12. Electromagnetic Assessment

Wimmera Plains Energy Facility

Electromagnetic Interference Risk Assessment

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1. Executive Summary

The Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria (Guidelines) specify that *"the potential electromagnetic interference from the generation of electricity from a wind energy facility should be minimised, if not eliminated, through appropriate turbine design and siting."*[1]

There is a number of critical services that depend upon the delivery of information via electromagnetic waves, or radio signals. In practice only two services have proven to be affected by wind farm developments, namely television broadcasting and microwave links.[2]

Historically, analogue television broadcasting has been more prone to interfere with wind turbines in the vicinity. However, the switchover to digital television has effectively eliminated wind farms as the cause of interference to individual television reception. Nonetheless, they can still cause large scale interference to television broadcasting if located too close to a broadcast site (transmitter tower). According to official data from the Australian Communications and Media Authority (ACMA) the nearest available television broadcast site is Arapiles being 38.3 km from the proposed wind farm.
At this distance, the wind farm will not be capable of causing large scale interference to television broadcasting - see Figure 1 – Television and Radio Broadcasting Sites in the Vicinity below.

In the case of microwave links, wind farms have the potential to cause electromagnetic interference (EMI) via two mechanisms. Near field interference can be caused by wind farms if they are located too close to a transmitter or receiver, and path obstruction can occur when they are located within the second Fresnel Zone of a radio link. However, according to official data from ACMA the nearest microwave transmitter or receiver is 6.2 km from the project site and the nearest link is more than 1.3 km to the east. — see Figure 5 –Microwave Links in the Vicinity below.
Given the above distances, the Wimmera Plains Energy Facility will not cause interference to microwave link activity via either mechanism.

[1] Victorian Department of Planning, Transport, and Local Infrastructure, "Policy and planning guidelines for development of wind energy facilities in Victoria," March 2019.
[2] Sengupta et al., 'Electromagnetic Interference from Wind Turbines.'

2. Introduction

There are a number of critical services that depend upon the delivery of information via electromagnetic waves, or radio signals. Electromagnetic interference occurs when the transmission of these waves or signals is impaired by obstruction, reflection or spurious emissions. In principle wind farms have the potential to cause electromagnetic interference via the following two mechanisms:

- Reflection: Reflection occurs when electromagnetic waves are reflected off the physical surfaces of a wind turbine or turbines. In the event that there is a receiver nearby to a reflected signal it will receive two signals—i.e. the original and the reflected signal - leading to a degradation of signal reception at that receiver location; and
- Emission: Emission occurs when wind turbines or an electrical plant associated with them emit electromagnetic waves. In the event that there is a receiver nearby to a powerful source of emission two signals will be received - i.e. the original signal and emitted noise - leading to a degradation of signal reception at that receiver location. [3]

In practice only one of these mechanisms has been shown to cause electromagnetic interference, namely reflection.[4] Because modern wind turbines and their associated infrastructure are required to meet strict electrical engineering standards, they emit very small amounts of electromagnetic radiation. This means that wind farms do not have the potential to cause EMI due to emission.

However, due to their large size and location on exposed hilltops, there is the potential for wind farms to be located in close proximity to transmitters or receiver, or line of site between a transmitter and a receiver, and thereby cause EMI by reflecting electromagnetic waves.

The services that are theoretically susceptible to EMI in this way are:

- Television and radio broadcasting
- Mobile phone services
- Navigational systems (VOR, DVOR, ILS, LORANC, and radar), and
- Microwave links.[5]

[3] Hall, S. 'The Assessment and Avoidance of Electromagnetic Interference Due to Wind Farms,' Wind Engineering, Vol. 16, No. 6, 1992; Sengupta D. & Senior T., 'Electromagnetic Interference from Wind Turbines,' in Spera, D., (ed.) *Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering*, New York: ASME Press, 1994.

[4] Ibid.

[5] Ibid.

In practice only two of these services have proven to be affected by wind farm developments, namely television broadcasting and microwave links.[6]

While radio broadcasting (AM and FM) is affected, it is only affected within a few tens of metres of a wind turbine, meaning the effect of wind turbine developments of radio broadcasting is negligible. Mobile phone services are designed to work in and around buildings and therefore already withstand any interference that would be posed by a wind farm development. Navigational systems are susceptible to interference from wind turbines; however, they are generally located in areas where wind farms are not - such as airports and major cities - and as such are rarely affected by wind farm developments. This leaves television broadcasting and microwave links as the two telecommunication systems most likely to be affected by a wind farm development. These two kinds of EMI are discussed below in turn.

