WATTA WELLA RENEWABLE ENERGY PROJECT

EMI Assessment

RES Australia Pty Ltd

Report No.: 10271936-AUMEL-R-02, Rev. D
Document No.: 10271936-AUMEL-R-02-D
Date: 5 July 2022
Status: Final

Image provided by the Customer. Image credit: Murra Warra Wind Farm Project Co Pty Ltd.

Project name:	Watta Wella Renewable Energy Project	DNV Energy Systems
Report title:	EMI Assessment	Renewables Advisory
Customer:	RES Australia Pty Ltd	Level 12, 350 Queen Street
	Suite 6.01, Level 6, 165 Walker Street,	Melbourne VIC 3000
	North Sydney, NSW 2060,	Australia
	Australia	Tel: +61 3 8615 1515
Customer contact:	Marton Kalocsay	ABN 19 094 520 760
Date of issue:	5 July 2022	
Project No.:	10271936	
Organisation unit:	K-KL-AD	
Report No.:	10271936-AUMEL-R-02, Rev. D	
Document No.:	10271936-AUMEL-R-02-D	

Applicable contract(s) governing the provision of this Report:

DNV proposal L2C-205875-AUME-P-01 Issue A, dated 11 September 2020

Objective: Watta Wella Renewable Energy Project EMI Assessment

Prepared by:	Verified by:	Approved by:
F Dahhan Engineer Project Development and Analytics	N Brammer Senior Engineer Project Development and Analytics	T Gilbert Principal Engineer, Head of Section Project Development and Analytics
N Brammer Senior Engineer Project Development and Analytics	T Gilbert Principal Engineer, Head of Section Project Development and Analytics	

DNV Distribution:

☒ OPEN. Unrestricted distribution, internal and external.

☐ INTERNAL use only. Internal DNV document.

☐ CONFIDENTIAL. Distribution within DNV according to applicable contract.*

☐ SECRET. Authorized access only.

*Specify distribution:

Keywords:

Watta Wella Renewable Energy Project EMI Assessment

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	2021-07-23	First issue - DRAFT	F Dahhan	N Brammer	T Gilbert
B	2022-06-14	Update based on customer comments	N Brammer	T Gilbert	T Gilbert
C	2022-07-04	Update based on customer comments	N Brammer	T Gilbert	T Gilbert
D	2022-07-04	FINAL	N Brammer	T Gilbert	T Gilbert

Table of contents

EXECUTIVE SUMMARY

DNV has been commissioned by RES Australia Pty Ltd ("the Proponent") to independently assess potential electromagnetic interference (EMI) impacts associated with the wind farm component of the proposed Watta Wella Renewable Energy Project ("the Project") in western Victoria. The results of the EMI assessment are described in this document and summarised in the table at the end of this section.

Background and methodology

DNV has assessed the potential EMI impacts for the Project in accordance with the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria [1] and Draft National Wind Farm Development Guidelines [2]. The methodology used in this study has been informed by these guidelines and various standard industry practices.

A Project layout consisting of 45 wind turbines with a rotor diameter of 178 m and tip height of 255 m has been considered. These dimensions represent the maximum overall tip height within the maximum rotor and tower hub height dimensions.

DNV notes that this assessment is based on a 45-turbine configuration while the Environmental Effects Statement (EES) referral for the Project considers an updated layout with 47 wind turbines. DNV understands that the EMI assessment will be updated post-referral decision and prior to planning submission to reflect the final design.

There are 69 dwellings that have been identified within 5 km of the Project, 10 of which are associated dwellings belonging to wind farm host landowners.

Outcomes of the assessment

The results of the assessment are summarised in the table below.

There are no turbines located within the exclusion zones calculated by DNV for the two fixed point-to-point links passing over the Project boundaries. However, one turbine within the 45-turbine layout considered in this assessment is located close to the exclusion zone for the link operated by Optus Mobile, who have requested that the turbine be moved 50 m further away from the link path. DNV understands that the Proponent has since moved this turbine as requested by Optus Mobile in order to minimise the potential for interference to the point-to-point link.

Based on the assessment undertaken by DNV, dwellings located within and adjacent to the Project boundaries and to the west and northwest of the Project have increased potential to experience interference to digital television signals from the Ballarat tower, particularly in areas to the west where the signal is already marginal. Digital television signals from the Horsham broadcast tower may also be impacted, although the coverage maps suggest that the potentially affected dwellings are unlikely to be receiving signals from this tower. However, feedback received from BAI Communications, who are responsible for broadcasting of national public television services in Australia, suggests that impacts to digital television signals are unlikely.

Interference to signals from satellites that transmit programs intended for international audiences is possible at several nearby dwellings, including one associated dwelling, although it is considered unlikely that residents will be receiving signals from these satellites. If interference is experienced, mitigation options could include realigning or upgrading the user's satellite dish or seeking an alternative source of the same programming or service. DNV recommends that the Proponent

engages with the residents or owners of potentially affected dwellings to determine if any are currently receiving these satellite signals, and to establish an understanding of how any impacts may be mitigated.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links and emergency services without obtaining further information from the service operators, consultation with the service operators has helped to determine the potential for the Project to cause interference to these services. The responses received to date are summarised in Table 16 of this document, and indicate that the Project is unlikely to have any impact on these services.

Potential EMI impacts on other services considered in this assessment, including meteorological radar, trigonometrical stations, mobile phone and wireless internet services, and broadcast radio, are either considered to be minor or are have been assessed through consultation with the service operators.

The Project is located in an area of high wind farm development activity, with several operational wind farms located nearby. Based on the relative locations of these wind farms, there is a risk of cumulative EMI-related impacts to broadcast digital television signals received at nearby dwellings. There is also potential for increased interference to mobile phone and FM radio signals in areas where there may be multiple wind turbines between the user and the transmission tower. Cumulative impacts to other services, including point-to-point links and NBN fixed wireless internet signals, are not expected.

Summary of EMI assessment results for the proposed Project

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Radiocommunication towers	No towers within 2 km of proposed turbine locations	Unlikely to cause interference	Unlikely to cause interference	None required
Fixed point-to-point links	Two links crossing Project boundary, operated by: Northern Grampians Shire Council Optus Mobile Diffraction effects: no turbines in exclusion zones established by DNV for either link. One turbine (T43) within 50 m of zone for link operated by Optus Mobile Reflection/scattering and near-field effects: turbines are sufficiently far from towers to avoid impacts	Unlikely to cause interference	Potential for interference to link operated by Optus Mobile; requested turbine T43 be moved at least 50 m further away from link path No response received from Northern Grampians Shire Council	DNV understands that the Proponent has since moved turbine T43 as requested by Optus Mobile No further mitigation required
Fixed point-to-multipoint links	40 assignments within 75 km of Project boundary Three base stations within 20 km of Project boundary, operated by: Central Highlands Water Stawell Gold Mines Grampians Wimmera Mallee Water	Potential for interference if link paths cross the Project site near turbines	No concerns raised	None required
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: No links crossing boundary Mobile telephony systems: unlikely to be affected	Unlikely to cause interference	No concerns raised by Ambulance Victoria, Country Fire Authority, and Regional Mobile Radio No response received from Corrections Victoria, VisionStream, St John Ambulance, and Victoria State Emergency Service	Point-to-point links: none required Mobile radio systems: 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	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Meteorological radar	Nearest radar: "Rainbow (Wimmera)", 133 km from Project	Potential for interference if turbines at the Project are visible to radars	Unlikely to cause interference	Notify the Bureau of Meteorology prior to planned wind farm shutdown to allow calibration of radar systems
Trigonometrical stations	Seven stations within 20 km of Project boundary Electronic equipment: unlikely to be affected Survey marks: unlikely to be affected Sight lines to other stations: may be blocked by turbines	Unlikely to cause interference	No concerns raised by DELWP regarding interference to GNSS signals, but potential for physical disturbance to survey marks noted No response received from Geoscience Australia	None required for electronic equipment Potential physical disturbance of survey marks to be mitigated through Proponent engagement with DELWP during construction if required
Citizen's band radio	Unlikely to be affected	Unlikely to cause interference	Consultation not considered necessary	None required
Mobile phones	Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	Low risk of interference	No response received regarding mobile phone services	If required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	Likely service providers: mobile phone networks NBN: available as a satellite service only	Unlikely to cause interference	No concerns raised by NBN Co No response received from Optus Mobile, Telstra, and Vodafone	Mobile phone networks: 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 two satellites intercepted at four dwellings	Unlikely to cause interference	Consultation with operators not considered necessary DNV recommends engaging with residents of potentially affected dwellings	If required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish at affected location

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

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Radio broadcasting	AM signals: unlikely to be affected FM signals: may experience interference in close proximity to turbines Digital radio signals: not available in vicinity of Project	Low risk of interference to FM signals	Consultation not considered necessary	AM signals and digital radio signals: none required FM signals: if required – install higher-quality antenna at affected location, increase signal strength form affected tower, move tower to a new location, install signal repeater, install additional tower
Television broadcasting	May experience interference in areas with poor or marginal reception *Ballarat (Lookout Hill) tower: 'variable' to 'good' coverage across the site* 35 dwellings in potential interference zone	Risk of interference	Low risk of interference for up to three residents, but no buildings identified in potential interference areas	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
	Horsham (Arapiles) tower: 'poor' to 'variable' coverage across the site 15 dwellings in potential interference zone	Risk of interference; although residents are likely to be able to receive alternative signals from the Ballarat tower	Not considered to be providing coverage in the area around the Project	

1 INTRODUCTION

RES Australia Pty Ltd ("the Proponent") has commissioned DNV to independently assess the potential electromagnetic interference (EMI) related impacts associated with the wind farm component of the proposed Watta Wella Renewable Energy Project ("the Project") in western Victoria. The results of this work are reported here. This document has been prepared in accordance with DNV proposal L2C-205875-AUME-P-01 Issue A, dated 11 September 2020, and is subject to the terms and conditions in that agreement.

In accordance with the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria (Victorian Guidelines) prepared by the Department of Environment, Land, Water and Planning (DELWP) in November 2021 [1] and the National Wind Farm Development Guidelines – Draft (Draft National Guidelines) prepared by the Environment Protection and Heritage Council (EPHC) in July 2010 [2], 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.

DNV notes that this assessment is based on a 45-turbine configuration while the Environmental Effects Statement (EES) referral for the Project considers an updated layout with 47 wind turbines. DNV understands that the EMI assessment will be updated post-referral decision and prior to planning submission to reflect the final design.

2 DESCRIPTION OF THE SITE AND PROJECT

2.1 The site

The broader Watta Wella Renewable Energy Project is located in the Wimmera region in western Victoria, approximately 16 km northeast of Stawell and 30 km north of Ararat. The site is characterised by open farmland on gently undulating terrain, interspersed with wind breaks and some areas of trees, including the Joel Joel Nature Conservation Reserve to the south and the Wimmera River to the east.

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 45 wind turbines [3]. A map of the site with the proposed turbine layout is shown in Figure 1, and the coordinates of the proposed turbine locations are presented in Table 7.

2.2.2 Dwelling locations

The locations of dwellings in the vicinity of the Project have been provided by the Proponent [4]. For the purposes of this assessment, DNV has considered all identified dwellings within 5 km of the Project site boundaries. There are 69 dwellings located within 5 km of the Project site boundaries, 10 of which are associated dwellings. Associated dwellings are defined as belonging to wind farm host landowners. The coordinates of these dwellings are presented in Table 8, and the dwellings and site boundaries 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 Proponent. For the purposes of this assessment, DNV has only considered buildings categorised as houses, and has assumed that all listed houses are inhabited.

3 REGULATORY REQUIREMENTS

There are two sets of guidelines that are potentially relevant to the assessment of EMI impacts for wind farms in Victoria.

The Victorian Guidelines [1] state that "*a wind energy facility can affect the amenity of the surrounding area due to … electromagnetic interference*" and that "*[t]he potential for electromagnetic interference from the generation of electricity from a wind energy facility should be minimised, if not eliminated, through appropriate turbine design and siting*".

Although the Victorian Guidelines state that *"potential electromagnetic interference effects can be calculated from information about affected telecommunications transmitting or receiving stations, local conditions, [and] turbine design and location"* 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) [2]. 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 recommendations of the Victorian Guidelines. Therefore the Draft National Guidelines have been used to inform the methodology adopted for this assessment.

4 METHODOLOGY AND RESULTS

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 Proponent has asked DNV to complete this assessment based upon a layout provided for the Project consisting of 45 wind turbines, as outlined in Table 7.

For the purpose of the EMI assessment, a hypothetical turbine with a rotor diameter of 178 m and a tip height of 255 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 178 m or less
- an upper tip height of 255 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 site, and then assess the radiocommunication licences attached to these towers. This reduces the likelihood that radiocommunication links crossing the site are inadvertently excluded from the assessment.

To conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the Project was obtained from an image of the Australian Communication and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database dated 31 May 2021 [5].

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 consulted with 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 16.

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.

4.1 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 [2], 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.

4.1.1 Locations of radiocommunication towers and potential for interference

From the ACMA RRL database, there are 396 radiocommunication towers within a nominal 75 km of the Project site boundary. The locations of these radiocommunication towers relative to the Project are shown in Figure 2.

There are no radiocommunication towers located within 2 km of the proposed turbine locations. The nearest tower is located approximately 3.8 km northeast of turbine T5 (site ID 10024561), and is licensed to ViaSat Australia.

4.2 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.

4.2.1 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 3. It can be seen that not all of the identified transmission towers have a fixed licence of point-to-point type transmission

vector. Some towers have no active licences associated with them, and some towers are used solely for point-to-area style transmissions, such as some emergency services towers.

There are two point-to-point links recorded in the ACMA RRL database that pass over the proposed Project site (operated by Northern Grampians Shire Council and Optus Mobile). The details of the links are provided in Table 9, and the link paths are shown in greater detail in Figure 4 based on information obtained from the ACMA RRL database, provided by the link operators, and extracted from aerial or satellite imagery.

The potential interference mechanisms and interference zones established by DNV for these links are described in Sections 4.2.1.1, 4.2.1.2, and 4.2.1.3, and summarised in Section 4.2.1.4. Feedback obtained from the operators of the links, including their recommended clearance zones to reduce the risk of interference, is summarised in Section 4.2.2.

4.2.1.1 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 [2] [6] [7], 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 [6], 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 site, 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 4. Each exclusion zone includes the rotor radius for turbines with a 178 m rotor diameter, and an additional buffer on either side to account for potential inaccuracies in the tower locations. The size of the uncertainty buffer for each link is based on the deviations between the tower locations provided by the link operators 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 boundaries over which the link crosses.

The results of this analysis are summarised in Table 1. There are no turbines located within the exclusion zones for either of the point-to-point links passing over the proposed Project site. However, turbine T43 is located within 50 m of the exclusion zone for the link operated by Optus Mobile.

4.2.1.2 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) [6].

Reference [6] 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.

DNV considers that the transmission towers for both of the point-to-point links crossing the Project boundary are sufficiently far from the proposed turbine locations to avoid reflection or scattering effects. Therefore, it is not expected that the Project will cause interference to the point-to-point links through this mechanism.

4.2.1.3 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 [6] 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.

DNV considers that the transmission towers for both point-to-point links crossing the Project boundary are sufficiently far from the proposed turbine locations to avoid near-field effects. Therefore, it is not expected that the Project will cause interference to the point-to-point links through this mechanism.

4.2.1.4 Summary of point-to-point interference effects

Table 1 summarises the turbines located within the calculated interference zones for each of the point-to-point links crossing the Project site.

Table 1 Details of turbines located within the interference zones established by DNV for point-to-point links crossing the proposed Project site

Link no.	Operator	Turbines within potential interference zone			
		Diffraction		Reflection/ scattering	Near-field
		Horizontal plane	Vertical plane		
1	Northern Grampians Shire Council	None	None	Not assessed[1]	Not assessed[1]
2	Optus Mobile	None	None	Not assessed[1]	Not assessed[1]

1. Transmission towers are located more than 5 km from the proposed turbine locations. Interference caused by reflection or scattering of signals or near-field effects is not expected for this link.

4.2.2 Stakeholder consultation and responses

DNV has contacted the operators of the point-to-point links crossing the proposed Project site 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.

Based on the 45-turbine layout considered in this assessment and provided to the operators of the point-to-point links, Optus Mobile have requested that turbine T43 be moved 50 m further away from their link path in order to avoid interference to the link. DNV understands that the Proponent has since moved turbine T43 as requested by Optus Mobile.

No response has been received from Northern Grampians Shire Council to date.

4.2.3 Mitigation options

DNV understands that, since this assessment, turbine T43 has been moved 50 m further away from the path of the Optus Mobile point-to-point link, as requested by Optus Mobile. Based on the assessment presented here and the feedback obtained from the operators of the point-to-point links crossing the Project boundaries, no further mitigation is required.

4.3 Fixed licences of point-to-multipoint type

Fixed licences of the point-to-multipoint type are a variation of the point-to-point type. The difference between them is administrative. A point-to-point licence permits communication between two static sites, where the locations of the sites are detailed in the 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.

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

From the ACMA RRL database, DNV has identified 40 point-to-multipoint Assignment IDs within approximately 75 km of the proposed Project site. These licences are shown in Figure 5. The details of the licence holders as given in the ACMA database are provided in Table 10.

There are three point-to-multipoint base stations within 20 km of the Project boundary. These stations are operated by Central Highlands Water (Site ID 9012292), Stawell Gold Mines (Site ID 305839), and Grampians Wimmera Mallee Water (Site ID 302772). There are also several point-to-multipoint base stations located more than 20 km from the site.

Wind turbines can cause interference to point-to-multipoint links through the same mechanisms as described for point-to-point links in Section 4.2.1. 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.

4.3.2 Stakeholder consultation and responses

DNV has contacted the operators of all potentially affected base stations within 60 km of the Project to determine the likelihood that the proposed Project will cause interference to their services. Responses have been received from all operators contacted, as summarised in Table 16, and no concerns have been raised.

4.4 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.

4.4.1 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 6 and Table 11.

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 4.5 and 4.10 respectively, while the potential for interference to radio and television broadcasting services is considered in Sections 4.13 and 4.14.

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 will be considered as part of an aviation impact study.

4.5 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.

4.5.1 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 12 along with their contact details. The nearest licence is associated with a tower located approximately 5 km from the site boundary.

There are no emergency services point-to-point links crossing the proposed Project site, and so there is no potential for interference with point-to-point licences operated by emergency services.

All other licences operated by emergency services in the vicinity of the Project are mobile telephony licences used for mobile radio and paging systems. As discussed in Section 4.4, mobile telephony systems are generally not affected by the presence of wind turbines any more than other forms of signal obstruction. 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 to these systems. 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 point-to-area style services [9].

Given the distance of the emergency services mobile telephony licences from the Project, DNV considers it unlikely that the Project will cause interference to mobile radio and paging systems operated by emergency services.

4.5.2 Stakeholder consultation and responses

DNV has contacted the operators of all 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.

Responses have been received from Ambulance Victoria, Country Fire Authority, and Regional Mobile Radio, as summarised in Table 16, and no concerns have been raised. No response has been received to date from Corrections Victoria, VisionStream, St John Ambulance, or Victoria State Emergency Service to date.

4.5.3 Mitigation options

As noted above, there is no risk of impacts to point-to-point links operated by emergency services, and interference with mobile telephony services 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.

4.6 Aircraft navigation systems and radar

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

4.7 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 [10].

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 [11, 12].

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 [13, 14], and approximately 100 km at a height of 1000 m [14]. 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 risk of complete or partial blockage of the radar signal and subsequent loss of weather data [15, 16]. 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 [2].

4.7.1 Locations of meteorological radars and potential for interference

DNV has identified that the BoM operates nine weather radars within 250 nautical miles of the proposed Project, with the closest radar, "Rainbow (Wimmera)", located approximately 133 km northwest of the Project site. The locations of these radars are shown in Figure 7 and the details of each radar are given in Table 13.

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

4.7.2 Stakeholder consultation and response

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 potential impact will be manageable, and no objections will be raised provided that the BoM is given at least two weeks' notice prior to any planned shutdown of the Project after construction. This will allow the BoM to calibrate their radar

systems while the turbines are not operating, and hence account for the presence of the Project in their signal processing and interpretation.

