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Telecommunications Impact Assessment

Liverpool Range Wind Farm 2013



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1 Executive summary

The objective of this report is to investigate the potential impacts of the Liverpool Range Wind Farm on existing radio telecommunication services in the vicinity of the proposal and to propose appropriate mitigation strategies for any impacts identified. An assessment of possible electric and magnetic fields associated with wind farms and their implications on human health is also presented.

Telecommunication services, including television and radio broadcasts, mobile phone services and point to point microwave radio communication services occur in proximity to population centres and often utilise the same ridgelines that provide optimum locations for wind turbines. Theoretically, as with any large structure, wind turbines have the potential to cause interference with such signals.

In general, VHF frequency band radio signals and digital voice based technologies such as GSM mobile are essentially unaffected by wind turbines. This includes land mobile repeaters, radio, the audio component of analogue television and mobile phones.¹

For broadcast signals which are usually omni-directional (point to area), interference can generally be avoided by locating wind turbines a certain distance from the broadcast tower. A clearance of 500m is recommended.² Interference to point to point communications services can be avoided by not impacting on the 2nd order Fresnel zone and distancing turbines from the broadcast tower to avoid near field scattering effects.

One omnidirectional broadcast tower and one point to point broadcast tower have been identified within 500m of the Liverpool Range Wind Farm project. Epuron is in discussion with the owners and operators of the towers to ensure the development of the proposed wind project does not have any adverse backscatter or near field effects from being near to broadcast or communications towers.

Following a review of the communication services near the wind farm site, the nature of potential interference and consultation with license holders and service providers, it is considered that the proposed wind farm would have minimal impact on existing radio telecommunications services. Where applicable, mitigation strategies are proposed to ensure any identified impacts can be managed appropriately.

The electromagnetic fields associated with generation and export of electricity from a wind farm does not pose a significant threat to public health.

Consequently, no adverse electromagnetic interference issues are anticipated from the wind farm.