3. Television Broadcasting

Digital television (DTV) broadcasting in Australia commenced on 1 January 2001 in Sydney, Melbourne, Brisbane, Adelaide and Perth using DVB-T (Digital Video Broadcasting – Terrestrial) standards. The phase out of analogue transmissions began in 2010 and was completed by 10th of December 2013. Since then all television networks in Victoria are transmitted via digital broadcasting which is more resistant to and generally unaffected by electromagnetic interference from wind farms.

Television broadcasting systems consist of a transmitter (or a series of transmitters) which broadcast electromagnetic waves in the UHF band. These signals are sent to a large area in all directions.

There are two ways in which a wind farm can cause interference to television broadcasting, namely large scale and small scale interference.

3.1. Small Scale Interference

Small scale interference occurs when a wind farm interferes with television reception in its immediate vicinity by degrading the signal at its point of reception. Since the switchover to digital television the risk of wind farms causing small scale interference has effectively been negated. This is due to the fact that DTV requires a much lower signal strength in order to deliver excellent video, meaning that even if a wind farm is causing a degradation of television signal, that signal will generally be strong enough for a digital receiver to produce an excellent video. It is for this reason that, prior to the switch over, digital television was used as an amelioration option for dwellings that were affected by wind farm developments. Accordingly, except in rare cases where reception is marginal in the first place, wind farms no longer pose a risk of causing small scale interference to television broadcasting.

The ACMA Broadcast Transmitter Database indicates that the Project area is served by two main DTV transmitters, namely Horsham and Ballarat broadcast towers at Arapiles (38.3 km distant) and Lookout

[6] Sengupta et al., 'Electromagnetic Interference from Wind Turbines.'

Hill (110 km distant) respectively as shown in Figure 1. However, it is also possible that residents to the south/south-east of the Project can receive signals from the Halls Gap transmitter approximately 68 km to the south from the site. This means that, firstly, it is highly unlikely that the wind farm will cause interference to television reception at nearby residences, but secondly, that even if the wind farm does cause interference it will be easily rectified by redirecting the antenna in question in the direction of the alternate broadcast site. Importantly, there are no dwellings located such that this amelioration option would not be available—i.e. because the wind farm blocks line of sight to both broadcast sites. Figures 2 and Figure 3 show digital television coverage in the area surrounding the Wimmera Plains Energy Facility by both main transmitters obtained from Australian Government mySwitch portal[7]. The two figures combined indicate that the area receives good to variable coverage.

[7] https://myswitch.digitalready.gov.au/. Accessed 08/10/2019.