4.7.3 Mitigation options

According to the WMO, there are currently no automated signal processing techniques available that can be used to effectively filter radar data to remove interference caused by wind farms [16], However, if analysis indicates there is a risk of the wind farm causing reflection or scattering of radar signals, the WMO suggests it may be possible to reduce the potential impact through the relocation of individual turbines prior to construction. In situations where the expected interference is limited to signal clutter, the radar operator may also be able to mask these effects in the data or train the users to take the locations of the wind farms into account. As noted above, feedback received from the BoM states that prior notification of any planned wind farm shutdown would allow the radar systems to be calibrated to account for the presence of the Project while the turbines are not operating.

4.8 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 risk of 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 [17].

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 [18]. 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) [19], 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 In Victoria, the DELWP also operates a state-wide GNSS CORS network, known as GPSnet, which is used to provide geospatial data for mapping, surveying, agriculture, and industry [20]. the AuScope GNSS network of around 100 CORS strategically distributed across the country. 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.

4.8.1 Locations of trigonometrical stations and potential for interference

According to Geoscience Australia [21], there are seven trig points within 20 km of the Project site boundary. The details of these trig points are provided in Table 14 and their locations are illustrated in Figure 8. There are also 25 permanent survey marks within the Project site boundary [22] as shown in Figure 9. The closest survey mark is located 143 m southeast of turbine T12.

DNV has reviewed the primary geodetic network of Australia [23] and observed that the Project is located within the first-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 22 km northwest of the Project, at Glenorchy [21]. 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.

4.8.2 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 the DELWP to inform them of the Project, and seek feedback regarding whether interference to their systems is possible.

The response received from the DELWP states that they do not expect the Project to have any impact on their positioning infrastructure, but that the survey marks located within the site boundary should not be disturbed during wind farm construction and operation. The DELWP have requested that they be notified if there is a need to disturb any of the survey marks.

No response has been received from Geoscience Australia to date.

4.9 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.

4.9.1 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 site 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.

4.9.2 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.

4.10 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.

4.10.1 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 10. The nearest mobile phone tower is located approximately 9 km east of the Project boundary.

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

Figure 11 shows the Optus Mobile 3G and 4G network coverage for the Project area [24]. Signal coverage is generally good across the site, with some areas to the west and south where 3G coverage is only available with an external antenna.

Figure 12 and Figure 13 show the Telstra 3G and 4G network coverage for the Project area [25]. The extent of coverage for both 3G and 4G is broadly similar, with signals available across most of the site. However, there are small areas within the site boundary and to the northeast, west and south where coverage is not available for either the 3G or 4G networks.

Figure 14 shows the Vodafone network coverage for the Project area [26]. Outdoor 3G and 4G coverage is available across most of the site, although there are small areas to the south where coverage is not available.

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

4.10.2 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. No detailed responses regarding impacts to mobile phone services have been received to date.

4.10.3 Mitigation options

As noted above, interference with mobile phone signals is considered unlikely in most cases. 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.

4.11 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).

4.11.1 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.

4.11.1.1 Availability of wireless broadband services and potential for interference

Residents in the vicinity of the Project are likely to use wireless broadband services provided by Optus, Telstra, and Vodafone where network coverage is available. These wireless broadband services use the same networks as mobile phone services for those providers, and therefore the comments made in Section 4.10.1 are applicable here. Specifically, there is a low theoretical risk of interference in areas with marginal reception if a wind turbine intercepts the signal between a receiver and the tower.

4.11.1.2 Stakeholder consultation and responses

DNV has contacted Optus, Telstra, and Vodafone to seek feedback regarding the potential for interference to their services. No detailed responses regarding impacts to wireless broadband or mobile phone services have been received to date.

4.11.1.3 Mitigation options

As noted above, interference with 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 4.10.3 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.

4.11.2 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 [27]. Consequently, the signals may be affected by physical obstructions such as terrain, vegetation, and wind turbines [28].

NBN satellite internet signals are available to rural and remote users in areas that are not able to receive fixed line or fixed wireless services. The potential for interference to satellite internet signals from the NBN Sky Muster I and II satellites is considered in Section 4.12.

4.11.2.1 Availability of NBN services and potential for interference

The National Broadband Network (NBN) website [29] indicates that the network is currently available as a satellite internet service using the NBN SkyMuster I and II satellites 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 network is currently available as a fixed wireless service in areas to the west and southwest of the Project, however given the relative locations of the dwellings and NBN towers, it is unlikely that the Project will have an impact on this service.

4.11.2.2 Stakeholder consultation and responses

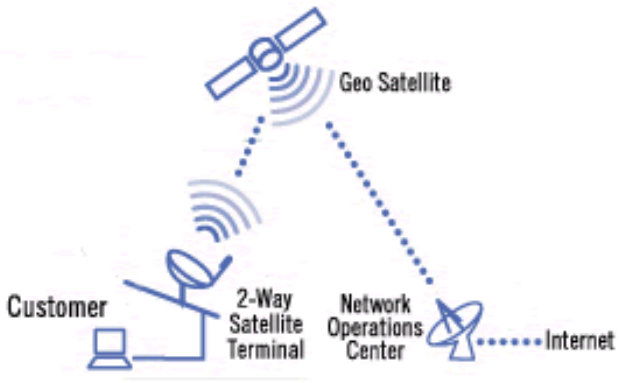
DNV has contacted NBN Co to seek feedback on whether there is potential for the Project to cause interference to their services, and to allow them to take the presence of the Project into account in their coverage planning maps. The response received from NBN Co indicates that they do not expect the Project to have any impact on their fixed wireless internet service.

4.12 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 [30, 31].

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 [32]

4.12.1 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. DNV has analysed the line-of-sight to dwellings in the vicinity of the Project for satellites which provide any television or internet services to eastern Australia. Although only a small number of satellites are likely to be providing services specifically intended for Australia, all theoretically viewable satellites have been considered.

The results of the analysis are shown in Table 2. Based on these results, turbines at the Project may intercept signals from two satellites to four nearby dwellings, one of which is an associated dwelling. However it is DNV's understanding that these satellites do not transmit signals designed for Australian audiences [33], and as such it is unlikely that residents in the vicinity of the Project will be receiving signals from these satellites.

Table 2 Satellite vectors with potential to be intercepted by the proposed Project

Intercepted satellite	Services provided [33]	Affected dwellings
Eutelsat 70B	Programs intended for international audiences	*171*, 178, 188, 218
Intelsat 22	Programs intended for international audiences	*171*, 178, 188

4.12.2 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.

4.13 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.

4.13.1 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.

4.13.1.1 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 [34], and are shown in Figure 16.

As AM radio signals are able to propagate around obstructions such as turbines, it is expected that the Project will not cause significant interference for a receiver. Additionally, due to the long wavelength of the signal, interference is only likely in the immediate vicinity of a turbine [35]. Any interference problems are likely to be easily resolved through the installation of a high quality antenna or amplifier.

4.13.2 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. The waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon, however they may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage, 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 [36]. 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 [35, 37].

Wind turbines located close to an FM transmission tower may also present a physical obstruction to the radio signal. If the line-of-sight between the tower 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 [36]. 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 transmission tower [38].

4.13.2.1 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 [34], and are shown in Figure 16.

The closest FM broadcast transmission tower is located approximately 10 km west of the proposed site boundary. Due to the considerable distance between the transmission tower and the site, it is not expected that the Project will cause interference to the FM radio signals from this tower.

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.

4.13.2.2 Mitigation options

If interference to FM radio signals is experienced, mitigation options include installing high-quality antennas or amplifiers at affected residences, increasing the broadcast signal strength from the transmission tower, moving the tower to a new location further away from the turbines, or installing a signal repeater or additional tower on the opposite side of the Project.

4.13.3 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 [39]. 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.

4.13.3.1 Availability of digital radio services and potential for interference

According to the digital radio coverage search functions available on the ABC website [40] and Digital Radio Plus website [41], digital radio is not yet available in the Project region. Hence, while there are no digital radio broadcasts in the vicinity of the Project, no interference to digital radio signals is possible.

4.14 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 [42]. 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 United Kingdom telecommunications regulator Ofcom [36] 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 wind turbines to the television broadcast tower
- the proximity of wind turbines to receivers (dwellings)

- the location of wind turbines in relation to dwellings and television broadcast towers
- 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.

4.14.1 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 [42], and are shown in Figure 16. The main DTV transmitter used by residents in the vicinity of the Project is the Ballarat transmitter at Lookout Hill. However, according to the Australian Government mySwitch website [43], it is also possible that residents to the north and northwest of the site may be able to receive DTV signals from the Horsham transmitter at Arapiles, although coverage from this transmitter is marginal. Coverage maps for these broadcast transmitters are reproduced in Figure 17 and Figure 18.

4.14.1.1 Interference caused by large scale effects

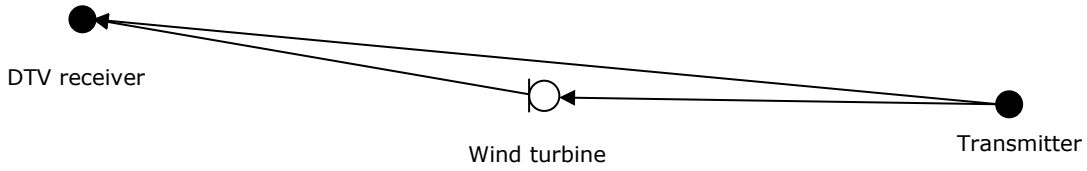
For broadcast signals, large scale interference can generally be avoided by placing the wind turbines distant from the broadcast tower. Broadcast transmitters may be either relay or primary transmitters. Relay transmitters are more commonly found in rural areas. Primary transmitter towers are higher power and are more commonly located near large urban areas. A clearance of at least 1 km is recommended for relay transmitters, while a clearance of at least 6 km is recommended for primary transmitters [7].

The closest DTV transmitter to the Project is the Ballarat transmitter at Lookout Hill, which is approximately 35 km southwest of the Project boundary. Therefore, it is considered unlikely that the Project will cause large scale interference to DTV signals.

4.14.1.2 Interference caused by forward and back scatter

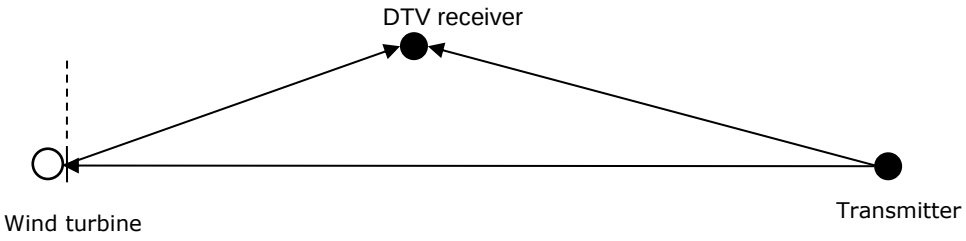
Wind turbines can cause interference to DTV signals by introducing reflections that may be received by the antenna at a dwelling, in addition to the signal received directly from the transmitter, which causes multipath errors. A wind turbine has the potential to scatter electromagnetic waves carrying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

Forward scatter can occur when the transmitter, one or more wind turbines, and receiver are almost aligned as shown below. The forward scatter region in this case is characterised by a shadow zone of reduced signal strength behind the turbine, where direct and scattered signals can be received, with the blade rotation introducing a rapid variation in the scattered signal [44]. Both of these effects can potentially degrade the DTV signal quality.



Forward scatter signal path

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



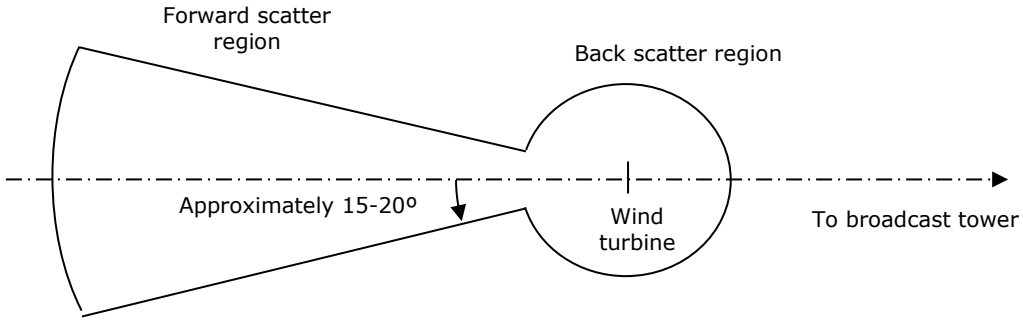
Back scatter signal path

Interference of DTV signals from wind turbine developments can potentially occur in both the forward and backward scatter region. The effect of a wind turbine on a DTV signal can be different depending on the scattering region where the receiver is located [44].

According to Ofcom [36], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [7, 45]. Interference may extend beyond 5 km if the dwellings are screened from the broadcast transmitter, but do have line-of-sight to the wind turbines [36]. 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 [7, 36], assuming a high gain, directional antenna that has a relatively high front-to-back ratio (meaning the signal received by the front of the antenna is much higher than that received from the back). If an antenna with a lower front-to-back ratio, or an omni-directional antenna is used, this region is likely be larger.

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



Potential television interference zones around a wind turbine

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

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

> *"In most of the situations where the impact of a wind farm to DVB-T reception quality was analyzed, the threshold C/N [carrier-to-noise] ratios obtained were similar to those expected in environments with the absence of wind farms. More precisely, in the forward scattering 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 [47] also highlight that in the case where there is significant blockage of the direct signal, but clear line-of-sight to one or more wind turbines, interference to the reception of the DTV signal is possible. Results of studies reported by the ITU also suggest that interference may be more likely in areas where the existing DTV signal is already weak or degraded [47].

With regards to back scattering, the ITU states:

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

In other words, the C/N ratio needs to be higher in the presence of significant back scatter to achieve the same QEF condition as is the case without the presence of wind turbines, which effectively means that interference is more likely to occur as coverage quality decreases. The implications of this conclusion for dwellings in the vicinity of the Project are discussed in Section 4.14.1.4.

4.14.1.3 Theoretical models for wind turbine scattering estimation

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

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

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

As an alternative, it is common practice to identify those dwellings or areas that are most likely to experience potential television interference based on likely forward and back scatter regions. As introduced above, this is often referred to as the 'keyhole' approach, and is an established technique for predicting where terrestrial television interference is most likely, based on a number of assumptions regarding receiving antenna characteristics. The approach involves combining multiple keyhole shaped areas that are placed over each turbine location [36]. The combination of these areas forms a region where there is an increased likelihood of interference to television signals occurring. The results of using this approach to identify the dwellings that have increased potential to receive scattered signals from a turbine in the Project, and hence have an increased likelihood of experiencing interference to television signals, are described in Section 4.14.1.4.

4.14.1.4 Potential impacts for nearby dwellings

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.

The coverage maps shown in Figure 17 and Figure 18 suggest that the primary transmitter for the area is the Ballarat tower, which offers 'good' coverage across most of the Project site, with some areas of 'variable' coverage to the west and south of the site boundary.

Coverage from the Horsham tower is 'poor' to non-existent across most of the site and surrounding area, and so it is likely that most residents will not be receiving signals from this tower.

Dwellings that have increased potential to receive back-scattered or forward-scattered signals from a turbine in 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 above.

The results of the analysis can be seen in Table 15, Figure 17 and Figure 18. The dwellings most likely to be susceptible to interference include those within the possible interference zones, as summarised in Table 3. Note that if the signal received at a dwelling from the transmitter is sufficiently weak, or an antenna with insufficient directional discrimination is installed (i.e., a low

gain or omni-directional antenna), interference may still occur outside of the identified interference zones.

Dwellings located within and adjacent to the Project boundaries and to the west and northwest of the Project have increased potential to experience interference to DTV signals from the Ballarat tower, particularly in areas to the west where the signal is already marginal. Dwellings in these areas of marginal coverage have the potential to receive a scattered signal from the wind turbines that is stronger than the signal received directly from the Ballarat transmitter.

Dwellings adjacent to the Project boundaries and to the east and southeast of the Project have been identified within the calculated interference zone for the Horsham tower. However, there is little to no signal coverage from this tower in most of the potentially-affected areas and so it is unlikely that the identified dwellings will be receiving signals from the Horsham tower.

Table 3 Number of dwellings located within potential interference zones for digital television broadcast transmitters in the vicinity of the Project site

Digital television broadcast tower	Number of dwellings in potential interference zone	Signal coverage in potential interference zone
Ballarat (Lookout Hill)	35 (4 stakeholder dwellings)	Variable to good across most of the site, marginal in some areas to the west of the site
Horsham (Arapiles)	15 (2 stakeholder 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 4.14.3.

4.14.2 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.

BAI Communications has conducted an assessment of the potential for turbines at the Project to interfere with DTV signals from the Ballarat (Lookout Hill), Halls Gap (Mt William), and Western Victoria (Mt Dundas) transmitters [49]. The Horsham (Arapiles) transmitter was not identified by BAI Communications as providing DTV coverage in the area around the Project. The method used by BAI Communications involved modelling the reflection or scattering of DTV signals from the wind turbines, and identifying locations within 10 km of the Project where the resulting C/I ratio for a directional antenna oriented towards the transmitter of interest would be less than required for adequate signal reception.

From the results of their modelling, BAI Communications have advised that they do not expect the Project to cause interference to DTV signals from the Halls Gap and Western Victoria transmitters, and only minor impacts are expected for signals from the Ballarat transmitter. Based on population density data for the areas identified as potentially affected by interference to DTV signals from the Ballarat transmitter, BAI Communications concluded that up to three residents are at low risk of

experiencing interference. However, BAI also noted that, based on satellite and aerial imagery, there are no buildings located within the predicted interference areas for the Ballarat transmitter.

DNV has reviewed the results provided by BAI Communications for DTV signals from the Ballarat transmitter in relation to the dwelling locations provided by the Proponent and considered in this assessment. There are no identified dwellings located within the interference areas predicted by BAI Communications for the Ballarat transmitter. Therefore, the results of the BAI Communications modelling suggest that impacts on DTV broadcasting are unlikely.

4.14.3 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 station.

In the event of significant interference in the backscatter region, a more directional antenna should ensure a stronger signal from the transmitter since the backscattered signal will originate from a different direction. 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 [44], DVB-T reception quality may not be substantially affected in the forward scatter region.

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

In the event that terrestrial DTV reception cannot be improved, satellite television represents another potential amelioration option. Satellite based television comprises of both free to air and subscription based broadcasts. Residents in areas which are unable to receive 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 [50].

In addition to the mitigation options outlined above, the Victorian Guidelines [1] include example permit conditions stating that, prior to commencing development, a survey must be undertaken to determine the average television and radio reception strength within 5 km of the wind farm site. If a complaint is later received regarding the effect of the wind farm on television or radio reception at a pre-existing dwelling within 5 km of the site, the operator must investigate that complaint. If the investigation finds that the wind farm has had a detrimental impact on the quality of television or radio reception, the operator must then restore reception at the affected dwelling to at least the quality determined in the pre-development survey to the satisfaction of the responsible authority.

4.15 Cumulative impacts

DNV notes that the Project is located in an area of high wind farm development activity, with multiple operational wind farms nearby. Consequently, it is possible that some radiocommunication services could experience cumulative impacts from the proposed Project.

The nearest wind farm developments are summarised in Table 4 and shown in Figure 19, based on information provided by the Proponent [51] and obtained from publicly available sources [52] [53] [54].

Table 4 Other wind farm developments located in the vicinity of the Project site

Wind farm	Status	Location
Bulgana Wind Farm	Operating	Adjacent to Project southern boundaries (nearest turbine less than 1 km from Project turbines)
Crowlands Wind Farm	Operating	12 km southeast of the Project boundaries
Ararat Wind Farm	Operating	14 km south of the Project boundaries

Table 5 summarises the anticipated EMI-related impact of the Project in isolation, and the risk of cumulative impacts from the Project in conjunction with the neighbouring wind farms. For services where impact from the Project itself is considered either unlikely or non-existent, it is generally expected that there will be no cumulative impact.

