions in those agreements.

In accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the Paling Yards Wind Farm [1], the NSW Wind Energy Guideline for State significant wind energy development (NSW Wind Energy Guideline) prepared by the NSW Department of Planning and Infrastructure in December 2016 [2], and the National Wind Farm Development Guidelines – Draft (Draft National Guidelines) prepared by the Environment Protection and Heritage Council (EPHC) in July 2010 [3], this assessment investigates the potential EMI 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
- Citizen's band (CB) radio and mobile phones
- wireless internet
- satellite television and internet
- broadcast radio and television.

"Radiocommunications" is used as a broad term in this report to encompass all services that rely on microwave or radio frequency electromagnetic waves to transfer information, including those listed above.

2 DESCRIPTION OF THE SITE AND PROJECT

2.1 The site

The Project site is located in New South Wales, approximately 30 km north of Taralga and 30 km south of Black Springs. The terrain within the Project boundary is moderately complex with turbine base elevations ranging between approximately 860 m and 1050 m above sea level. Ground cover within the Project boundary consists primarily of farmland, interspersed with some areas of bushes and small patches of trees. Denser areas of forestry are located in the areas surrounding the Project.

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of up to 47 wind turbines [4]. A map of the site with the 47-turbine layout considered in this assessment is shown in Figure 1, and the coordinates of the turbine locations are presented in Table 8.

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by the Customer [5, 6]. For the purposes of this assessment, DNV has evaluated the potential for EMI-related impacts at identified dwellings within 5 km of the Project boundary. The locations of identified dwellings more than 5 km from the Project boundary have also been shown, where available, but impacts at these dwellings have not been considered in detail. There are 38 dwellings located within 5 km of the Project boundary, nine of which are involved dwellings. The coordinates of these dwellings are presented in Table 9, and the dwellings and Project boundary considered in this assessment are shown in Figure 1.

DNV has not carried out a detailed and comprehensive survey of building locations in the area and is relying on information provided by the Customer. For the purposes of this assessment, DNV has assumed that all listed dwellings are inhabited.

3 REGULATORY REQUIREMENTS

The SEARs for the Paling Yards Wind Farm [1] outline the following requirements for the assessment of interference to telecommunication services:

> *"Telecommunications – identify possible effects on telecommunication systems, assess impacts and mitigation measures including undertaking a detailed 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."*

In addition, the NSW Wind Energy Guideline [2] currently states:

> *"…the consent authority will give consideration to the risk of electromagnetic interference with telecommunication services in the area, and the adequacy of the measures proposed to ensure the level of service is maintained."*

Although both the SEARs and the NSW Wind Energy Guideline describe the requirements for assessing EMI related impacts, they do not provide detailed methodologies for these assessments.

The EPHC, in conjunction with Local Governments and the Planning Ministers' Council released a draft version of the National Wind Farm Development Guidelines in July 2010 (Draft National Guidelines) [3]. The Draft National Guidelines cover a range of issues across the different stages of wind farm development.

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

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

4 EMI CAUSED BY THE PHYSICAL PRESENCE OF WIND TURBINES

4.1 Assessment approach

If not properly designed, wind farms have the potential to interfere with radiocommunication services. Two services that are most likely to be affected are television broadcast signals and fixed point-to-point signals. Terrestrial broadcast signals are commonly used to transmit domestic television, while point-to-point 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 Customer has asked DNV to complete this assessment based upon a layout provided for the Project consisting of 47 wind turbines, as outlined in Table 8.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 158 m and a tip height of 240 m has been considered. These dimensions represent the maximum tip height and rotor diameter under consideration for the Project. The results generated based on this turbine configuration will be conservative for all turbine configurations with dimensions that remain inside the turbine envelope by satisfying all of the following criteria:

- a rotor diameter of 158 m or less
- an upper tip height of 240 m or less.

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

To conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the Project was obtained from a copy of the Australian Communication and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database dated 10 June 2022 [7].

Other services with the potential to experience interference from the Project have also been identified, and the potential for interference to those services assessed. These services include meteorological radars, trigonometrical stations, CB radio and mobile phones, wireless internet, broadcast radio, satellite television and internet, and broadcast television.

The Draft National Guidelines recommend that consultation with the relevant operator be undertaken if a turbine is located within 2 km of a radiocommunication site, within the second Fresnel zone of a point-to-point link, or within 250 nautical miles of an aeronautical or meteorological radar site. DNV has contacted organisations operating services that may be impacted by the development and operation of the Project, to disseminate basic information on the Project and request responses from the organisations regarding whether they foresee any potential EMI-related impacts on their operations and services. The organisations that have been contacted and all responses received to date are summarised in Table 18.

The radiocommunication licences and services with potential to experience EMI-related impacts from the proposed Project are considered in the following sections. Each section contains a brief overview of the relevant technology, followed by an assessment of the identified licences and

services in the area around the Project and the expected potential for interference. Details of any feedback obtained from the service operators and potential mitigation options are also included where appropriate.

4.2 Radiocommunication towers

Wind turbines located close to radiocommunication sites have the potential to cause interference through near-field effects or reflection or scattering of the signals. According to the Draft National Guidelines [3], the near-field zone for a transmission tower can vary from several metres to approximately 720 m depending on the service type. The Draft National Guidelines therefore recommend that any radiocommunication site within 1 km of a proposed turbine location be considered as a having the potential to be impacted by near-field effects. The potential for a turbine to cause reflection or scattering of signals also depends on a number of factors, including the service type, the required signal-to-noise ratio for the service, and the distances between the user, transmission tower, and turbine. Since there is no single criterion for potential impact on radiocommunication services due to near-field effects and reflection or scattering, the Draft National Guidelines recommend consulting with the service operator if any turbine is to be located within 2 km of a radiocommunication site.

4.2.1 Locations of radiocommunication towers and potential for interference

From the ACMA RRL database, there are 640 radiocommunication towers within a nominal 75 km of the Project boundary. The locations of these radiocommunication towers relative to the Project are shown in Figure 2.

There are three radiocommunication towers located within 2 km of the proposed turbine locations. These towers and the consultation zones recommended by the Draft National Guidelines [3] are shown in Figure 3 based on information obtained from the ACMA RRL database and extracted from aerial or satellite imagery. Each consultation zone includes the rotor radius for wind turbines with a 158 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations given in the ACMA RRL database. The size of the uncertainty buffer for each tower is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

Details of the licences associated with these radiocommunication towers are given in Table 1**.** These licences and services include point-to-point links and point-to-area style communications, comprising land mobile licences used for private mobile telephony (mobile radio and paging systems) and spectrum licences used for commercial public mobile phone networks.

Table 1 Details of radiocommunication towers located within 2 km of turbines at the proposed Project

Site ID	Operator	Licence/service types	Distance to nearest turbine [m]
202200	New South Wales Government Telecommunications Authority (NSW Telco Authority)	Point-to-point links Point-to-area (land mobile)	203
	NSW Police Force	Point-to-point links Point-to-area (land mobile)	
	NSW Rural Fire Service	Point-to-point links	
205732	Telstra Corporation Limited (Telstra)	Point-to-point links	1725
10006826	Telstra Corporation Limited (Telstra)	Point-to-point links Point-to-area (spectrum)	374

The potential for the Project to interfere with point-to-point links through reflection or scattering of signals or near-field effects is discussed further in Section 4.3. For the point-to-point links associated with the radiocommunication towers shown in Table 1, DNV has established potential reflection/scattering and near-field interference zones as described in Sections 4.3.1.2 and 4.3.1.3. Based on these interference zones, it is not expected that the Project will cause interference to the point-to-point links through near-field effects. However, there may be potential for the Project to cause interference to the point-to-point links through reflection or scattering of the signals.

Point-to-area style radiocommunications such as mobile radio and paging systems and commercial mobile phone networks are typically designed to operate in a range of environments and are generally not affected by the presence of WTGs any more than other effects such as terrain, vegetation, and other forms of signal obstruction. However, interference caused by reflection or scattering of signals or near-field effects can be a problem if the turbines are located close to the transmission tower. Reference [8] provides general guidance regarding the potential for interference with mobile radio systems, and suggests that a clearance of 500 m from the tower is sufficient to avoid significant impacts due to reflection or scattering of signals. Other references recommend that turbines be kept outside of clearance zones ranging from a distance of 200 m to 1200 m from the tower for these types of services [9]. Previous advice received from mobile phone network operators in Australia has suggested that clearances of between 500 m and 1000 m from their towers may be required to avoid the potential for impacts to mobile phone signals.

Given the proximity of the proposed wind turbine locations to the towers shown in Table 1, there is a potential for the Project to interfere with the associated point-to-area style communications through reflection or scattering of the signals. Near-field zones for these types of systems are typically only a few metres in radius, and so it is considered unlikely that the Project will cause interference to the services associated with these towers through near-field effects.

4.2.2 Stakeholder consultation and responses

DNV has contacted the operators of the services associated with the towers shown in Table 1 to determine the likelihood that the proposed Project will cause interference to their services through near-field effects or reflection or scattering of signals.

The responses received from the NSW Telco Authority and NSW Police Force indicate that there is potential for the Project to cause interference to their point-to-area style communications operated

from the radiocommunication tower at Site ID 202200. To avoid the potential for impacts to their point-to-area style communications, both the NSW Telco Authority and the NSW Police Force have requested that turbines be relocated to be outside a 1 km radius around the tower. This requested clearance zone is shown in Figure 4, with an additional buffer to account for potential inaccuracies in the tower locations given in the ACMA RRL database as discussed in Section 4.2.1. There are four turbines (PY-23, PY-24, PY-25, and PY-26) located within the 1 km clearance zone requested by the NSW Telco Authority and NSW Police Force for their point-to-area style licences.

A preliminary response has been received from Telstra, indicating that there is potential for the Project to cause interference to their mobile phone services operated from the radiocommunication tower at Site ID 10006826. To avoid the potential for impacts to their services, Telstra has requested that turbine PY-24 be relocated by at least 50 m north to northwest of its current proposed location. DNV understands that Telstra is currently undertaking a more detailed assessment of the potential for impacts to their assets and services, and expects to receive further feedback once this assessment is complete.

Table 2 summarises the turbines located within the requested clearance zones for each of the radiocommunication towers located within 2 km of the proposed turbine locations.

The responses received from the NSW Telco Authority and NSW Police Force regarding the potential for impacts to their point-to-point links associated with the tower at Site ID 202200 are discussed in Section 4.3.2. No response has been received to date from the NSW Rural Fire Service in relation to the tower identified in Table 1, or from Telstra in relation to their point-to-point links associated with the towers identified in Table 1, although DNV has been advised by both operators that their assessment is currently underway.

Table 2 Details of turbines located within the clearance zones requested by the operators for radiocommunication towers within 2 km of turbines at the proposed Project

Site ID	Operator	Requested clearance zone	Turbines within requested clearance zones
202200	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 km from tower	4 turbines (PY-23, PY-24, PY-25, PY-26)
	NSW Police Force	1 km from tower	
	NSW Rural Fire Service	No response received to date	
205732	Telstra Corporation Limited (Telstra)	No response received to date	-
10006826	Telstra Corporation Limited (Telstra)	Clearance zone not specified, relocation of turbine PY-24 by 50 m north to northwest requested	Relocation of turbine PY-24 requested

4.2.3 Mitigation options

To avoid the potential for impacts to the point-to-area style communications operated by the NSW Telco Authority and NSW Police Force from the tower at Site ID 202200, DNV recommends that turbines PY-23, PY-24, PY-25, and PY-26 be relocated to be outside of the clearance zones

requested by these operators. Given the importance of the tower to police service communications in the area around the Project, the NSW Police Force has indicated that alternative mitigation options may not be available for this tower.

Similarly, to avoid the potential for impacts to the mobile phone services operated by Telstra from the tower at Site ID 10006826, DNV recommends that turbine PY-24 be relocated as requested. It is also possible that relocation of turbine PY-24 to maintain the clearances requested by the NSW Telco Authority and NSW Police Force for the tower at Site ID 202200, as described in Section 4.3.2, may mitigate the potential for interference to the mobile phone services operated by Telstra from the tower at Site ID 10006826, but this would need to be confirmed by Telstra. Alternative mitigation measures would need to be determined in consultation with Telstra, but may include increasing the signal strength from the affected tower or alternative towers, or installing additional towers in the vicinity of the Project.

Mitigation options to resolve any impacts to point-to-point links are discussed in Section 4.3.3.

4.3 Fixed licences of point-to-point type

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 frequency of common microwave signals varies from approximately 1 GHz to 30 GHz.

Wind turbines can potentially cause interference to point-to-point microwave links and, in some cases, point-to-point ultra high frequency (UHF) links through three mechanisms: diffraction of the signal, reflection or scattering of the signal, and near-field effects. It is generally possible to design around these issues as the link paths and potential interference zones for these signals can be determined.

4.3.1 Locations of point-to-point links and potential for interference

DNV has analysed the registered licences for each radiocommunication tower according to the ACMA RRL database to determine the transmission paths of the licenced links. For this analysis, DNV has used a wider and more conservative frequency range of 0 GHz to 50 GHz.

Each individual link was given a unique identifier or "Assignment ID" so that it could be readily distinguished. This Assignment ID was taken as either the Device Registration ID (for spectrum licences associated with the use of certain frequency band within a particular geographic area) or the EFL ID (for apparatus licences associated with the use of a particular device).

The links paths associated with the analysed towers are shown in Figure 5. 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 emergency services towers.

There are nine point-to-point links recorded in the ACMA RRL database that pass over the proposed Project boundary, operated by the NSW Telco Authority, NSW Police Force, NSW Rural Fire Service, and Telstra. The details of the links are provided in Table 10, and the link paths are shown in greater detail in Figure 6 based on information obtained from the ACMA RRL database and extracted from aerial or satellite imagery.

The potential interference mechanisms and interference zones established by DNV for these links are described in Sections 4.3.1.1, 4.3.1.2, and 4.3.1.3, and summarised in Section 4.3.1.4.

Feedback obtained from the operators of the links, including their recommended clearance zones to reduce the potential for interference, is summarised in Section 4.3.2.

4.3.1.1 Interference caused by diffraction

The potential for interference to a fixed point-to-point link through diffraction or obstruction of the signal can usually be avoided by keeping clear of an exclusion zone of circular cross-section around the link path from the transmitter to the receiver [3, 10, 11], typically defined in terms of the Fresnel zones for the link. The *n*th Fresnel zone is comprised of all points for which, if the 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.

The radius of the *n*th Fresnel zone varies along the length of the signal, and is given by:

$$R_{Fn} = \sqrt{\frac{n\lambda d_1 d_2}{D}}$$

where d_1 is the distance from the transmitter
d_2 is the distance from the receiver
D is the distance from the transmitter to receiver, such that $d_1+d_2 = D$

To avoid interference to point-to-point links caused by signal diffraction, wind turbines, including the blades, should be kept outside of an exclusion zone based on either the second Fresnel zone as recommended in [10], or potentially 60% of the first Fresnel zone for links below 1,000 MHz with a clear line of sight as suggested in [8] (although DNV understands that this zone is under review by the authors of that document). For each of the links crossing the proposed Project boundary, DNV has established a diffraction exclusion zone based on the second Fresnel zone for that link.

It is common practice to have multiple Assignment IDs for the same physical link to cover practicalities such as licensing for sending or receiving signals. Accordingly, the second Fresnel zone for each link has been calculated based on the Assignment ID with the lowest frequency.

The potential diffraction exclusion zones in the horizontal plane are shown in Figure 6. Each exclusion zone includes the rotor radius for turbines with a 158 m rotor diameter, and an additional buffer on either side to account for potential inaccuracies in the tower locations given in the ACMA RRL database. The size of the uncertainty buffer for each link is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery.

DNV has also assessed the potential for the turbine blades to intersect with the diffraction exclusion zone for each point-to-point link in the vertical plane. This was achieved by examining the elevation and antenna heights at the end of each link, as well as the approximate elevation of areas within the Project boundary over which the link crosses.

The results of this analysis are summarised in Table 3. Considering the diffraction exclusion zones in both the horizontal and vertical planes, there are two turbines located within the exclusion zone established by DNV for one point-to-point link operated by the NSW Rural Fire Service. The diffraction exclusion zones for all other point-to-point links crossing the Project boundary are either clear of turbines in the horizontal plane or are expected to pass under the turbine rotors in the vertical plane.

4.3.1.2 Interference caused by reflection or scattering

Interference due to reflection or scattering of a fixed point-to-point link can occur when the signal produced by the transmitting antenna is reflected, scattered, or re-radiated by an intervening object into the corresponding receiver antenna. If the reflected or scattered signal is sufficiently strong that the ratio of the direct signal to the indirect signal is lower than the required carrier-to-interference (C/I) ratio, or protection ratio, for the link, the link performance can be degraded. The extent to which an object such as a wind turbine will reflect or scatter electromagnetic waves is characterised by its radar cross section (RCS) [10].

Reference [10] describes a methodology for calculating the C/I ratio that might be expected at a receiver in the presence of a reflected or scattered signal from a wind turbine at a specified location. By evaluating the C/I ratio for incremental changes in the distances between the transmitter, receiver, and wind turbine, and comparing this to the required C/I ratio, a potential interference zone can be defined.

For each of the identified links with a transmission tower near the proposed turbine locations, DNV has established a reflection/scattering interference zone based on the antenna gains and length of the link, the worst-case RCS for the turbine calculated according to the equation proposed in [12], and an assumed minimum C/I ratio of 20 dB [12]. The radiation patterns for the antennas were approximated using the reference radiation patterns given in the International Telecommunication Union (ITU) Recommendation F.699-8 [13].

The potential reflection/scattering interference zones are shown in Figure 6. Each interference zone includes the rotor radius for turbines with a 158 m rotor diameter, and an additional buffer to account for potential inaccuracies in the tower locations given in the ACMA RRL database. The size of the uncertainty buffer for each link is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery. For comparison, Figure 6 also shows the 2 km radius consultation zones for reflection or scattering effects as recommended by the Draft National Guidelines, centred on the transmission towers for the point-to-point links crossing the Project boundary.

The results of this analysis are summarised in Table 3. There are 25 turbines located within the potential reflection/scattering interference zones for the point-to-point links passing over the proposed Project boundary.

The method used to establish the reflection/scattering interference zones shown in Figure 6 assumes that the direct path for the point-to-point link has a clear line of sight with respect to the first Fresnel zone, and that the paths for the reflected or scattered signal from the transmitter to the turbine and from the turbine to the receiver also have a clear line of sight with respect to terrain [10]. For low frequency links, the direct path between the transmitter and the receiver is often obstructed by terrain. In this situation, a signal that has been reflected or scattered from a wind turbine with a clear line of sight to the transmitter or receiver may be considerably stronger than the direct signal and therefore have greater potential to cause interference [8]. As indicated in Table 3, the low frequency point-to-point link crossing the Project boundary operated by NSW Rural Fire Service does not have a clear line of sight between the transmitter and receiver. For this link, the necessary clearance zone to minimise the potential for interference caused by reflection or scattering may be larger than that shown in Figure 6.

Nevertheless, DNV notes that the reflection/scattering interference zones shown in Figure 6 are approximations only and may be overly conservative [3]. This is especially true for high frequency

links where increased antenna directionality (or gain) and narrower scatter regions can make the signal less susceptible to interference caused by reflection or scattering [8]. The turbine RCS and C/I ratios used to establish the interference zones were based on recommendations developed on behalf of the United Kingdom telecommunications regulator Ofcom [12], and may not be appropriate for point-to-point links operating in Australia. Uncertainties are also associated with the assumptions used to derive the Ofcom recommendations, and the use of ITU reference radiation patterns rather than the actual radiation patterns for the transmitting and receiving antennas. To account for these uncertainties, the potential for the Project to cause interference to fixed point-to-point links passing over the proposed Project boundary through reflection or scattering has been further assessed through consultation with the operators of those links, as described in Section 4.3.2.

4.3.1.3 Interference caused by near-field effects

The potential for interference to fixed point-to-point links caused by near-field effects can generally be avoided by keeping clear of the near-field zone for the transmitting or receiving antenna. Within the near-field zone, local inductive and capacitive effects are significant and it is difficult to predict the potential impacts of other objects on the transmitted or received signal. Although the near-field distance typically varies with direction relative to the link path, for most practical purposes the near-field zone can be approximated as a sphere centred on the transmitting or receiving antenna.

Reference [10] presents an equation for estimating the radius of the near-field zone for a point-to-point link from the properties of the transmitting or receiving antenna.

For each of the identified links with a transmission tower located near the proposed turbine locations, DNV has established a near-field interference zone based on the operating frequency and antenna gain for that link.

The potential near-field interference zones are shown in Figure 6. Each interference zone includes the rotor radius for turbines with a 158 m rotor diameter, and an additional buffer of to account for potential inaccuracies in the tower locations given in the ACMA RRL database. The size of the uncertainty buffer for each link is based on the deviations between the tower locations given in the ACMA RRL database and the apparent locations determined from aerial or satellite imagery

The results of this analysis are summarised in Table 3. There are no turbines located within the near-field interference zone for any of the point-to-point links passing over the proposed Project boundary. Therefore, it is not expected that the Project will cause interference to the point-to-point links through near-field effects.

4.3.1.4 Summary of point-to-point interference effects

Table 3 summarises the turbines located within the calculated diffraction, reflection/scattering, and near-field interference zones for each of the point-to-point links crossing the Project boundary.

Table 3 Details of turbines located within the interference zones established by DNV for point-to-point links crossing the proposed Project boundary

Link no.	Operator	Turbines within potential interference zone			
		Diffraction		Reflection/ scattering	Near-field
		Horizontal plane	Vertical plane		
1	New South Wales Government Telecommunications Authority (NSW Telco Authority)	None	Not assessed[1]	13 turbines (PY-8, PY-9, PY-10, PY-11, PY-12, PY-14, PY-15, PY-17, PY-20, PY-22, PY-23, PY-24, PY-26)	None
2	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 turbine (PY-24)	None[2]	5 turbines (PY-23, PY-24, PY-25, PY-26, PY-27)	None
3	New South Wales Government Telecommunications Authority (NSW Telco Authority)	None	Not assessed[1]	4 turbines (PY-23, PY-24, PY-25, PY-26)	None
4	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 turbine (PY-24)	None[2]	3 turbines (PY-23, PY-24, PY-26)	None
5	NSW Police Force	1 turbine (PY-24)	None[2]	6 turbines (PY-21, PY-23, PY-24, PY-25, PY-26, PY-27)	None
6	NSW Rural Fire Service	2 turbines (PY-28, PY-29)	2 turbines (PY-28, PY-29)	6 turbines[3] (PY-24, PY-26, PY-27, PY-28, PY-29, PY-30)	None
7	NSW Rural Fire Service	1 turbine (PY-24)	None[2]	4 turbines (PY-23, PY-24, PY-25, PY-26)	None
8	Telstra Corporation Limited (Telstra)	1 turbine (PY-17)	None[2]	11 turbines (PY-1, PY-2, PY-3, PY-4, PY-13, PY-14, PY-15, PY-16, PY-17, PY-23, PY-24)	None
9	Telstra Corporation Limited (Telstra)	None	Not assessed[1]	1 turbine (PY-34)	None

1. Wind turbines are sufficiently clear of the diffraction zone in the horizontal plane.
2. Second Fresnel zone is expected to pass under the turbine rotors in the vertical plane.
3. Direct link path does not have a clear line-of-sight with respect to the first Fresnel zone. The necessary clearance zone to minimise potential for interference caused by reflection or scattering may be larger than shown in Figure 6 for this link.

4.3.2 Stakeholder consultation and responses

DNV has contacted the operators of the point-to-point links crossing the proposed Project boundary to determine the likelihood that the proposed Project will cause interference to their operations and services through diffraction, reflection or scattering, or near-field effects.

The response received from the NSW Police Force indicates that there is potential for the Project to cause interference to their point-to-point link crossing the Project boundary. To avoid the potential for impacts to their link, the NSW Police Force has requested that turbines be relocated to be outside of a 1 km zone either side of the link path. This requested clearance zone is shown in Figure 7, with an additional buffer to account for potential inaccuracies in the tower locations given in the ACMA RRL database as discussed in Section 4.3.1. There are five turbines (PY-23, PY-24, PY-

25, PY-26, and PY-27) located within the 1 km clearance zone requested by the NSW Police Force for their point-to-point link.

The response received from the NSW Telco Authority also indicates that there is potential for the Project to cause interference to their point-to-point links crossing the Project boundary. To avoid the potential for impacts to their services, the NSW Telco Authority has requested that turbines be relocated to be outside a 1 km radius around the tower at Site ID 202200, but has not specified a clearance in relation to the point-to-point link paths. As discussed in Section 4.2.2 and shown in Figure 4, there are four turbines (PY-23, PY-24, PY-25, and PY-26) located within the 1 km clearance zone requested by the NSW Telco Authority for their radiocommunication tower.

Table 4 summarises the turbines located within the requested clearance zones for each of the point-to-point links crossing the Project boundary.

No responses have been received to date from the NSW Rural Fire Service or Telstra in relation to their point-to-point links crossing the Project boundary, although DNV has been advised by both operators that their assessments are currently underway.

Table 4 Details of turbines located within the clearance zones requested by the operators for point-to-point links crossing the proposed Project boundary

Link no.	Operator	Requested clearance zone	Turbines within requested clearance zones
1	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 km from tower	4 turbines (PY-23, PY-24, PY-25, PY-26)
2	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 km from tower	4 turbines (PY-23, PY-24, PY-25, PY-26)
3	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 km from tower	4 turbines (PY-23, PY-24, PY-25, PY-26)
4	New South Wales Government Telecommunications Authority (NSW Telco Authority)	1 km from tower	4 turbines (PY-23, PY-24, PY-25, PY-26)
5	NSW Police Force	1 km from tower and link path	5 turbines (PY-23, PY-24, PY-25, PY-26, PY-27)
6	NSW Rural Fire Service	No response received to date	-
7	NSW Rural Fire Service	No response received to date	-
8	Telstra Corporation Limited (Telstra)	No response received to date	-
9	Telstra Corporation Limited (Telstra)	No response received to date	-

4.3.3 Mitigation options

To avoid the potential for interference to the NSW Police Force and NSW Telco Authority point-to-point links crossing the Project boundary, DNV recommends that turbines PY-23, PY-24, PY-25, PY-26, and PY-27 be relocated to be outside of the clearance zones requested by the operators.