1 <http://www.dungog.nsw.gov.au/files/2142/File/GreenpowerEMIAnalysisIssue.pdf>

2 Ibid

2 Existing Environment

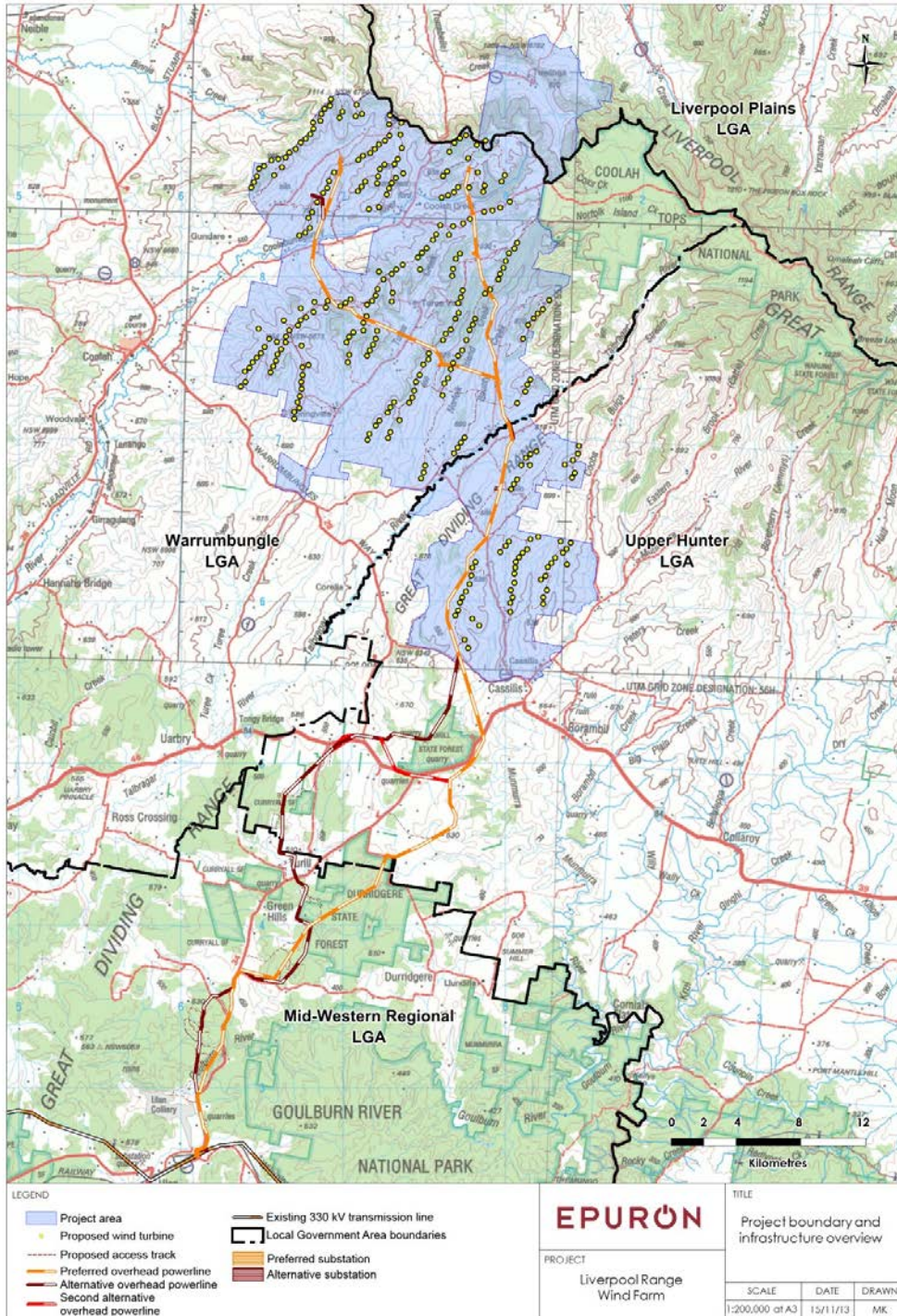


Figure 2-1 – Liverpool Range Wind Farm Site Locality

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The proposed Liverpool Range Wind Farm is located to the east of Coolah and the north of Cassilis in New South Wales, as shown in Figure 2-1. It is approximately 370km north of Sydney and is located on freehold and leasehold land within and adjacent to agricultural areas, predominantly used for grazing sheep and cattle. A review of the telecommunication technologies in use in the vicinity of the proposed Liverpool Range Wind Farm identified the following:

- ▶ TV and radio broadcasting;
- ▶ Mobile phone services provided by telecommunication companies;
- ▶ Radio communication systems, including point to point microwave links, licensed by the Australian Communications and Media Authority (ACMA), and;
- ▶ Other radio links including mobile radio, CB radio.

The Australian Communications and Media Authority (ACMA) issue apparatus licences under the Radio communications Act 1992. The ACMA is the federal government authority responsible for regulation and management of the radio communications spectrum. It was formed in July 2005 by the merging of Australian Broadcasting Authority (ABA) and the Australian Communications Authority (ACA).

The ACMA authorises licensees to operate radio communications devices such as transmitters and receivers. In effect, they are licences to use specific segments of the radiofrequency spectrum for particular purposes. A system of apparatus licence types are used to apply common licence conditions and fee structures to categories of radio communications service.

Electromagnetic interference (EMI) has the potential to cause degradation or total loss of signal strength and may cause poor TV reception and/or “ghosting” effects. EMI may also result in a reduction in the coverage of mobile phone, radio, wireless internet and radio communications in certain instances. There are three principal mechanisms by which wind turbines may cause EMI: reflection, diffraction and near field effects.³

Reflection & scattering

When a signal sent between a transmitter and receiver becomes obstructed by an object located within the path of a signal, reflection and/or scattering may occur. If the rotating blade of a wind turbine receives a primary transmitted signal, a scattered time delayed (or out of phase) signal may be produced and transmitted to the receiver. The out of phase signal will be distorted in relation to the primary signal, causing EMI.⁴

Diffraction

In some instances when an object is located in the path of a signal wave front, the object can both reflect and absorb the signal. This phenomenon is commonly referred to as diffraction.⁵

Near field effects

Wind turbines may cause interference to radio signals due to the electromagnetic fields emitted by the generator and the switching components within the turbine nacelle. This is referred to as a near field effect.⁵ Due to advances in technology and compliance with the Electromagnetic Emission Standard, EN 61000-6-4 (AS/NZ 4251.2:1999) Emission standard for industrial environments, modern wind turbines will not cause active EMI due to near field effects.