Table 5 Risk of cumulative EMI-related impacts from the Project and neighbouring wind farms

Licence or service type	Anticipated impact from the Project in isolation	Risk of cumulative impact from the Project and neighbouring wind farms
Radiocommunication towers	Low risk of interference (see Section 4.1)	No risk of cumulative impact
Fixed point-to-point links	Unlikely to cause interference (see Section 4.2)	No risk of cumulative impact, as the link paths do not cross neighbouring wind farms
Fixed point-to-multipoint links	Potential for interference if link paths cross the site near turbines (see Section 4.3) DNV has consulted with the operators to establish link paths and potential for impact Based on the responses received to date, there are no links crossing the Project site	No risk of cumulative impact, based on consultation responses received to date
Other licence types	Point-to-area style communications: see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting	
Emergency services	Unlikely to cause interference (see Section 4.5)	Very low risk of cumulative impact
Meteorological radar	Low risk of interference (see Section 4.7)	Low risk of cumulative impact, based on response from consultation with the BoM
Trigonometrical stations	Unlikely to cause interference (see Section 4.8)	Very low risk of cumulative impact
Citizen's band radio	Unlikely to cause interference (see Section 4.9)	Very low risk of cumulative impact
Mobile phones	Low risk of interference in areas with marginal coverage (see Section 4.10)	Risk of cumulative impact where there are multiple turbines between the tower and the user
Wireless internet	Low risk of interference to services provided by mobile phone networks (see Section 4.11.1) Unlikely to cause interference to NBN fixed wireless internet service (see Section 4.11.2)	Risk of cumulative impact to services provided by mobile phone networks where there are multiple turbines between the tower and the user No risk of cumulative impact to NBN fixed wireless signals as turbines are outside or on the periphery of service area
Satellite television and internet	No risk of interference to services intended for Australian audiences, low risk of interference to services intended for international audiences (see Section 4.12)	No risk of cumulative impact
Radio broadcasting	Low risk of interference to FM signals received in close proximity to turbines (see Section 4.13)	Risk of cumulative impact where there are multiple turbines between the tower and the user
Television broadcasting	Risk of interference to signals from the Ballarat tower (see Section 4.14)	Risk of cumulative impact to signals from the Ballarat tower received at dwellings located to the west and southwest of the Project

The greatest risk of cumulative EMI-related impact is to broadcast DTV signals received at nearby dwellings. Given the close proximity of the Bulgana Wind Farm and the relative locations of the broadcast towers servicing the area, there is potential for increased interference to signals received from the Ballarat tower at dwellings located to the west and southwest of the proposed Project, as shown in Figure 20.

As discussed in Section 4.14.3, the planning permit conditions for the Project are expected to include a requirement to determine the average television and radio reception strength in the vicinity of the Project prior to construction. This pre-development survey may help to better understand the DTV signal coverage in the surrounding area and the potential for cumulative impacts at the dwellings located between the Project and the Bulgana Wind Farm. If interference is found to be a problem at these dwellings after construction of the Project, the mitigation options given in Section 4.14.3 may be applicable.

There is also some potential for increased interference to other point-to-area style services, such as mobile phone and FM radio signals, in areas with marginal coverage or where there may be multiple wind turbines between the user and the transmission tower. Based on the coverage maps reproduced in Figure 11 to Figure 14, cumulative impacts are more likely to be an issue for the Telstra and Vodafone mobile networks, as the signal coverage for these services is limited in some areas in the southern part of the Project site near the neighbouring Bulgana Wind Farm. If interference to these services is experienced, the mitigation options given in Sections 4.10.3 and 4.13.2.2 may be applicable.

Cumulative impacts to both point-to-point links crossing the Project site are not expected, as these links do not cross any of the neighbouring wind farm sites.

Cumulative impacts to the NBN fixed wireless internet service are not expected, as both the Project and the neighbouring Bulgana Wind Farm turbines are located outside or on the periphery of the service area.

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 45 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 178 m or less and an upper tip height of 255 m or less.

The results of this assessment, including feedback obtained to date from relevant stakeholders, are summarised in Table 6.

One turbine within the 45-turbine layout considered in this assessment is close to the exclusion zone for a fixed point-to-point link operated by Optus Mobile, who have requested that the turbine be moved 50 m further away from the link path. DNV understands that the Proponent has since moved this turbine as requested by Optus Mobile in order to minimise the potential for interference to the point-to-point link.

Based on the assessment undertaken by DNV, dwellings located within and adjacent to the Project boundaries and to the west and northwest of the Project have increased potential to experience interference to DTV signals from the Ballarat tower, particularly in areas to the west where the signal is already marginal. Digital television signals from the Horsham broadcast tower may also be impacted, although the coverage maps suggest that the potentially affected dwellings are unlikely to be receiving signals from this tower. However, feedback received from BAI Communications, who are responsible for broadcasting of national public television services in Australia, suggests that impacts to digital television signals are unlikely.

Interference to signals from satellites that transmit programs intended for international audiences is possible at several nearby dwellings, including one associated dwelling, although it is considered unlikely that residents will be receiving signals from these satellites. If interference is experienced, mitigation options could include realigning or upgrading the user's satellite dish or seeking an alternative source of the same programming or service. DNV recommends that the Proponent engages with the residents or owners of potentially affected dwellings to determine if any are currently receiving these satellite signals, and to establish an understanding of how any impacts may be mitigated.

Since it is not possible to determine the potential EMI impacts on point-to-multipoint links and emergency services without obtaining further information from the service operators, consultation with the service operators has helped to determine the potential for the Project to cause interference to these services. The responses received to date indicate that the Project is unlikely to have any impact on these services.

Potential EMI impacts on other services considered in this assessment, including meteorological radar, trigonometrical stations, CB radio, mobile phones, wireless internet services, and broadcast radio, are either considered to be minor or have been assessed through consultation with the service operators.

The Project is located in an area of high wind farm development activity, with several operational wind farms located nearby. Based on the relative locations of these wind farms, there is a risk of cumulative EMI-related impacts to broadcast DTV signals received at nearby dwellings. There is also potential for increased interference to mobile phone and FM radio signals in areas where there may be multiple wind turbines between the user and the transmission tower. Cumulative impacts

to other services, including point-to-point links and NBN fixed wireless internet signals, are not expected.

Table 6 Summary of EMI assessment results for the proposed Project

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Radiocommunication towers	No towers within 2 km of proposed turbine locations Nearest tower: 3.8 km from turbines	Unlikely to cause interference	Unlikely to cause interference	None required
Fixed point-to-point links	Two links crossing Project boundary, operated by: Northern Grampians Shire Council Optus Mobile Diffraction effects: no turbines in exclusion zones established by DNV for either link. One turbine (T43) within 50 m of zone for link operated by Optus Mobile Reflection/scattering and near-field effects: turbines are sufficiently far from towers to avoid impacts	Unlikely to cause interference	Potential for interference to link operated by Optus Mobile; requested turbine T43 be moved at least 50 m further away from link path No response received from Northern Grampians Shire Council	DNV understands that the Proponent has since moved turbine T43 as requested by Optus Mobile No further mitigation required
Fixed point-to-multipoint links	40 assignments within 75 km of Project boundary Three base stations within 20 km of Project boundary, operated by: Central Highlands Water Stawell Gold Mines Grampians Wimmera Mallee Water	Potential for interference if link paths cross the Project site near turbines	No concerns raised	None required
Other licence types	Point-to-area style communications: see findings for emergency services, mobile phones, radio broadcasting, and television broadcasting Aeronautical and radiodetermination: to be considered as part of an aviation impact assessment	-	-	
Emergency services	Point-to-point links: No links crossing boundary Mobile telephony systems: unlikely to be affected	Unlikely to cause interference	No concerns raised by Ambulance Victoria, Country Fire Authority, and Regional Mobile Radio No response received from Corrections Victoria, VisionStream, St John Ambulance, and Victoria State Emergency Service	Point-to-point links: none required Mobile telephony systems: if required – increase signal strength from affected tower or alternative towers, install signal repeater, install additional tower

Table 6 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Meteorological radar	Nearest radar: "Rainbow (Wimmera)", 133 km from Project	Potential for interference if turbines at the Project are visible to radars	Unlikely to cause interference	Notify of the Bureau of Meteorology prior to planned wind farm shutdown to allow calibration of radar systems
Trigonometrical stations	Seven stations within 20 km of Project boundary Electronic equipment: unlikely to be affected Survey marks: unlikely to be affected Sight lines to other stations: may be blocked by turbines	Unlikely to cause interference	No concerns raised by DELWP regarding interference to GNSS signals, but potential for physical disturbance to survey marks noted No response received from Geoscience Australia	None required for electronic equipment Potential physical disturbance of survey marks to be mitigated through Proponent engagement with DELWP during construction if required
Citizen's band radio	Unlikely to be affected	Unlikely to cause interference	Consultation not considered necessary	None required
Mobile phones	Fair to good coverage across site, with coverage not available in some areas Unlikely to be affected in areas with good coverage, may experience interference in areas with marginal coverage	Low risk of interference	No response received regarding mobile phone services	If required – increase signal strength from affected tower or alternative towers, install additional tower
Wireless internet	Likely service providers: Mobile phone networks NBN: Available as a satellite service only in areas surrounding the Project	Unlikely to cause interference	No concerns raised by NBN Co No response received from Optus Mobile, Telstra, and Vodafone	Mobile phone networks: as for mobile phones NBN: none required

Table 6 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Satellite television and internet	Services intended for Australian audiences: unlikely to be affected Services intended for international audiences: signals from two satellites intercepted at four dwellings	Unlikely to cause interference to services intended for Australian audiences Low risk of interference to services intended for international audiences	Consultation with operators not considered necessary DNV recommends engaging with residents of potentially affected dwellings	If required – redirect satellite dish to alternative satellite, install larger or higher-quality satellite dish, change location or height of satellite dish at affected location
Radio broadcasting	AM signals: unlikely to be affected FM signals: may experience interference (low level hiss or distortion) in close proximity to turbines Digital radio signals: not available in vicinity of Project	Low risk of interference to FM signals	Consultation not considered necessary	AM signals and digital radio signals: none required FM signals: if required – install higher-quality antenna at affected location, increase signal strength form affected tower, move tower to a new location, install signal repeater, install additional tower

Table 6 Summary of EMI assessment results for the proposed Project (continued)

Licence or service type	Assessment findings	Expected impact	Stakeholder feedback (to date)	Potential mitigation options
Television broadcasting	Digital signals: may experience interference in areas with poor or marginal reception			
	Ballarat (Lookout Hill) tower: 'variable' to 'good' coverage across the site 35 dwellings (4 associated dwellings) in potential interference zone	Risk of interference	Low risk of interference for up to three residents, but no buildings identified in potential interference areas	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
	Horsham (Arapiles) tower: 'poor' to 'variable' coverage across the site 15 dwellings (2 associated dwellings) in potential interference zone	Risk of interference; although residents are likely to be able to receive alternative signals from the Ballarat tower	Not considered to be providing coverage in the area around the Project	

6 REFERENCES

[1] Department of Environment, Land, Water and Planning, "Policy and planning guidelines for development of wind energy facilities in Victoria," State of Victoria, November 2021.

[2] Environment Protection and Heritage Council (EPHC), "National Wind Farm Development Guidelines - Draft," July 2010.

[3] "'PAUSplc026_unlocked.shp'," attachment to email from N Kelly (RES) to F Dahhan (DNV), 31 May 2021.

[4] "'WW_House_Layer_5km_260521.shp'," attachment to email from N Kelly (RES) to F Dahhan (DNV), 31 May 2021.

[5] Australian Communications and Media Authority (ACMA), "Radiocommunications Licence Data," 31 May 2021. [Online]. Available: http://www.acma.gov.au/Industry/Spectrum/Radiocomms-licensing/Register-of-radiocommunications-licences/radiocomms-licence-data. [Accessed 31 May 2021].

[6] D. Bacon, "Fixed-link wind turbine exclusion zone method - Version 1.1," 28 October 2009.

[7] S. H. Hall, "The assessment and avoidance of electromagnetic interference due to wind farms," *Wind Engineering,* vol. 16, no. 6, pp. 326-338, 1992.

[8] Joint Radio Company, "Calculation of Wind Turbine clearance zones for JRC managed fixed services with particular reference to UHF (460MHz) Telemetry Systems when turbine sizes and locations are accurately known," Issue 4.2, December 2014.

[9] L. Derrick, "Bulgana Wind Farm Electromagnetic and Communication Assessment," Lawrence Derrick & Associates, 26 August 2014.

[10] Bureau of Meteorology, "Service Announcements - 2019 Archive," 2020. [Online]. Available: http://www.bom.gov.au/weather-services/announcements/archive-2019.shtml. [Accessed 5 March 2020].

[11] Bureau of Meteorology, "How does a weather radar work?," 9 June 2017. [Online]. Available: http://media.bom.gov.au/social/blog/1459/how-does-a-weather-radar-work/. [Accessed 5 March 2020].

[12] Bureau of Meteorology, "About Doppler Wind Images," 2020. [Online]. Available: http://www.bom.gov.au/australia/radar/about/doppler_wind_images_intro.shtml. [Accessed 5 March 2020].

[13] Bureau of Meteorology, "Optimal Radar Coverage Areas," 2020. [Online]. Available: http://www.bom.gov.au/australia/radar/about/radar_coverage_national.shtml. [Accessed 5 March 2020].

[14] Bureau of Meteorology, "Radar Frequently Asked Questions," 2020. [Online]. Available: http://www.bom.gov.au/australia/radar/about/radarfaq.shtml. [Accessed 5 March 2020].

[15] World Meteorological Organisation (WMO), "Commission for Instruments and Methods of Observation, Fifteenth Session: Abridged final report with resolutions and recommendations," 2-3 September 2010.

[16] World Meteorological Organization, Commission for Basic Systems and Commission for Instruments and Methods of Observation, "Joint meeting of CBS expert team on surface-based remotely-sensed observations and CIMO expert team on remote sensing upper-air technology and techniques," Geneva, Switzerland, 23-27 November 2009.

[17] J. Nascarella, "Equipment database - EDM," Department of Geomatics, University of Melbourne, 2000.

[18] Geoscience Australia, Australian Government, "Global Navigation Satellite System Networks," [Online]. Available: http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/gnss-networks. [Accessed 3 June 2021].

[19] Australian National Data Service, "Australian Fiducial Network Coordinates and Mark Descriptions," [Online]. Available: https://researchdata.ands.org.au/australian-fiducial-network-mark-descriptions/1262584. [Accessed 4 June 2021].

[20] The State of Victoria, "Vicmap Position," 29 November 2020. [Online]. Available: http://gnss.vicpos.com.au/Map/SensorMap.aspx. [Accessed 4 June 2021].

[21] Geoscience Australia, Australian Government, "Historic Geodetic Benchmarks," 2021. [Online]. Available: https://geodesyapps.ga.gov.au/historic-geodetic-benchmarks/. [Accessed 4 June 2021].

[22] State of Victoria, Department of Environment, Land, Water and Planning, "Survey Control Mark Information," 4 June 2021. [Online]. Available: https://maps.land.vic.gov.au/lassi/SmesUI.jsp. [Accessed 4 June 2021].

[23] Intergovernmental Committee on Surveying and Mapping (ICSM), "Surveying for Mapping," [Online]. Available: http://www.icsm.gov.au/education/fundamentals-mapping/surveying-mapping/introduction. [Accessed 25 June 2021].

[24] Singtel Optus Pty Limited, "Optus Mobile Network Coverage," [Online]. Available: http://www.optus.com.au/shop/mobile/network/coverage. [Accessed 7 June 2021].

[25] Telstra, "Telstra - Our Coverage," [Online]. Available: https://www.telstra.com.au/coverage-networks/our-coverage. [Accessed 7 June 2021].

[26] Vodaphone Australia, "Network Coverage Checker," 2021. [Online]. Available: http://www.vodafone.com.au/aboutvodafone/network/checker. [Accessed 7 June 2021].

[27] NBN Co Ltd, "nbn Fixed Wireless explained," 2019. [Online]. Available: https://www.nbnco.com.au/residential/learn/network-technology/fixed-wireless-explained#. [Accessed 25 July 2019].

[28] NBN Co, *Fact Sheet: How will we design the fixed wireless network?,* June 2013.

[29] NBN Co, "nbn rollout map," 2021. [Online]. Available: https://www.nbnco.com.au/learn/rollout-map. [Accessed 28 June 2021].

[30] Satbeams, "Channels in Australia," [Online]. Available: https://www.satbeams.com/search-89?ordering=newest&searchphrase=all&searchword=australia. [Accessed 6 February 2018].

[31] LyngSat, "Free TV from Australia," [Online]. Available: http://www.lyngsat.com/freetv/Australia.html. [Accessed 3 June 2021].

[32] Wafa Satellite Broadband, "How VSATs Work," 2017. [Online]. Available: http://wafa.ae/en/vsat/faq/about-satellite-internet.aspx. [Accessed 3 August 2017].

[33] "LyngSat," 12 April 2021. [Online]. Available: https://www.lyngsat.com/. [Accessed 14 April 2021].

[34] Australian Communications and Media Authority (ACMA), "List of transmitters with a licence to broadcast," 31 May 2021. [Online]. Available: https://www.acma.gov.au/list-transmitters-licence-broadcast. [Accessed 31 May 2021].

[35] D. Spera, "Wind Turbine Technology," ASME Press, 1994.

[36] Ofcom, "Tall structures and their impact on broadcast and other wireless services," 2009.

[37] National Research Council, "Environmental Impacts of Wind-Energy Projects," The National Acadamies Press, Washington, D.C., 2007.

[38] F. Marlowe, "The importance of electromagnetic-impact analyses for wind permitting," *Windpower Engineering & Development,* 10 July 2015.

[39] Australian Communications and Media Authority (ACMA), "What is digital radio?," 5 October 2020. [Online]. Available: https://www.acma.gov.au/what-digital-radio. [Accessed 3 June 2021].

[40] Australian Broadcasting Corporation (ABC), "Search for known ABC frequencies & coverage," 2021. [Online]. Available: http://reception.abc.net.au/. [Accessed 22 June 2021].

[41] Commercial Radio Australia, "Can I Get DAB+ Digital Radio?," 22 June 2021. [Online]. Available: https://www.digitalradioplus.com.au/can-i-get-digital-radio. [Accessed 22 June 2021].

[42] Australian Government Department of Infrastructure, Transport, Regional Development and Communications, "Digital TV," [Online]. Available: https://www.communications.gov.au/what-we-do/television/digital-tv. [Accessed 12 April 2021].

[43] Australian Government, "mySwitch," [Online]. Available: http://myswitch.digitalready.gov.au/. [Accessed 7 June 2021].

[44] I. Angulo, et al., "Impact analysis of wind farms on telecommunication services," *Renewable and Sustainable Energy Reviews,* vol. 32, pp. 84-99, 2014.

[45] International Telecommunications Union (ITU), "Assessment of the impairment caused to analogue television reception by a wind turbine," Recommendation ITU-R BT.805, March 1992.

[46] International Telecommunications Union (ITU), "Assessment of impairment caused to digital television reception by a wind turbine," Recommendation ITU-R BT.1893, October 2015.

[47] International Telecommunications Union (ITU), "The effect of the scattering of digital television signals from a wind turbine," Report ITU-R BT.2142-1, July 2015.

[48] I. Angulo, et al., "An empirical comparative study of prediction methods for estimating multipath due to signal scattering from wind turbines on Digital TV Services," *IEEE Transactions on Broadcasting,* vol. 57, no. 2, June 2011.

[49] BAI Communications, "Watta Wella, Vic, Wind Farm Study," Document No.: WPV-REP-1745, Version: 0.1, 15 September 2021.

[50] Australian Government, "VAST - Viewer Access Satellite Television," [Online]. Available: https://www.myvast.com.au/. [Accessed 7 December 2015].

[51] "'CRL Turbine Layout', ;RE As built Bulgana wind turbine locations'," attachments to email from N Kelly (RES) to F Dahhan (DNV), 24 June 2021.