Given the importance of their link to police service communications in the area around the Project, the NSW Police Force has indicated that alternative mitigation options may not be available for this link.

Similarly, to avoid the potential for interference to the NSW Rural Fire Service point-to-point links crossing the Project boundary, DNV recommends that turbines PY-28 and PY-29 be moved outside of the diffraction exclusion zone established by DNV and shown in Figure 6. Alternative mitigation options would need to be identified in consultation with the NSW Rural Fire Service, but may include upgrading the equipment for the link, re-routing the link via an existing or new tower, or replacing the link with an alternative communication technology.

If interference to other point-to-point links is experienced after the Project is operational, mitigation options may also include upgrading the equipment for the link, re-routing the link via an existing or new tower, or replacing the link with an alternative communication technology.

4.4 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 ACMA RRL database. A point-to-multipoint licence allows communication between one or more static sites and multiple points or between the points, and is usually licensed for a defined operational area.

Administratively, the ACMA RRL database details the location of the static station for a fixed licence of the point-to-multipoint type but does not include the remote stations that communicate with the static station. Hence, the paths of the transmission vectors are not readily identifiable.

4.4.1 Locations of point-to-multipoint licences and potential for interference

From the ACMA RRL database, DNV has identified 156 point-to-multipoint Assignment IDs within approximately 75 km of the proposed Project boundary. These licences are shown in Figure 8. The details of the licence holders as given in the ACMA RRL database are provided in Table 11.

There are no point-to-multipoint base stations within 20 km of the Project boundary. However, there are several point-to-multipoint base stations located more than 20 km from the Project.

Wind turbines can cause interference to point-to-multipoint links through the same mechanisms as described for point-to-point links in Section 4.3.1. However, as it is not possible to know the link paths in a point-to-multipoint network without obtaining further information about the locations of each station in the network, consultation with the relevant operators is needed to determine the potential for interference.

4.4.2 Stakeholder consultation and responses

DNV has contacted the operators of potentially affected point-to-multipoint base stations within 60 km of the Project boundary, to determine the likelihood that the Project will cause interference to their services. Responses have been received from Ace Internet Services, the Bureau of Meteorology (BoM), and Water NSW, and no concerns have been raised. No other responses have been received to date.

4.4.3 Mitigation options

If interference to point-to-multipoint links is experienced after the Project is operational, mitigation options may include re-routing the links, installing additional towers, or replacing the affected links with alternative communications infrastructure.

4.5 Other licence types

Besides fixed point-to-point and point-to-multipoint licences, other licence types recorded in the ACMA RRL database include spectrum licences that permit a range of radiocommunications in a specific geographic area and frequency band, private mobile radio and public telecommunications service (PTS) licences, television and radio broadcasting licences, amateur apparatus licences, and aeronautical licences for ground to aircraft communications.

4.5.1 Locations of other licences and potential for interference

DNV has identified a number of other licences in the ACMA RRL database within 75 km of the proposed Project boundary. The locations of these licences and number of associated Assignment IDs for each licence type are shown in Figure 9 and Table 12.

Most of the licences identified can be broadly described as base to mobile station or point-to-area style communications, including commercial and private mobile telephony and radio and television broadcasting. These licence types are generally not affected by the presence of wind turbines any more than other effects such as terrain, vegetation, and other forms of signal obstruction.

The potential for interference to emergency services signals and commercial mobile telephony signals is discussed further in Sections 4.6 and 4.11 respectively, while the potential for interference to radio and television broadcasting services is considered 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. DNV understands that potential impacts to these services have been considered as part of an aviation impact study.

4.6 Emergency services

Licence types operated by emergency services such as state ambulance, police, fire, and rescue services typically comprise fixed point-to-point link and mobile radio communications.

4.6.1 Locations of emergency services licences and potential for interference

DNV has reviewed the ACMA RRL database to identify emergency services with licences for radiocommunication assets operating in the vicinity of the Project. The groups identified are listed in Table 13 along with their contact details. The nearest licence is associated with a tower located within the Project boundary approximately 200 m from the nearest proposed turbine.

The potential for the turbines at the Project to interfere with emergency services point-to-point links crossing the proposed Project site is discussed in Section 4.3.

All other licences operated by emergency services in the vicinity of the Project are point-to-area style licences used for mobile radio and paging systems. As discussed in Section 4.2, these types of systems are generally not affected by the presence of wind turbines any more than other forms of signal obstruction, provided that a suitable clearance from the transmission tower is maintained.

Considering the proximity of the proposed wind turbine locations to the transmission towers identified in Section 4.2, there is a potential for the Project to interfere with point-to-area style communications operated by the NSW Telco Authority and NSW Police Force from the tower at Site ID 202200, which is within 2 km of the proposed turbine locations. However, given the distance of other emergency services point-to-area style licences from the Project, DNV considers it unlikely that the Project will cause interference to the mobile radio and paging systems operated from those towers.

4.6.2 Stakeholder consultation and responses

DNV has contacted the operators of emergency services point-to-area style communications operated from towers within 2 km of the proposed turbine locations and point-to-point links crossing the Project boundary, to seek feedback regarding the potential for the Project to interfere with their operations and services. The responses received from those operators are discussed in Sections 4.2.2 and 4.3.2 respectively.

DNV has also contacted the operators of all other potentially affected stations within approximately 60 km of the Project to seek feedback regarding any potential impact that the Project could have on their operations and services. A response has been received from St John Ambulance, and no concerns have been raised. No other responses have been received to date.

4.6.3 Mitigation options

Potential mitigation options for impacts to emergency services point-to-area style communications operated from towers within 2 km of the proposed turbine locations and point-to-point links point-to-point links crossing the Project boundary are discussed in Sections 4.2.3 and 4.3.3 respectively.

Interference with point-to-area style communications operated from other towers is considered unlikely. If localised interference to mobile radio or paging system signals is experienced, this can often be mitigated by the user moving a short distance to a new or higher location to receive a clearer signal or by using an external antenna to improve the signal reception. Other mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing a signal repeater or additional tower on the opposite side of the Project.

4.7 Aircraft navigation systems and radar

DNV understands that a separate aviation impact study has been undertaken to assess the impact of the Project on nearby aviation navigation systems and radar.

4.8 Meteorological radar

The Bureau of Meteorology (BoM) operates a network of weather radars across Australia consisting of high-resolution Doppler radars and standard weather watch or weather surveillance radars. Operation of the BoM's part-time wind finding radar installations ceased in August 2019 [14].

Standard weather watch radars emit pulsed microwave radiation and use reflections or "echoes" of that radiation from water particles in the atmosphere to detect rain and storm activity. Doppler radar installations operate in the same way but are also able to measure the speed of the moving water particles, and therefore can provide information about wind speed and direction [15, 16].

While 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. Because radar installations monitor the current weather situation over a wide

area, the information they provide can be used to indicate the possibility and approach of severe storms, tropical cyclones, and flooding events. Wind profile measurements are also 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.

The optimal coverage area for a weather radar generally extends approximately 200 km from the radar installation at a height of around 3000 m [17, 18], and approximately 100 km at a height of 1000 m [18]. Therefore, wind farms can theoretically impact on weather radar operations when located within several hundred kilometres of an installation. However, due to the curvature of the earth and intervening terrain, the range at or near ground level is generally less.

The World Meteorological Organisation (WMO) currently states that wind turbines should not be located within 5 km of a meteorological radar site, due to the high potential for complete or partial blockage of the radar signal and subsequent loss of weather data [19, 20]. For wind farms located between 5 km and 20 km of a radar, the WMO recommends consultation and analysis to assess the likelihood of turbines causing reflection or scattering of the radar signals or interfering with Doppler velocity measurements. At distances of between 20 km and 45 km, the presence of a wind farm may produce radar echoes or signal clutter that can cause loss of data or be mistaken for rain. Significant impacts are generally not expected for wind farms located more than 45 km from a meteorological radar, since in most cases the turbine will below the radar scan line of sight. However, the WMO notes that these guidelines are only applicable to typical radar installations in flat terrain and may need to be modified for higher-powered radars or specific situations.

Recent advice received from the BoM also suggests that there may be potential for interference to meteorological radar operations from wind farms over much greater distances than indicated by the WMO guidelines, depending on the relative elevations of the radar and the wind farm and the intervening terrain.

According to the Draft National Guidelines, operators of weather radars within 250 nautical miles (463 km) of the proposed Project should be consulted [3].

4.8.1 Locations of meteorological radars and potential for interference

DNV has identified that the BoM operates 16 weather radars within 250 nautical miles of the proposed Project, with the closest radar located approximately 78 km east of the Project, at Camden. The locations of these radars are shown in Figure 10 and the details of each radar are given in Table 14.

Although the distance between the Project and the nearest BoM radar is greater than the distances at which the WMO suggests impact may occur, consultation with the BoM is needed to determine the potential for interference.

4.8.2 Stakeholder consultation and responses

DNV has contacted the BoM regarding the Project, as recommended by the Draft National Guidelines, to seek feedback on whether interference to their operations and services is likely.

The response received from the BoM indicates that the Project has potential to materially impact the operation of their Wollongong radar, which is located approximately 98 km east of the Project at Letterbox. Specifically, analysis undertaken by the BoM based on a turbine tip height of 230 m considered at the time of consultation has suggested that 10 turbines (PY-33, PY-34, PY-35, PY-36, PY-37, PY-38, PY-39, PY-43, PY-45, and PY-47) have potential to be visible on the first three scan

angles for the Wollongong radar and hence interfere with weather monitoring and predictions from this facility. Further advice provided by the BoM has confirmed that an increase in the turbine tip height from 230 m to 240 m would not change their conclusions and the same 10 turbines would be expected to be visible to the Wollongong radar for a tip height of 240 m.

To minimise the potential for impacts to their services and operations, the BoM has requested that turbines be relocated to be outside of the areas shown in Figure 11. Alternatively, if the identified areas cannot be kept clear of turbines, the BoM has asked that the Customer enter into a formal legal agreement to establish a strategic collaborative framework with the BoM that will enable the Project to proceed while minimising and managing the potential impacts on the BoM's operations. The BoM has provided a template for an agreement, which requires that the Customer commit to:

- informing the BoM of the final turbine layout for the Project and changes to the Project design, including changes to the turbine locations or height
- giving the BoM advance notice of any planned shutdown of the Project, to allow the BoM to calibrate their systems while the turbines are not operating and hence account for the presence of the Project in their signal processing and interpretation
- collaborating and cooperating with the BoM in the event of severe weather conditions in the interests of community safety, where such cooperation may include complying with a request from the BoM to shut down the identified turbines during critical weather conditions for an agreed period of time.

4.8.3 Mitigation options

To help minimise and manage the potential impact of the Project on the BoM's operations, without requiring the relocation of turbines, DNV recommends that the Customer engages further with the BoM to establish a strategic collaborative framework as outlined in Section 4.8.2. Alternatively, if desired by the Customer, the potential for interference to the Wollongong radar could be avoided by relocating turbines to be outside of the exclusion zone provided by the BoM.

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 Global Positioning System (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 km to 5 km, and could be intercepted or obstructed by the presence of turbines. However, the potential for impact is considered low as it is likely to be possible to relocate the target to obtain an unobstructed view of the trig point. Microwave systems can measure distances up to 150 km, but such systems are not limited by the line of sight or affected by visibility [21].

Global navigation satellite system (GNSS) technology is also commonly used for surveying and distance measurements, as it enables users to accurately determine their geographic location using positioning and timing information received from satellite signals. Geoscience Australia currently

operates several GNSS networks across Australia, including the Australian Regional GNSS Network (ARGN) and the AuScope GNSS network [22]. The ARGN is comprised of 20 permanent GNSS Continuously Operating Reference Stations (CORS) which provide the geodetic framework for the spatial data infrastructure in Australia and its territories. Eight stations from the ARGN form the Australian Fiducial Network (AFN) [23], through which the Geocentric Datum of Australia (GDA) is defined. The ARGN also provides information for the measurement of geological processes and contributes data to the International GNSS Service. Additional geospatial information aimed at enhancing the accuracy and resolution of the National Geospatial Reference System is provided by the AuScope GNSS network of around 100 CORS strategically distributed across the country, and several private and state-based GNSS CORS networks. GNSS stations are typically equipped with EDM devices and GPS receivers, and transmit data to Geoscience Australia or the relevant state authority via phone lines, internet, or satellite communications.

4.9.1 Locations of trigonometrical stations and potential for interference

According to Geoscience Australia [24], there are 12 trig points within 20 km of the Project boundary. One trig point, Defiance, is located inside the Project boundary approximately 256 m east of the nearest proposed turbine location. The details of these trig points are provided in Table 15 and their locations are illustrated in Figure 12.

DNV has reviewed the primary geodetic network of Australia [25] and observed that the Project is located within the third-order triangulation region. First-order triangulation depends on trigonometrical stations of known positions, baselines and heights, with the highest degree of accuracy. Points determined from first-order triangulation are then used for the second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

The closest GNSS station is located approximately 36 km southwest of the Project, at Crookwell [26]. Due to the significant distance between the Project and the GNSS station, it is considered unlikely that the Project will cause interference to the GNSS network.

4.9.2 Stakeholder consultation and responses

Although it is unlikely that the trig points in close proximity to the Project host EDM devices or other equipment that may be subject to EMI, DNV has contacted Geoscience Australia and NSW Spatial Services to inform them of the Project, and seek feedback regarding whether interference to their systems is possible.

The responses received from Geoscience Australia and NSW Spatial Services indicate that they do not expect the Project to interfere with their systems. However NSW Spatial Services has noted the proximity of the proposed turbine locations to the trig point at Defiance (identified by NSW Spatial Services as TS1797) and associated witness marks. Therefore, NSW Spatial Services has advised that they have no objection to the Project provided that the following conditions are met:

- NSW Spatial Services is advised of any distance-related restrictions for working in proximity to a wind turbine that would prevent surveyors from accessing and using the trig point and associated witness marks
- the trig point and any associated witness marks are located and physically protected from disturbance during construction of the Project
- photographs of the trig point and any associated witness marks are taken before and after construction of the Project and submitted to NSW Spatial Services

- the construction supervisor is advised of the importance of protecting the survey marks and associated witness marks
- a new submission is lodged for assessment by NSW Spatial Services if there are any major variations to the Project proposal.

4.10 Citizen's band radio

Citizen's band radio, also known as CB radio, is a class-licensed two-way, short distance communication service that can be used by any person in Australia for private or work purposes. It is commonly used in rural areas for emergency communications, road safety information, communication between recreational travellers, and general conversation. 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 communication activities, telemetry, and telecommand applications. The radio service operates on two frequency bands, namely the high frequency (HF) band between 26.965 MHz and 27.405 MHz and the ultra-high frequency (UHF) band between 476.425 MHz and 477.400 MHz.

The HF CB radio service was legalised in Australia in the 1970s as a temporary move to switch to UHF CB over the following five years, and transmits 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 the HF 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 a clear line-of-sight for a strong signal and is easily hindered by hilly terrain and forested areas. Even in the absence of physical obstructions, UHF CB radio signals generally cannot travel beyond the effective radio horizon, which depends on elevation, antenna height, weather, and atmospheric conditions. If located on a hilltop, CB radio signals can be transmitted over at least 50 km. However, under normal conditions on flat ground, signal range is typically limited to around 5 km. CB repeater stations are often 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.

4.10.1 Locations of CB radio devices and potential for interference

Since users of CB radio services 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. Given the limitations of UHF radio signals, CB radio services are typically only intended for local or short-range communications. CB radio signals passing through the Project are likely to be intercepted by existing obstructions such as terrain and vegetation, and there is little evidence in the literature to suggest that wind turbines pose a particular risk of interference to these systems. Therefore, the impact of the Project on CB radio services is expected to be minimal.

4.10.2 Mitigation options

If interference to CB radio signals is experienced, simple steps such as moving a short distance to a new or higher location until the signal strength improves may help to mitigate the impact. CB radio users can also increase their signal range and improve reception by switching their equipment to a higher power setting, using a longer antenna, or increasing the antenna mounting height.

4.11 Mobile phones

Mobile phone networks typically operate at frequencies of either between 700 and 900 MHz, or between 1800 MHz and 2600 MHz, however some new services may operate at up to 3500 MHz. At such frequencies, signals may be affected by physical obstructions such as buildings and wind turbines. However, mobile phone networks are designed to operate in such conditions and in most cases, if there is sufficient mobile network coverage and signal strength, the presence of wind turbines is unlikely to cause any interference.

In rural areas, the mobile network coverage may be more susceptible to physical obstructions due to the large distance between the phone towers and the mobile phone user. In that case, it is theoretically possible that wind turbines could cause some interference to the signal. However, there is little evidence in the literature of wind turbines interfering with mobile phone signals, and DNV notes that previous advice received from mobile phone network operators in Australia has generally indicated that they do not expect wind farm developments to interfere with their services provided that appropriate clearances from the mobile phone towers are maintained.

4.11.1 Availability of mobile phone services and potential for interference

DNV has reviewed the locations of mobile phone towers in the vicinity of the proposed Project. The locations of these towers are shown in Figure 13. The nearest mobile phone tower is located within the Project boundary, approximately 374 m northeast of the nearest proposed turbine location.

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

Figure 14 and Figure 15 show the Optus Mobile network coverage for the Project area [27]. Optus 3G coverage is limited to small, isolated areas to the south and southwest of the Project, and is only available outdoors with the use of an external antenna. Similarly, Optus 4G coverage is limited to outdoor coverage in small, isolated areas to the south, southwest, and west of the Project, although there are some areas where an external antenna is not required. There is essentially no Optus 3G or 4G network coverage within the Project boundary or in the immediate vicinity.

Figure 16 and Figure 17 show the Telstra network coverage for the Project area [28]. Telstra 3G and 4G coverage is available across most of the area within the Project boundary, and in the areas surrounding the Project. However, there are many locations in the vicinity of the Project where Telstra network coverage is not available, presumably due to obstruction of the signals caused by the local terrain.

Figure 18 shows the Vodafone network coverage for the Project area [29]. Vodafone 3G and 4G coverage is only available in outdoor areas to the northeast, east, and southeast of the Project, and requires the use of an external antenna. There is no Vodafone network coverage within the Project boundary or in the immediate vicinity.

As discussed in Section 4.2, there is a potential for the Project to interfere with Telstra services operated from a tower within 2 km of the proposed turbine locations through reflection or scattering of the signals. For services operated from other towers, interference to mobile phone

signals is generally considered unlikely in areas with good coverage. However, for areas where the reception is likely to be marginal, such as those where an external antenna is required, the possibility for interference exists if a wind turbine intercepts the signal between a mobile phone and the tower. Since there is essentially no Optus or Vodafone signal coverage in the immediate vicinity of the Project, it is unlikely that nearby residents are using these networks and therefore unlikely that these services will be impacted by the Project. For Telstra services operated from towers other than the tower within the Project boundary, there is a low theoretical potential for interference in areas with marginal reception if a wind turbine intercepts the signal between a receiver and the tower.

4.11.2 Stakeholder consultation and responses

DNV has contacted Optus, Telstra, and Vodafone to inform them of the proposed Project and to seek feedback on any potential impact that the Project could have on their services. The responses received from Optus and Vodafone indicate that they do not expect the Project to interfere with their services.

The preliminary response received from Telstra regarding potential impacts to their mobile phone network is discussed in Section 4.2.2. More generally, Telstra have advised that they currently operate underground telecommunications infrastructure within the Project boundary and have asked that the Customer seek further information about the locations of this infrastructure and advise Telstra if any physical impacts are expected.

Telstra have also advised that, in addition to an assessment of potential EMI impacts on their wireless radiocommunications, they also need to consider potential electrical impacts on their network infrastructure. DNV is currently engaging with Telstra to facilitate this assessment.

4.11.3 Mitigation options

Potential mitigation options for impacts to Telstra services operated from the mobile phone tower within 2 km of the proposed turbine locations are discussed in Section 4.2.3.

Interference with mobile phone signals from other towers is considered unlikely. If localised interference is experienced by mobile phone users, this can often be rectified by the user moving a short distance to a new or higher location until the signal improves, or using an external antenna to improve the signal reception. For interference over a larger area, or in cases where it would not be possible or practical for the user to change their location, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing an additional tower on the opposite side of the Project.

4.12 Wireless internet

Wireless internet services in Australia include wireless broadband provided by mobile phone network operators and other internet service providers, and fixed wireless or satellite internet services through the National Broadband Network (NBN).

4.12.1 Wireless broadband services

Wireless broadband services allow the user to connect to the internet without the need for a phone line or cable connection. The wireless signals may operate by line of sight between a base station and the user's antenna as part of a point-to-multipoint network, or may use point-to-area style transmissions such as mobile phone networks.

4.12.1.1 Availability of wireless broadband services and potential for interference

Ace Internet Services Pty Ltd holds point-to-multipoint licences in the vicinity of the Project, with a base station located 55 km from the Project. Other possible internet service providers also hold point-to-multipoint or point-to-area style licences in the vicinity of the Project, but all such licences are more than 60 km from the Project boundaries. As the locations of the customers of these internet service providers are not known, it is not possible to determine whether there is any potential for interference to their services. However, given the significant distances between the Project and the licences held by potential internet service providers, it is considered unlikely that these operators will be servicing customers in the vicinity of the proposed Project.

However, residents in the vicinity of the Project may use wireless broadband services provided by Telstra. The Telstra wireless broadband service use the same network as the mobile phone service, and therefore the comments made in Section 4.11.1 are applicable here. Specifically, there is potential for the Project to interfere with Telstra services operated from a tower within 2 km of the proposed turbine locations through reflection or scattering of the signals. For services operated from other towers, there is a low theoretical potential for interference in areas with marginal reception if a wind turbine intercepts the signal between a receiver and the tower.

4.12.1.2 Stakeholder consultation and responses

DNV has contacted Optus, Telstra, and Vodafone to seek feedback on any potential impacts that that the Project could have on their services, as discussed in Section 4.11.2. The responses received from Optus and Vodafone indicate that they do not expect the Project to interfere with their services. The preliminary response received from Telstra regarding potential impacts to their mobile phone network, which is also used for their wireless broadband service, is discussed in Section 4.2.2.

DNV has also contacted Ace Internet Services to seek feedback regarding the potential for interference to their services. The response received from Ace Internet Services indicates that they do not expect the Project to interfere with their services.

4.12.1.3 Mitigation options

Potential mitigation options for impacts to Telstra services operated from the mobile phone tower within 2 km of the proposed turbine locations are discussed in Section 4.2.3.

Interference with other wireless broadband services is considered unlikely. If interference to the wireless broadband services provided by mobile phone networks occurs, the mitigation options given in Section 4.11.3 may be applicable. Specifically, localised interference can often be rectified by the user moving a short distance or using an external antenna to improve signal reception. For interference over a larger area, or in cases where it would not be possible or practical for the user to change their location, mitigation options may include increasing the signal strength from the affected tower or alternative towers, or installing a signal repeater or additional tower on the opposite side of the Project.

4.12.2 National Broadband Network

The NBN is a national wholesale broadband access network, which consists of fixed line, fixed wireless, and satellite internet services.

NBN fixed line services use wired connections to provide internet signals directly to the user. This technology is typically only available in urban areas and is not expected to be affected by wind farm developments.

NBN fixed wireless services are available in many rural and regional areas. The signals operate by line of sight between an NBN tower and the user's antenna, with a maximum range of 14 km [30]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [31].

For rural and remote users in areas that are not able to receive fixed line or fixed wireless services, NBN satellite internet signals are available from the NBN Sky Muster I and II satellites.

4.12.2.1 Availability of NBN services and potential for interference

The NBN website [32] indicates that the network is currently available as a satellite internet service using the NBN SkyMuster I and II satellites only in the areas surrounding the Project site. It is therefore likely that some residents are currently accessing the internet via the NBN and that the network will also be available to other residents in the vicinity of the Project in the near future. However, given that the network is only available as a satellite internet service service, it is unlikely that the Project will impact on residents who are currently using the NBN.

The potential for interference to satellite internet signals from the NBN Sky Muster I and II satellites is considered in Section 4.13.

4.12.2.2 Stakeholder consultation and responses

DNV has contacted NBN Co to seek feedback on whether there is potential for the Project to cause interference to their services, and to allow them to take the presence of the Project into account in their coverage planning maps. The response received from NBN Co indicates that they do not expect the Project to interfere with their services. However, NBN Co has requested that the Customer provides details of any radiocommunication equipment planned to be used during construction or operation of the Project, once this information is available, so that any potential for interference from that equipment can also be assessed.

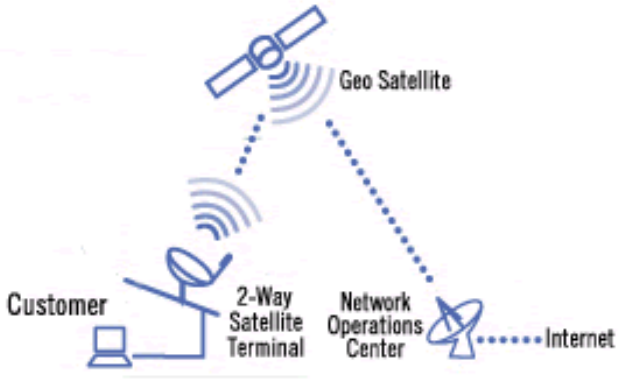
4.13 Satellite television and internet

In some rural or remote areas, television and internet access can only be provided through satellite signals.

Satellite television is delivered via a communication satellite to a satellite dish connected to a set-top box. Satellite television signals are typically transmitted to the user's antenna in one of two frequency bands: the C-band between 4 GHz and 8 GHz, or the Ku-band 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. 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. The main satellites that transmit Australian free-to-air or subscription television channels are the Optus C1, D1, and D3 satellites and the Intelsat 19 satellite [33, 34].