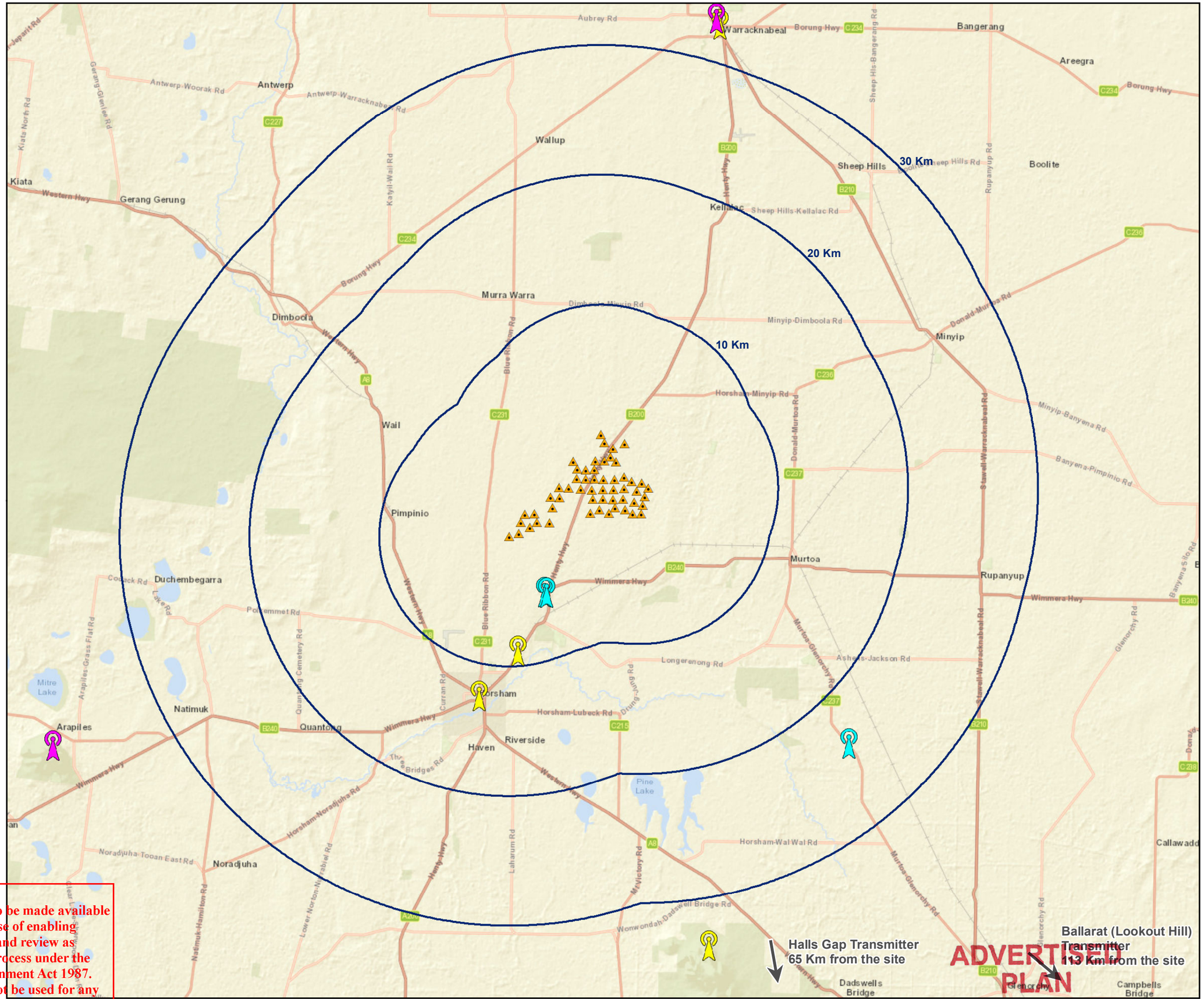
Figure 1. Television and Radio Broadcast Sites in the Vicinity of the Wind Farm

Wimmera Plains Energy Facility

Television and Radio Broadcasting Sites in the Vicinity of the Facility

Legend

- Turbine Location
- DTV Transmitter
- AM Radio Transmitter
- FM Radio Transmitter