[52] Bulgana Green Power Hub, "Location," 2021. [Online]. Available: https://bulganagreenpowerhub.com.au/. [Accessed 8 June 2021].

[53] Pearce Geotech, "Crowlands Wind Farm," 2021. [Online]. Available: https://www.pearcegeotech.com.au/projects/crowlands-wind-farm/. [Accessed 23 June 2021].

[54] Ararat Wind Farm, "About," 2020. [Online]. Available: https://www.ararat-windfarm.com/about/. [Accessed 18 July 2021].

LIST OF TABLES

Table 7 Proposed turbine layout for the Project site [3]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]
T1	669456	5901184	258	T24	673163	5899173	247
T2	669771	5905747	205	T25	672661	5899189	241
T3	670243	5899928	259	T26	674502	5902083	225
T4	670703	5902617	225	T27	674268	5903473	212
T5	670676	5907048	203	T28	670360	5906355	205
T6	671165	5906212	215	T29	671664	5905115	215
T7	672673	5900064	235	T30	673740	5902224	231
T8	670785	5899686	242	T31	673115	5904473	219
T9	671239	5901414	238	T32	670775	5901176	235
T10	671558	5899817	222	T33	672346	5902262	223
T11	673206	5903124	230	T34	674696	5898420	238
T12	670222	5905422	204	T35	669448	5900550	267
T13	674797	5897777	242	T36	674735	5902637	215
T14	669836	5900213	253	T37	675751	5898414	227
T15	672612	5903494	231	T38	677361	5900566	229
T16	672046	5904239	225	T39	678084	5900510	221
T17	670304	5903498	218	T40	671170	5903819	211
T18	671687	5906301	207	T41	671571	5902917	217
T19	672207	5906287	209	T42	669486	5899801	264
T20	675354	5898061	239	T43	672508	5905083	216
T21	671126	5900043	236	T44	670175	5901136	246
T22	673162	5900290	238	T45	673634	5903931	211
T23	674987	5897292	254				

1. Coordinate system: MGA zone 54, GDA94 datum.

Table 8 Dwellings in the vicinity of the proposed Project [4]

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine [km]
4	665357	5897761	Not associated	4.6
6	665681	5897410	Not associated	4.5
12	665957	5903024	Not associated	4.0
14	666200	5898160	Not associated	3.7
19	666316	5897301	Not associated	4.0
21	666416	5902176	Not associated	3.2
22	666554	5902624	Not associated	3.2
25	666710	5903276	Not associated	3.5
27	666755	5903320	Not associated	3.4
32	666811	5897384	Not associated	3.6
34	666916	5902928	Not associated	3.1
37	667060	5902548	Not associated	2.8
38	667108	5904421	Not associated	3.0
40	*667118*	*5897585*	*Associated*	*3.2*
45	*667187*	*5897581*	*Associated*	*3.2*
48	667205	5903133	Not associated	3.0
55	667326	5902953	Not associated	2.8
59	667593	5906565	Not associated	2.3
61	667832	5905304	Not associated	2.0
62	667892	5902287	Not associated	1.9
65	667935	5903141	Not associated	2.4
68	668056	5903838	Not associated	2.3
72	668066	5904348	Not associated	2.2
75	668127	5907399	Not associated	2.3
79	668246	5902202	Not associated	1.6
82	668307	5903398	Not associated	2.0
85	668397	5903953	Not associated	2.0
86	668400	5904575	Not associated	1.8
90	668508	5904151	Not associated	1.9
94	668850	5909059	Not associated	2.7
100	669091	5895802	Not associated	4.0
101	*669099*	*5907458*	*Associated*	*1.6*
106	*669752*	*5902272*	*Associated*	*1.0*
120	*670958*	*5897218*	*Associated*	*2.5*
131	*672066*	*5908386*	*Associated*	*1.9*
147	673668	5908568	Not associated	2.7
159	*673775*	*5907532*	*Associated*	*2.0*
161	675005	5900349	Not associated	1.8
171	*676130*	*5901653*	*Associated*	*1.6*
178	676186	5903029	Not associated	1.5
188	676351	5901672	Not associated	1.5
192	676591	5903697	Not associated	2.1
202	676882	5906823	Not associated	4.2
211	676990	5895734	Not associated	2.5
212	677000	5902379	Not associated	1.8
218	677145	5902054	Not associated	1.5
221	677643	5894110	Not associated	4.1
222	*677902*	*5895855*	*Associated*	*3.2*
224	*678366*	*5898547*	*Associated*	*2.0*
229	678874	5902526	Not associated	2.2
230	679033	5895220	Not associated	4.5

Table 8 Dwellings in the vicinity of the proposed Project [4] (continued)

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine [km]
231	679221	5898491	Not associated	2.3
232	679860	5903588	Not associated	3.6
242	666680	5903303	Not associated	3.5
243	676661	5897096	Not associated	1.6
245	668891	5910093	Not associated	3.5
246	681847	5897453	Not associated	4.8
248	681732	5900310	Not associated	3.7
249	682740	5901721	Not associated	4.8
250	682257	5898829	Not associated	4.5
251	682473	5901803	Not associated	4.6
252	681509	5900852	Not associated	3.4
253	682906	5902233	Not associated	5.1
254	682958	5901793	Not associated	5.0
255	679934	5905124	Not associated	5.0
256	681606	5901548	Not associated	3.7

1. Coordinate system: MGA zone 54, GDA94 datum.

Associated dwellings are indicated by *underlined italic text*.

Table 9 Details of point-to-point links crossing the proposed Project site

Link no.	Licence number	Assignment ID	Frequency [MHz]	Licence owner
1	9862001/1	1349839, 1349840	7431.500	Northern Grampians Shire Council PO Box 580 STAWELL VIC 3380
		1349837, 1349838	7592.500	
2	1923764/1	893670, 893671	7762.525	Optus Mobile Pty Limited PO Box 888 NORTH RYDE NSW 1670
		893668, 893669	8073.845	

Table 10 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
3331264	10008624	10378122/1	-37.228100	143.200600	27	Bureau of Meteorology GPO Box 1289 MELBOURNE VIC 3001
3331267	10008624	10378122/1	-37.228100	143.200600	27	
3331262	11733	10378121/1	-37.294985	142.603725	38	
3331259	11733	10378121/1	-37.294985	142.603725	38	
900071	9012292	1928160/1	-36.963388	143.097409	9	Central Highlands Region Water Corporation PO Box 152 BALLARAT VIC 3353
900074	9012292	1928160/1	-36.963388	143.097409	9	
966603	9019657	1968909/1	-36.944083	143.318428	28	
966600	9019657	1968909/1	-36.944083	143.318428	28	
1514337	404211	9996009/1	-37.087620	143.482770	43	
1514340	404211	9996009/1	-37.087620	143.482770	43	
832751	404211	1565855/1	-37.087620	143.482770	43	
832748	404211	1565855/1	-37.087620	143.482770	43	
832764	9004356	1565857/1	-37.260508	143.533626	54	
832767	9004356	1565857/1	-37.260508	143.533626	54	
750920	9001492	1149775/1	-37.424532	143.381306	54	
750917	9001492	1149775/1	-37.424532	143.381306	54	
750928	306085	1149777/1	-37.073644	143.738021	65	
750925	306085	1149777/1	-37.073644	143.738021	65	
832959	306085	1565998/1	-37.073644	143.738021	65	
832956	306085	1565998/1	-37.073644	143.738021	65	
793546	11753	1326725/1	-36.722226	143.645966	64	Coliban Region Water Corporation 37-45 Bridge Street BENDIGO VIC 3550
877060	11753	1913356/1	-36.722226	143.645966	64	
793549	11753	1326725/1	-36.722226	143.645966	64	
877063	11753	1913356/1	-36.722226	143.645966	64	
6309815	302772	10895446/1	-37.202719	142.854898	17	Grampians Wimmera Mallee Water Authority PO Box 481 HORSHAM VIC 3400
6309818	302772	10895446/1	-37.202719	142.854898	17	
6309956	11733	10895501/1	-37.294985	142.603725	38	
6309959	11733	10895501/1	-37.294985	142.603725	38	
3799563	11728	10457447/1	-37.265124	142.890157	23	Powercor Australia Ltd C/- Commander Enterprise Service Pty Ltd Locked Bag 14090 Attn: Sam Devadason MELBOURNE VIC 8001
3799570	11728	10457448/1	-37.265124	142.890157	23	
3799567	11728	10457448/1	-37.265124	142.890157	23	
3799566	11728	10457447/1	-37.265124	142.890157	23	
943371	304700	1956930/1	-37.393517	143.112728	39	
943368	304700	1956930/1	-37.393517	143.112728	39	
3923067	47946	10480978/1	-36.308677	143.145441	74	
3923064	47946	10480978/1	-36.308677	143.145441	74	
1294342	305839	1327664/1	-37.069409	142.808736	9	Stawell Gold Mines Pty Ltd Box 265 STAWELL VIC 3380
1294345	305839	1327664/1	-37.069409	142.808736	9	

Table 10 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
2112529	404211	10127656/1	-37.087620	143.482770	43	Wireless Network (Ballarat) Pty Ltd
2112532	404211	10127656/1	-37.087620	143.482770	43	10 Bogart Drive WENDOUREE VIC 3355

Table 11 Details of other licences identified within 75 km of the proposed Project

Licence category	Licence type	Number of assignment IDs
1800 MHz Band	Spectrum	192
2 GHz Band	Spectrum	182
2.3 GHz Band	Spectrum	4230
2.5 GHz Band	Spectrum	128
2.5 GHz Mid Band Gap	Spectrum	4
3.4 GHz Band	Spectrum	248
700 MHz Band	Spectrum	589
800 MHz Band	Spectrum	315
Aeronautical Assigned System	Aeronautical	65
Amateur Repeater	Amateur	53
Ambulatory - Initial	Land Mobile	4
Ambulatory System	Land Mobile	38
AWL - FSS Only	Spectrum	60
CBRS Repeater	Land Mobile	6
Commercial Radio	Broadcasting	4
Commercial Television	Broadcasting	6
Community Broadcasting	Broadcasting	2
Fixed Receive	Fixed Receive	1
Land Mobile System - > 30MHz	Land Mobile	991
Land Mobile System 0-30MHz	Land Mobile	128
Narrowband Area Service station(s)	Broadcasting	2
Narrowcasting Service (Fixed Tax)	Broadcasting	4
Narrowcasting Service (LPON)	Broadcasting	19
National Broadcasting	Broadcasting	11
Paging System - Exterior	Land Mobile	31
Paging System - Interior	Land Mobile	6
PMTS Class B	PTS	196
PMTS Class B (935-960 MHz)	PTS 900 MHz	92
Retransmission	Broadcasting	3
Retransmission (Out of Area)	Broadcasting	3
Scientific Assigned	Scientific	2

Table 12 Emergency services with radiocommunication assets in the vicinity of the proposed Project

Emergency service	Contact details	Distance from closest site to Project boundary [km]
Ambulance Victoria	Ambulance Victoria Attn: Tim McCallum 303 Gillies Street North WENDOUREE VIC 3355	42
Ararat Fire Brigade	Ararat Fire Brigade PO Box 501 ARARAT VIC 3377	24
Country Fire Authority	Country Fire Authority PO Box 701 MOUNT WAVERLEY VIC 3149	6
Department of Justice and Community Safety (Corrections Victoria)	Department of Justice and Community Safety Corrections Victoria SESG Radiocommunications Coordinator Locked Bag 7 LARA VIC 3212	24
Department of Justice and Community Safety (Regional Mobile Radio)	Department of Justice and Community Safety RMR Regional Mobile Radio C/- Level 2 Bld M5 30 Henderson Rd CLAYTON VIC 3168	16
Department of Justice and Community Safety (Visionstream)	Department of Justice and Community Safety Visionstream Australia Locked Bag 4001 Attn: Rosario Holden HEATHERTON VIC 3202	5
Radio Rescue Emergency Communications Inc	Radio Rescue Emergency Communications Incorporated 97 Murray Drive RIVERGLADES SA 5253	47
St John Ambulance Australia	St John Ambulance Australia Incorporated Technical Services 170 Forster Road MOUNT WAVERLEY VIC 3149	38
Victoria State Emergency Service	Victoria State Emergency Service 168 Sturt St SOUTHBANK VIC 3006	11

Table 13 BoM radar sites in the vicinity of the proposed Project

BoM radar site	Radar type	Latitude[1]	Longitude[1]	Distance to Project [km]
Rainbow (Wimmera)	Doppler	-35.998	142.013	133
Melbourne (Laverton)	Doppler	-37.855	144.755	180
Melbourne (Broadmeadows)	Doppler	-37.691	144.946	187
Mount Gambier	Standard weather watch	-37.748	140.775	204
Yarrawonga	Doppler	-36.030	146.023	291
Mildura	Doppler	-34.287	141.598	319
Bairnsdale	Doppler	-37.888	147.576	416
Adelaide (Sellicks Hill)	Standard weather watch	-35.330	138.500	435
Wagga Wagga	Standard weather watch	-35.167	147.467	450

1. Coordinate system: Lat/Lon GDA94 datum.

Table 14 Trigonometrical stations in the vicinity of the proposed Project

Station name	Datum	Latitude[1]	Longitude[1]	Distance to Project [km]
Avon Rise	AGD66	-36.840	142.785	17
Concongella	AGD66, AGD84, GDA94	-37.035	142.894	1
Landsborough Hill	AGD66, GDA94	-36.968	143.146	13
Panrock	AGD66	-37.146	142.768	17
Stawell	AGD66	-37.054	142.788	10
Tucker Hill	AGD66	-37.161	142.908	12
Warrawing	AGD66	-36.886	142.983	8

1. Coordinate system: Lat/Lon GDA94 datum.

Table 15 Dwellings with increased potential to experience EMI to DTV from television broadcast towers

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Located in potential interference zone	
			Ballarat	Horsham
12	665957	5903024	X	
21	666416	5902176	X	
22	666554	5902624	X	
25	666710	5903276	X	
27	666755	5903320	X	
34	666916	5902928	X	
37	667060	5902548	X	
38	667108	5904421	X	
48	667205	5903133	X	
55	667326	5902953	X	
59	667593	5906565	X	
61	667832	5905304	X	
62	667892	5902287	X	
65	667935	5903141	X	
68	668056	5903838	X	
72	668066	5904348	X	
75	668127	5907399	X	
79	668246	5902202	X	
82	668307	5903398	X	
85	668397	5903953	X	
86	668400	5904575	X	
90	668508	5904151	X	
94	668850	5909059	X	
101	*669099*	*5907458*	*X*	
106	*669752*	*5902272*	*X*	
131	*672066*	*5908386*	*X*	
161	675005	5900349	X	X
171	*676130*	*5901653*	*X*	*X*
178	676186	5903029	X	X
188	676351	5901672	X	X
192	676591	5903697	X	X
211	676990	5895734		X
212	677000	5902379	X	X
218	677145	5902054	X	X
222	*677902*	*5895855*		*X*
229	678874	5902526		X
230	679033	5895220		X
231	679221	5898491		X
242	666680	5903303	X	
243	676661	5897096		X
245	668891	5910093	X	
248	681732	5900310		X
250	682257	5898829		X

1. Coordinate system: MGA zone 54, GDA94 datum.

Associated dwellings are indicated by *underlined italic text.*

Table 16 Summary of service operators contacted by DNV and responses received to date

	Licence/service type	Distance of closest site	Operator and DNV reference	Response received to date
1	Fixed point-to-point	No turbines in diffraction exclusion zone established by DNV Potential reflection/scattering and near-field effects not considered	Northern Grampians Shire Council 10271936-AUME-L-01	No response received to date
2	Fixed point-to-point PMTS/spectrum (mobile phone)	No turbines in diffraction exclusion zone established by DNV Potential reflection/scattering and near-field effects not considered Mobile phone: 10 km	Optus Mobile Pty Limited (Optus Mobile) 10271936-AUME-L-02	<u>Response received by email on 19/07/21:</u> *"Please be advised that Optus microwave 8GHz point to point license 1923764/1 will be impacted by the proposal.* *Appreciate if your team can relocate T43 turbine location further 50 m away from microwave path."*
3	Fixed point-to-multipoint Meteorological radar	Point-to-multipoint: 27 km Meteorological radar: 133 km	Bureau of Meteorology 10271936-AUME-L-03	<u>Response received by email on 21/07/21:</u> *"Our analysis shows that the proposed wind farm … has manageable impact on our weather radar network on normal weather conditions. Therefore, the Bureau is ready to agree with your proposed wind farm should the farm operator/owner agreed [sic] with the following conditions:* *1- To inform the Bureau of any changes in the wind farm including varying the layout of the farm, changing the location of each turbine more than 100 m or altering the turbine's height.* *2- Notify the Bureau at least two weeks before any planned shut-down of the farm (for maintenance or any other reason) enabling us to calibrate our radar systems without the effect of rotating turbines.* *If the above-mentioned conditions are acceptable, please kindly send us a letter confirming that you agreed with those terms."* <u>Response received by email on 26/07/21:</u> *"The two PMP stations are OK and the proposed wind farm… doesn't have any foreseeable effect."*

Table 16 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type	Distance of closest site	Operator and DNV reference	Response received to date
4	Fixed point-to-multipoint	17 km	Grampians Wimmera Mallee Water Authority (GWMWater) 10271936-AUME-L-04	Response received by email on 13/08/21: *"We've looked at the information you've provided and we don't believe the proposal will interfere with our radio equipment located in the Eastern Grampians."*
5	Fixed point-to-multipoint	23 km	Powercor Australia Pty Ltd (Powercor) 10271936-AUME-L-05	Response received by email on 15/07/21: *"I can confirm that the Point to Multipoint links are all clear of the Watta Wella WF boundary.* *The radio links do not intersect the WF boundary or cut across the turbine field."*
6	Emergency service	Land mobile: 42 km	Ambulance Victoria 10271936-AUME-L-06	Response received by email on 13/07/21: *"Based on the location of the proposed Windfarm and the direction Ambulance Victoria uses the nearby site this will have no impact to our services."*
7	Emergency service	Land mobile: 24 km	Ararat Fire Brigade 10271936-AUME-L-07	Response received by email on 13/07/21: *"The majority of this proposed Wind farm will [be] located in the Stawell Fire Brigade area of operation with a small block on the Western side in the Joel Joel Brigade area. Both these brigades still fall under the CFA District 16 area of control."* Response received by email from CFA on 13/07/21: *"I confirm that the CFA radio services (fixed radio links and land mobile services) are not affected by the proposed wind turbines."*
8	Emergency service	Land mobile: 6 km	Country Fire Authority (CFA) 10271936-AUME-L-08	Response received by email on 13/07/21: *"I confirm that the CFA radio services (fixed radio links and land mobile services) are not affected by the proposed wind turbines."*
9	Emergency service	Land mobile: 24 km	Department of Justice and Community Safety – Corrections Victoria SESG 10271936-AUME-L-09	No response received to date

Table 16 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type	Distance of closest site	Operator and DNV reference	Response received to date
10	Emergency service	Land mobile: 16 km	Department of Justice and Community Safety – Regional Mobile Radio (RMR) 10271936-AUME-L-10	Response received by email on 13/07/21: *"From the information you have provided, we see no impact to our RMR services."*
11	Emergency service	Land mobile: 5 km	Department of Justice and Community Safety – VisionStream 10271936-AUME-L-11	No response received to date
12	Emergency service	Land mobile: 38 km	St John Ambulance Australia 10271936-AUME-L-12	No response received to date
13	Emergency service	Land mobile: 11 km	Victoria State Emergency Service (VICSES) 10271936-AUME-L-13	No response received to date
14	Trigonometrical stations	1 km	Geoscience Australia 10271936-AUME-L-14	No response received to date
15	Trigonometrical stations	Within site boundaries	Department of Environment, Land, Water and Planning (DELWP) 10271936-AUME-L-15	Response received by email on 13/07/21: *"I have assessed the positioning infrastructure located around and within the proposed wind farm site. I do not believe the wind farm will cause any interference with the positioning infrastructure in this region. There are survey control marks of varying quality located throughout the area. The survey marks are located within road reserve so should be well clear of the wind turbine infrastructure. The survey marks should not be disturbed as part of any construction or ongoing maintenance works. However, if there is a need to disturb the survey marks then please notify us at smes.support@delwp.vic.gov.au so we can update our online records."*