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 or 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. Satellite internet signals are typically transmitted in the Ku-band, as for satellite television, or the Ka-band, with frequencies ranging from 26.5 GHz to 40 GHz. Like signals in the Ku-band, signals in the Ka-band are susceptible to deterioration caused by moisture in the air, but newer satellites contain technologies that help to minimise the loss of signal quality associated with rain

and other weather conditions. The main satellites for providing satellite internet in Australia are the IPSTAR (THAICOM-4) and Optus D2 satellites, and the NBN SkyMuster I and II satellites.



Two-way connection to the internet via satellite [35]

4.13.1 Locations of satellite vectors and potential for interference

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

A number of satellites transmit television and internet signals that can be received in Australia. Although only a small number of satellites are likely to be providing services specifically intended for Australian audiences, DNV has considered the line of sight to dwellings in the vicinity of the Project from all theoretically viewable satellites.

The results of the analysis are shown in Table 16 and summarised in Table 5. Based on these results, turbines at the Project may intercept signals from 53 satellites at 13 nearby dwellings, five of which are involved dwellings.

DNV understands that all the potentially affected satellites shown in Table 16 provide television signals intended for international audiences, and considers it unlikely that residents in the vicinity of the Project will currently be receiving signals from these satellites. Many of the satellites have a low angle of elevation above the horizon at the wind farm site location, and so degradation caused by atmospheric effects or interference from terrain or other obstacles may already prevent the signals from being received at the affected dwellings. For some of these satellites, the programs transmitted on the beam footprints that cover Australia may also be available through other satellite services which have a higher angle of elevation above the horizon and are not expected to be intercepted by turbines at the Project. If residents are not currently receiving signals from the satellites identified in Table 16, either by choice or because those signals are not available due to existing degradation or interference, there will be no potential for the Project to impact on those services.

Table 5 Number of satellites with potential for signals to nearby dwellings to be intercepted by the proposed Project

Satellite service	Number of potentially affected satellites	Number of potentially affected dwellings
Services intended for Australian audiences	None	None
Services intended for international audiences	53	13 (5 involved dwellings)

4.13.2 Stakeholder consultation

As discussed in Section 4.13.1, it is unlikely that nearby residents are currently receiving signals from satellites that may be affected by interference from turbines at the Project. If desired by the Customer, the potential for impact could be confirmed by engaging with the residents of the dwellings identified in Table 5 prior to construction of the Project to determine if any are currently receiving signals from the potentially affected satellites and to establish an understanding of how any impact to these services may be mitigated.

4.13.3 Mitigation options

If interference to satellite television signals is experienced at dwellings in the vicinity of the Project, several mitigation options may be available. If an alternative source of the same programming is available, the satellite dishes at affected dwellings can simply be re-directed to receive signals from the other satellite. In some cases, residents may also be able to access the affected programs directly over the internet. If an alternative source of programming is not available, it may be possible to rectify interference by installing a larger or higher-quality satellite dish, or by changing the height or location of the dish to obtain a stronger signal.

4.14 Radio broadcasting

Radio stations typically broadcast using one of two forms of transmission: either amplitude modulation (AM) or frequency modulation (FM). In Australia, AM radio operates in the medium wave (MW) band at frequencies between 520 kHz and 1610 kHz, while FM radio operates in the very high frequency (VHF) band between 87.5 MHz and 108 MHz.

4.14.1 AM radio

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 physical obstructions on the surface of the earth (such as wind turbines), however they do not propagate easily through some dense building materials such as brick, concrete, and aluminium.

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

However, as noted above, the presence of physical obstructions such as turbines is unlikely to cause significant interference to AM radio signals. Due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a turbine [36].

4.14.1.1 Locations of AM transmitters and potential for interference

The locations of AM broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [37], and are shown in Figure 19.

It is unlikely that any permanent AM radio receivers will be located sufficiently close to the Project to be affected by interference to the radio signals from the turbines.

4.14.1.2 Mitigation options

In the event that localised interference to AM radio signals is experienced, this can potentially be rectified by installing a high-quality antenna or amplifier at the affected residence.

4.14.2 FM radio

FM radio signals are better suited to short range broadcasting. Unlike lower frequency signals (such as AM signals), they are not reflected or refracted off the ionosphere. Instead, the waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon. However, FM radio signals may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage, which 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. Interference to FM signals can occur by two mechanisms: reflection or scattering of the radio waves, or physical obstruction and attenuation of the broadcast signal.

Reflection or scattering of radio waves by physical structures such as wind turbines can reduce the 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 result in hissing, fluttering, or distortion being heard by the listener [38]. However, this type of interference is typically only experienced in the immediate vicinity (within several tens of metres) of a wind turbine, where the signal-to-noise ratio is low [36, 39].

Wind turbines located close to an FM transmitter may also present a physical obstruction to the radio signal. If the line-of-sight between the transmitter and a radio receiver is blocked by a turbine, this can cause a noticeable decrease in signal quality or may lower the signal strength below the threshold of the receiver's sensitivity [38]. In these situations, the attenuation of the signal may be as great as 2.5 dB in the direction of the obstructing wind turbine. However, this type of interference is generally only a problem near the edges of the FM signal coverage area, where the broadcast signal is already weak. For commercial FM broadcast signals, physical obstruction of the signal may occur if the turbines are located within approximately 4 km of the transmitter [40].

4.14.2.1 Locations of FM transmitters and potential for interference

The locations of FM broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [37], and are shown in Figure 19.

The closest FM broadcast transmitter is located approximately 35 km from the proposed Project boundary. Therefore, it is considered unlikely that the Project will cause interference to the FM radio signals from this transmitter.

It is unlikely that any permanent FM radio receivers will be located sufficiently close to the Project to be affected by reflection or scattering of the radio signals from the turbines.

4.14.2.2 Mitigation options

In the event that localised interference to FM radio signals is experienced, this can potentially be rectified by installing a high-quality antenna or amplifier at the affected residence.

4.14.3 Digital radio

Digital radio services were introduced in metropolitan licence areas in Australia in 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 [41]. Digital radio broadcasts in Australia operate in the VHF band at frequencies between 174 MHz and 230 MHz, and therefore tend to have only local coverage within the visual horizon.

The UK telecommunications regulator Ofcom [38] states that *"In contrast [to FM signals], the signal format used for DAB digital radio is designed to offer high levels of robustness in difficult conditions and it is not materially affected by reflections. FM and DAB reception can be affected where a structure blocks signals and both may cease to function if signals are reduced below a certain threshold"*. DNV has therefore concluded that DAB signals are not affected by reflection or scattering from physical structures in the same way as FM signals, and so digital radio broadcasts are generally not susceptible to interference from wind farm developments. However, interference may be experienced if the line-of-sight between a DAB transmitter and a radio receiver is blocked by a wind turbine.

4.14.3.1 Availability of digital radio services and potential for interference

According to the digital radio coverage search function available on the Digital Radio Plus website [42], the Project is outside the intended service area for digital radio broadcasts. Since it is therefore unlikely that residents in the vicinity of the Project are currently receiving digital radio signals, it is not expected that the Project will cause interference to these services.

4.15 Terrestrial television broadcasting

Terrestrial television is broadcast in Australia by a number of networks, both public and commercial. As of December 2013, all television broadcasts in Australia are now digital broadcasts [43]. Digital television (DTV) signals are typically more robust in the presence of interference than analogue television signals, and are generally unaffected by interference from wind turbines. DNV has experience in situations where dwellings were able to receive adequate DTV reception in an area of adequate signal strength where the DTV signal was passing through a wind farm.

The susceptibility of DTV signals to interference from wind turbines is discussed further in Section A.1 of Appendix A.

4.15.1 Availability of DTV broadcasting and potential for interference

The locations of DTV broadcast transmitters in the vicinity of the Project were determined from the ACMA Broadcast Transmitter Database [43], and are shown in Figure 19. The main DTV transmitter used by residents in the vicinity of the Project is the Central Tablelands transmitter at Mt Canobolas. However, according to the Australian Government mySwitch website [44], it is also possible that residents to the northeast and east of the Project may be able to receive DTV signals from the Illawarra transmitter at Knights Hill or the Canberra transmitter at Black Mountain.

Coverage maps for the Central Tablelands, Illawarra, and Canberra broadcast transmitters are reproduced in Figure 20 to Figure 22. Coverage from the Central Tablelands transmitter is patchy across most of the area around the Project, with small, isolated areas of variable to good coverage close to the proposed turbine locations in the west of the Project and within approximately 10 km of the turbine locations to the north, south, and southwest. However, there are also large areas around the Project where coverage from the Central Tablelands transmitter is not available. Coverage from the Illawarra transmitter is also patchy with variable to good coverage in areas to the northeast and east of the Project, but variable to poor coverage within the Project boundary and in isolated areas to the north, south, and southeast. There is essentially no coverage from the Illawarra transmitter to the northwest, west, or southwest of the Project. Similarly, variable to poor coverage from the Canberra transmitter is available in some areas to the northeast and east of the Project, within the Project boundary, and in very small, isolated areas to the south, but there is essentially no coverage in all other areas around the Project within approximately 10 km of the turbine locations.

Other DTV transmitters servicing the broader area around the Project include the Crookwell and Taralga relay transmitters, located to the southwest and southeast of the Project respectively. However the mySwitch website suggests that neither of these transmitters provide reliable DTV coverage within approximately 5 km of the Project and coverage at up to 10 km from the Project is also extremely limited. Therefore, it is considered unlikely that residents in the vicinity of the Project will currently be receiving signals from the Crookwell and Taralga transmitters and so the potential for the Project to interfere with the signals from those transmitters has not been considered further in this assessment.

4.15.1.1 Interference caused by large scale effects

For broadcast signals, large scale interference can generally be avoided by placing the wind turbines at some distance from the transmitter. Broadcast transmitters may be either relay or primary transmitters. Relay transmitters are more commonly found in rural areas. Primary transmitters are higher power and are more commonly located near large urban areas. A clearance of at least 1 km is recommended for relay transmitters, while a clearance of at least 6 km is recommended for primary transmitters [11].

The closest DTV transmitter to the Project is the Taralga relay transmitter which is approximately 26 km away. Therefore, it is considered unlikely that the Project will cause large scale interference to signals from this transmitter.

4.15.1.2 Interference caused by reflection or scattering

Although DTV signals are generally unlikely to be susceptible to interference from wind turbines in areas of adequate coverage, interference could be encountered in areas where coverage is marginal and antennas at dwellings may receive a reflected signal from a turbine that is of sufficient power to interfere with the signal received directly from the transmitter. Based on the coverage maps for the area around the Project, it is possible that some areas could be deemed to have marginal reception and interference could be encountered.

Due to the lack of an accurate theoretical scattering model, DNV has not performed detailed scatter calculations to predict DTV interference. Instead, dwellings that have increased potential to receive back-scattered or forward-scattered signals from a turbine at the Project (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 in Section A.3 of Appendix A, with a forward-scatter distance of 5 km and a back-scatter distance of 500 m.

The results of the analysis can be seen in Table 17 and Figure 20 to Figure 22. The dwellings most likely to be susceptible to interference include those within the possible interference zones, as summarised in Table 6.

Note that if the signal received at a dwelling from the transmitter is sufficiently weak, or an antenna with insufficient directional discrimination is installed (i.e., a low gain or omni-directional antenna), interference may still occur at dwellings outside of the identified interference zones. Circumstances under which interference may occur outside the interference zones typically established using the 'keyhole' approach are discussed further in Section A.2 of Appendix A. In particular, although DNV has considered the potential for interference to DTV signals at dwellings within 5 km of the proposed turbine locations, previous advice received from BAI Communications, who are responsible for broadcasting of national public television services in Australia, has indicated that interference to DTV broadcasting may be experienced at distances of up to 10 km from turbines. For comparison, Figure 20 to Figure 22 also show the area within 10 km of the proposed turbine locations, although a more detailed assessment would be required to determine whether there is any potential for interference to DTV signals received at dwellings outside the 'keyhole' interference zones.

Based on this analysis, dwellings located within the Project boundary and to the south and southeast of the Project have increased potential to experience interference to DTV signals from the Central Tablelands transmitter, while dwellings located within the Project boundary and to the immediate north have increased potential to experience interference to signals from the Illawarra and Canberra transmitters. According to the coverage maps shown in Figure 20 to Figure 22, dwellings within the potential interference zones but outside the Project boundary are unlikely to be receiving signals from the corresponding transmitter. However, if any dwellings are currently receiving signals from one of these transmitters, those signals are likely to be weak or marginal and there may be potential for the dwelling to receive a stronger reflected signal from a turbine and therefore to experience interference. The dwellings with the greatest potential to experience interference to DTV signals from the identified transmitters are those located within the Project boundary, close to the turbines in the western part of the Project, although even these dwellings are unlikely to be receiving signals from the Illawarra or Canberra transmitters.

Table 6 Number of dwellings located within potential interference zones for digital television broadcast transmitters in the vicinity of the Project

DTV broadcast transmitter	Number of dwellings in potential interference zone	Signal coverage in potential interference zone
Central Tablelands (Mt Canobolas)	13 (6 involved dwellings)	Variable to good near turbines in the western part of the Project, limited elsewhere – dwellings in the potential interference zone but outside the Project boundary are unlikely to be receiving signals from this transmitter
Illawarra (Knights Hill)	6 (3 involved dwellings)	Limited – dwellings in the potential interference zone are unlikely to be receiving signals from this tower
Canberra (Black Mountain)	10 (8 involved dwellings)	Limited – dwellings in the potential interference zone are unlikely to be receiving signals from this tower

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 in most cases as the implications of potential television interference are typically low. If reception difficulties are encountered, there are a number of mitigation options available as discussed in further detail in Section 4.15.3.

4.15.2 Stakeholder consultation and responses

DNV has contacted BAI Communications, who are responsible for broadcasting of national public television services in Australia, to inform them of the proposed Project and seek feedback on any potential impact that the Project could have on DTV signals in the surrounding area. No response has been received to date.

4.15.3 Mitigation options

In the event that television interference is an issue during construction or after commissioning of the Project, there are several amelioration options available:

1. Realigning the user's television antenna more directly towards their existing transmitter.
2. Tuning the user's antenna into alternative sources of the same television signal or a substitute signal.
3. Installing a more directional or higher gain antenna at the affected dwelling.
4. Relocating the antenna to a less affected position.
5. Installing cable or satellite television at the affected dwelling.
6. Installing a television relay transmitter.

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. However, the effectiveness of this mitigation may be reduced if there is no clear line of sight from the antenna to the transmitter. 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 [45], DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [46] identified that the receiver height can also affect interference. In areas that are relatively flat and free of vegetation, reflections can enhance or decrease the received signal strength relative to the free path signal strength. The ITU found that the received signal strength may not increase monotonically with receiver height. In other words, lowering the receiver height can improve reception in some cases.

In the event that terrestrial DTV reception cannot be improved, satellite television represents another potential amelioration option. Satellite based television comprises of both free to air and subscription-based broadcasts. Residents in areas which are unable to receive DTV through their normal television antenna due to local interference, terrain, or distance from the transmitter in their area may be eligible to access the Australian Government funded Viewer Access Satellite Television (VAST) service [47].

5 CONCLUSIONS

Broadcast towers and transmission paths around the Project were investigated to determine if EMI would be experienced as a result of the development and operation of the Project. The Project will involve the installation of up to 47 wind turbine generators. DNV has considered a turbine geometry that will be conservative for turbine configurations with dimensions satisfying all of the following criteria: a rotor diameter of 158 m or less and an upper tip height of 240 m or less.

The results of this assessment, including feedback obtained from relevant stakeholders, are summarised in Table 7.

It is noted that, in its current configuration, the Project has the potential to interfere with several point-to-point links crossing the proposed Project boundary and point-to-area style communications hosted by radiocommunication towers located within 2 km of the proposed turbine locations.

To avoid the potential for impact to their point-to-point links and point-to-area style communications, the NSW Telco Authority has asked that turbines be relocated to be outside a 1 km radius around the tower hosting their services. The NSW Police Force has also raised concerns about the potential for impact to their operations, and has asked that turbines be relocated to be outside both a 1 km radius around the relevant tower and a 1 km clearance zone on either side of the link path for their point-to-point link crossing the Project boundary.

Although feedback has not yet been received from either Telstra or the NSW Rural Fire Service regarding potential impacts to their point-to-point links crossing the Project boundary, DNV recommends that turbines be relocated to be outside the diffraction exclusion zone established in this assessment for a point-to-point link operated by NSW Rural Fire Service. Additionally, a preliminary response from Telstra regarding potential impacts to their mobile phone services operated from a tower located within 2 km of the proposed turbine locations has asked that one turbine be relocated by at least 50 m from its current proposed location. Consultation with both Telstra and the NSW Rural Fire Service is ongoing to confirm the potential for impact to their assets and any required clearances.

Feedback received from the BoM indicates that there is potential for the Project to materially impact on the operation of their Wollongong radar facility and the associated weather monitoring and prediction services. To avoid the potential for impact to their operations, the BoM has asked that turbines be relocated to be outside of a defined exclusion zone. Alternatively, the Customer may enter into a formal agreement to establish a strategic collaborative framework with the BoM to help minimise and manage the potential impacts without the relocation of turbines.

Turbines at the Project may also interfere with public point-to-area style services such as mobile phone signals from towers outside the Project boundary, radio broadcasting, and terrestrial television broadcasting, particularly in areas with poor or marginal signal coverage. Dwellings in the vicinity of the Project may experience interference to digital television broadcast signals from the Central Tablelands, Illawarra, and Canberra transmitters. Coverage maps for these transmitters indicate that most of the identified dwellings are unlikely to be receiving signals from the affected transmitter. However, if any dwellings are currently receiving signals from these transmitters there may be potential for those dwellings to receive a stronger reflected signal from a turbine and therefore to experience interference. If interference to public point-to-area style services is experienced, a range of options are available to rectify difficulties.

Potential EMI impacts on other services considered in this assessment, including other emergency services, point-to-multipoint links, satellite television and internet signals, trigonometrical stations, and CB radio are either considered to be minor or have been assessed through consultation with the service operators.

Table 7 Summary of EMI assessment results for the proposed Project

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio-communication towers	3 towers within 2 km of proposed turbine locations, hosting point-to-point links and point-to-area style communications operated by: NSW Telco Authority NSW Police Force NSW Rural Fire Service Telstra Corporation Limited Nearest tower: 203 m from turbines	**NSW Telco Authority, NSW Police Force:** potential for interference raised (see feedback for point-to-point links and emergency services) **Telstra:** potential for interference raised (see feedback for mobile phones) **NSW Rural Fire Service:** no response received	**Point-to-point links:** see findings for point-to-point links **Point-to-area style communications:** see findings for emergency services and mobile phones	**Point-to-point links:** see mitigation for point-to-point links below **Point-to-area style communications:** see mitigation for emergency services and mobile phones
Fixed point-to-point links	9 links crossing Project boundary, operated by: NSW Telco Authority NSW Police Force NSW Rural Fire Service Telstra **NSW Telco Authority links:** no turbines in diffraction or near-field zones, 15 turbines in potential reflection/scattering zones **NSW Police Force link:** no turbines in diffraction or near-field zones, 6 turbines in potential reflection/scattering zones **NSW Rural Fire Service links:** 2 turbines in diffraction zone for one link, 7 turbines in potential reflection/scattering zones, no turbines in potential near-field zones **Telstra links:** no turbines in diffraction or near-field zones, 12 turbines in potential reflection/scattering zones	**NSW Telco Authority:** potential for interference raised, 1 km clearance around tower requested – *4 turbines in requested clearance zone* **NSW Police Force:** potential for interference raised, 1 km clearance around tower and link path requested – *5 turbines in requested clearance zone* **Other operators:** no response received	**NSW Telco Authority, NSW Police Force, NSW Rural Fire Service links:** high likelihood of interference **Other links:** low likelihood of interference	**NSW Telco Authority and NSW Police Force links:** relocate turbines to be outside clearance zones requested by operators **NSW Rural Fire Service link:** relocate turbines to be outside diffraction exclusion zone established by DNV **Other links:** if required - relocate turbines to be outside any requested clearance zones, reroute affected links, replace affected links with alternative technologies
Fixed point-to-multipoint links	156 assignments within 75 km of Project boundary No base stations within 20 km of Project boundary	**Ace Internet Services, BoM, Water NSW:** no concerns raised **Other operators:** no response received	**Ace Internet Services, BoM, Water NSW licences:** none **Other licences:** potential for interference if link paths cross the Project near turbines	If required – relocate turbines to be outside any interference zones, reroute affected links, install additional towers, replace affected links with alternative technologies

Table 7 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Other licence types	**Point-to-area style communications:** see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting **Aeronautical and radiodetermination:** considered as part of an aviation impact assessment	-	-	-
Emergency services	**Point-to-point links:** NSW Telco Authority, NSW Police Force, and NSW Rural Fire Service links crossing boundary (see findings for point-to-point links) **Point-to-area style communications:** NSW Telco Authority and NSW Police Force towers within 2 km of turbines	**NSW Telco Authority:** potential for interference raised, 1 km clearance around tower requested – *4 turbines in requested clearance zone* **NSW Police Force:** potential for interference raised, 1 km clearance around tower and link path requested – *5 turbines in requested clearance zone* **St John Ambulance:** no concerns raised **Other operators:** no response received	**Point-to-point links:** see findings for point-to-point links **Services from towers within 2 km of turbines:** high likelihood of interference **Other services:** unlikely to cause interference	**Point-to-point links:** see mitigation for point-to-point links **Services from towers within 2 km of turbines:** relocate turbines to be outside clearance zones requested by operators **Other services:** if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower
Meteorological radar	Nearest radar: 78 km from Project	Concerns raised regarding potential for interference to Wollongong radar, necessary exclusion zone identified – *10 turbines in requested exclusion zone*	High likelihood of interference	Relocate turbines to be outside exclusion zones requested by the Bureau of Meteorology (BoM) Alternatively, enter into formal agreement to advise the BoM of the final turbine layout and any changes to the Project design, notify the BoM prior to any planned shutdown of the Project to allow calibration of systems, collaborate with the BoM in the event of severe weather conditions

Table 7 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Trigonometrical stations	12 stations within 20 km of Project boundary, 1 station within Project boundary Electronic equipment: unlikely to be affected Sight lines to other stations: may be blocked by turbines	**Geoscience Australia:** no concerns raised **NSW Spatial Services:** no concerns raised, provided assets are protected from physical disturbance during construction	Unlikely to cause interference	None required
Citizen's band radio	Unlikely to be affected	Consultation not considered necessary	Unlikely to cause interference	None required
Mobile phones	**Telstra:** 1 tower within 2 km of turbines, fair to good coverage across Project **Optus and Vodafone:** limited to no coverage across Project Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	**Telstra:** potential for interference raised, *relocation of one turbine by at least 50 m requested* **Other operators:** no concerns raised	**Telstra services from towers within 2 km of turbines:** high likelihood of interference **Telstra services from other towers:** low likelihood of interference **Other services:** unlikely to cause interference	**Telstra services from towers within 2 km of turbines:** relocate turbine as requested by Telstra **Other services:** if required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	**Mobile broadband service providers:** Ace Internet Services Pty Ltd, Telstra, NBN Co **NBN:** available as a satellite service only	**Telstra:** potential for interference raised (see feedback for mobile phones) **Other operators:** no concerns raised	**Mobile broadband services:** see findings for mobile phones **NBN:** none	**Mobile broadband services:** as for mobile phones **NBN:** none required
Satellite television and internet	**Services intended for Australian audiences:** unlikely to be affected **Services intended for international audiences:** signals from 53 satellites intercepted at 13 dwellings	Consultation with operators not considered necessary	Unlikely to cause interference	If required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish

Table 7 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Results of DNV assessment	Stakeholder feedback (to date)	Expected impact	Potential mitigation options
Radio broadcasting	**AM and FM signals:** may experience interference in close proximity to turbines **Digital radio signals:** Project is outside the intended coverage area	Consultation not considered necessary	**AM and FM signals:** low likelihood of interference **Digital radio signals:** none	**AM and FM signals:** if required – install higher-quality antenna at affected location **Digital radio signals:** none required
Television broadcasting	Digital signals: may experience interference in areas with poor or marginal reception **Central Tablelands transmitter:** patchy coverage with 'variable' to 'good' coverage in small areas close to turbines in west of Project and small areas to north, south, and southwest, 'poor' to no coverage elsewhere 13 dwellings (6 involved dwellings) in potential interference zone	No response received	Low likelihood of interference – most identified dwellings are unlikely to be receiving signals from the corresponding transmitter, but dwellings that are receiving signals may experience interference	If required – re-align antenna at affected dwelling to existing tower, re-direct antenna to alternative tower, install more directional or higher gain antenna, change location of antenna, install cable or satellite television, install relay transmitter
	Illawarra transmitter: patchy coverage with 'variable' to 'good' coverage in areas to northeast and east, 'poor' to 'variable' coverage in small areas within Project boundary and small areas to north, south, and southeast, no coverage elsewhere 6 dwellings (3 involved dwellings) in potential interference zone	No response received		
	Canberra transmitter: patchy coverage with 'poor' to 'variable' coverage in small areas within Project boundary and small areas to northeast, east and south, no coverage elsewhere 10 dwellings (8 involved dwellings) in potential interference zone	No response received		

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APPENDIX A – TELEVISION INTERFERENCE CAUSED BY REFLECTION OR SCATTERING OF SIGNALS

A.1 Susceptibility of DTV signals to reflection or scattering

The United Kingdom telecommunications regulator Ofcom [38] states the following with regard to interference to DTV 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 has drawn two conclusions from this report:

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

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

- the proximity of turbines to the television broadcast transmitter
- the proximity of turbines to receivers (dwellings)
- the location of turbines in relation to dwellings and television broadcast transmitters
- the rotor blade material, rotor speed, and rotor blade direction (always into the wind)
- the properties of the receiving antenna (e.g., type, directionality, and height)
- the location of the television receiver in relation to terrain and other obstacles
- the frequency and power of the television broadcast signal.

A.2 Forward and back scatter of DTV signals

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

Forward scatter can occur when the transmitter, one or more turbines, and receiver are almost aligned as shown in Figure A.1. The forward scatter region in this case is characterised by a shadow zone of reduced signal strength behind the turbine, where direct and scattered signals can be received, with the blade rotation introducing a rapid variation in the scattered signal [45]. Both of these effects can potentially degrade the DTV signal quality.