N
W E
S

Scale at A3:
1:275,000

0 7.5 15 km

Date: 03/04/2020

Figure 2. Horsham (Arapiles) DTV Broadcast Coverage

Wimmera Plains Energy Facility

Horsham (Arapiles)
DTV Broadcast Coverage

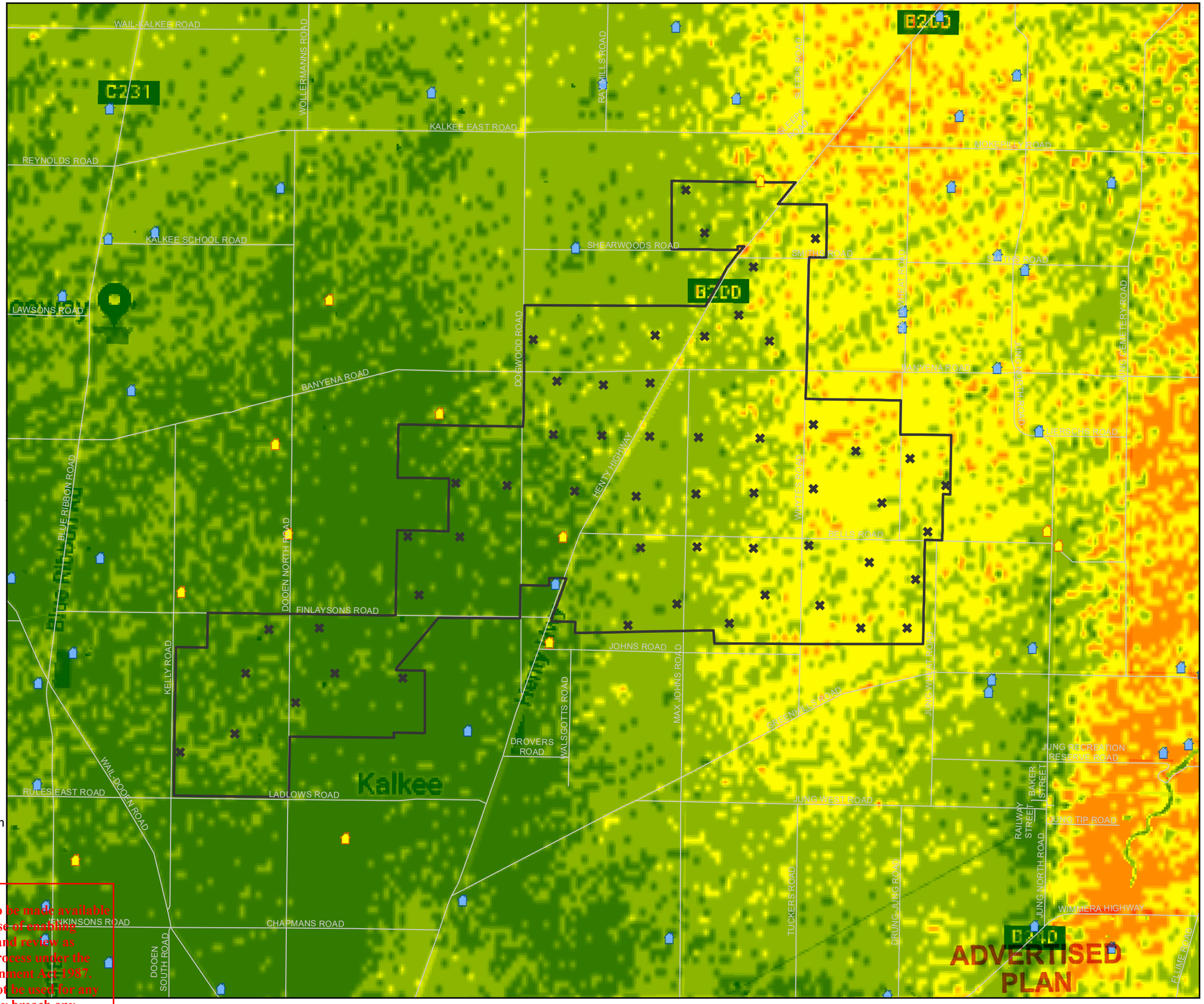
Legend

Dwellings

- Non-stakeholder
- Stakeholder
- Turbine Location
- Site Envelope

DTV Coverage

- Bad
- Variable
- Good



N
W E
S

Scale at A3:
1:50,000

0 1.5 3 km

BayWare.

Date: 05/04/2020

Figure 3. Ballarat (Lookout Hill) DTV Broadcast Coverage

Wimmera Plains Energy Facility

Ballarat (Lookout Hill)
DTV Broadcast Coverage

Legend

Dwellings

- Non-stakeholder
- Stakeholder
- Turbine Location
- Site Envelope

DTV Coverage

- Bad
- Variable
- Good

N
W E
S

Scale at A3:
1:50,000

0 1.5 3 km

BayWare

Date: 06/04/2020

3.2. Large Scale Interference

Large scale interference occurs when a wind farm development interacts with a broadcast site and therefore interferes with the broadcast signal at its point of transmission, thereby affecting the entire coverage area associated with it. Large scale interference can be avoided by ensuring that wind turbines are not located in the near vicinity of broadcast stations. It is generally recommended that wind farms should be located at least 6 km from primary television transmitters, and 1 km relay transmitters. According to official broadcast transmitter data from ACMA the nearest primary television broadcast site to the proposed wind farm is located at a distance of 38.3 km (Horsham - Arapiles) and the nearest relay transmitter is ca. 32.8 km (Warracknabeal) – Figure 1 above. Therefore, the proposed wind farm does not pose a risk of causing large scale interference to television broadcasting.