Table 16 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type	Distance of closest site	Operator and DNV reference	Response received to date
16	PMTS/spectrum (mobile phone)	9 km	Telstra Corporation Limited (Telstra) 10271936-AUME-L-16	Response received by email on 12/08/21: *"The response from Radio is that the proposed turbine locations will not impact our existing radio system."*
17	PMTS/spectrum (mobile phone)	10 km	Vodafone Australia Pty Limited (Vodafone) 10271936-AUME-L-17	No response received to date
18	Spectrum (wireless internet)	10 km	NBN Co 10271936-AUME-L-18	Response received by email on 14/07/21: *"While some proposed towers are near existing nbn wireless coverage boundaries these towers do not appear to obstruct existing nbn wireless connections or dwellings.* *The proposed tower locations [do] not pose any risk of introducing a physical obstruction to wireless customer RF Profiles or any boresight paths of existing nbn microwave links.* *A standard nbn response for wind farm applications regarding potential interference impact on the nbn Fixed Wireless network is as follows:* *Referring to an email dated 13th July 2021 regarding the application for the Watta Wella Wind Farm:* *We confirm that NBN Co Spectrum Pty Ltd (nbn Spectrum) has a number of spectrum licenses within 75 km of the proposed … Watta Wella 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."*

Table 16 Summary of service operators contacted by DNV and responses received to date (continued)

	Licence/service type	Distance of closest site	Operator and DNV reference	Response received to date
19	Broadcasting	35 km	BAI Communications 10271936-AUME-L-19	<u>Response received by email on 14/07/21:</u> *"BAI Communications has done a study on the proposed wind farm located in Watta Wella, Vic. The impact on three broadcast facilities were studied, all digital television. The results show that only one of the broadcast facility is somewhat impacted (Lookout Hill) and that 3 people are predicted to be at low risk of interference to digital television services due to the scatter interference effects of the wind farm.* *…BAI Communications has conducted field tests on existing wind farms in the past for the impact on FM services. The field test measurements concluded that FM radio had some minor reflections observed but these would not be expected to cause any noticeable effect on reception. Thus, this report will not consider further impacts on FM broadcast, just digital television…* *BAI have modelled the proposed Watta Wella wind turbines to assess how they will affect DTV services broadcast from Mt Dundas (ACMA Site ID 38531), Mt William WIN (ACMA Site ID 36653), and Lookout Hill (ACMA Site ID 36240).* *Interference analysis predicts that only Lookout Hill (3 low risk persons) DTV services are affected by the proposed wind farm. No interference is predicted to the coverage of Mt William WIN and Mt Dundas.* *Whilst there are minimal persons predicted to be impacted by the wind farm, any degradation of DTV services caused by the wind farm development would be expected to be rectified as part of the project.* *Visual inspections in Google Earth does not show any buildings in the predicted low risk interference area for Lookout Hill."*

LIST OF FIGURES

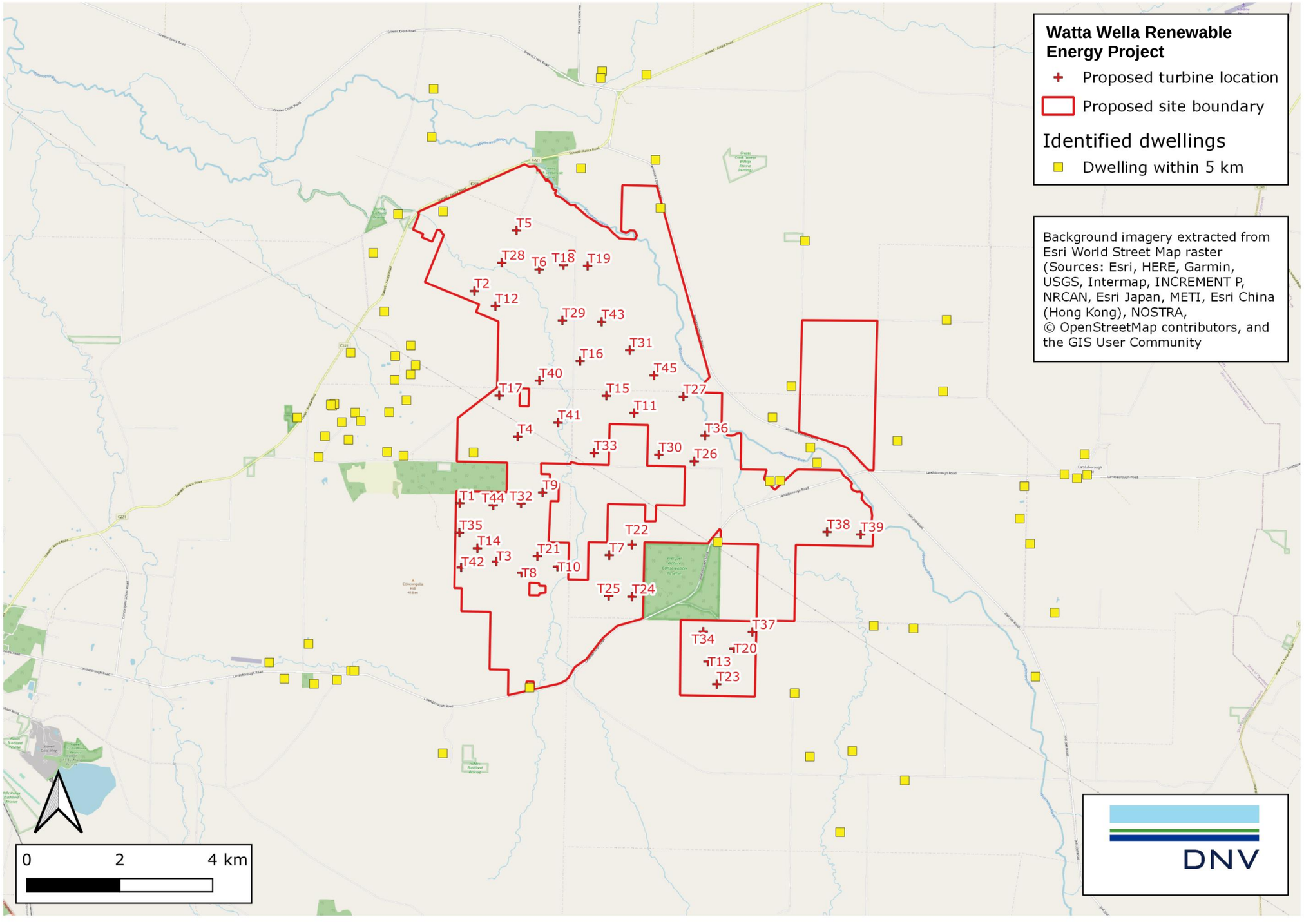


Figure 1 Map of the proposed Project, showing site boundaries, turbine locations, and locations of nearby dwellings

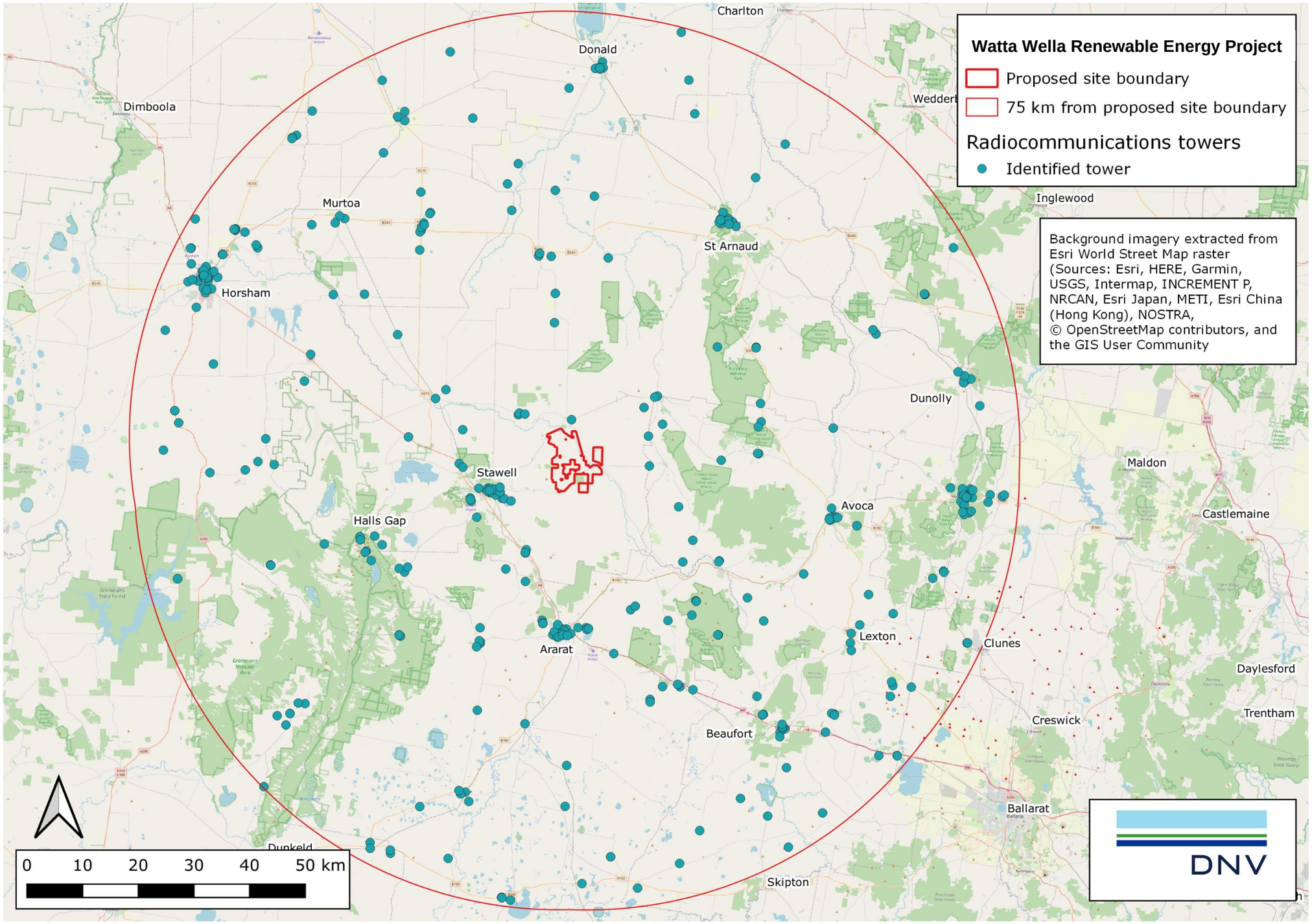


Figure 2 Location of the proposed Project and identified nearby radiocommunication sites

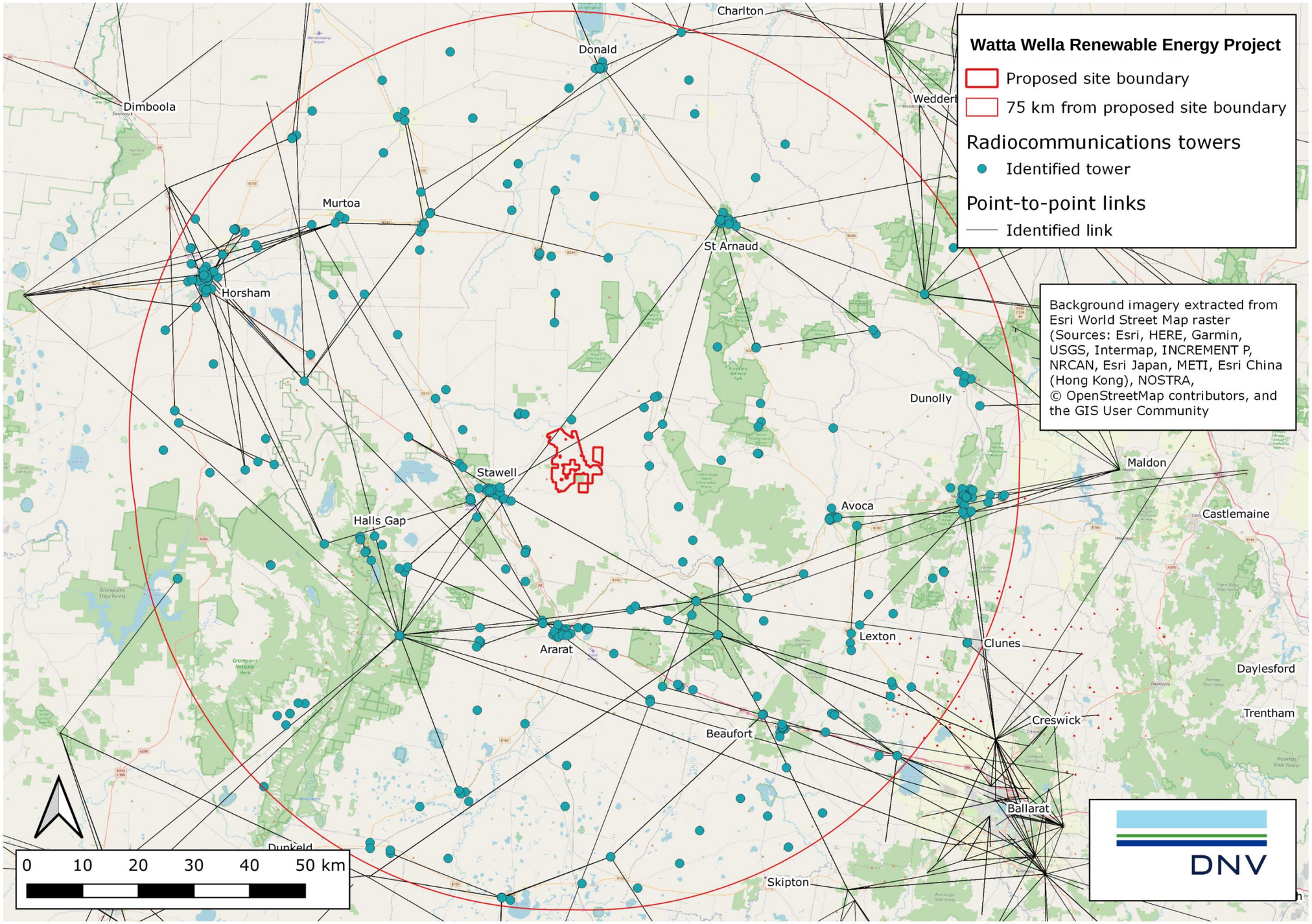


Figure 3 Identified transmission vectors for fixed licences of point-to-point type in the vicinity of the proposed Project

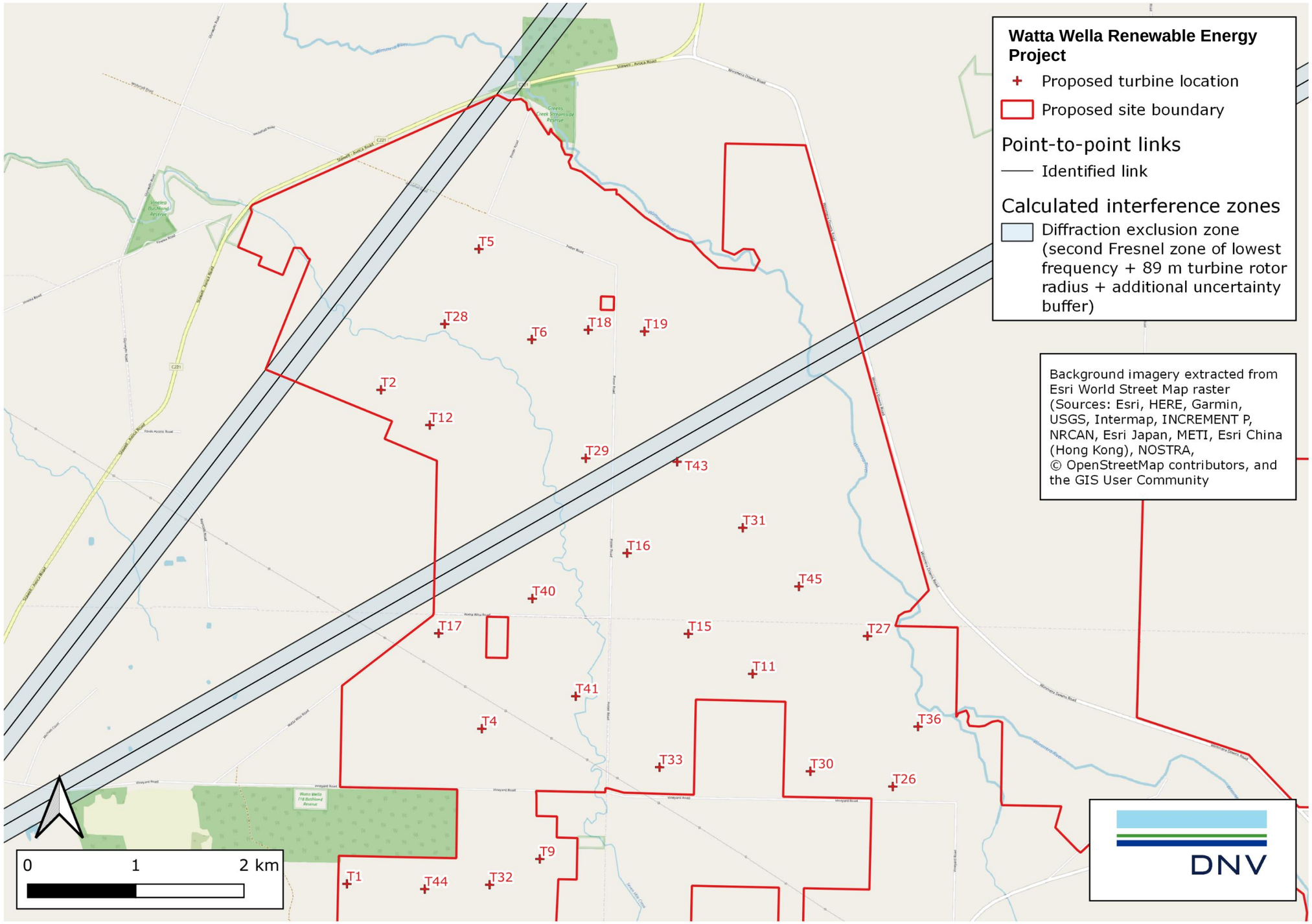


Figure 4 Identified point-to-point radiocommunication vectors crossing the proposed Project and calculated interference zones