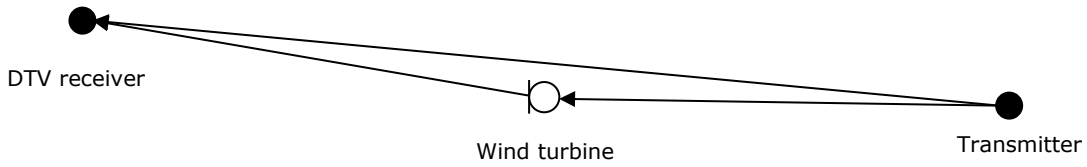

Figure A.1 Forward scatter signal path for DTV signals

Back scatter from wind turbines occurs when DTV signals are reflected from turbine towers and blades onto a receiver as shown in Figure A.2. The reflected signals are attenuated, time-delayed and phase-shifted (due to a longer path from transmitter to receiver) compared to the original signal. The reflected signals are also time-varying due to the rotation of the blades and vary with wind direction. The resultant signal at the receiver includes the original signal (transmitter to receiver) and a series of time-varying multipath signals (transmitter-turbine-receiver).

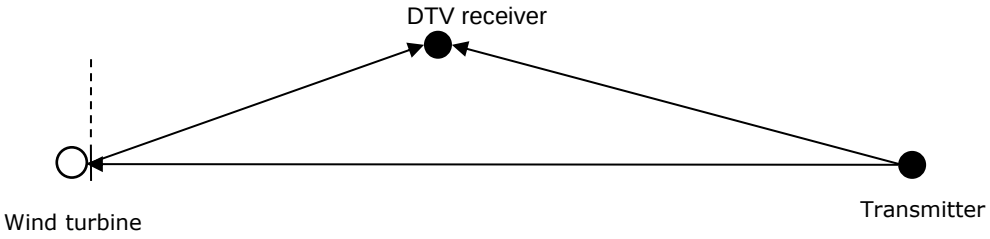

Figure A.2 Back scatter signal path for DTV signals

Interference to DTV signals from wind turbines can potentially occur in both the forward and backward scatter region. The effect of a turbine on a DTV signal can be different depending on the scattering region where the receiver is located [45].

According to Ofcom [38], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [11, 48]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the turbines [38]. The shape of this region, assuming a relatively high gain, directional antenna, can be represented by a circular segment with an azimuthal range of approximately ±15° to ±20°, corresponding to the beam width of the antenna. If a lower gain or omni-directional antenna is being used, this region is likely to be larger.

Back scattered signals arrive at the dwelling delayed relative to the source signal from the broadcast transmitter. The back scatter region generally does not extend further than 500 m [11, 38], 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 Figure A.3, resembles a keyhole.

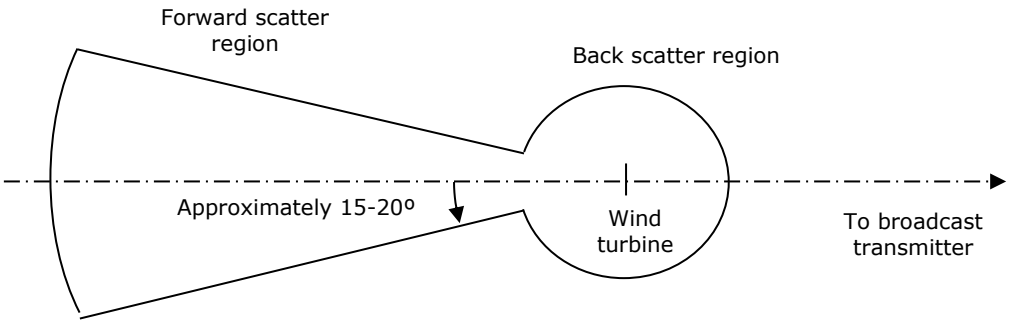

Figure A.3 Potential television interference zones around a wind turbine

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

In Australia, DTV signals are transmitted using the DVB-T (Digital Video Broadcasting – Terrestrial) standard. The International Telecommunication Union (ITU) Recommendation BT.1893 [49] states the following in regards to the forward scatter region for DVB-T signals:

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

In other words, wind turbines are not generally expected to affect DVB-T DTV signals in the forward scatter region. However, the ITU [46] also highlight that in the case where there is significant blockage of the direct signal, but clear line-of-sight to one or more turbines, interference to the reception of the DTV signal is possible. Results of studies reported by the ITU also suggest that interference may be more likely in areas where the existing DTV signal is already weak or degraded [46].

With regards to back scattering, the ITU states:

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

In other words, the C/N ratio needs to be higher in the presence of significant back scatter to achieve the same QEF condition as is the case without the presence of turbines, which effectively means that interference is more likely to occur as coverage quality decreases.

A.3 Theoretical models for wind turbine scattering estimation

Various theoretical scatter models to predict scatter of terrestrial television signals have been proposed, some dating back to the late 1970s. A review of these models, as well as a comparison against empirical data has been reported in [50]. 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 [49], was found to be the most inaccurate, and does not provide signal estimations in the forward scattering zone of the blades. Additionally, DNV notes that it only applies to a single wind turbine rather than a wind farm as a whole.

As an alternative to signal scattering models, it is common practice to identify those dwellings or areas that are most likely to experience potential television interference based on likely forward and back scatter regions. As introduced above and shown in Figure A.3, this is often referred to as the 'keyhole' approach and is an established technique for predicting where terrestrial television interference is most likely, based on a number of assumptions regarding receiving antenna characteristics. The approach involves combining multiple keyhole shaped areas that are placed over each turbine location [38]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring.

LIST OF TABLES

Table 8 Proposed turbine layout for the Project [4]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation[2] [m]
PY-1	750791	6214083	889	PY-25	753741	6217699	1006
PY-2	751181	6214433	901	PY-26	753904	6218069	1007
PY-3	751425	6214787	923	PY-27	753741	6219320	992
PY-4	751942	6215115	944	PY-28	754162	6219612	1004
PY-5	747801	6214761	892	PY-29	754331	6220009	979
PY-6	748520	6214803	860	PY-30	754518	6220470	980
PY-7	749055	6215129	870	PY-31	754970	6220320	964
PY-8	749638	6214879	869	PY-32	755527	6220446	992
PY-9	750046	6215203	874	PY-33	755988	6220403	1038
PY-10	750521	6215025	912	PY-34	756386	6220593	1050
PY-11	750915	6215238	915	PY-35	757375	6217237	1027
PY-12	751277	6215444	931	PY-36	756992	6217538	1029
PY-13	751743	6215430	942	PY-37	756711	6217870	1033
PY-14	751924	6215913	974	PY-38	757117	6217957	1046
PY-15	752167	6216399	976	PY-39	757375	6218321	1031
PY-16	752655	6216325	985	PY-40	757656	6218768	1019
PY-17	752852	6216863	972	PY-41	757360	6219305	984
PY-18	751295	6216935	940	PY-42	758118	6219898	996
PY-19	751592	6217222	955	PY-43	758168	6220297	1022
PY-20	751942	6217474	976	PY-44	758672	6219951	943
PY-21	751953	6218025	971	PY-45	758948	6220374	1028
PY-22	752264	6217765	992	PY-46	759907	6221290	971
PY-23	753090	6218124	996	PY-47	759979	6221614	982
PY-24	753402	6218432	991				

1. Coordinate system: MGA zone 55, GDA94 datum.
2. Base elevations have been determined by DNV based on publicly available SRTM1 data.

Table 9 Dwellings in the vicinity of the proposed Project [5, 6]

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Status	Distance to nearest turbine [km]
3	758075	6222553	Not involved	2.1
4	757579	6222366	Not involved	2.1
6	*758737*	*6221235*	*Involved*	*0.9*
6A	*759167*	*6220887*	*Involved*	*0.6*
7	*755747*	*6219917*	*Involved*	*0.5*
7A	*754860*	*6219774*	*Involved*	*0.6*
8	*752734*	*6217366*	*Involved*	*0.5*
8A	*752774*	*6217698*	*Involved*	*0.5*
9	*752472*	*6215504*	*Involved*	*0.7*
9A	*752296*	*6215591*	*Involved*	*0.5*
9B	*752585*	*6215759*	*Involved*	*0.6*
10	745867	6215676	Not involved	2.1
13	757536	6227258	Not involved	6.2
15	743699	6212243	Not involved	4.8
21	749214	6209545	Not involved	4.8
22	750359	6209023	Not involved	5.1
23	749303	6208555	Not involved	5.7
29	755306	6211087	Not involved	5.2
30	756650	6209854	Not involved	7.1
108	761796	6219158	Not involved	2.8
113	762845	6221306	Not involved	2.9
115	761552	6220096	Not involved	2.0
116	761945	6219840	Not involved	2.5
117	762965	6217831	Not involved	4.6
123	759186	6212424	Not involved	5.1
125	759102	6212302	Not involved	5.2
126	759054	6212194	Not involved	5.3
127	760498	6214491	Not involved	4.2
128	753141	6211562	Not involved	3.4
129	763234	6216864	Not involved	5.5
130	763718	6216627	Not involved	6.0
135	759978	6213043	Not involved	4.9
136	761312	6214998	Not involved	4.5
143	757492	6210376	Not involved	6.9
150	763557	6216624	Not involved	5.9
152	755215	6210789	Not involved	5.4
153	755381	6210652	Not involved	5.6
154	756546	6209997	Not involved	6.9

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

Table 10 Details of point-to-point links crossing the proposed Project

Link no.	Licence number	Assignment ID	Frequency [Hz]	Licence owner
1	10593872/1	4666813	7610000000	New South Wales Government Telecommunications Authority NSW Telco Authority Locked Bag 2 HAYMARKET NSW 1240
		4666814	7610000000	
		4666815	7449000000	
		4666816	7449000000	
2	11185850/1	7537046	7645000000	
		7537047	7645000000	
		7537048	7484000000	
		7537049	7484000000	
3	11185851/1	7537050	7617000000	
		7537051	7617000000	
		7537052	7456000000	
		7537053	7456000000	
4	11186350/1	7537599	7662500000	
		7537600	7662500000	
		7537601	7501500000	
		7537602	7501500000	
5	10444001/1	3766172	849900000	NSW Police Force Radio Engineering Services Level 4, 151-241 Goulburn St Sydney Police Centre SURRY HILLS NSW 2010
		3766173	849900000	
		3766174	804900000	
		3766175	804900000	
6	1212495/1	769901	460200000	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142
		769902	460200000	
		769903	450700000	
		769904	450700000	
7	1955737/1	941448	7718500000	
		941449	7718500000	
		941450	7557500000	
		941451	7557500000	
8	10287618/2	4644451	6389965000	Telstra Corporation Limited Radio Engineering Attn Nik Patel Locked Bag 3501 BRISBANE QLD 4001
		4644452	6389965000	
		4644453	6137925000	
		4644454	6137925000	
9	1231888/1	779344	10623000000	
		779345	10623000000	
		779346	10558000000	
		779347	10558000000	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
6667627	9015800	10941475/1	-34.4577	150.2661	55	
6667624	9015800	10941475/1	-34.4577	150.2661	55	
6667620	9015800	10941474/1	-34.4577	150.2661	55	
6667623	9015800	10941474/1	-34.4577	150.2661	55	
5936115	9011047	10764857/1	-34.4805	150.3978	66	
5936119	9011047	10764857/1	-34.4805	150.3978	66	
1005218	9011047	1987472/1	-34.4805	150.3978	66	
5936096	9011047	10764856/1	-34.4805	150.3978	66	
5936100	9011047	10764856/1	-34.4805	150.3978	66	
5936099	9011047	10764856/1	-34.4805	150.3978	66	Ace Internet Services Pty Ltd Locked Bag 4000 BOWRAL NSW 2576
5936112	9011047	10764857/1	-34.4805	150.3978	66	
5936108	9011047	10764857/1	-34.4805	150.3978	66	
5936116	9011047	10764857/1	-34.4805	150.3978	66	
5936111	9011047	10764857/1	-34.4805	150.3978	66	
5936104	9011047	10764856/1	-34.4805	150.3978	66	
5936103	9011047	10764856/1	-34.4805	150.3978	66	
5936107	9011047	10764856/1	-34.4805	150.3978	66	
1005221	9011047	1987472/1	-34.4805	150.3978	66	
6668823	10009502	10942192/1	-34.4777	150.4852	72	
6668820	10009502	10942192/1	-34.4777	150.4852	72	
995030	9022370	1982914/1	-33.5671	149.6275	62	Bathurst Regional Council IT Manager 158 Russell Street BATHURST NSW 2795
995033	9022370	1982914/1	-33.5671	149.6275	62	
771594	203217	1217864/1	-34.4916	150.4173	68	Bowral Golf Club PO Box 934 BOWRAL NSW 2576
771591	203217	1217864/1	-34.4916	150.4173	68	
1306386	205714	1231627/1	-33.8967	149.8505	24	
1306389	205714	1231627/1	-33.8967	149.8505	24	
1306278	205697	1231600/1	-34.5500	149.8667	41	
1306281	205697	1231600/1	-34.5500	149.8667	41	
1306277	9480	1231599/1	-34.5668	149.9928	47	
1306274	9480	1231599/1	-34.5668	149.9928	47	
1306354	9308	1231619/1	-33.8683	150.2727	49	
1306357	9308	1231619/1	-33.8683	150.2727	49	
1306314	35638	1231609/1	-34.4301	150.2343	50	
1306317	35638	1231609/1	-34.4301	150.2343	50	
1306321	54625	1231610/1	-34.3710	150.3355	55	Bureau of Meteorology GPO Box 1289 MELBOURNE VIC 3001
1306318	54625	1231610/1	-34.3710	150.3355	55	
1306362	9301	1231621/1	-34.0688	150.4422	56	
1306365	9301	1231621/1	-34.0688	150.4422	56	
1306346	9297	1231617/1	-33.8896	150.3849	57	
1306349	9297	1231617/1	-33.8896	150.3849	57	
1306325	205704	1231611/1	-34.1538	150.4662	59	
1306322	205704	1231611/1	-34.1538	150.4662	59	
1306309	205701	1231607/1	-34.7583	149.7645	62	
1306306	205701	1231607/1	-34.7583	149.7645	62	
1306358	205709	1231620/1	-33.6003	150.2567	69	
1306361	205709	1231620/1	-33.6003	150.2567	69	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project (continued)

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
1255734	10476	26977/1	-33.4999	150.1497	74	City of Lithgow Council PO Box 19 LITHGOW NSW 2790
1255733	10476	26977/1	-33.4999	150.1497	74	
943082	10522	1956681/1	-33.9158	148.9429	75	Cowra Shire Council Private Bag 342 COWRA NSW 2794
5304292	10522	10684557/1	-33.9158	148.9429	75	
5304293	10522	10684557/1	-33.9158	148.9429	75	
943079	10522	1956681/1	-33.9158	148.9429	75	
2764937	204067	9848202/3	-34.3708	150.3355	55	Endeavour Energy PO Box 6366 BLACKTOWN DC NSW 2148
2764936	204067	9848202/3	-34.3708	150.3355	55	
2891885	9028231	10293526/1	-33.6906	150.2101	58	
2891886	9028231	10293526/1	-33.6906	150.2101	58	
2764876	10335	1982190/3	-33.7030	150.2895	62	
2764877	10335	1982190/3	-33.7030	150.2895	62	
2765192	9002254	1184813/3	-34.6455	150.1463	62	
2765193	9002254	1184813/3	-34.6455	150.1463	62	
2765057	9002254	10099495/3	-34.6455	150.1463	62	
2765056	9002254	10099495/3	-34.6455	150.1463	62	
2764796	10338	1937896/3	-33.7054	150.3156	63	
2764797	10338	1937896/3	-33.7054	150.3156	63	
2765268	9362	1213142/3	-34.4646	150.4282	67	
2765269	9362	1213142/3	-34.4646	150.4282	67	
2765281	9362	32207/3	-34.4646	150.4282	67	
2765280	9362	32207/3	-34.4646	150.4282	67	
2765125	9344	52078/3	-34.2287	150.5890	71	
2765124	9344	52078/3	-34.2287	150.5890	71	
2765249	10474	1219102/3	-33.5059	150.1478	73	
2765248	10474	1219102/3	-33.5059	150.1478	73	
2764928	10474	9800311/3	-33.5059	150.1478	73	
2764929	10474	9800311/3	-33.5059	150.1478	73	
2765108	10474	52070/3	-33.5059	150.1478	73	
2765109	10474	52070/3	-33.5059	150.1478	73	
2765121	9335	52076/3	-34.1910	150.6387	75	
2765120	9335	52076/3	-34.1910	150.6387	75	
808691	404074	1427988/1	-34.7690	149.7317	63	Essential Energy Attn: Ray Northcott PO Box 5730 PORT MACQUARIE BC NSW 2444
808694	404074	1427988/1	-34.7690	149.7317	63	
2979648	10007401	10308431/1	-34.6736	149.9835	58	Goulburn Mulwaree Council Locked Bag 22 GOULBURN NSW 2580
2979649	10007401	10308431/1	-34.6736	149.9835	58	
681534	35237	26488/1	-34.7384	149.6877	60	
681535	35237	26488/1	-34.7384	149.6877	60	
4643398	9023709	10588354/1	-34.7564	149.6881	62	
4643397	9023709	10588354/1	-34.7564	149.6881	62	
806974	10474	1425349/1	-33.5059	150.1478	73	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142
806968	10474	1425349/1	-33.5059	150.1478	73	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project (continued)

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
1264343	138155	1968364/1	-34.0572	150.4472	57	Sada Pty Ltd Wollondilly Coal Prep Plant Burragorang Road NATTAI NSW 2570
1264340	138155	1968364/1	-34.0572	150.4472	57	
7336991	10021920	11125752/1	-34.7668	149.7478	63	Skynet Broadband Pty Ltd PO Box 740 NOWRA NSW 2541
7336988	10021920	11125752/1	-34.7668	149.7478	63	
7336987	10021920	11125751/1	-34.7668	149.7478	63	
7336984	10021920	11125751/1	-34.7668	149.7478	63	
765571	200515	1202983/1	-34.2862	149.9811	22	Telstra Corporation Limited Radio Engineering Attn Nik Patel Locked Bag 3501 BRISBANE QLD 4001
765570	200515	1202983/1	-34.2862	149.9811	22	
765946	10409	1204710/1	-34.1801	150.0755	24	
765943	10409	1204710/1	-34.1801	150.0755	24	
765561	9377	1202981/1	-34.3081	150.0753	31	
765564	9377	1202981/1	-34.3081	150.0753	31	
765577	200514	1202984/1	-34.3363	150.1653	39	
765580	200514	1202984/1	-34.3363	150.1653	39	
690054	36699	65314/1	-33.7154	150.3118	62	
690053	36699	65314/1	-33.7154	150.3118	62	
690034	36699	65291/1	-33.7154	150.3118	62	
690033	36699	65291/1	-33.7154	150.3118	62	
1310708	203170	1217740/1	-33.7228	150.3441	64	The Leura Golf Club Ltd Sublime Point Road LEURA NSW 2780
1310711	203170	1217740/1	-33.7228	150.3441	64	
965098	9019482	1968121/1	-34.3967	149.8136	24	Upper Lachlan Shire Council PO Box 42 GUNNING NSW 2581
965101	9019482	1968121/1	-34.3967	149.8136	24	

Table 11 Details of point-to-multipoint licences within 75 km of the proposed Project (continued)

Assignment ID	Site ID	Licence no.	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]	Licence owner
2863347	100685	1220705/2	-33.9920	149.3020	41	WATER NSW Attn: P Dudley PO Box 398 Parramatta NSW 2124
2825760	100685	10276001/1	-33.9920	149.3020	41	
2825757	100685	10276001/1	-33.9920	149.3020	41	
2863348	100685	1220705/2	-33.9920	149.3020	41	
2863356	9534	1220708/2	-34.1607	149.2382	41	
2863355	9534	1220708/2	-34.1607	149.2382	41	
2825741	9534	10275997/1	-34.1607	149.2382	41	
2825744	9534	10275997/1	-34.1607	149.2382	41	
2498959	9011752	10213156/1	-33.7247	149.8669	43	
2498962	9011752	10213156/1	-33.7247	149.8669	43	
3370612	10428	10385697/1	-33.7220	149.9448	44	
3370615	10428	10385697/1	-33.7220	149.9448	44	
1366295	9301	9869749/1	-34.0688	150.4422	56	
1366292	9301	9869749/1	-34.0688	150.4422	56	
2498966	10004857	10213157/1	-33.9813	148.9478	72	
2498963	10004857	10213157/1	-33.9813	148.9478	72	
3370608	10593	10385696/1	-33.4710	149.9878	72	
3370611	10593	10385696/1	-33.4710	149.9878	72	
2863352	10652	1220706/2	-33.6465	149.1807	74	
2825717	10652	10275991/1	-33.6465	149.1807	74	
2825720	10652	10275991/1	-33.6465	149.1807	74	
2863351	10652	1220706/2	-33.6465	149.1807	74	
2863360	10522	1220709/2	-33.9158	148.9429	75	
2863359	10522	1220709/2	-33.9158	148.9429	75	
2825728	10522	10275993/1	-33.9158	148.9429	75	
2825725	10522	10275993/1	-33.9158	148.9429	75	
7053782	10021261	10737835/2	-34.5005	150.3360	63	Wingecarribee Shire Council Water and Sewer PO Box 141 MOSS VALE NSW 2577
7053781	10021261	10737835/2	-34.5005	150.3360	63	
1556443	9028337	10000499/1	-34.4420	150.4167	65	
1556440	9028337	10000499/1	-34.4420	150.4167	65	
6800431	402472	10660527/2	-34.3576	150.4815	66	
6800432	402472	10660527/2	-34.3576	150.4815	66	
6800424	9362	10144394/2	-34.4646	150.4282	67	
6800423	9362	10144394/2	-34.4646	150.4282	67	
1205748	9362	96701/1	-34.4646	150.4282	67	
1205749	9362	96701/1	-34.4646	150.4282	67	
7200716	9362	10660064/3	-34.4646	150.4282	67	
7200715	9362	10660064/3	-34.4646	150.4282	67	
6954009	402473	10980103/1	-34.4054	150.4879	69	
6954008	402473	10980103/1	-34.4054	150.4879	69	
1556926	9028336	10000679/1	-34.6090	150.3092	69	
1556923	9028336	10000679/1	-34.6090	150.3092	69	
5685232	10017527	10737845/1	-34.5584	150.3827	70	
5685233	10017527	10737845/1	-34.5584	150.3827	70	
5685228	138680	10737843/1	-34.6565	150.3062	73	
5685229	138680	10737843/1	-34.6565	150.3062	73	

Table 12 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	1343
2 GHz Band	Spectrum	1175
2.3 GHz Band	Spectrum	2344
2.5 GHz Band	Spectrum	486
3.4 GHz Band	Spectrum	2276
700 MHz Band	Spectrum	988
800 MHz Band	Spectrum	819
Aeronautical Assigned System	Aeronautical	37
Amateur Repeater	Amateur	94
Ambulatory - Initial	Land Mobile	42
Ambulatory System	Land Mobile	90
AWL - FSS Only	Spectrum	183
AWL - Standard	Spectrum	12
CBRS Repeater	Land Mobile	12
Commercial Radio	Broadcasting	14
Commercial Television	Broadcasting	9
Community Broadcasting	Broadcasting	5
Earth Receive	Earth Receive	2
HF Domestic Service	Broadcasting	1
Land Mobile System - > 30MHz	Land Mobile	1138
Land Mobile System 0-30MHz	Land Mobile	10
Narrowband Area Service station(s)	Broadcasting	2
Narrowcasting Service (Fixed Tax)	Broadcasting	5
Narrowcasting Service (LPON)	Broadcasting	39
National Broadcasting	Broadcasting	17
Paging System - Exterior	Land Mobile	59
Paging System - Interior	Land Mobile	3
PMTS Class B	PTS	144
PMTS Class B (935-960 MHz)	PTS 900 MHz	196
Radiodetermination	Radiodetermination	13
Retransmission	Broadcasting	18
Retransmission (Out of Area)	Broadcasting	6
Scientific Assigned	Scientific	18

Table 13 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
NSW Ambulance	Ambulance Service of NSW Service Manager Telecommunications Matt Wheat Locked Bag 105 ROZELLE NSW 2039	15
CREST NSW	CREST NSW Inc 2 Tamworth Place ALLAMBIE HEIGHTS NSW 2100	69
Laggan and District Bushfire Brigade	Laggan and District Bushfire Brigade PO Box 105 CROOKWELL NSW 2583	28
Mulwaree Goulburn Emergency Repeater Group	Mulwaree Goulburn Emergency Repeater Group 9 William Street GOULBURN NSW 2580	71
NSW Telco Authority	New South Wales Government Telecommunications Authority NSW Telco Authority Locked Bag 2 HAYMARKET NSW 1240	Within Project boundary
NSW Police Force	NSW Police Force Radio Engineering Services Level 4, 151-241 Goulburn St Sydney Police Centre SURRY HILLS NSW 2010	Within Project boundary
NSW Rural Fire Service	NSW Rural Fire Service Locked Mail Bag 17 GRANVILLE NSW 2142	Within Project boundary
Office of Environment and Heritage (NSW National Parks and Wildlife Service)	Office of Environment and Heritage Asset Management Unit Level 3 4 PSQ 12 Darcy Street PARRAMATTA NSW 2150	17
St John Ambulance	St John Ambulance Australia 9 Deane Street BURWOOD NSW 2134	28
NSW State Emergency Service	State Emergency Service (Nsw) New South Wales State Emergency Service PO Box 6126 WOLLONGONG NSW 2500	23
VRA Rescue NSW	VRA Rescue NSW Limited VRA ICT Committee PO Box 6151 DURAL DC NSW 2158	62