3 D. F. Bacon, A Proposed Method for Establishing an Exclusion Zone around a Terrestrial Fixed Link outside of which a Wind Turbine will cause Negligible Degradation of the Radio Link, Radiocommunications Agency UK Report Ver 1.1, 28 Oct 2002

4 URS Woodlawn Wind Farm Environmental Impact Statement 2004

5 Ibid.

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The level of EMI produced by a wind turbine due to reflection or scattering, diffraction and near field effects is dependent on a number of factors, including placement of the wind turbine in relation to the signal path/s; the signal frequency; the characteristics & composition of the wind turbines rotor blades; the receiver characteristics; and the propagation characteristics of the radio wave in the local atmospheric conditions.⁵

While the site proposed for the development of the wind farm is a rural area, a number of communications links and broadcast networks are present in the surrounding region.

As with any large structure, there may be circumstances where wind turbines can cause disruption to the electromagnetic signals used in a variety of commonly used radar, navigation and telecommunications services.

ACMA Site license holders identified via the ACMA RADCOM database within a 25km radius of the wind farm were notified of the proposal in relation to potential impacts and asked to provide comments.

The following approach was adopted to identify the impact of the proposal on telecommunications:

- ▶ Identify radio license holders within a 25km radius of the proposed wind farm site, and point to point microwave radio links in the vicinity of the site, using information sourced from the ACMA RADCOM database⁶;
- ▶ Provide notification of the wind farm proposal and seek comments from each license holder identified via the ACMA RADCOM database within a 25km radius of the site;
- ▶ Record and review all responses received to identify any issues raised by license holders;
- ▶ Discuss any issues raised with relevant license holder with the aim to resolve or identify mitigation options;
- ▶ Carry out an assessment of the “Fresnel zone” associated with each fixed point to point microwave communications link crossing the site;
- ▶ Determine appropriate exclusion zones for proposed turbine layout based on Fresnel zone calculations and advice from relevant license holders;
- ▶ Confirm that all turbines (including blades) are located outside the calculated exclusion zone;
- ▶ Determine appropriate additional mitigation measures which may be required.

The possible impact of the proposed wind farm on the most common communications services has been investigated separately in the following sections. These services include television and radio broadcast services, mobile phone services and radio communication point to point services. Various measures are available to help mitigate potential impacts and are discussed below.

6 ACMA June 2012 data

3 Television and radio broadcast services

3.1 Existing services and facilities

The ACMA RADCOM database lists the following broadcasters for television and radio, under postcode 2843, Coolah, NSW.

Television broadcasting

- ▶ ABC30, ABC55, SBS52, CBN58, WIN61, CTC64, NBN33, NBN39, ABC42

Radio broadcasting

- ▶ 2TRR

The closest transmitter of television programs is at Queensborough, Coolah located about 5 kilometres North of Coolah.

Satellite provided services such as television and internet are also received at various locations throughout the area. These services may either be used where local services are not able to be received or may be accessed as additional program content to complement local services. They are not subject to the same topographic screening that can affect the land based TV transmissions. Due to the distance of residences from the wind farm it is very unlikely that satellite based television or internet services would be subject to interference due to the wind farm's operation.⁷

3.1 Interference and impact analysis

Television broadcasting

Television Interference (TVI) is dependent on a range of factors including environmental factors (topography, direct signal strength, transmitter type, receiver type etc) and wind farm design factors (turbine elevation, rotor size and orientation, speed of rotation, blade material and pitch).

TVI caused by the operation of wind turbines is characterised by analogue television video distortion, while the audio component of the signal is not affected.⁸ Due to the variability of local conditions and the characteristics of antennae used in particular installations, there is a degree of uncertainty regarding predicted levels of interference.

The level of TVI may be influenced by a number of factors including:

- ▶ Where the receiver is located relative to the TV transmitter and the wind farm;
- ▶ The frequency of the transmitted TV signal;
- ▶ Whether there are any other tall structures in the vicinity of the receiver;
- ▶ The direction of the rotor blades and blade material, and;
- ▶ The nature of the receiving aerial e.g. design, height, directionality, power.

7

ibid

8 David E Spera, Wind Turbine Technology, Chapter 9 ASME Press 1994

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In general, the potential for interference at receiver locations can increase with distance of the receiver from the transmitter, as signal strength decreases with increasing distance from the source. As such, a wind farm in an area of already poor signal strength may potentially have a greater impact on reception than the same wind farm in an area of relatively strong signal strength. In addition, reception in the vicinity of the wind farm can vary with the degree of topographic obstruction of the signal.