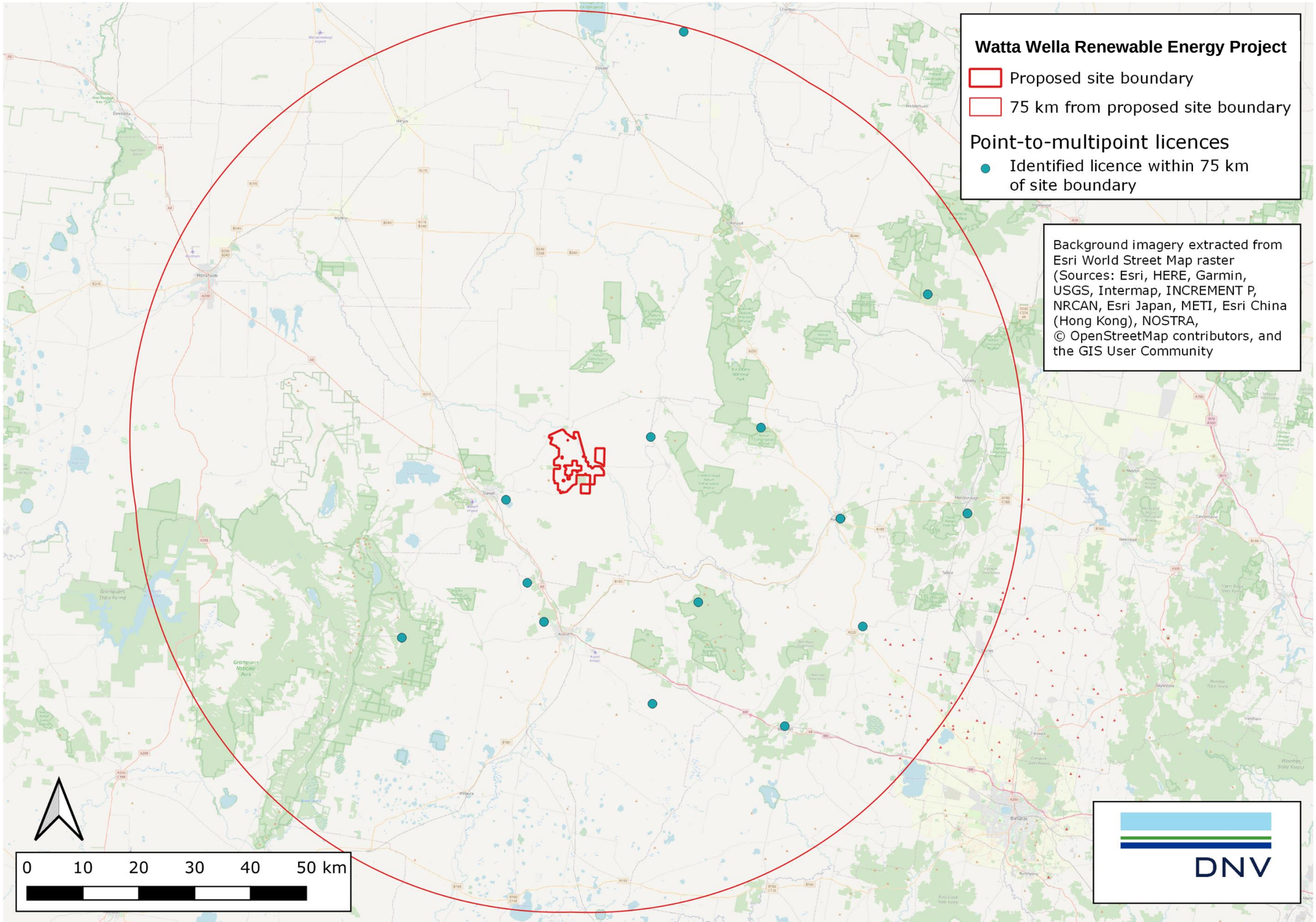


Figure 5 Location of point-to-multipoint licences in the vicinity of the proposed Project

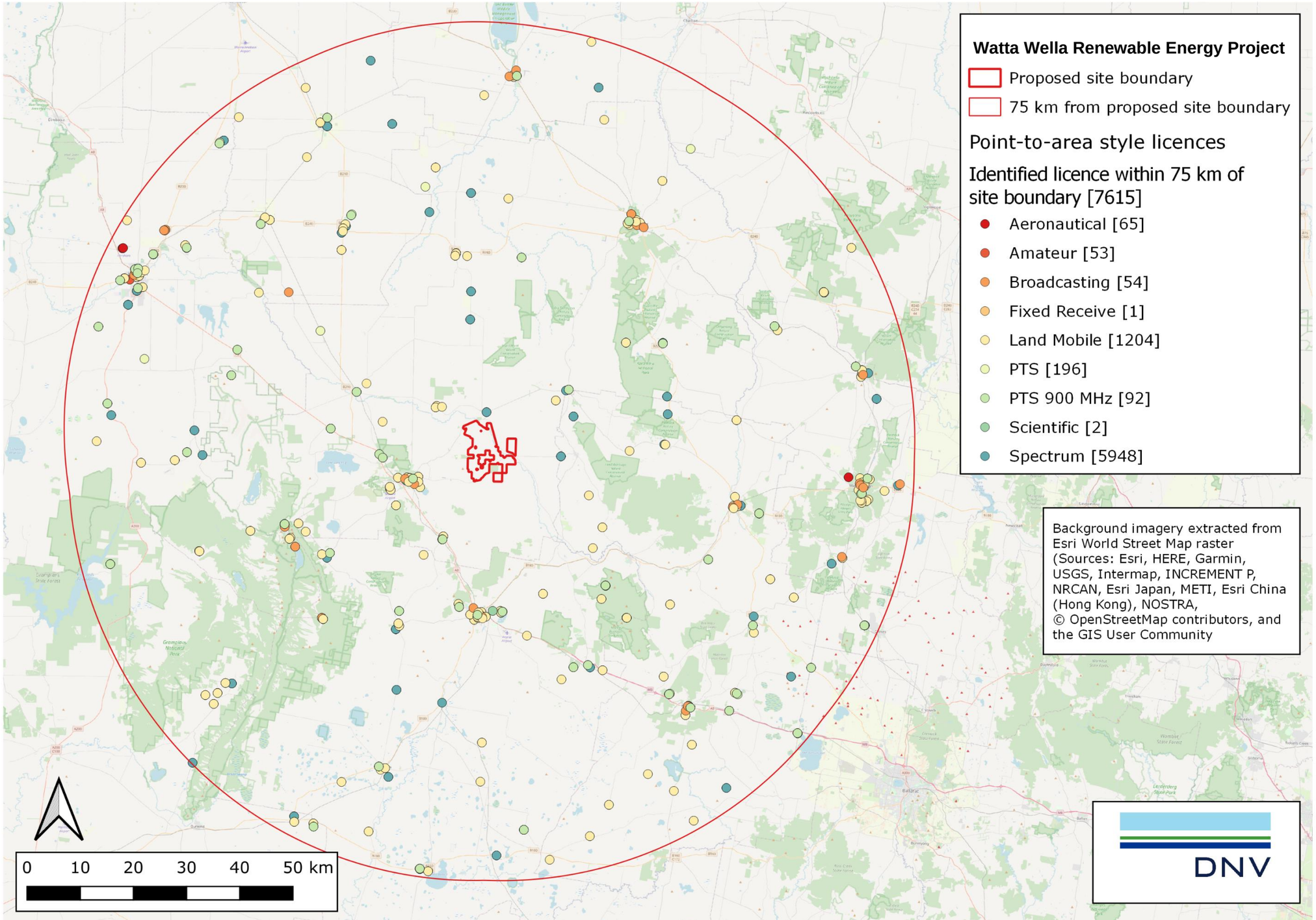


Figure 6 Location of general point-to-area style licences within 75km of the proposed Project

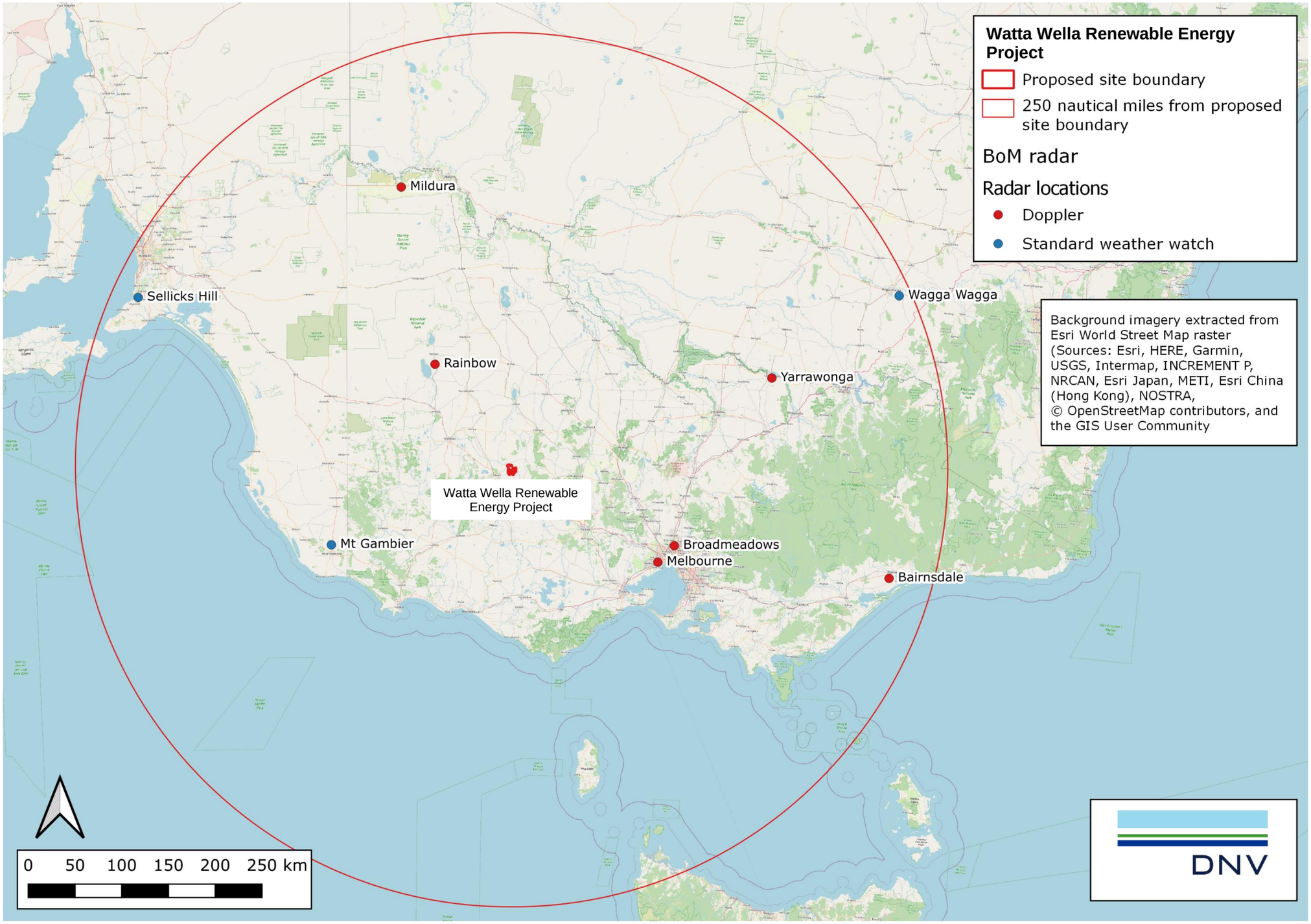


Figure 7 Location of meteorological radar sites within 250 nautical miles of the proposed Project

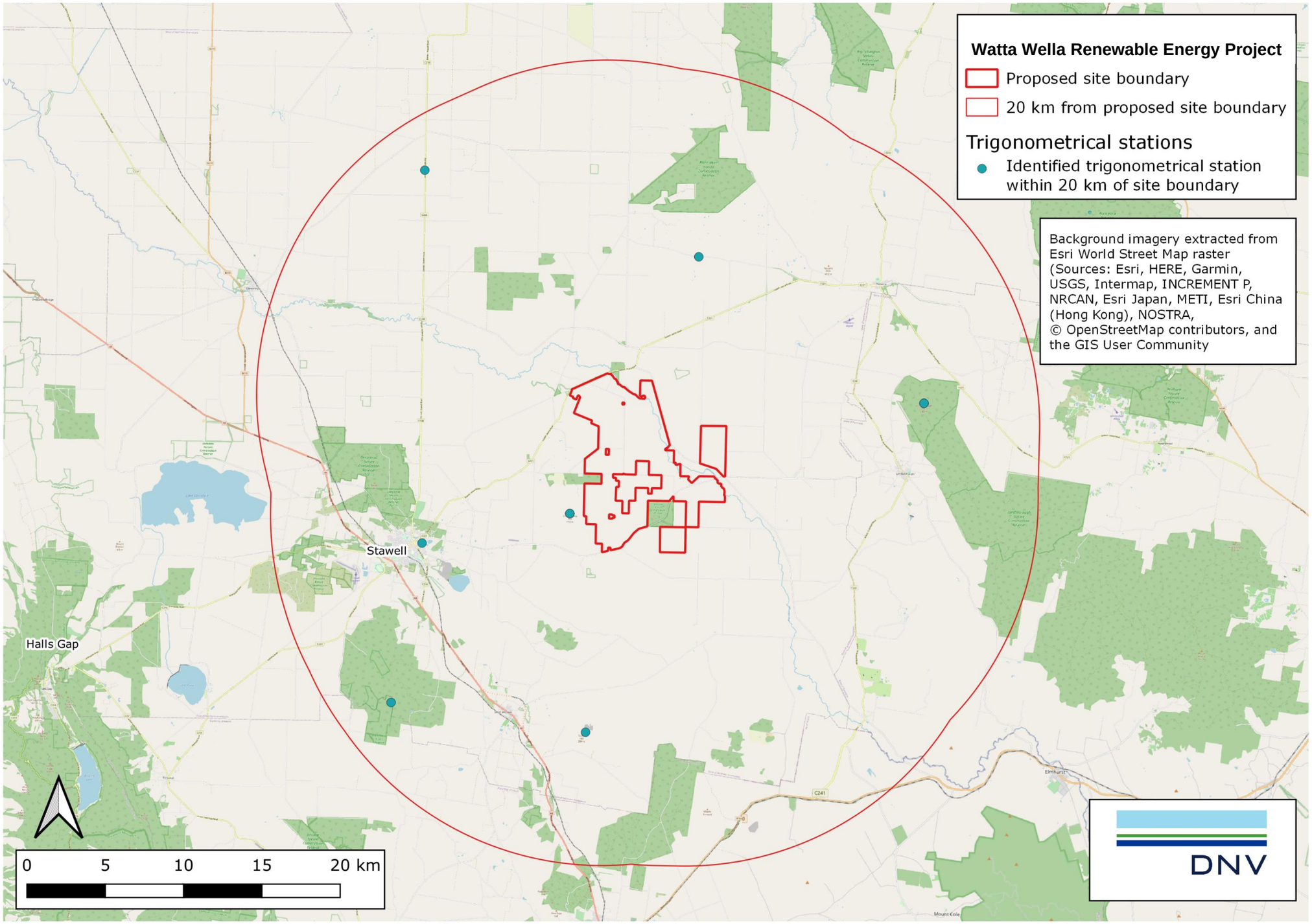


Figure 8 Location of trigonometrical stations within 20 km of the proposed Project

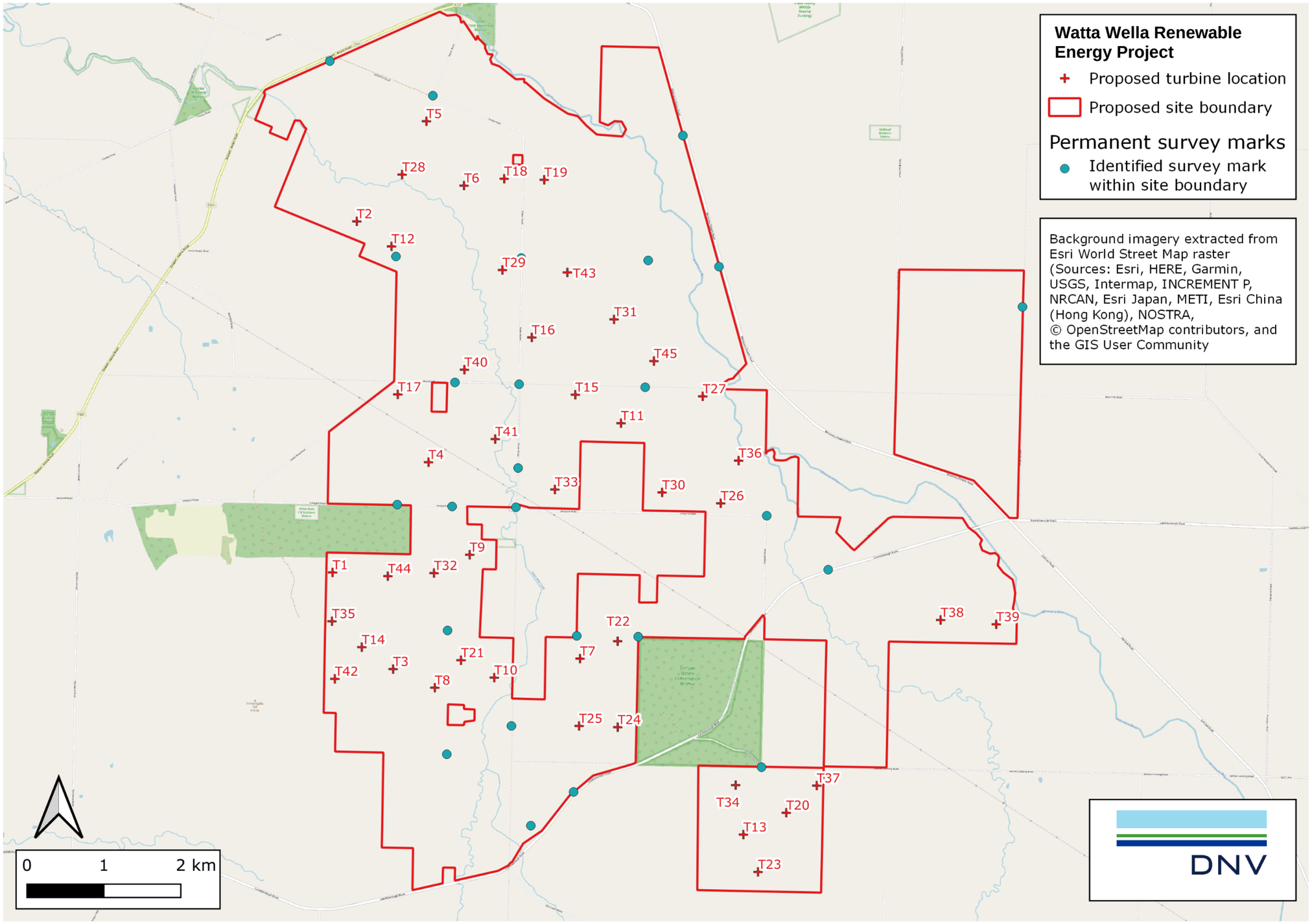


Figure 9 Location of permanent survey marks within the proposed Project boundaries

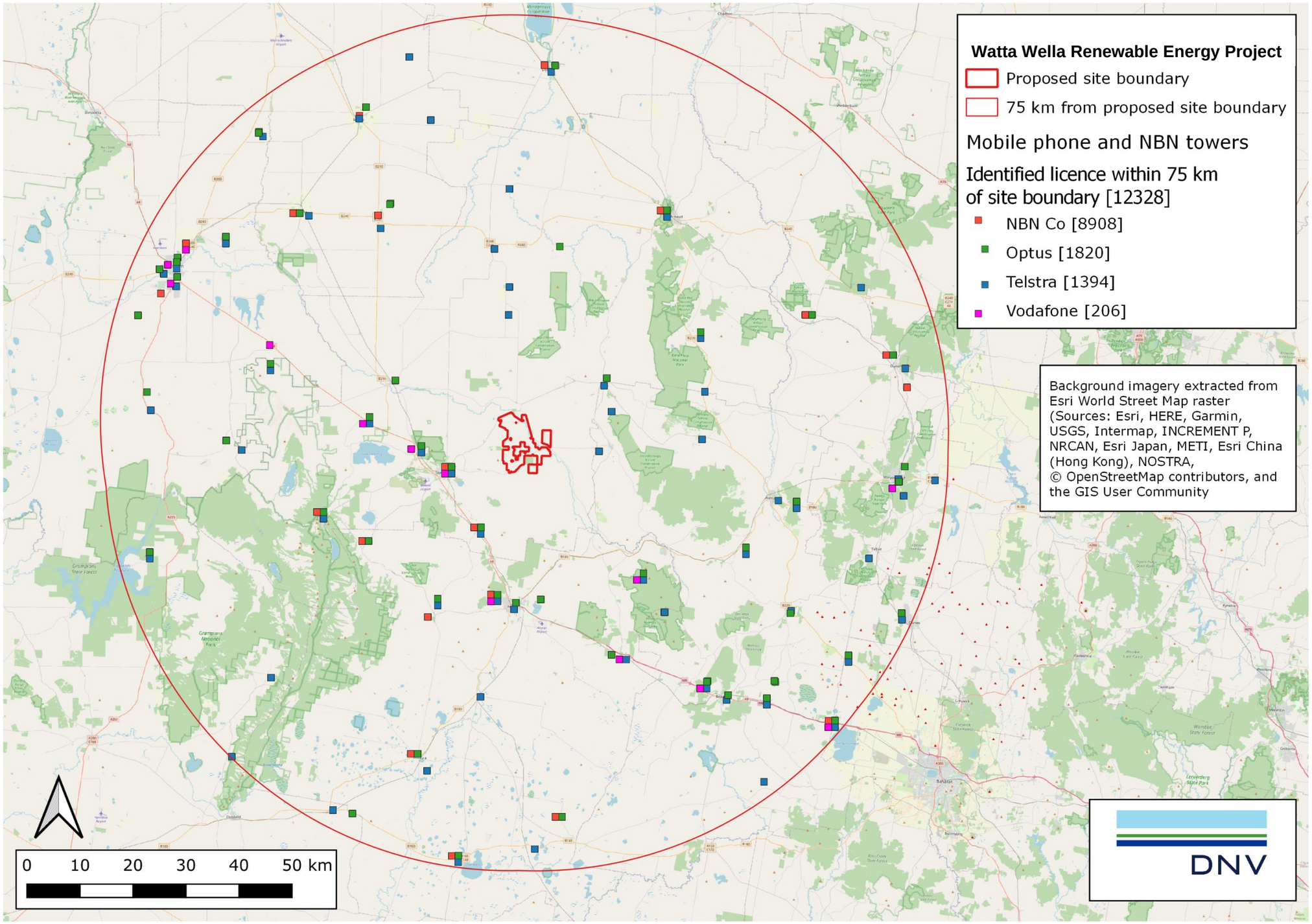


Figure 10 Location of mobile phone and NBN towers within 75 km of the proposed Project