Table 14 BoM radar sites in the vicinity of the proposed Project

Site ID	Site name	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
9319	Werombi Road CAMDEN	-34.0540	150.6775	78
9208	Met Bureau/Telstra Site LETTERBOX	-34.2651	150.8792	98
10209	NSW Parks Stony Creek Road SHANES PARK	-33.7128	150.7935	99
55275	Emerg Evacnorth South Runway 34l SYDNEY AIRPORT	-33.9632	151.1854	126
201694	Met Bureau Site Water Reservoir Polo Rd KURNELL PENINSULA	-34.0145	151.2256	129
49736	Bureau of Meteorology CANBERRA AIRPORT	-35.3084	149.2007	132
137803	BOM Weather Radar Lot 270 Corner Mona Vale & Myoora Roads TERREY HILLS	-33.7008	151.2095	135
201743	IPS Radio Site MOUNT STROMLO	-35.3159	149.0011	140
204400	BOM 27m Radar Tower, Mount Cowangerong Off Captains Flat Rd Jingera	-35.6615	149.5123	164
10023488	Yeoval Radar off Bournewood Road 6 km East of YEOVAL	-32.7440	148.7085	181
201025	Meteorological Office WAGGA WAGGA	-35.1582	147.4563	231
205157	Met Bureau Site Hunter Water Corp Reservoir off Industrial Cres LEMON TREE PASSAGE	-32.7283	152.0261	255
138133	Mt Blackjack lot 60 on plan 755474 7K8ms SW of Town Hall GUNNEDAH	-31.0218	150.1925	344
10021356	Hillston Radar off Griffith Road 8 km S of HILLSTON	-33.5520	145.5286	391
304566	Met Bureau Site YARRAWONGA AIRPORT	-36.0297	146.0227	392
136953	Weather Radar site Bairnsdale Aerodrome Aerodrome Road BAIRNSDALE	-37.8875	147.5755	453

Table 15 Trigonometrical stations in the vicinity of the proposed Project

Station name	Datum	Latitude [GDA94]	Longitude [GDA94]	Distance to Project [km]
Cockerill	AGD66	149.9842	-34.0400	16
Defiance	AGD66	149.7477	-34.1466	Within Project boundaries
Garrynian	AGD66	149.7591	-33.9692	16
Golspie	AGD66	149.6611	-34.2987	13
Gurnang	AGD66	149.8293	-34.0428	7
Jaunter	AGD66	149.9462	-33.9783	18
Leighwood	AGD66	149.6462	-34.2211	5
Macarthur	AGD66	149.7815	-34.3055	13
Reedy	AGD66	149.6376	-34.0419	13
Shivering	AGD66, AGD84, GDA94	150.0338	-34.1258	19
Thalaba	AGD66	149.5296	-34.3000	19
Werong	AGD66	149.9019	-34.0959	7

Table 16 Satellite vectors with potential to be intercepted by the proposed Project

Intercepted satellite	Services provided [51]	Affected dwellings[1]
Eutelsat 70B (E70B, W5A, Eutelsat W5A)	Programs intended for international audiences	113, 115, 116
Intelsat 22 (IS-22)	Programs intended for international audiences	*8*, 116, 129, 130, 135, 136, 150
G-Sat 11, G-Sat 14, G-Sat 18, G-Sat 7 (Insat 4F, Rukmini)	Programs intended for international audiences	*8*, 116, 130
ABS 2 (ST 3, Koreasat 8, Condosat 2), ABS 2A (Mongolosat-1)	Programs intended for international audiences	*8*, *8A*, *9B*, 116
Apstar 7, Express 80, Thaicom 6 (Africom 1), Thaicom 8	Programs intended for international audiences	*8*, *8A*, *9B*
G-Sat 10, G-Sat 12, G-Sat 30, G-Sat 6 (Insat 4E)	Programs intended for international audiences	*8A*, *9B*
Horizons 2, Insat 4B, Intelsat 15 (IS-15, JCSat 85)	Programs intended for international audiences	*7A*, *9B*
ChinaSat 12 (ZX-15A, Chinasat 15A, ZX-12, Apstar 7B, SupremeSat 1), Kazsat 2, ST 2	Programs intended for international audiences	*7A*, *8A*, *9B*
JCSat 16, Yamal 401 (Yamal 400 KA-1)90	Programs intended for international audiences	*7A*, *8A*
AsiaSat 5, ChinaSat 2E, ChinaSat 9 (Zhongxing-9, ZX-9), ChinaSat 9A (Zhongxing 9A, ZX 9A, Sinosat 4, Xinnuo 4), Chinasat 11, Express 103, G-Sat 15, G-Sat 17, G-Sat 9 (South Asia Satellite), Measat 3 (Measat 3, Malaysia East Asia Sat 3), Measat 3A (Measat 1R), Measat 3B (Jabiru 2), SES 12, SES 8, Skynet 5A, Thuraya 3	Programs intended for international audiences	*7A*
Luch 5V (Loutch-5V)	Private communications	*7A*
Asiasat 7 (AsiaSat 5C), BSat 3B, BSat 3C (JCSat 110R), Bsat 3A, Bsat 4A, ChinaSat 10, ChinaSat 16 (Zhongxing 16, ZX-16, Shijian 13, SJ-13), JCSat 15 (JCSat 110A), N-SAT-110 (Superbird S, Superbird D, NSAT 110, N-Sat 110, JCSat 110), SES 7 (Protostar 2, Indostar 2, Galaxy 8iR, Cakrawarta 2, Protostar II), SES 9, Telkom 4 (Merah Putih)	Programs intended for international audiences	*9A*

1. Involved dwellings are indicated by *underlined italic text*.

Table 17 Dwellings with increased potential to experience EMI to DTV from television broadcast transmitters

Dwelling ID[1]	Easting[2] [m]	Northing[2] [m]	Located in potential interference zone		
			Central Tablelands	Illawarra	Canberra
3	758075	6222553		X	X
4	757579	6222366		X	X
6	*758737*	*6221235*			*X*
6A	*759167*	*6220887*			*X*
7	*755747*	*6219917*	*X*	*X*	*X*
7A	*754860*	*6219774*	*X*	*X*	*X*
8	*752734*	*6217366*	*X*		*X*
8A	*752774*	*6217698*			*X*
9	*752472*	*6215504*	*X*		
9A	*752296*	*6215591*	*X*	*X*	*X*
9B	*752585*	*6215759*	*X*		*X*
10	745867	6215676		X	
108	761796	6219158	X		
115	761552	6220096	X		
116	761945	6219840	X		
117	762965	6217831	X		
127	760498	6214491	X		
128	753141	6211562	X		
135	759978	6213043	X		

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

Table 18 Summary of service operators contacted by DNV and responses received to date

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
1	Fixed point-to-point: 4 links crossing the Project Interference zones established by DNV: no turbines in diffraction exclusion zones, 15 turbines in potential reflection/scattering interference zones, no turbines in potential near-field interference zones Point-to-area: 203 m from nearest turbine	New South Wales Government Telecommunications Authority (NSW Telco Authority) 10277372-AUMEL-L-01-A	Response received by email on 3 August 2022: *"We have completed our assessment and would like to note the concerns and suggested relocations below.* *The following four proposed turbines need to be moved out of a circle with a radius of 1km around the site of Mt Defiance (-34.145626°, 149.749788°), we've attached a kmz file for the 1km radius circle.* *[Identified turbines: PY-23, PY-24, PY-25, PY-26* *Specific movements proposed to maintain 1km minimum clearance around radio site]* *Number of links crossing over: 5* *Number of links impacted: 5* *Number of windfarm turbines need to be shifted: 4"*
2	Fixed point-to-point: 1 link crossing the Project Interference zones established by DNV: no turbines in diffraction exclusion zone, 6 turbines in potential reflection/scattering interference zone, no turbines in potential near-field interference zone Point-to-area: 203 m from nearest turbine	NSW Police Force 10277372-AUMEL-L-02-A	Response received by email on 4 August 2022: *"Based on the attached kml files, and the pdf file document with information in relation to the proposed Paling Yards Wind Farm, an assessment is conducted with reference to those wind turbine locations…* *From the layout of the proposed Paling Yards Wind Farm, wind turbines are not densely distributed within the vicinity area of Mt Defiance.* *...there are three wind turbines PY-24, PY-23, PY-27 within 1km distance separation from the direct line-of-sight path (between Mt Defiance and Mt Ryan); whilst wind turbines PY-26, PY-25 are located 0.422km and 0.615km respectively from the telecommunication assets of Mt Defiance.* *As a result these FIVE wind turbines PY-23, PY-24, PY-25, PY-26, PY-27 are to be relocated (over 1km distance separation from Mt Defiance) to avoid possible impact to existing telecommunications assets."*

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
			Follow-up response received by email on 16 August 2022: *"As Mt Defiance is the only base site providing radio communications in the vicinity area (of Paling Yards, Jerrong & Gurnang) with service covering at least over 28km radius (before the next NSWPF radio site within the Chifley Police District) and channel is linking back to Mt Ryan at a distance of over 40km away. Any disruption of radio operation would have a significant impact to police service in the area.* *Furthermore… PY-25 & PY-26 are in the potential reflection/scattering interference zone.* *In this case we would like to keep the 1km distance separation requirement to avoid possible impact to existing telecommunications assets by those FIVE wind turbines PY-23, PY-24, PY-25, PY-26, PY-27."*
3	Fixed point-to-point: 2 links crossing the Project Interference zones established by DNV: 2 turbines in diffraction exclusion zones, 7 turbines in potential reflection/scattering interference zones, no turbines in potential near-field interference zones Point-to-area: 23 km from Project boundary	NSW Rural Fire Service 10277372-AUMEL-L-03-A	No response received to date

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
4	Fixed point-to-point: 2 links crossing the Project Interference zones established by DNV: no turbines in diffraction exclusion zones, 12 turbines in potential reflection/scattering interference zones, turbines in potential near-field interference zones Fixed point-to-multipoint: 22 km from Project boundary PMTS/spectrum (mobile phone): 374 m from nearest turbine	Telstra Corporation Limited (Telstra) 10277372-AUMEL-L-04-A	Response received by email on 22 August 2022: *"I am able to advise underground network has been identified within the proposed boundary. Please engage Dial Before You Dig for network details and advise potential impacts to the existing underground network if applicable."* Response received by email on 21 September 2022: *"There are a number of turbines that will be located close to existing radio paths, and I have not yet received a detailed response from our RF engineers' assessment.* *I can advise our Mobiles team have expressed concern over the location of one turbine in particular (PY-24) as below. The concern is the central positioning of the turbine within the sectored beam of the antenna, possibly compromising the entire sector. They would request an alternate location be considered closer to the northern boundary of the sector, at least 50m North to North West of the current proposed location. We cannot consider a location to the southern boundary as this will likely interfere with the existing radio transmission path feeding the mobiles base."*
5	Fixed point-to-multipoint: 24 km from Project boundary Meteorological radar: 78 km from Project boundary	Bureau of Meteorology (BoM) 10277372-AUMEL-L-05-A	Response received by email on 18 July 2022: *"The analysis shows that there are 10 turbines that impact our first three radar scans and hence the risk to the service is categorized medium. The problematic turbines are #33-39 and #43, 45, 47.* *If the farm developer could consider the relocation of those turbines or reducing their tip height, then it might provide a pathway for the coexistence of two systems. Otherwise, we can discuss about operational limitations in the event of harsh weather environment as already suggested for similar scenarios."* Meeting held between the Customer and the BoM on 22 July 2022 Follow-up response received by email on 22 July 2022: *"As discussed, there are currently 10 turbines… affecting our first three scans of Wollongong radar. Figure below shows those problematic turbines (turbines in red areas).* *As discuss, one solution would be relocating those turbines to green areas. I am attaching a KML file… [so that you can] see how much each turbine shall relocate.* *I am also attaching another KML file… that shows how reducing the tip height of turbines by 30 m, 200 m instead of 230 m, will impact the number of problematic turbines.* *And finally, the template for legal agreement is attached for your consideration."*

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
			Extract from Strategic Relationship Framework legal agreement template provided on 22 July 2022: *"The objective of this Framework is to demonstrate the Parties' commitment to work together…* *The Agreement establishes a strategic collaborative framework within which the Parties are able to support each other to minimize and manage the potential impacts of the Project on the equipment and work of the Bureau…* *The Partner agrees to inform the Bureau of final layout of the Project once it is been [sic] finalized.* *Any changes in the layout of the Project… will be notified by the Partner to the Bureau as soon as practicable.* *Where the wind farm is scheduled to be closed-down for maintenance or any other reasons, the Partner will inform the Bureau… before such close-down. This will provide the Bureau enough time to calibrate its radar network without the impact of rotating wind turbines.* *The Partner agrees to collaborate and cooperate with the Bureau in the event of severe weather condition for the safety of community. This may include agreeing and following to a request by the Bureau to shut-down turbines to enable the Bureau to provide its services for the community in critical harsh weather conditions."* Follow-up response received by email on 29 August 2022: *"We ran the two types of simulations by increasing turbine tip height from 230 m to 240 m.* *It does not significantly increase the coverage are in and around the wind farm and the same number of turbines will impact the Wollongong radar."* Follow-up response received by email on 14 September 2022: *"The agreement we request is only for the turbines within radar coverage area and not for the entire wind farm."*
6	Trigonometrical station: 256 m from nearest turbine GNSS station: 36 km from Project boundary	Geoscience Australia 10277372-AUMEL-L-06-A	Response received by email on 8 July 2022: *"Geoscience Australia do not foresee any impact to Commonwealth owned trigonometrical stations or Global Navigation Satellite System (GNSS) reference stations or associated assets from the proposed Paling Yards Wind Farm development.* *The identified trigonometrical station is used by the NSW Spatial Services."*

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
7	Trigonometrical station: 256 m from nearest turbine GNSS station: 36 km from Project boundary	NSW Spatial Services 10277372-AUMEL-L-07-A	<u>Response received by email on 18 July 2022:</u> *"The supplied document and files show that the proposed wind turbine construction locations DO NOT affect NSW State Survey for the purpose of this infrastructure project. Turbine 23 is in the vicinity of TS1797 and its associated witness marks.* *The Office of the Surveyor-General raises no objection to the proposed development subject to the following conditions:* *The closest proximity of any turbine construction to NSW Spatial Services critical infrastructure is No.24 (254m to TS797). Considering the specified diameter of turbine blades and structure height... it's estimated TS1797 will be, at its closest, over 100m from No.24's turbine blade trajectory at any given time.* *1. Therefore, only if there are 'restrictions' for working within a proximity (m) of a wind turbine... which will affect access and use of TS1797, then the proposed location of No.24 will have to be revised, or this approval rescinded. Please advise if there are any access/working restrictions relating to the above.* *2. Prior to commencement of construction, TS1707 and any associated witness marks must be located by your site surveyor and protected by erection of an appropriate physical barrier... to prevent disturbance by construction crews...* *3. Photographs of TS1797 and any associated witness marks must be taken prior to the commencement of construction AND after construction is completed. Submit photographs through the DCS Spatial Services Customer Hub...* *4. The construction site foreman is informed of the importance of protecting TS1797 and their associated witness marks from disturbance...* *5. If there are any major variations to the subject proposal, this consent is nullified, and a new submission must be lodged for assessment by the Office of the Surveyor-General.* *Please note:* *- TS1797 and its associated witness marks are important parts of the State's geodetic infrastructure; they are also protected marks under the Surveying and Spatial Information Act 2002 which has penalties for the disturbance of such marks.* *- If any survey mark(s) are proposed to be disturbed or destroyed, formal approval to disturb or destroy the mark(s) must be granted by the Office of the Surveyor-General prior to commencement of any works affecting the mark(s)..."*

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
8	Fixed point-to-multipoint: 55 km from Project boundary	Ace Internet Services Pty Ltd 10277372-AUMEL-L-08-A	Response received by email on 14 September 2022: *"We don't anticipate any impact to our network from the proposed development."*
9	Fixed point-to-multipoint: 55 km from Project boundary	Endeavour Energy 10277372-AUMEL-L-09-A	No response received to date
10	Fixed point-to-multipoint: 24 km from Project boundary	Upper Lachlan Shire Council 10277372-AUMEL-L-10-A	No response received to date
11	Fixed point-to-multipoint: 41 km from Project boundary	Water NSW 10277372-AUMEL-L-11-A	Response received by email on 8 September 2022: *"WaterNSW's Telecommunications Network Engineer has reviewed the proposal and images provided. From this review I can confirm that the proposed is not expected to affect or impact Water NSW assets in the area."*
12	Point-to-area: 28 km from Project boundary	Laggan and District Bushfire Brigade (Laggan & District Rural Fire Brigade) 10277372-AUMEL-L-12-A	No response received to date
13	Point-to-area: 17 km from Project boundary	Office of Environment and Heritage (NSW National Parks and Wildlife Service) 10277372-AUMEL-L-13-A	No response received to date
14	Point-to-area: 28 km from Project boundary	St John Ambulance Australia 10277372-AUMEL-L-14-A	Response received by email on 6 September 2022: *"I have reviewed the proposed location and can confirm it will have negligible impact to our radio communications in the area.* *As such we have no objection to this proposal."*
15	Point-to-area: 23 km from Project boundary	State Emergency Service (NSW) (NSW SES) 10277372-AUMEL-L-15-A	No response received to date

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
16	PMTS/spectrum (mobile phone): 23 km from Project boundary	Optus Mobile Pty Ltd (Optus) 10277372-AUMEL-L-16-A	Response received by email on 6 September 2022: *"There are no nearby Optus MW links near the… wind farm area."* Response received by email on 7 September 2022: *"The proposed wind farm would not have any impact on our services in the area from the mobile coverage perspective as well. So overall, Optus do not have any concern regarding the Paling Yards Wind Farm."*
17	PMTS/spectrum (mobile phone): 45 km from Project boundary	Vodafone Australia Pty Ltd (Vodafone) 10277372-AUMEL-L-17-A	Response received by email on 5 September 2022: *"I do not see any problems with Paling Yards turbines causing interference with Vodafone assets nor any microwave links in that area.* *Screenshot showing Paling Yards in red and 2 closest Vodafone sites in purple. All clear."* *"I can confirm that the location will not impact our radio network."*

Table 18 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type and distance of closest site	Operator name and DNV reference	Response received to date
18	Spectrum (wireless internet): 43 km from Project boundary	NBN Co 10277372-AUMEL-L-18-A	<u>Response received by email on 8 September 2022:</u> *"I have reviewed the data provided based on the proposed wind farm location; none of the proposed towers are inside any existing nbn wireless coverage boundaries and the proposed wind tower locations do not pose any risk of introducing a physical obstruction to existing wireless customer's RF Path Profiles or any boresight paths of existing nbn microwave links.* *Once known, please provide information on any RF transmission equipment planned to be used during construction or permanently installed so a potential interference impact can be assessed. This information should include as a minimum the operating transmission frequencies and transmit power, channel bandwidths, antenna types and radiation patterns as well as the exact location with antenna height, boresight azimuth and tilt [mechanical and electrical tilt].* *A standard nbn response for wind farm applications regarding potential interference impact on the nbn Fixed Wireless network is as follows;* *Potential Impacts of the Proposed Paling Yards Wind Farm on NBN Co Spectrum Communication Assets* *Referring to your email dated 5th September 2022 regarding the application for the Paling Yards Wind Farm.* *We confirm that NBN Co Spectrum Pty Ltd (nbn Spectrum) has a number of spectrum licenses within 75 km of the proposed Paling Yards Wind Farm.* *nbn have strict obligations to provide internet services to the community, and this area has been determined as a FW service area where the footprint of this service is now in place.* *nbn will be forced to consider its position as part of the planning should there an interference issue.* *If the Application is amended before it is lodged we request that we are sent any amended Application so we can determine whether we have any objections to the amended Application.* *We note that, as you would be aware, under section 197 of the Radiocommunications Act 1992 (Cth) it is an offence to knowingly or recklessly do anything likely to interfere substantially with radiocommunications or otherwise substantially disrupt or disturb radiocommunications."*
19	DTV broadcasting: 26 km from Project boundary	BAI Communications 10277372-AUMEL-L-19-A	No response received to date

LIST OF FIGURES

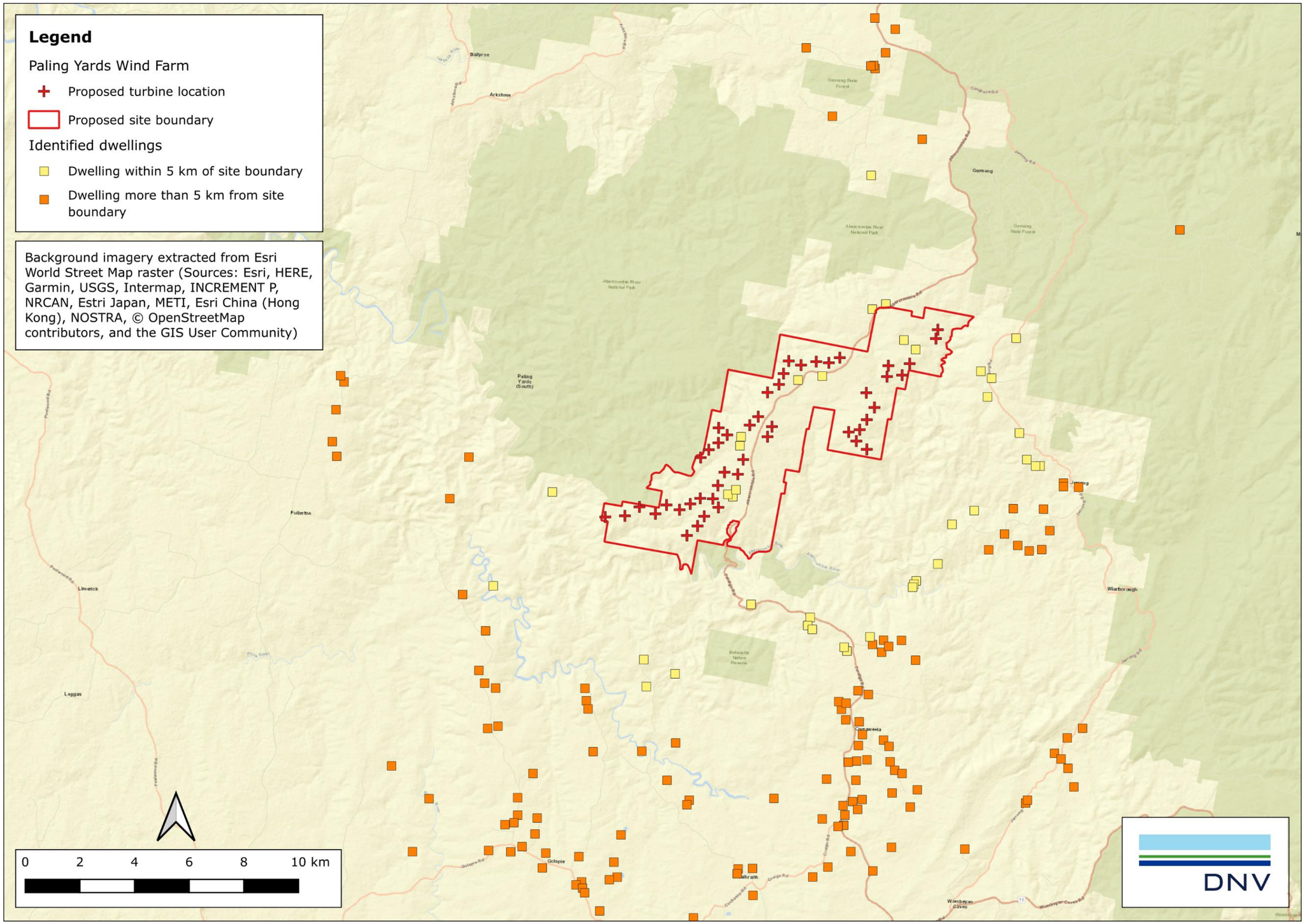

Figure 1 Map of the proposed Project, showing proposed boundary, turbine locations, and locations of nearby dwellings

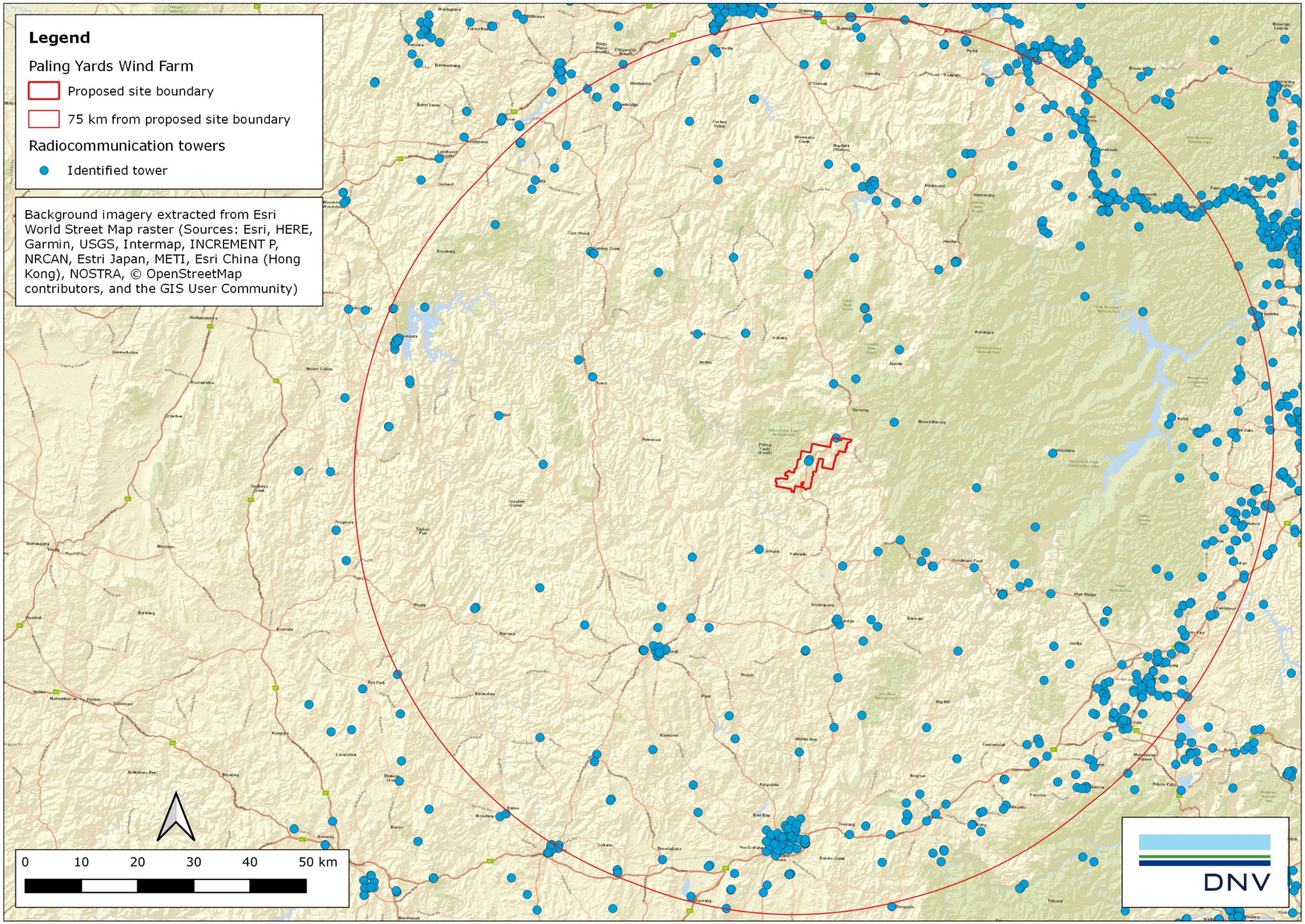

Figure 2 Location of the proposed Project and identified nearby radiocommunication sites