A wind turbine has the potential to scatter analogue television waves both forward and back. Forward scatter will only occur if a wind turbine is located approximately between the dwelling and the broadcast site. The forward scatter region is as shown in the figure below, and generally does not extend further than 5 km for the worst combination of factors. Interference may extend beyond 5 km if the dwellings are screened from the broadcast tower, but do have line of sight to the wind turbines. The effect of the forward scatter is to potentially cause the brightness of the television picture to vary with the rotation of each blade. Modern television sets usually incorporate Automatic Gain Compensators (AGC) which act to lessen or eliminate variations in picture gain or brightness.⁹

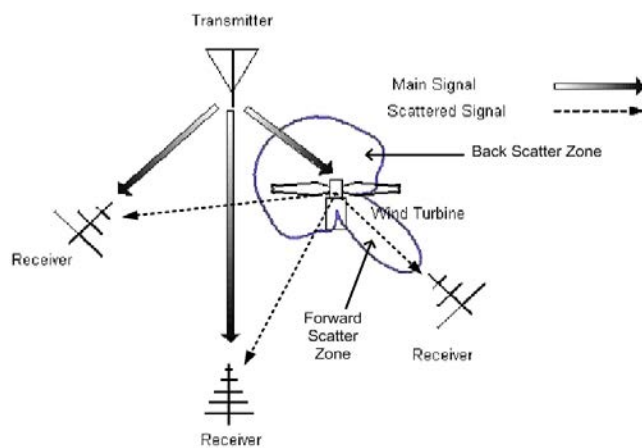


Figure 3-1 – Schematic Diagram of potential analogue television signal interference zones around a wind turbine (Courtesy of CanWEA Guidelines V8.0)

The zone of potential interference for a wind farm is the resultant total of the effects from the individual turbines. The International Telecommunications Union Recommendation ITU-R BT.805 states that impacts beyond 5 kilometres are unlikely.

It also indicates that interference may extend beyond 5km where the receiver location is shielded from the direct signal, but in direct line of sight to the turbine. The form of interference, if experienced, will depend on the relative positions of the wind farm, the transmitting station and the receiver.

Analogue television interference can take the form of either a “ghost” image that pulsates horizontally at the “blade pass” frequency or a fluctuation in picture brightness, also at the “blade pass” frequency.¹⁰

There are approximately 121 houses within 5km of the proposed wind farm site as shown in Figure 3-2.