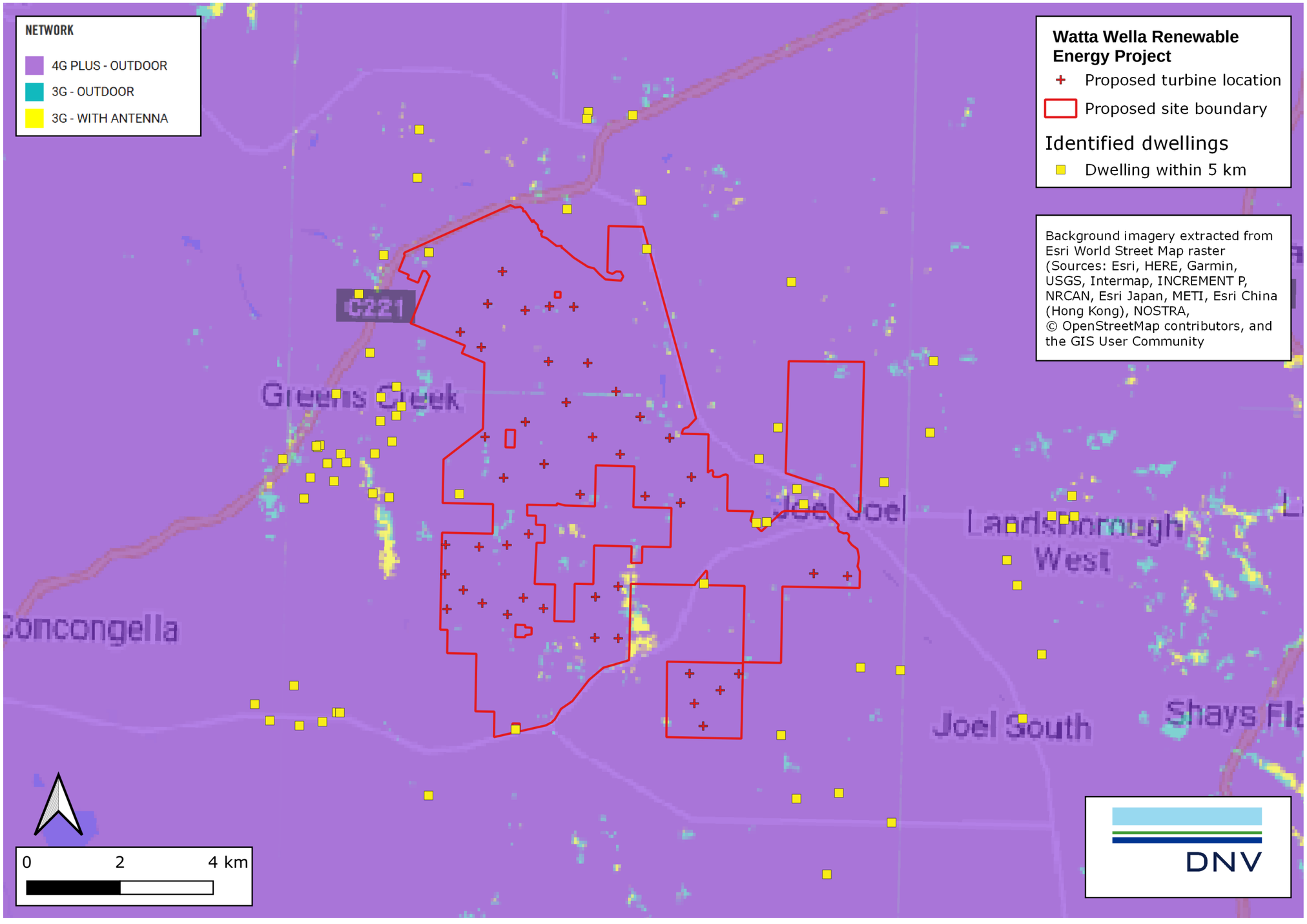


Figure 11 Optus Mobile network coverage for the proposed Project

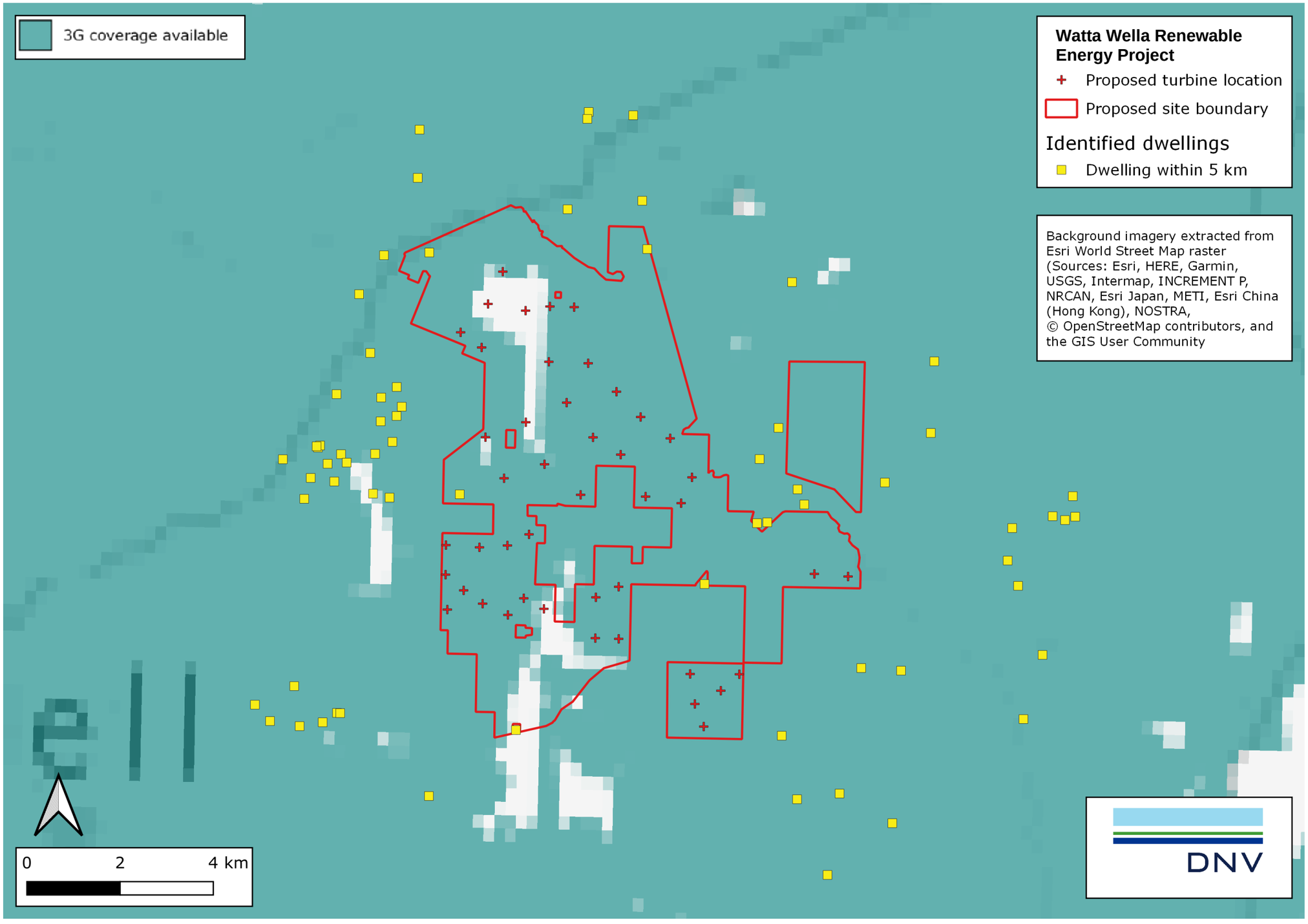


Figure 12 Telstra 3G network coverage for the proposed Project

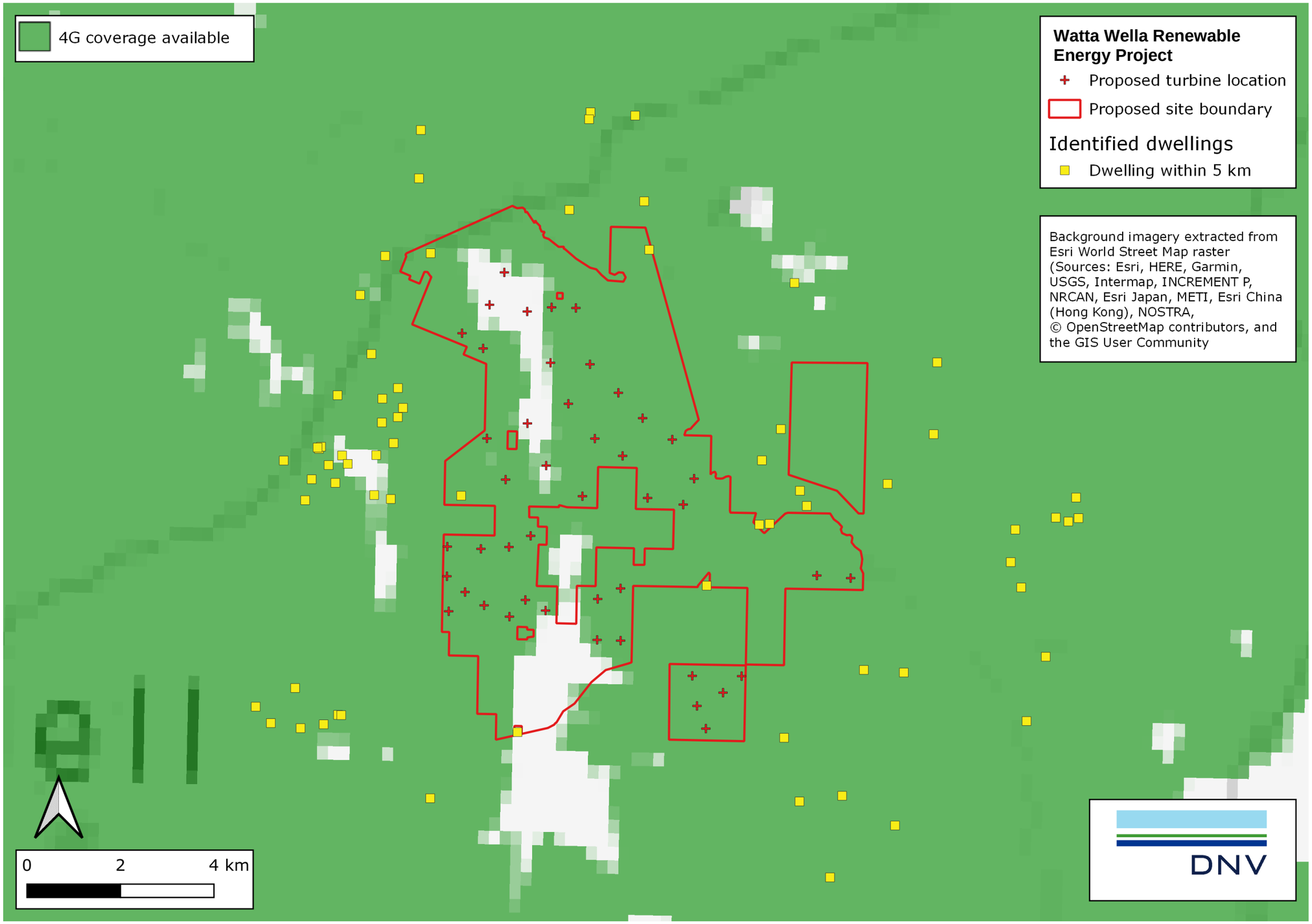


Figure 13 Telstra 4G network coverage for the proposed Project

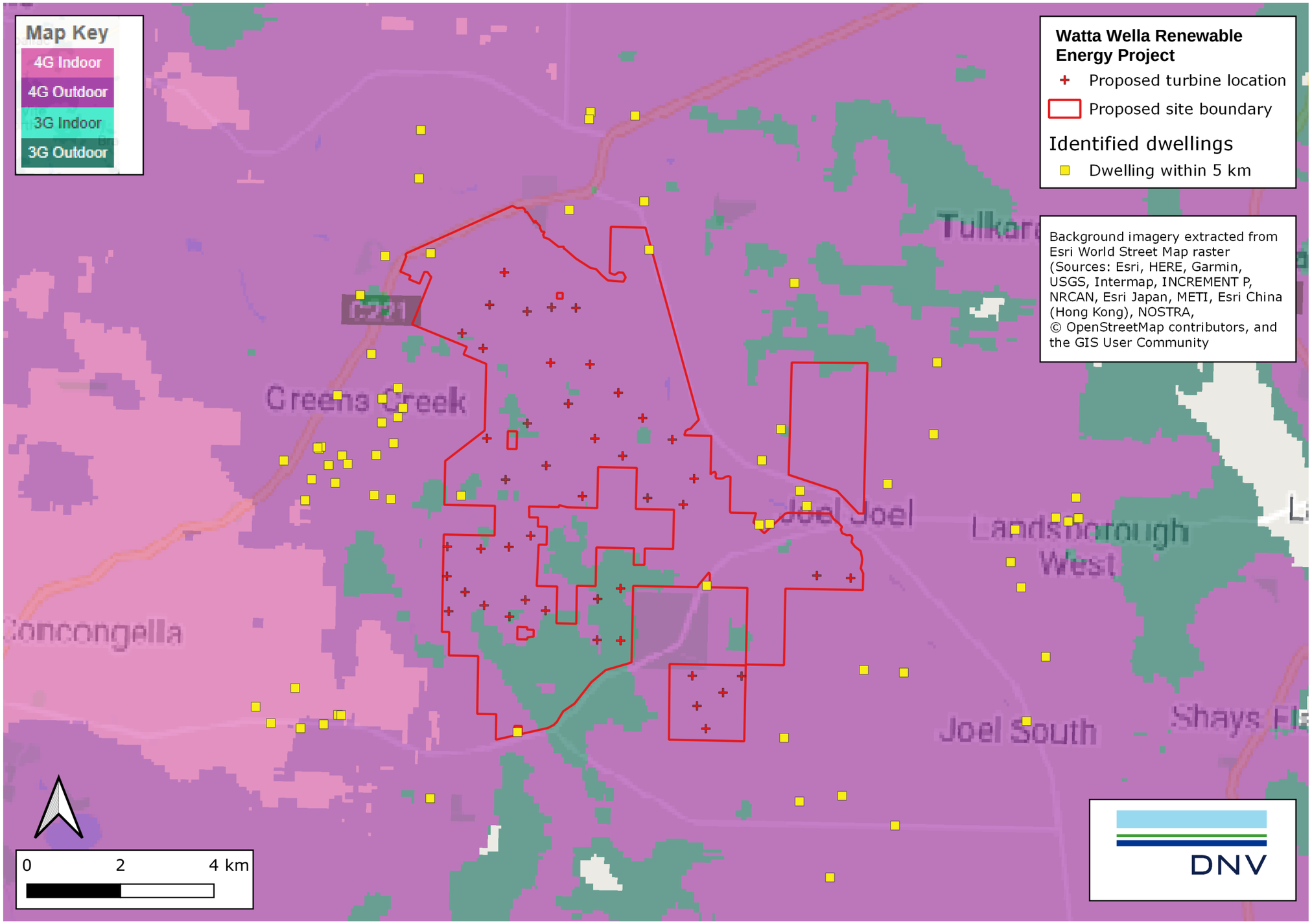


Figure 14 Vodafone network coverage (Apple iPhone 12 handset) for the proposed Project