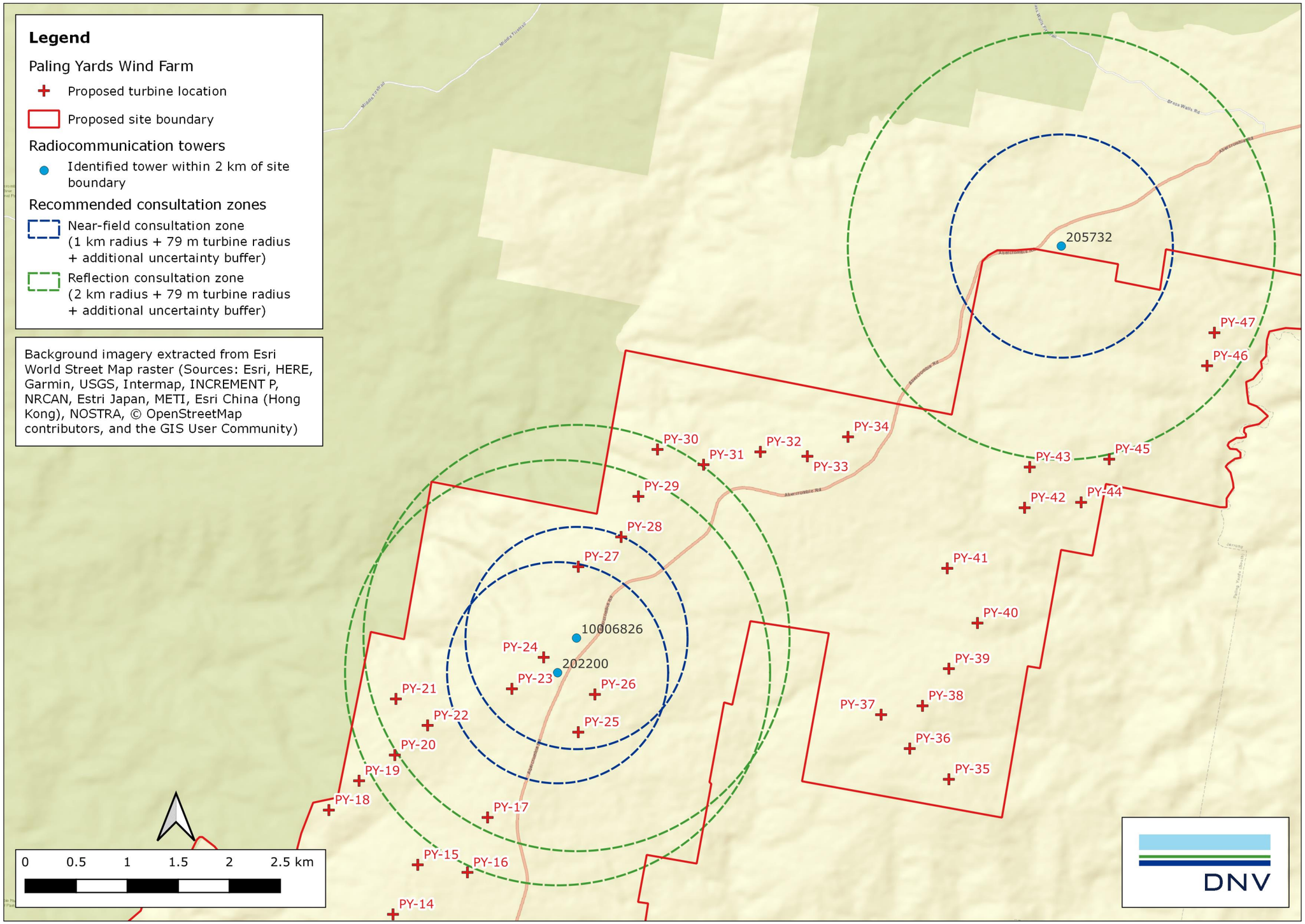

Figure 3 Identified radiocommunication sites within 2 km of the turbine locations for the proposed Project and recommended consultation zones

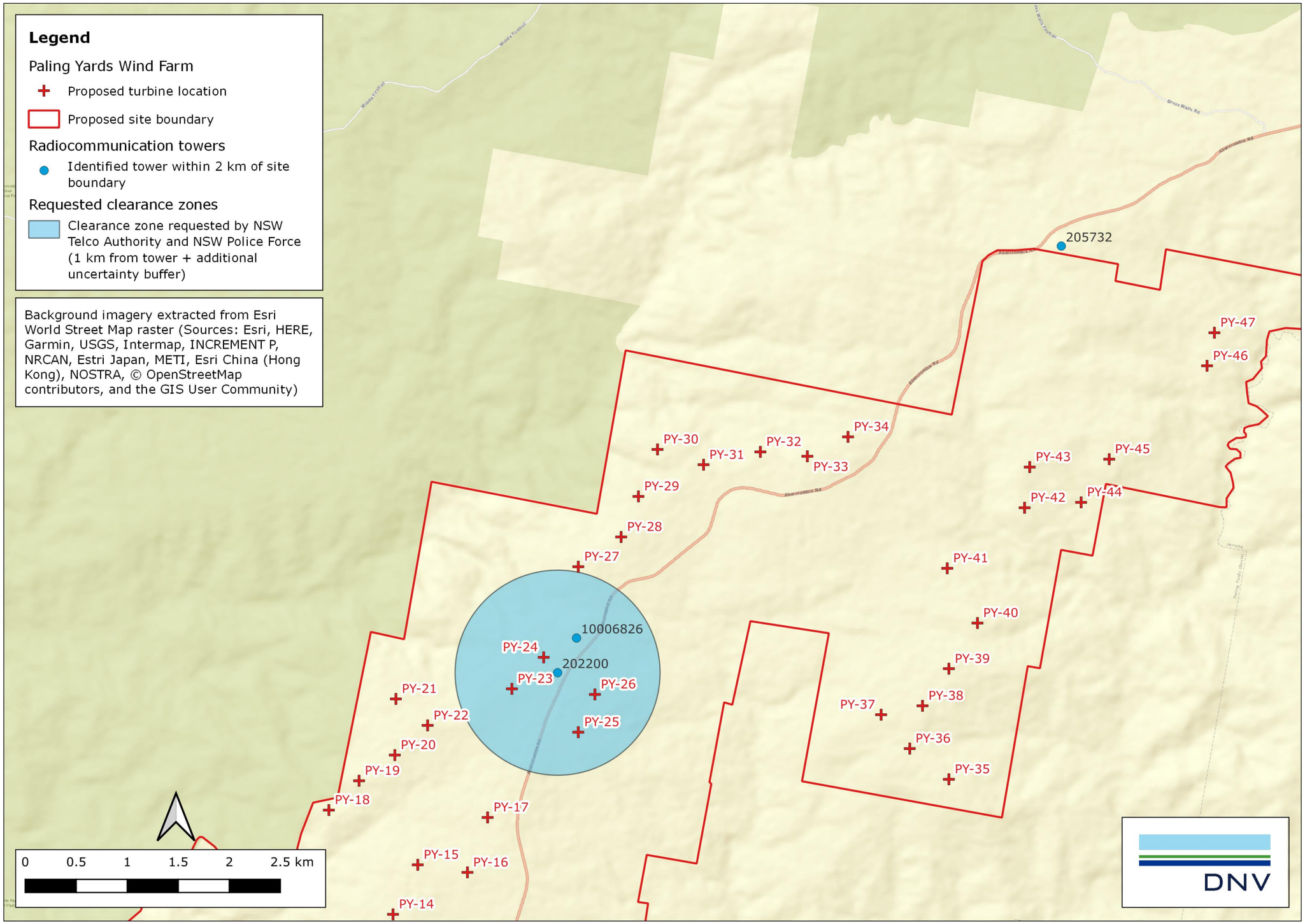

Figure 4 Identified radiocommunication sites within 2 km of the turbine locations for the proposed Project and requested clearance zones

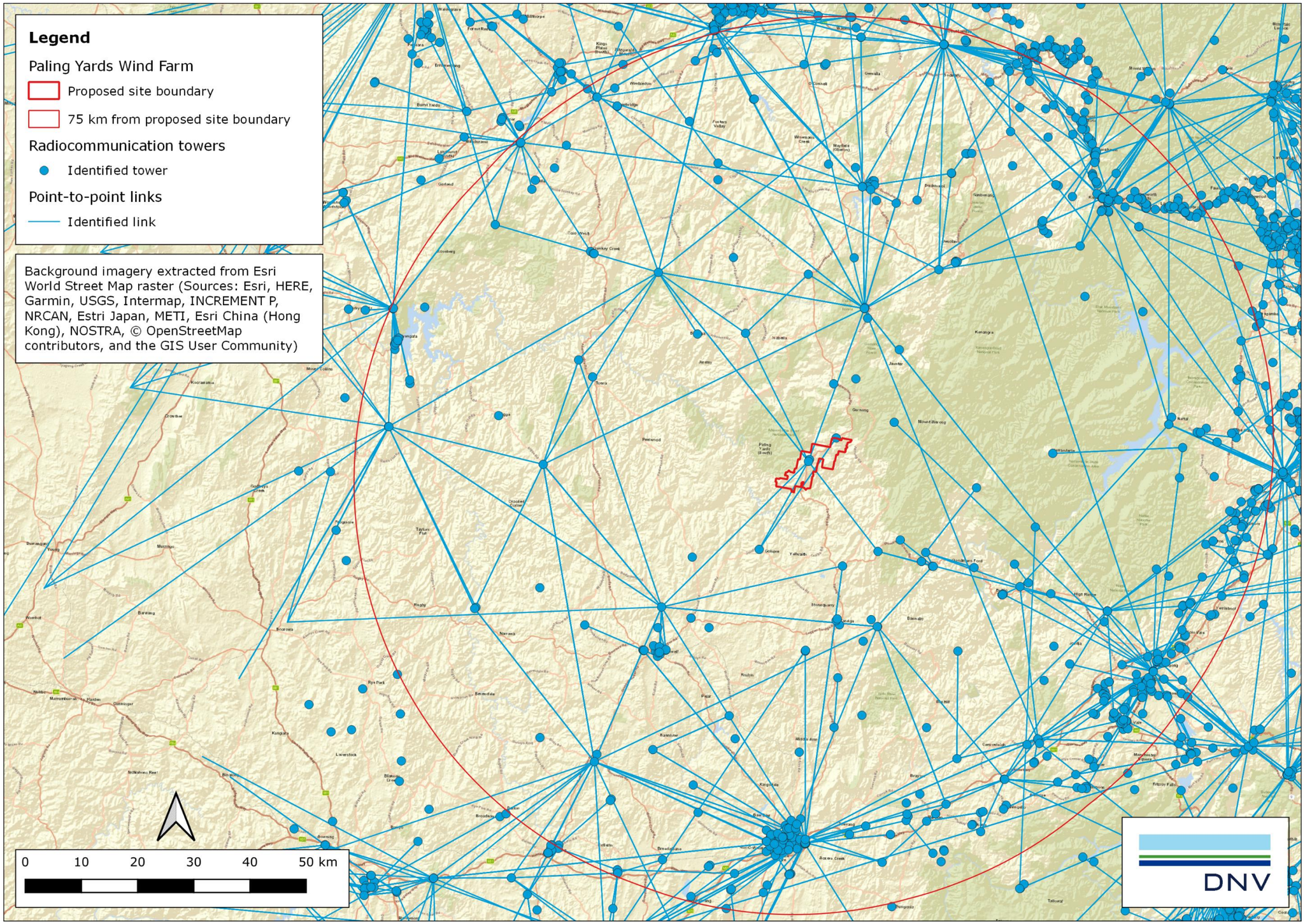

Figure 5 Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Project

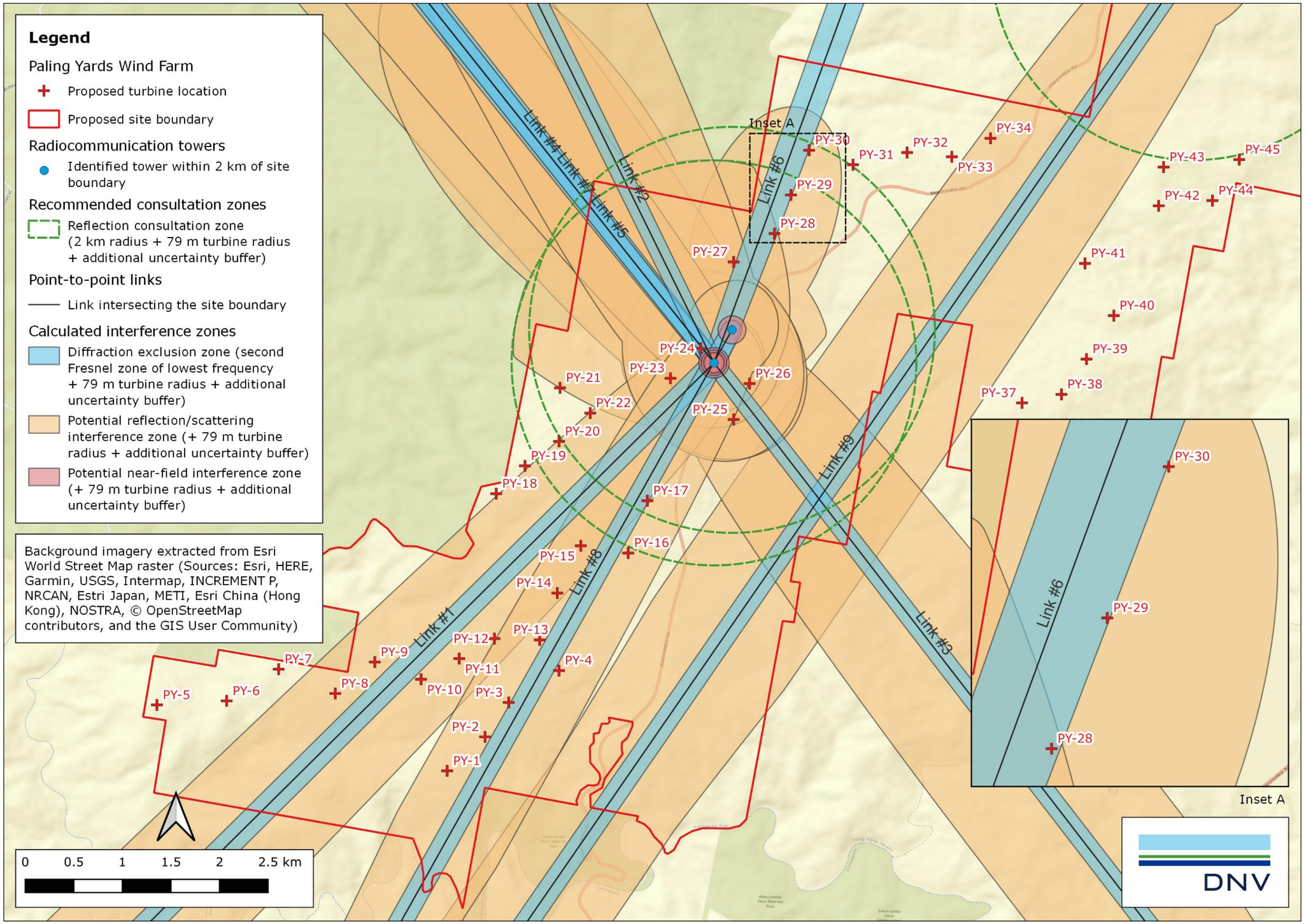

Figure 6 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

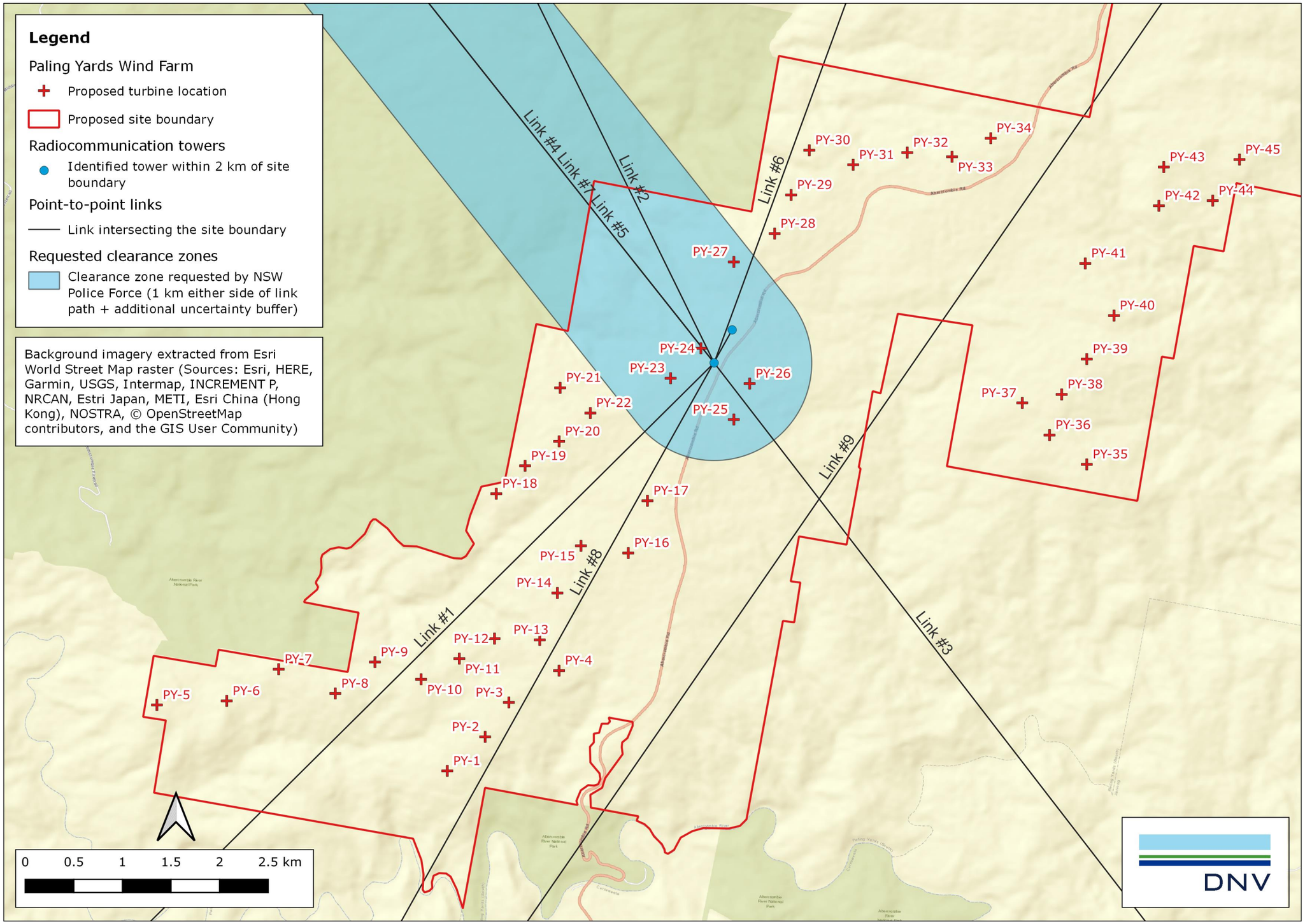

Figure 7 Identified point-to-point radiocommunication vectors crossing the proposed Project and requested clearance zones

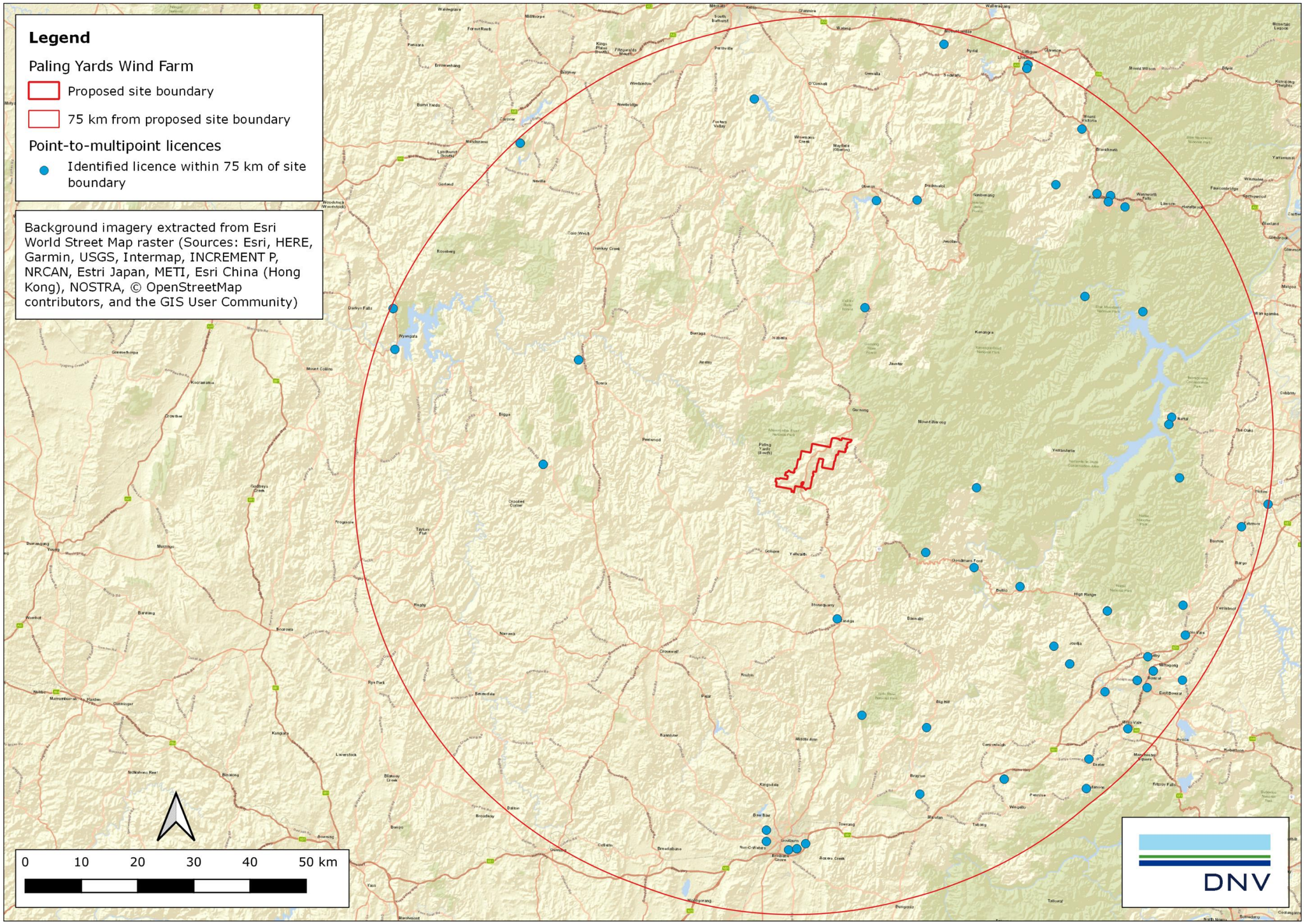

Figure 8 Location of point-to-multipoint licences in the vicinity of the proposed Project