4. Microwave Links

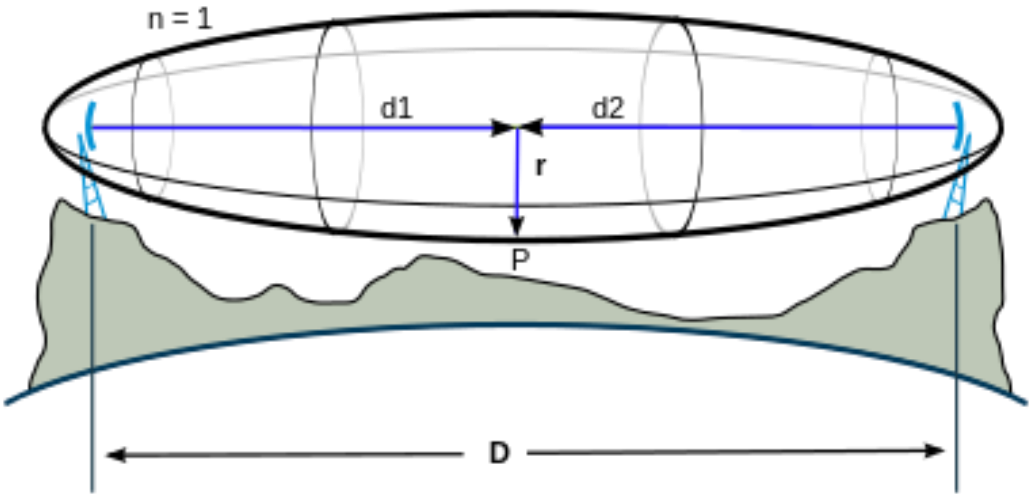
Unlike television broadcasting which emanates from a single point to a large area, microwave links transfer information between single points, or from point to point. These systems operate in the ultra high frequency range UHF (1 GHz to 30 GHz) sending and receiving highly focused signals between transmitters and receivers. The path of these signals is effectively identical to the line of sight between a transmitter and a receiver; however, it is not limited to a straight line. Rather the path of a microwave link covers an elliptical area surrounding the central path of the beam known as the Fresnel Zone. The Fresnel Zone consists of a series of concentric ellipses of increasing radius from the centre point of the beam, usually termed the first, second and third Fresnel Zones. The radius of these Fresnel Zones is a function of the distance between the transmitter and the receiver, and the wavelength of the signal, as per the simple formula shown below.

$$R_n = \sqrt{((n\lambda D_1 D_2)/(D_1 + D_2))}$$

Where:
R_n = radius of the nth Fresnel Zone
n = Fresnel Zone number
λ = wavelength
D_1 = distance between transmitter and point of interest (wind farm)
D_2 = distance between receiver and point of interest (wind farm)

A graphical representation of the Fresnel Zone around a microwave link is shown in the Figure 4 below.

Figure 4. Geometry of a Fresnel Zone Around a Microwave Link



There are two ways in which a wind farm development can cause interference to a microwave link, namely near field interference and path obstruction.[8]

4.1. Path Obstruction

Path obstruction occurs when a physical object is located in the path of a microwave link, otherwise known as the Fresnel Zone. In order to avoid causing interference via path obstruction it is generally recommended that wind turbines be located outside of the second Fresnel Zone of a microwave link.[9]
The nearest microwave links to the wind farm have been identified using official data from ACMA.[10] These links are shown in Figure 5 below. According to ACMA data the nearest microwave link passes the site at a distance of over 1.32 km and has a frequency of 7.7045 GHz. By applying the formula above, the radius of the second Fresnel zone at the point is 22 m. Therefore, the proposed wind farm does not pose a risk of causing interference to microwave links via path obstruction.

[8] Hall, S. 'The Assessment and Avoidance of Electromagnetic Interference Due to Wind Farms;' Sengupta et. al., 'Electromagnetic Interference from Wind Turbines.'
[9] Ibid.
[10] https://webracma.gov.au/rrl/register_search.main_page. Accessed 15/05/2019.