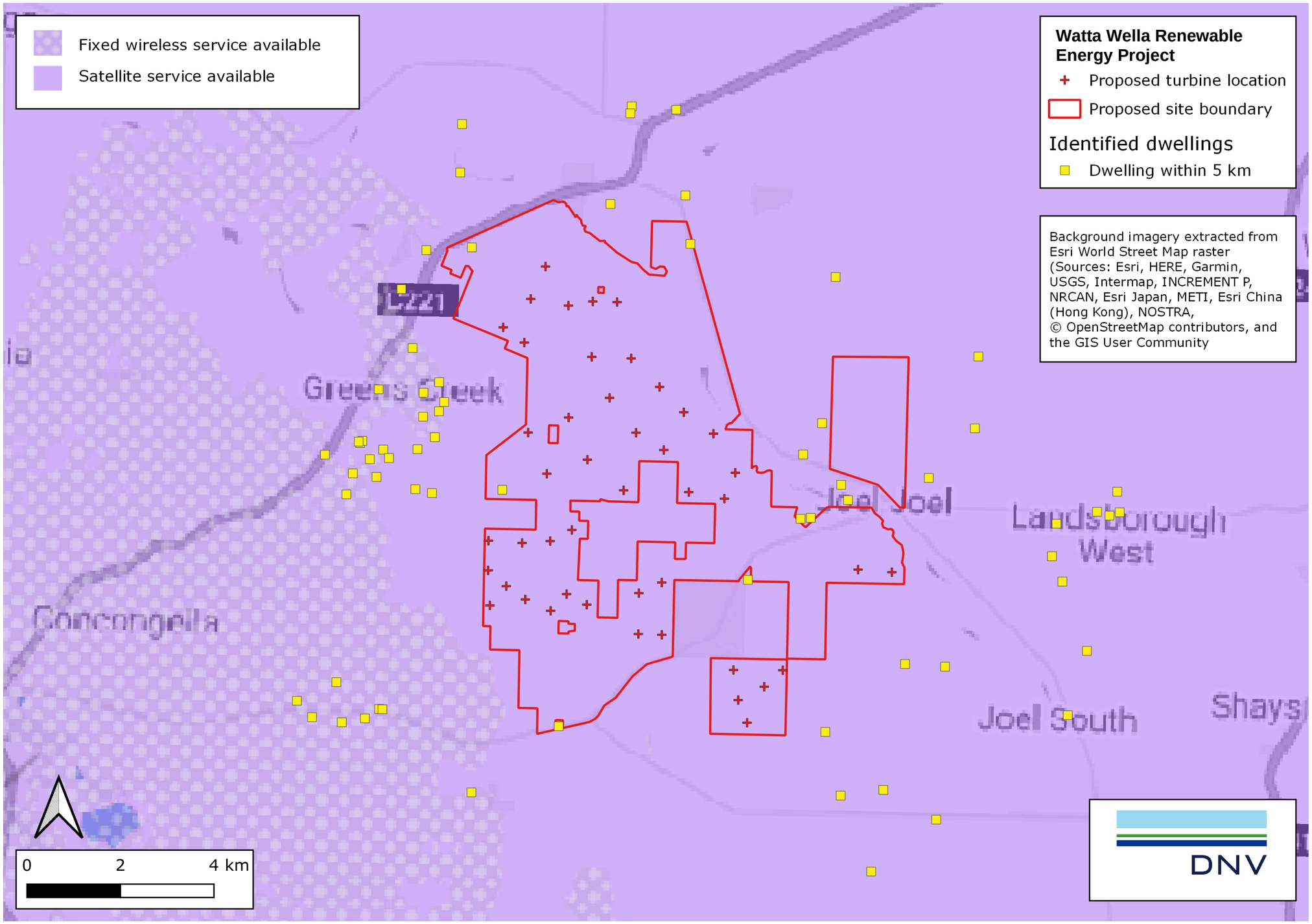


Figure 15 NBN internet coverage in the vicinity of the proposed Project

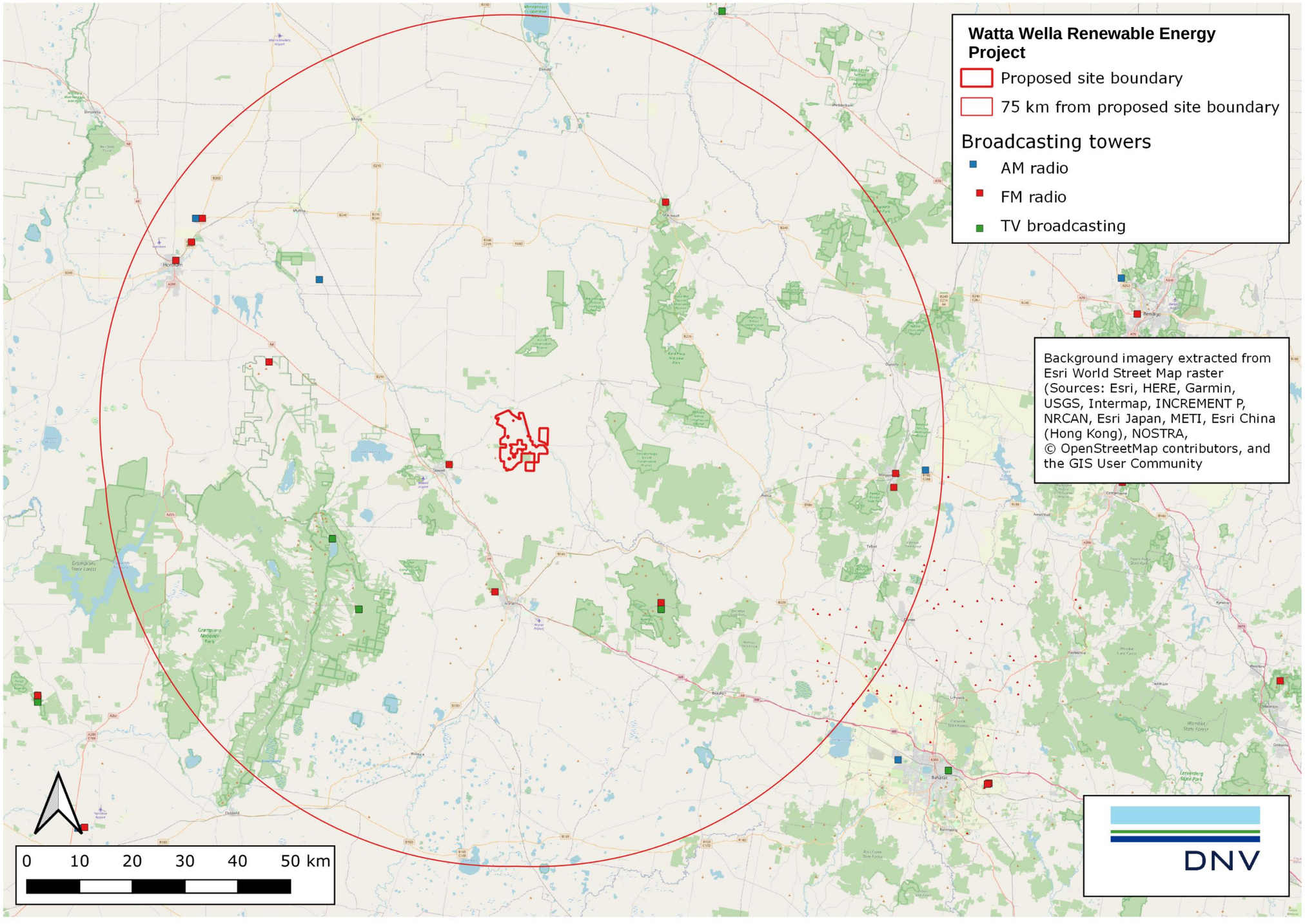


Figure 16 Location of broadcast transmitters in the vicinity of the proposed Project

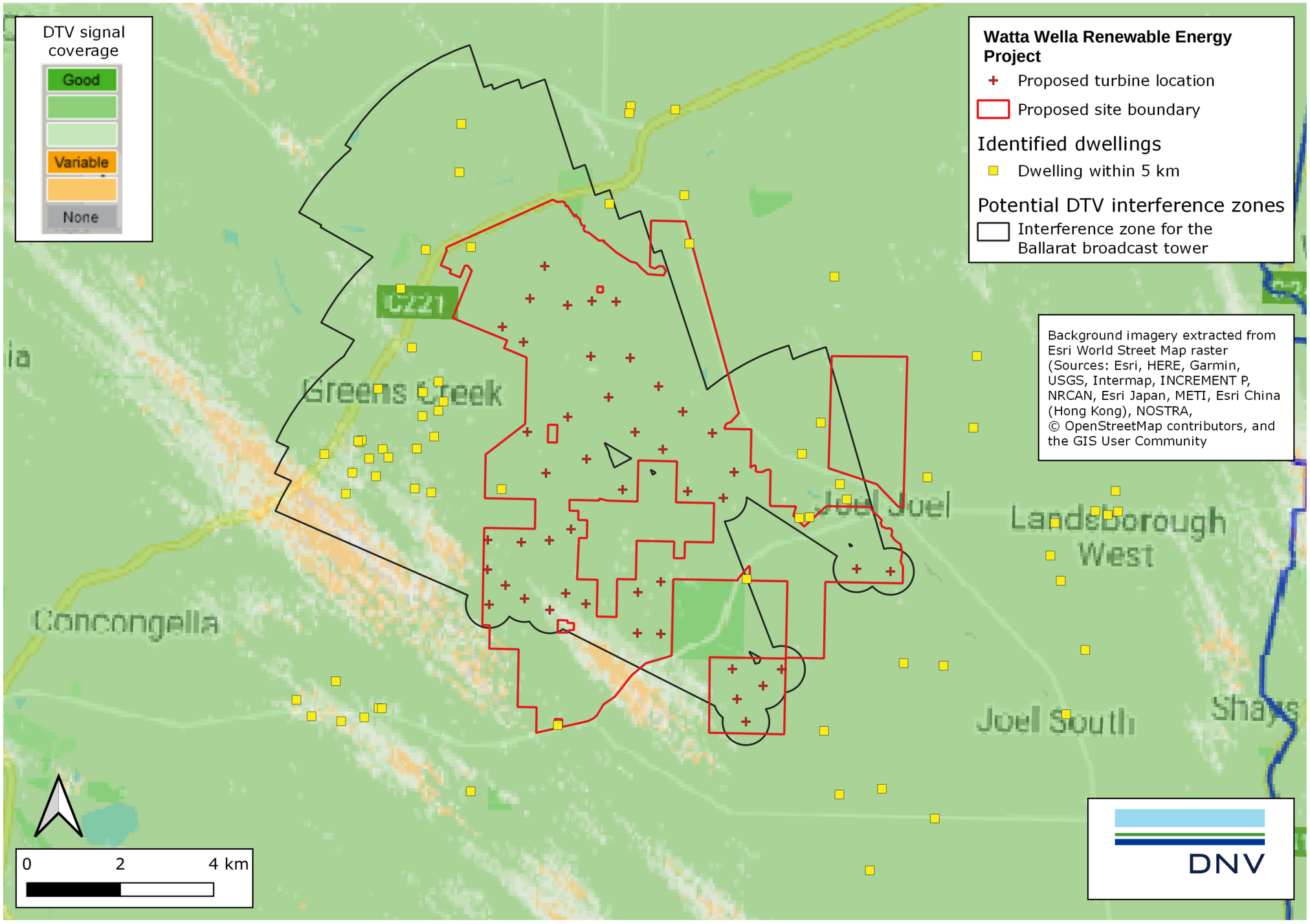


Figure 17 Potential television EMI zones for the Ballarat broadcast tower from the proposed Project

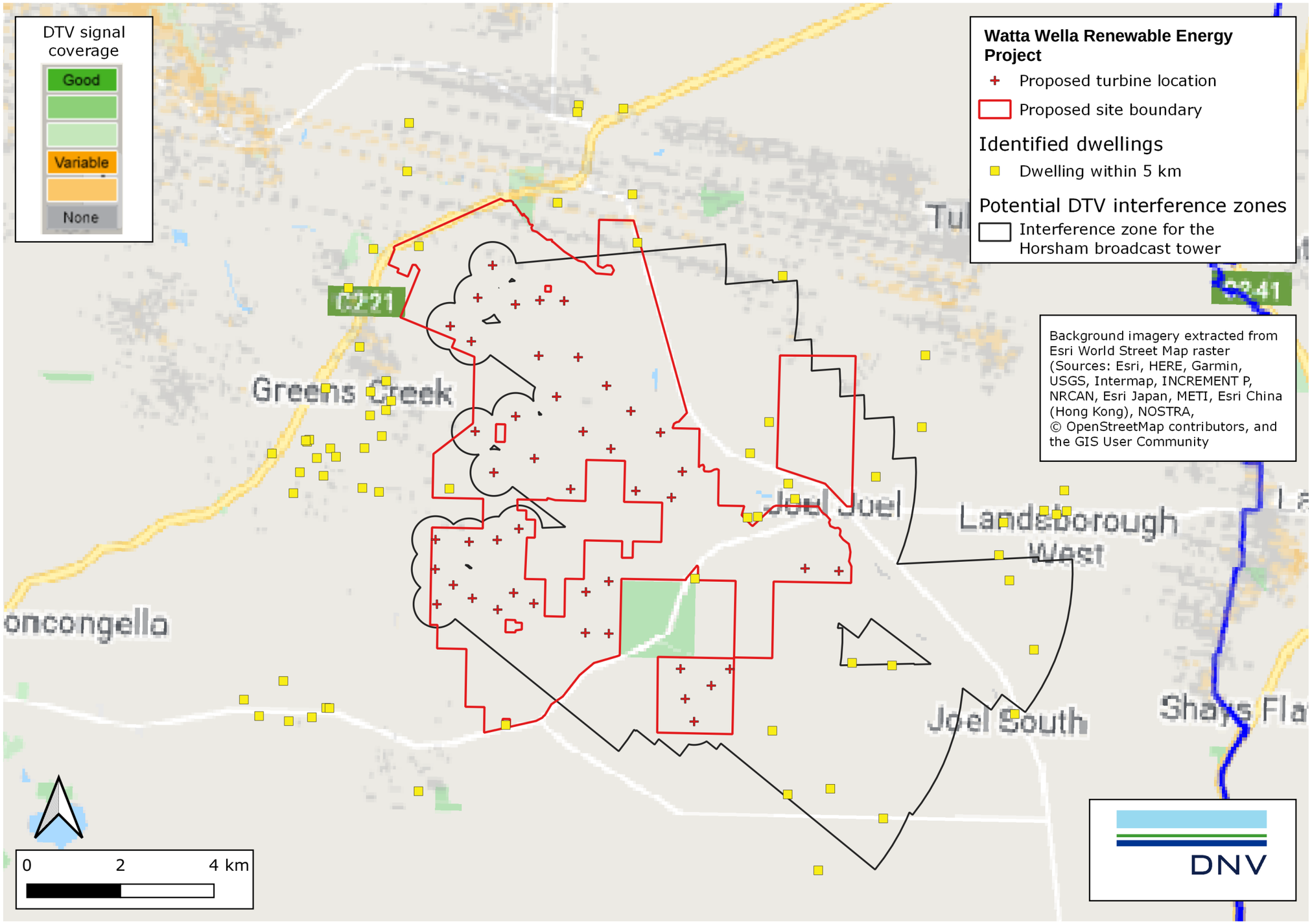


Figure 18 Potential television EMI zones for the Horsham broadcast tower from the proposed Project

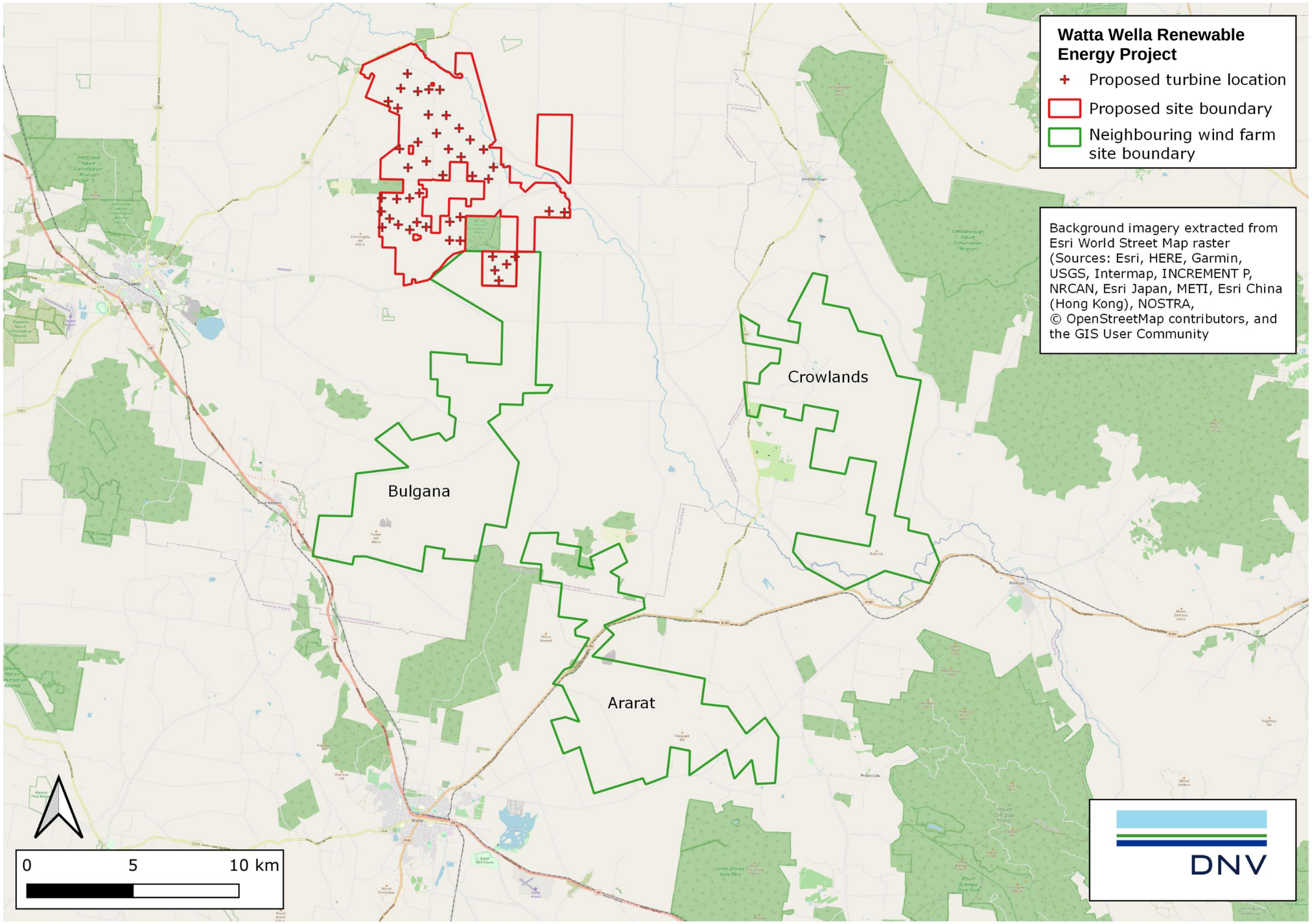


Figure 19 Map of the proposed Project, showing neighbouring wind farm developments

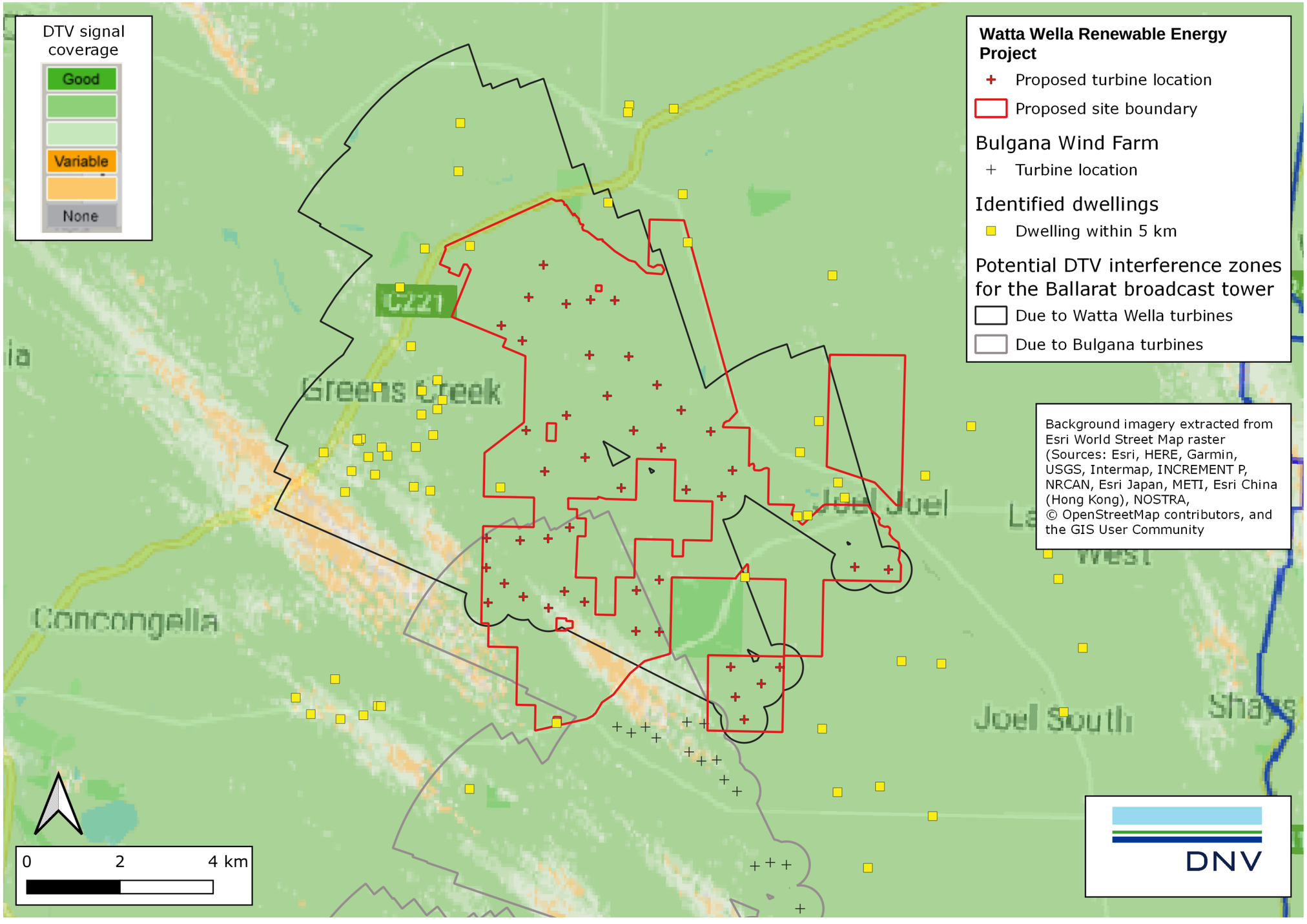


Figure 20 Potential cumulative EMI impacts to television signals from the Ballarat broadcast tower

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.