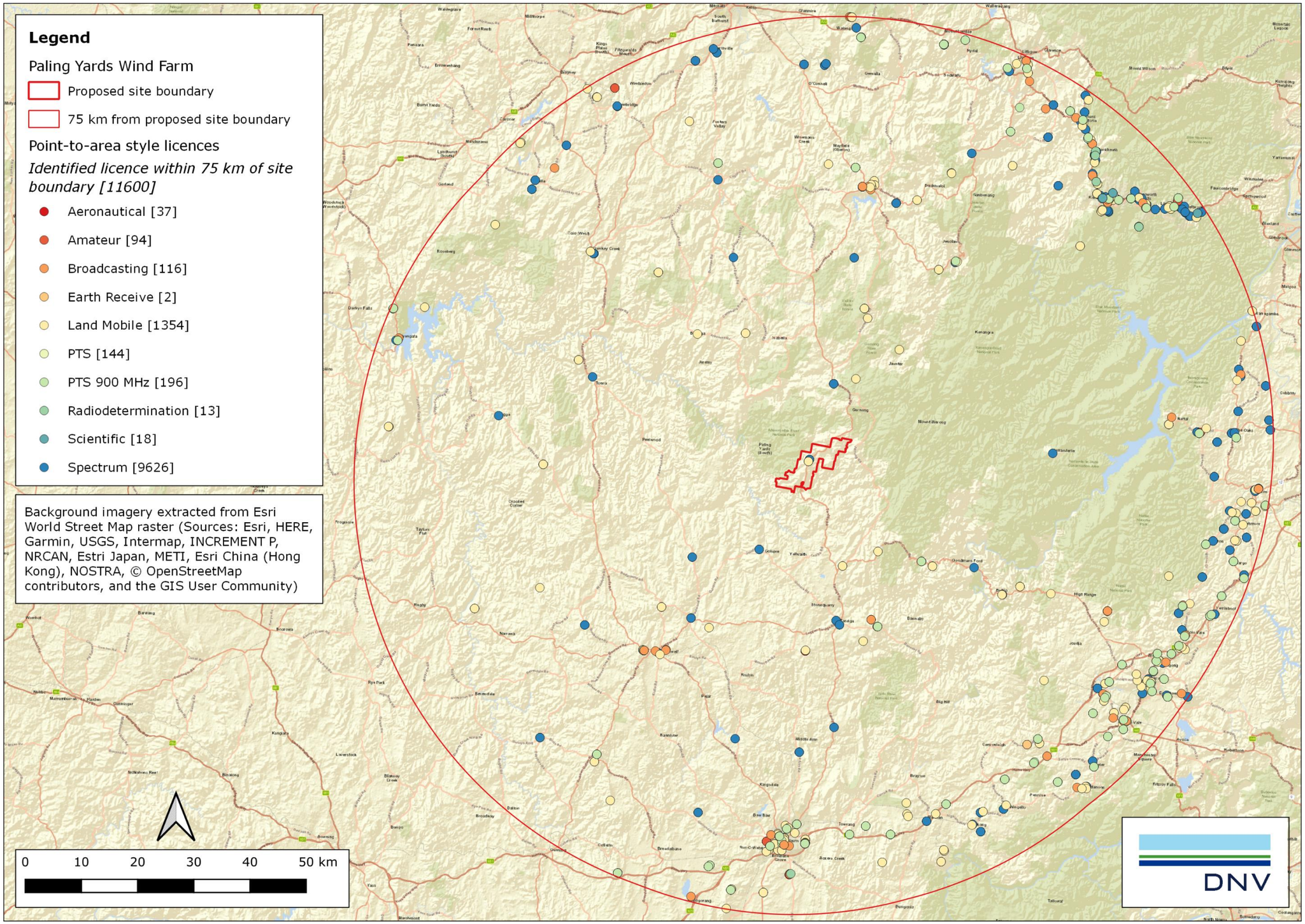

Figure 9 Location of general point-to-area style licences within 75 km of the proposed Project

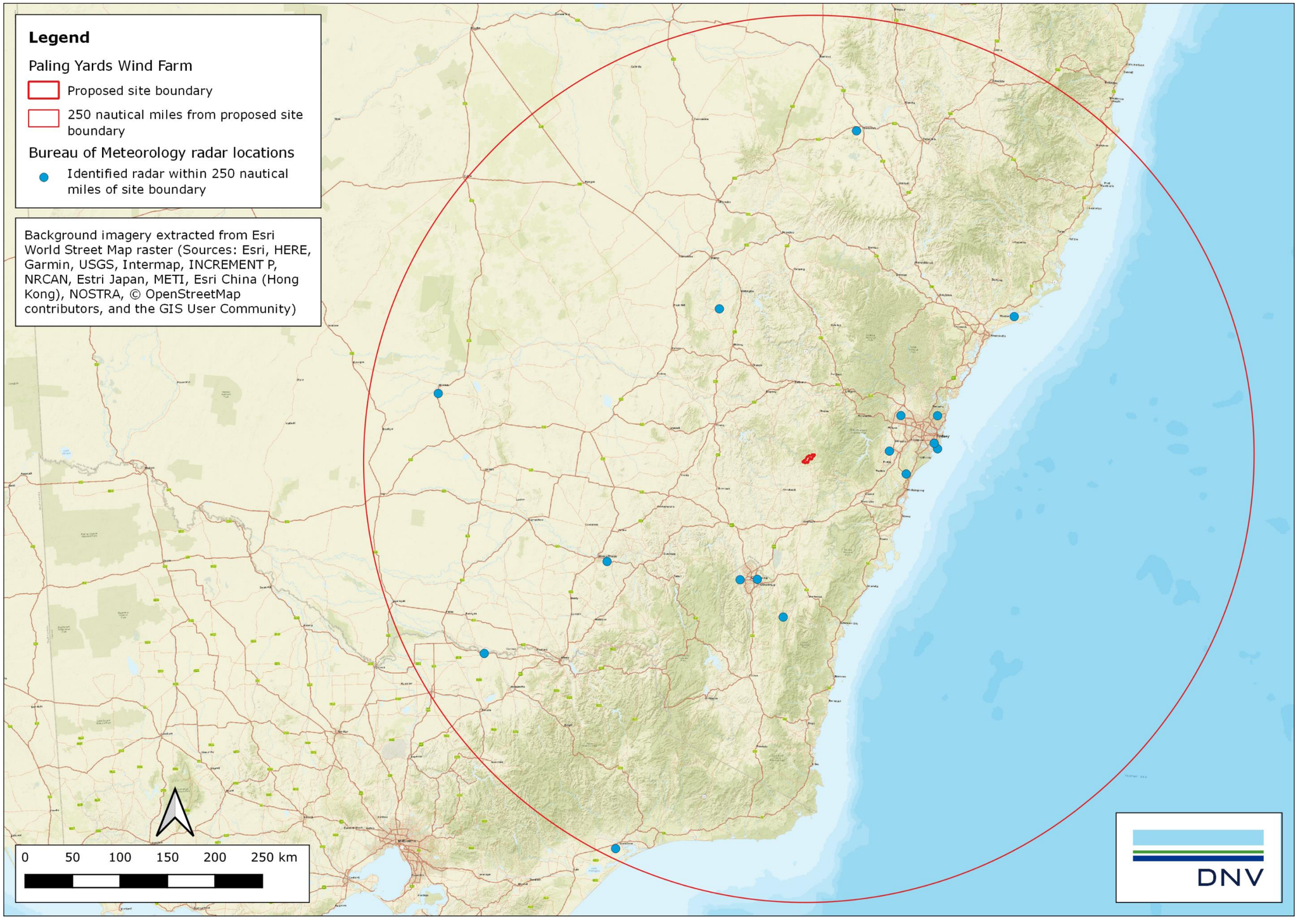

Figure 10 Location of meteorological radar sites within 250 nautical miles of the proposed Project

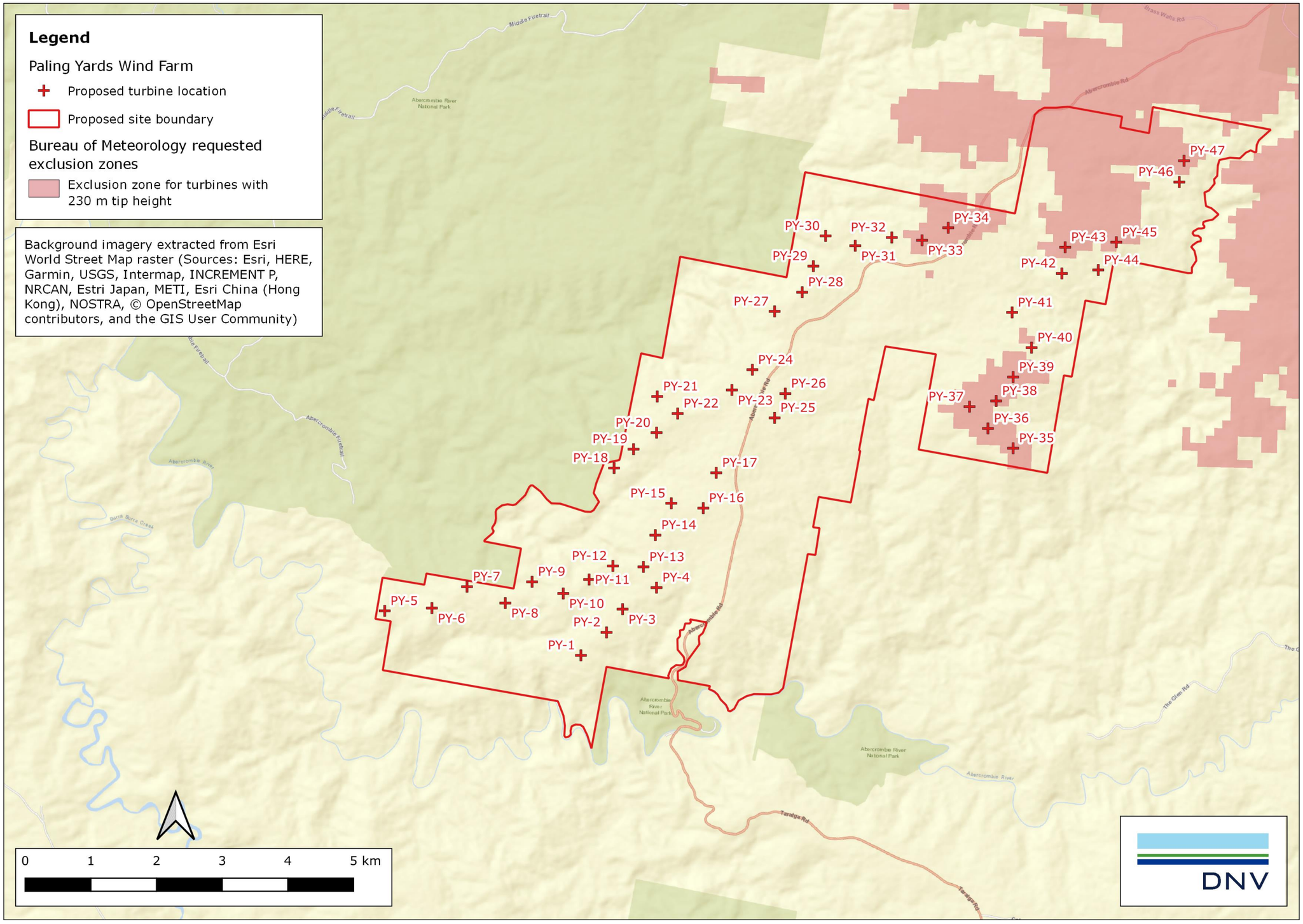

Figure 11 Turbine exclusion zones requested by the Bureau of Meteorology for the Wollongong meteorological radar

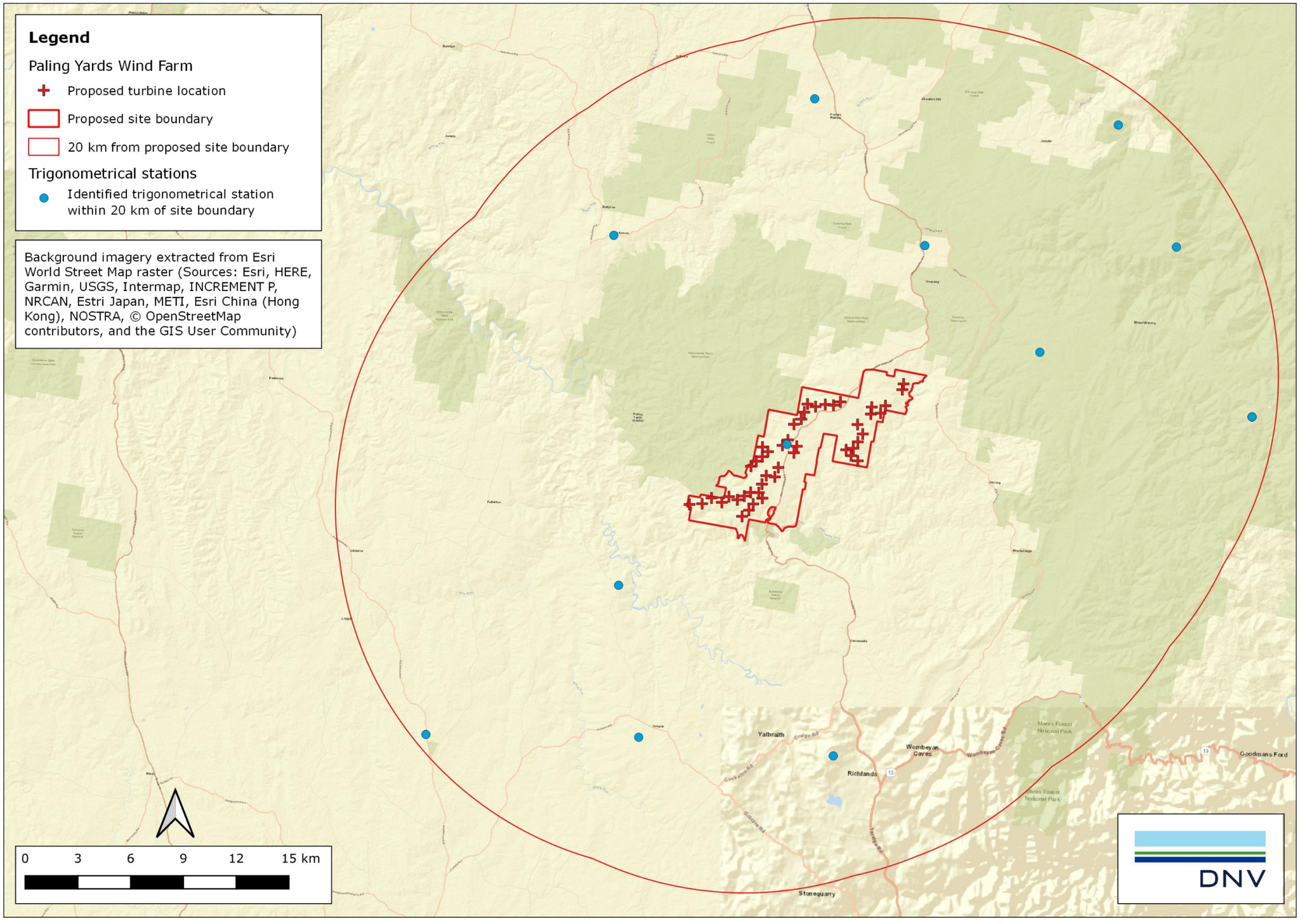

Figure 12 Location of trigonometrical stations within 20 km of the proposed Project

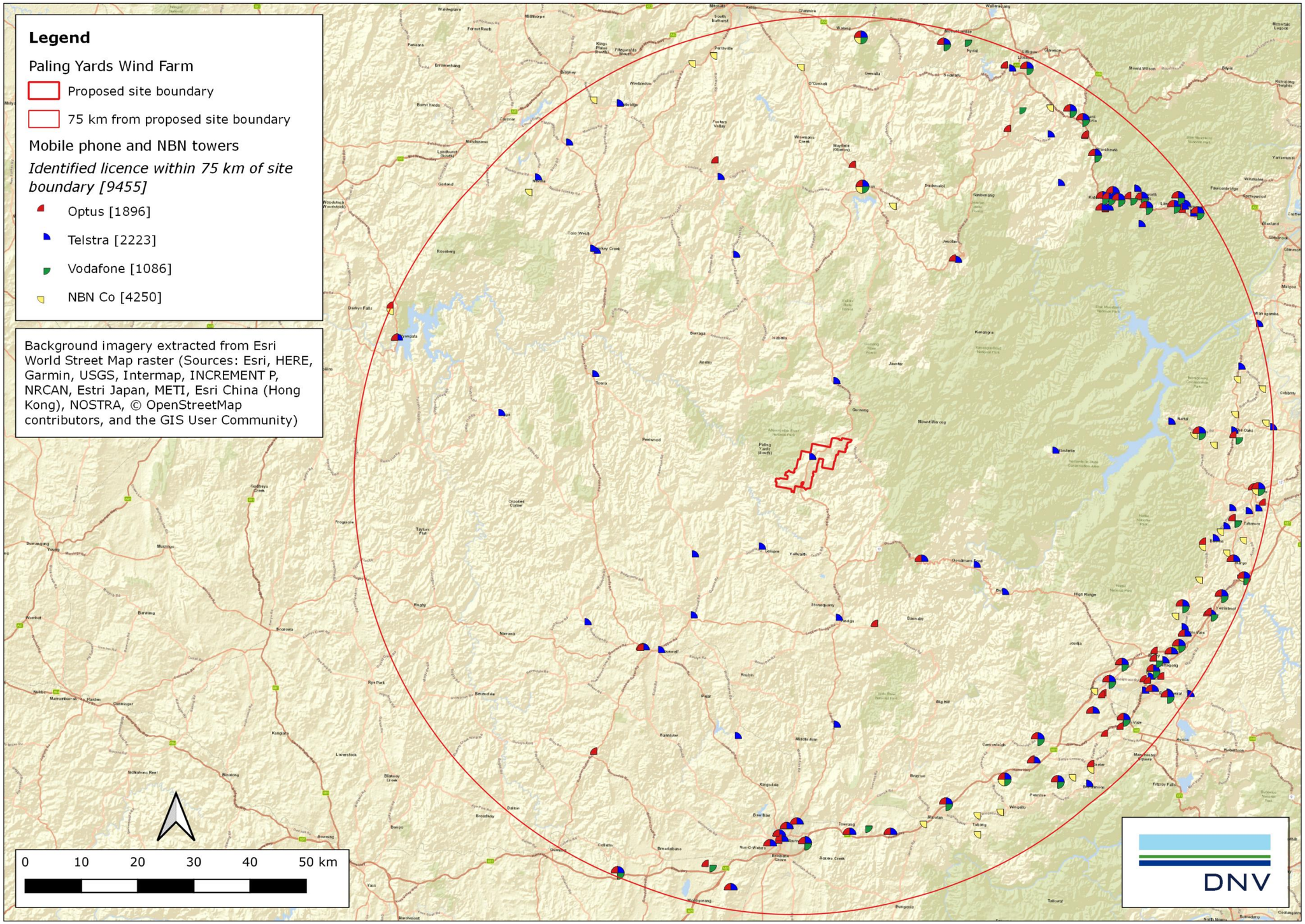

Figure 13 Location of mobile phone and NBN towers within 75 km of the proposed Project