Figure 5. Microwave Links in the Vicinity of the Wind Farm

Wimmera Plains Energy Facility

Microwave Links in the Vicinity of the Facility

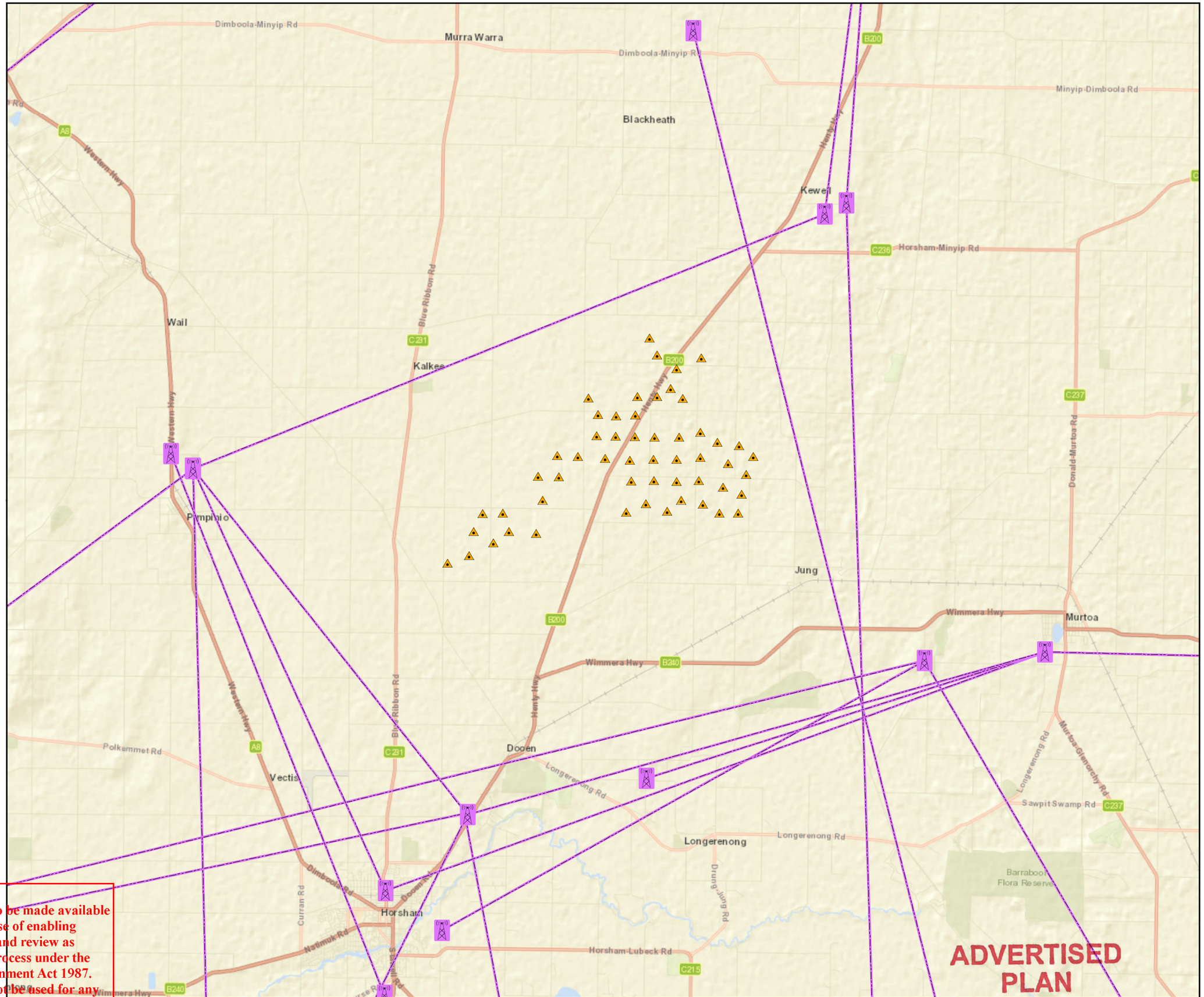
Legend

- Turbine Location
- Microwave Towers
- Microwave Links

N
W E
S

Scale at A3:
1:125,000

0 3 6 km



Date: 03/04/2020

4.2. Near Field

The near field is a region surrounding every transmitter and receiver within which they are highly susceptible to interference. Different telecommunications systems have different sensitivities to near field interference. In the case of microwave links the transmitters and receivers used for relaying signals are highly sensitive, meaning the area within which they are susceptible to near field interference is quite large. The extent of the near field is a function of the diameter of the antenna and wavelength of the signal, as per the equation shown below.

$$D_f = {}^{2D^2}/_{\lambda}$$

Where:
D_f = linear extent of the near field zone
D = diameter of antenna
λ = wavelength

However, a conservative recommendation is that near field interference can be avoided by ensuring the turbines are located at least 1 km from a transmitter or receiver. According to official data from ACMA the nearest transmitter or receiver of microwave links to the wind farm is located at a distance of 6.2 km to the northeast of the site - see Figure 5 –Microwave Links in the Vicinity. Therefore, the proposed wind farm does not pose a risk of causing interference to microwave links via near field interference.

References

Australian Communications and Media Authority (ACMA). Broadcast Transmitter Data, https://www.acma.gov.au/Industry/Spectrum/Radiocomms-licensing/Apparatus-licences/list-of-licensed-broadcasting-transmitters. Accessed 15/05/2019.

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