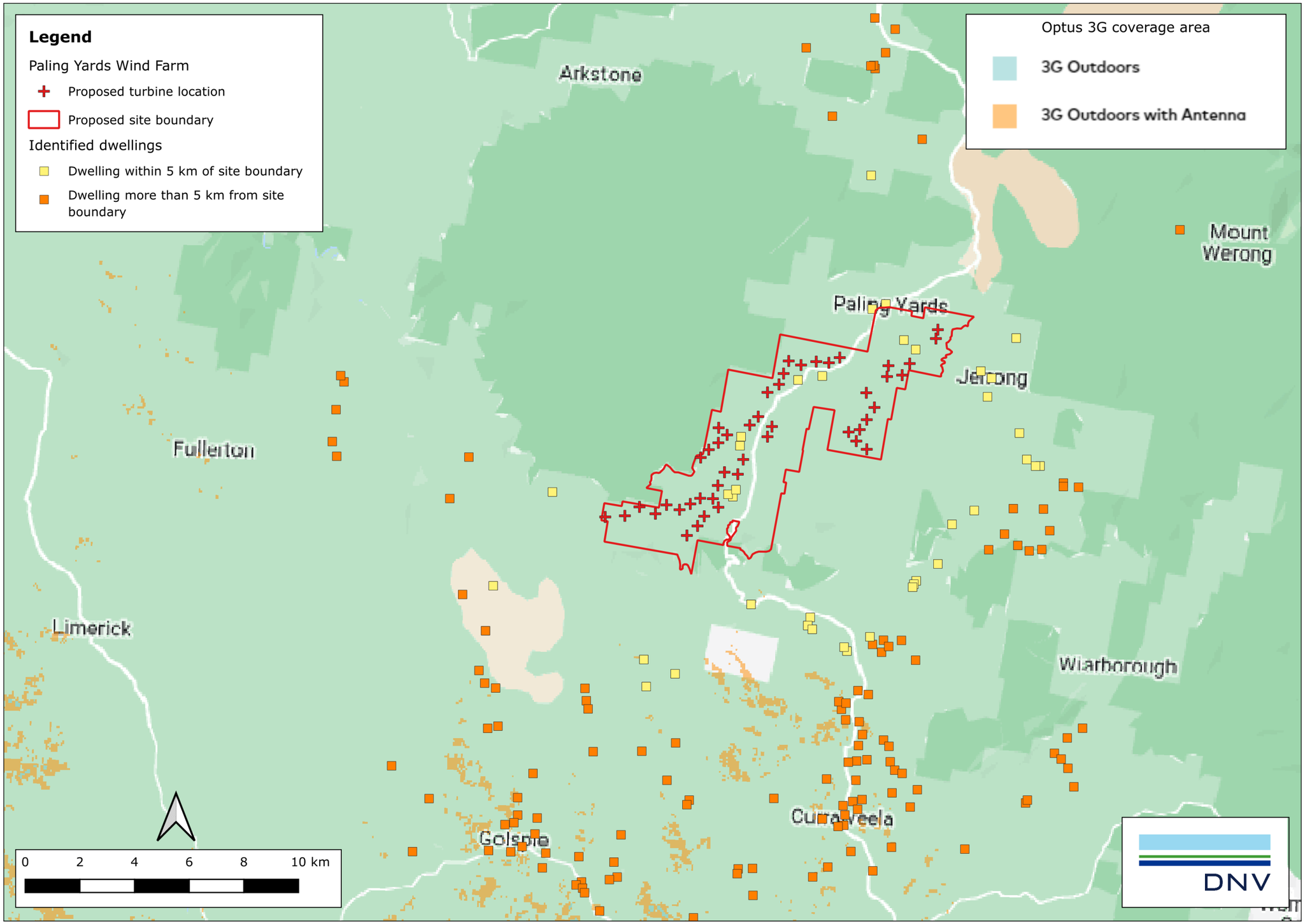

Figure 14 Optus Mobile 3G network coverage for the proposed Project

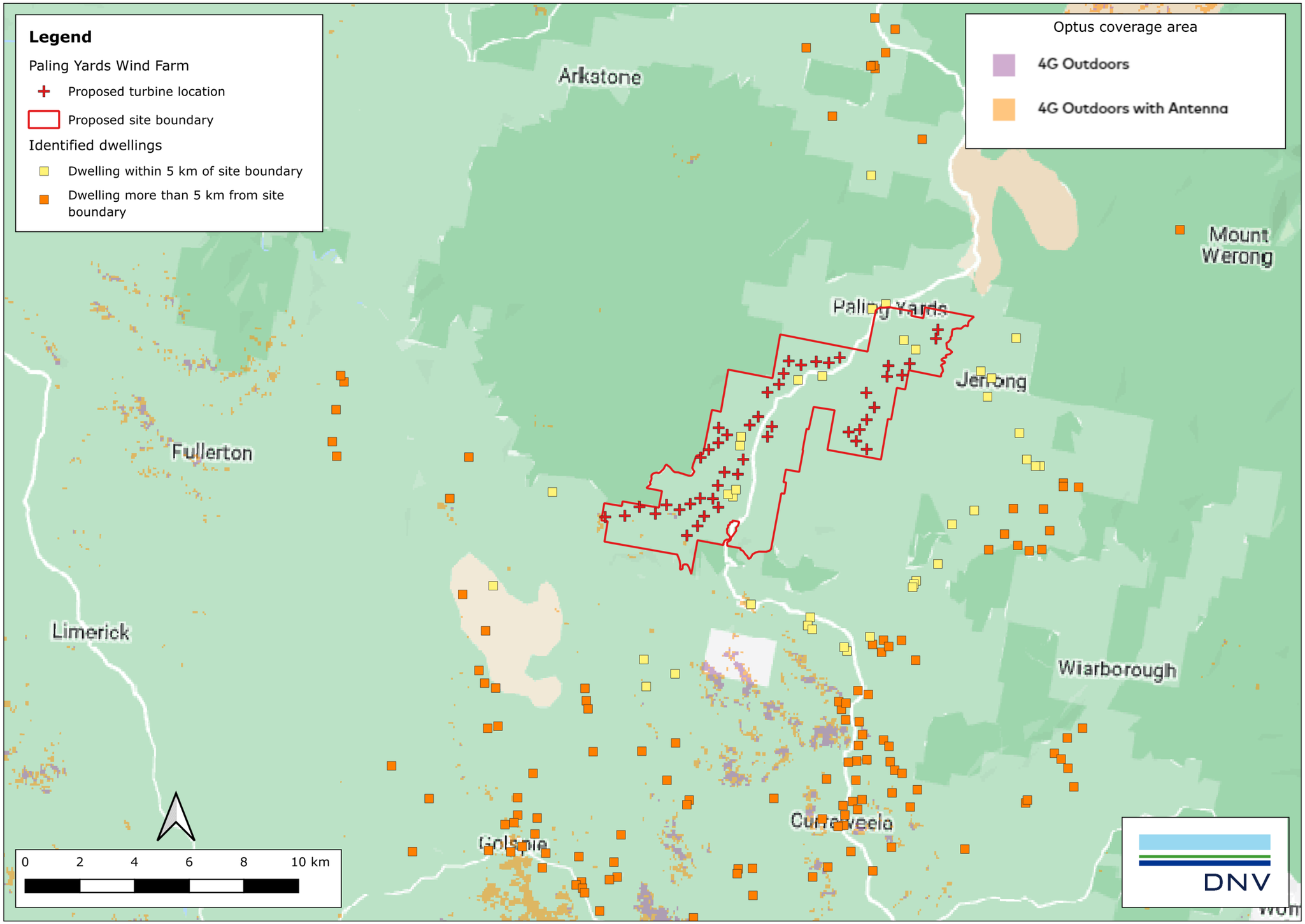

Figure 15 Optus Mobile 4G network coverage for the proposed Project

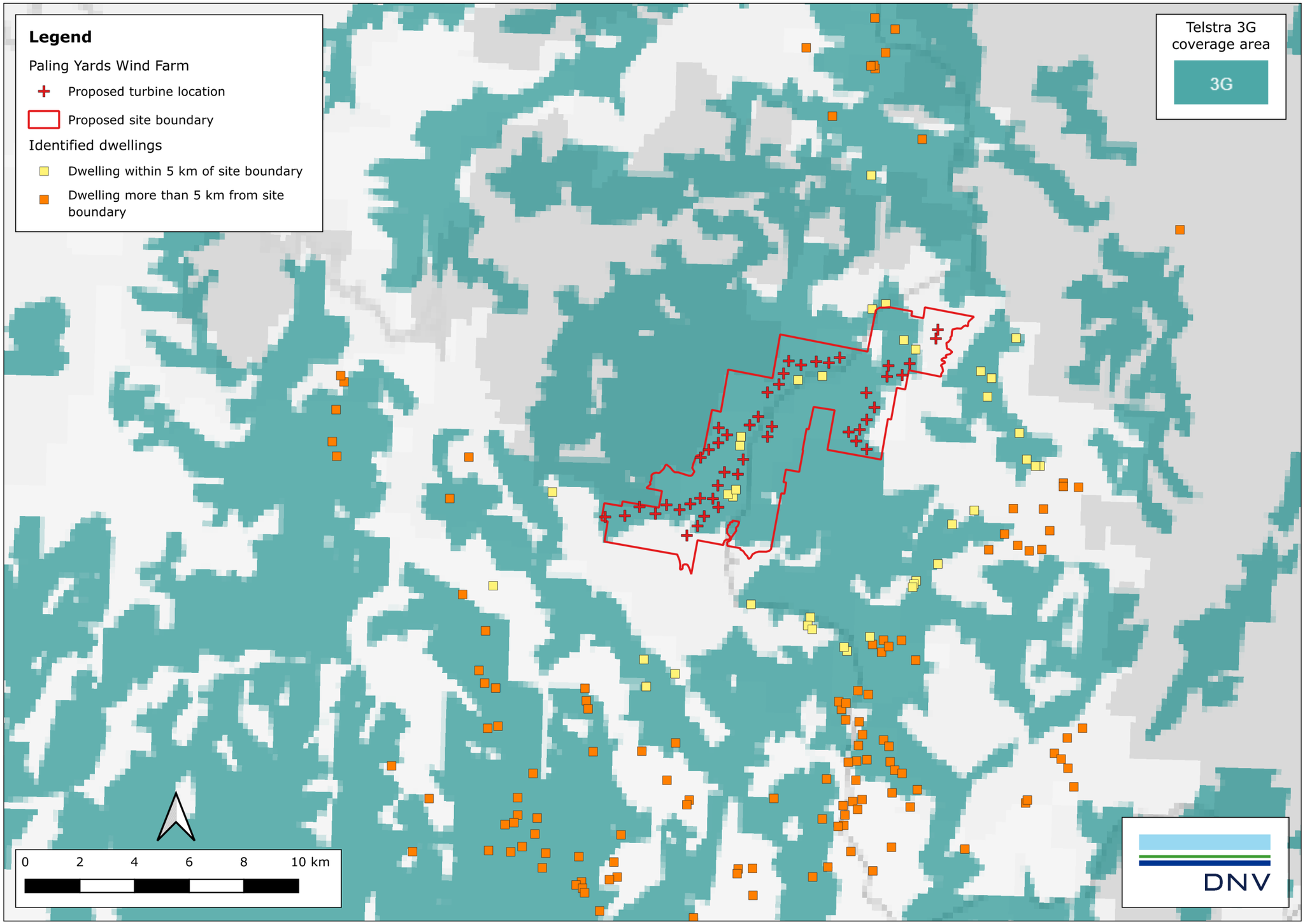

Figure 16 Telstra 3G network coverage for the proposed Project

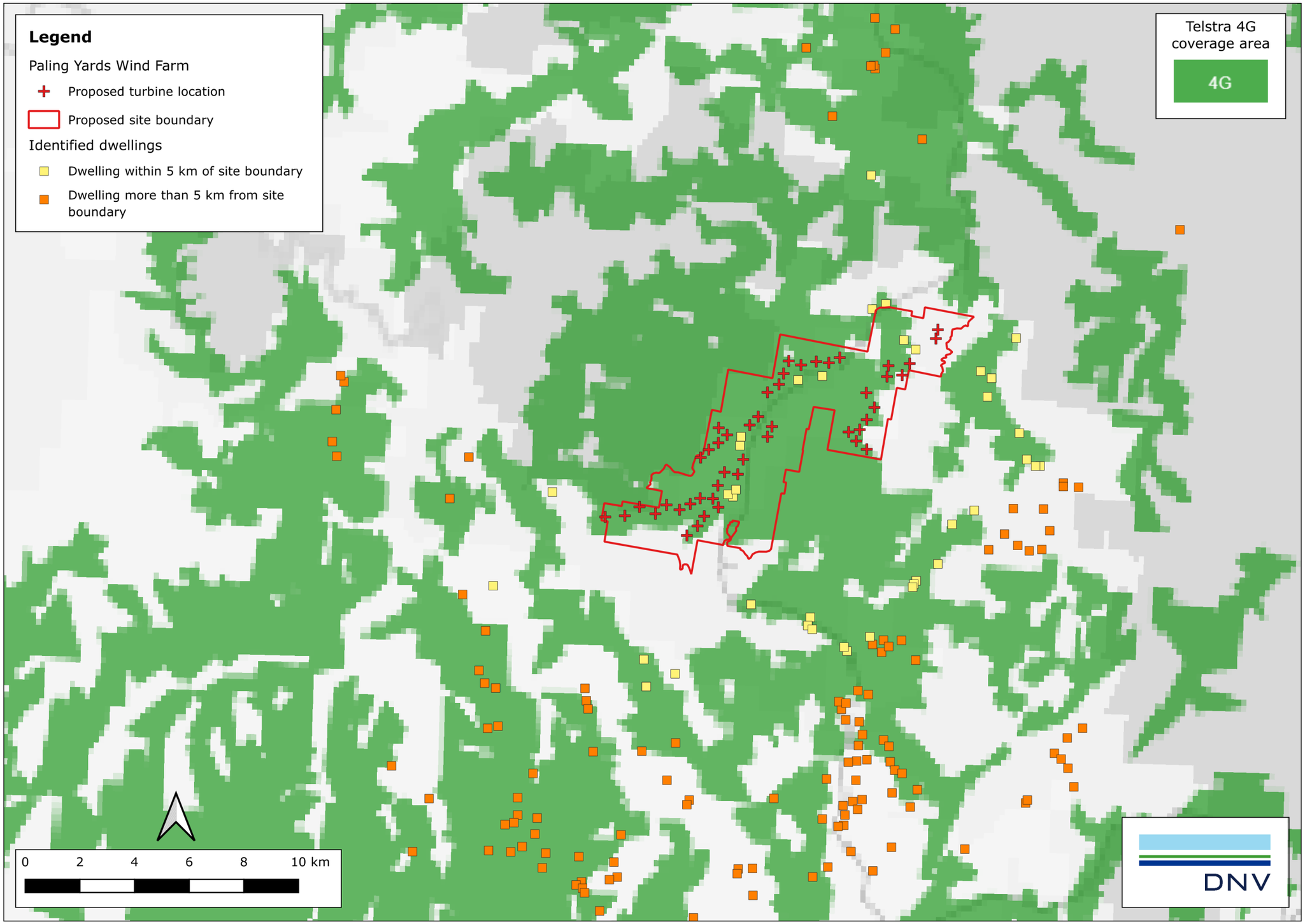

Figure 17 Telstra 4G network coverage for the proposed Project

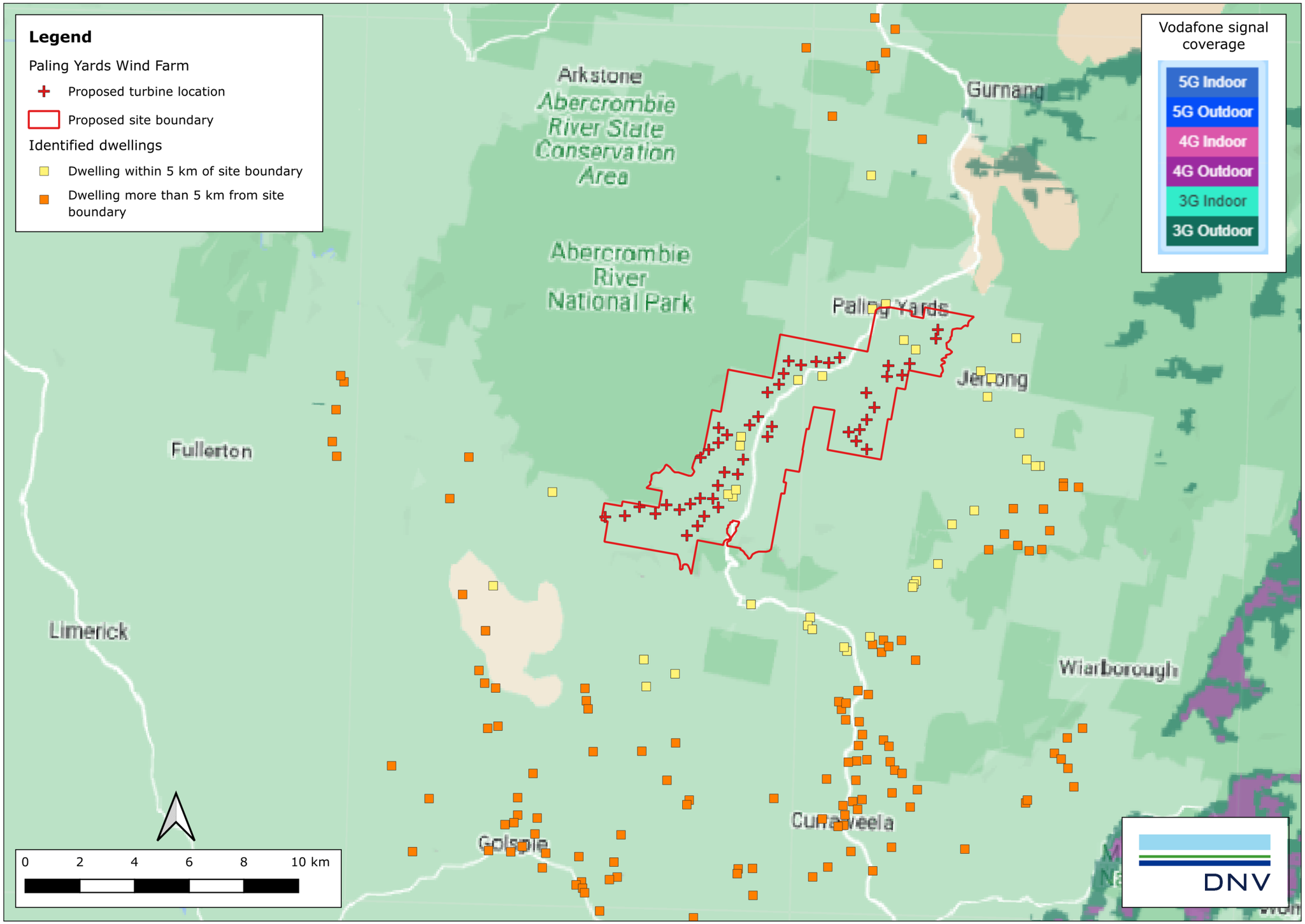

Figure 18 Vodafone network coverage (Apple iPhone 13 handset) for the proposed Project

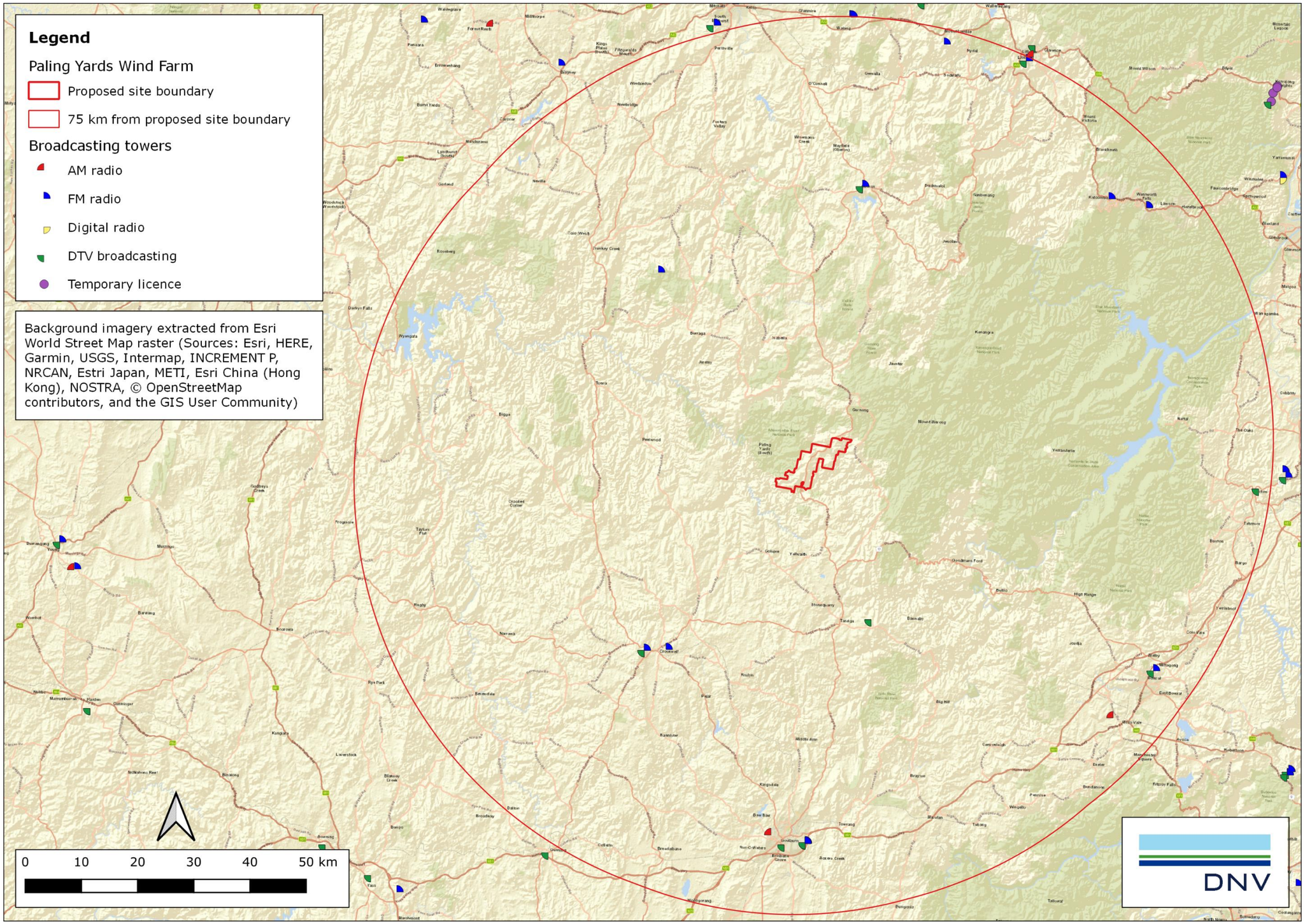

Figure 19 Location of broadcast transmitters in the vicinity of the proposed Project

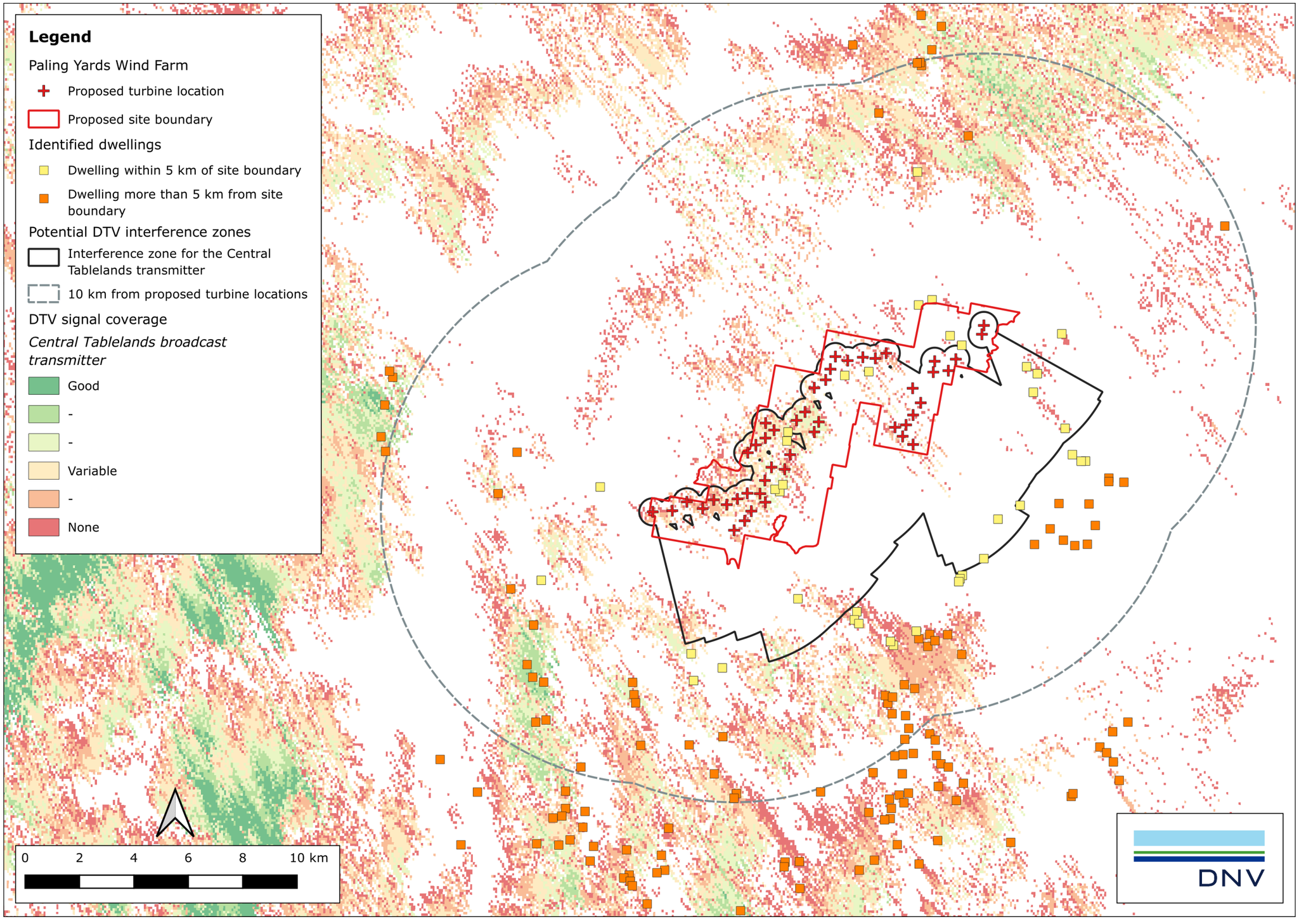

Figure 20 Potential television EMI zones for the Central Tablelands broadcast transmitter from the proposed Project

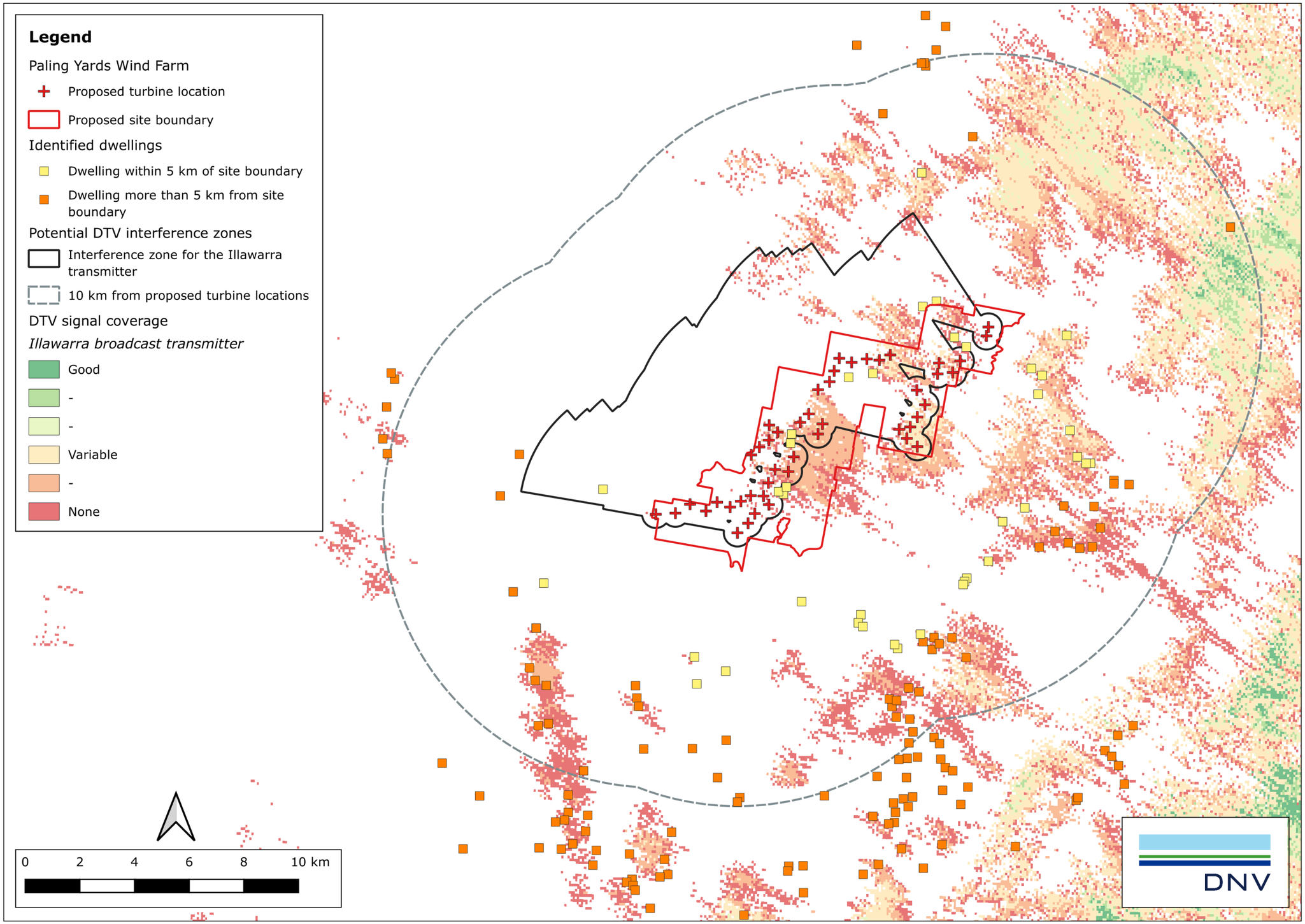

Figure 21 Potential television EMI zones for the Illawarra broadcast transmitter from the proposed Project

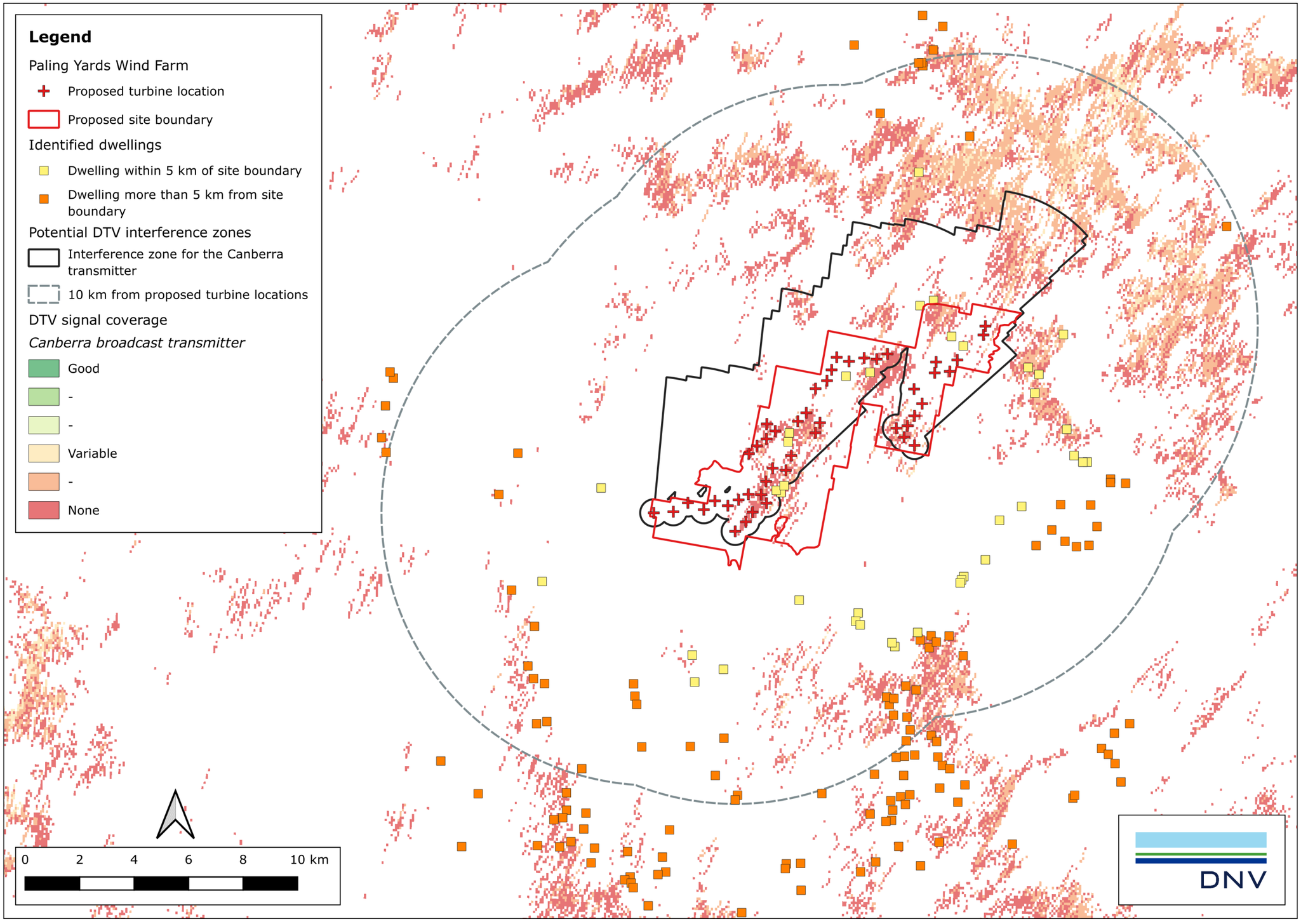

Figure 22 Potential television EMI zones for the Canberra broadcast transmitter from the proposed Project

About DNV

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