9 <http://www.dungog.nsw.gov.au/files/2142/File/GreenpowerEMIAnalysisIssue.pdf>

10 Connell Wagner Delta Electricity Gunning Environmental Impact Statement 2004

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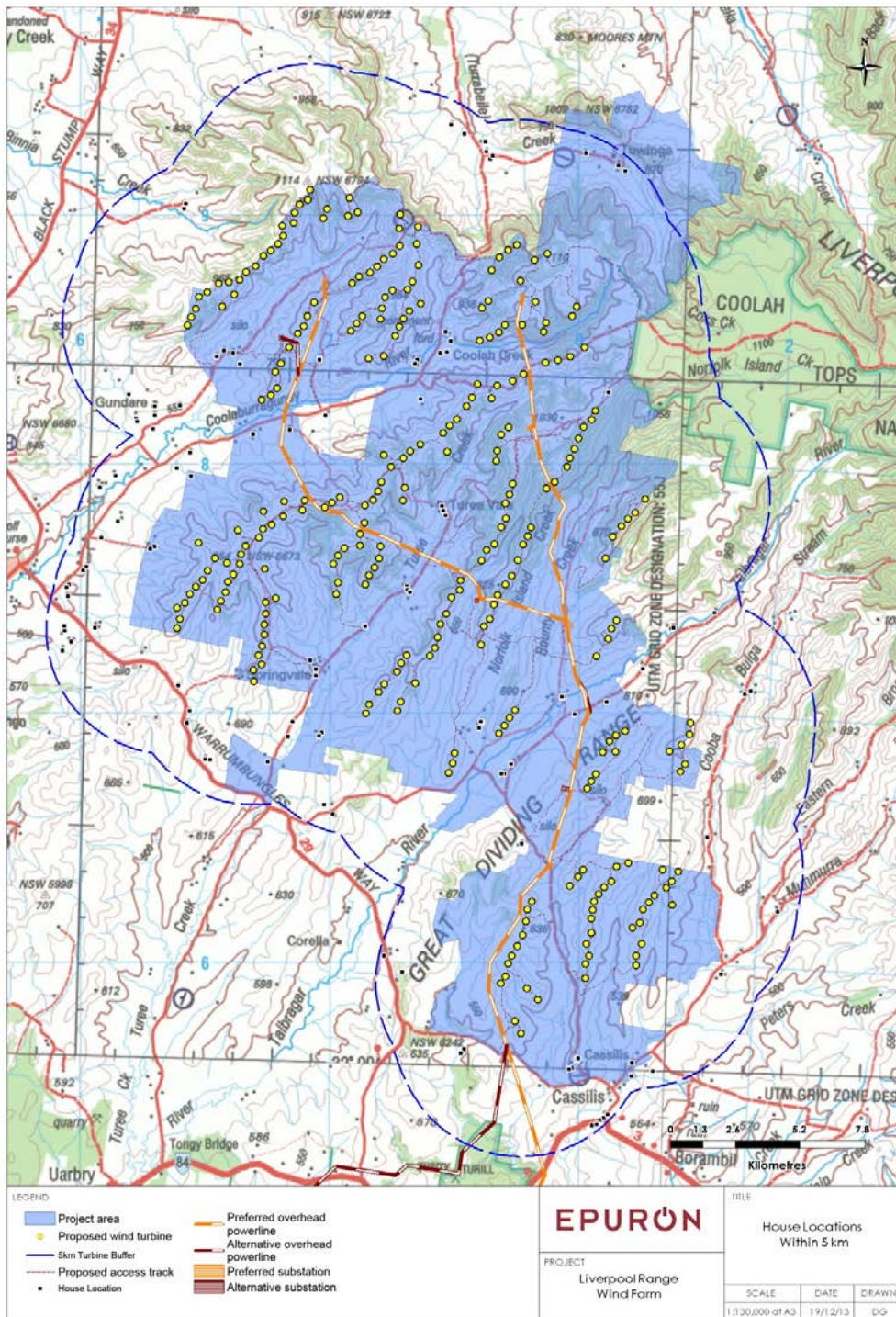


Figure 3-2 – Houses within 5km of the Liverpool Range Wind Farm

It is difficult to assess the likely impact on these specific house locations and once the wind farm is operational it is possible that analogue television reception could be affected at some of these locations

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unless some form of mitigation is introduced. However, houses further than 5km from the site are unlikely to be affected.

Analogue TV transmission is currently planned to be phased out by 2013 and replaced by digital. Digital TV is not susceptible to visible “ghosting” degradation. Any impact of reflections from the turbines would be a minor reduction of coverage at the limit of the service area.

Radio broadcasting

The level of radio broadcast interference experienced can be influenced by a variety of variables including:

- ▶ Abnormal weather conditions;
- ▶ Multi-path distortion (reception of a signal directly from a transmitter and also a reflected signal from hills, structures etc.);
- ▶ Overloading (occurs when an FM receiver receives too strong a signal);
- ▶ Electrical interference from household appliances etc;

Overseas and recent local experience indicates that radio reception and the audio component of television reception are unlikely to be affected by operating wind farms. In regard to the Blayney Wind Farm that was commissioned in 2000, testing of radio reception for Council and RFS signals in the area around the operational wind farm showed that radio reception was not affected at the locations tested. The locations tested included situations where the radio signal transmission path passed through the operating wind farm.¹¹

Satellite pay television

Some homes in the area may have satellite pay TV service antenna installations.

Unless a particular subscriber’s antenna reception direction and elevation is aligned with a turbine, no impacts on satellite provided TV reception are likely.¹²

3.2 Mitigation measures

In the design of the project, the proponent will carry out the following mitigation measures to help minimise TVI:

- ▶ Use of primarily non-metallic turbine blades;
- ▶ Use wherever practical of equipment complying with the Electromagnetic Emission Standard, AS/NZS 4251.2:1999;

Once the wind farm is operational, the proponent will offer to undertake a monitoring program of houses within 5km of the wind farm to determine any loss in television signal strength, if requested by the affected resident. In the event that TVI is experienced by existing receivers in the vicinity of the wind farm, the source and nature of the interference will be investigated by the proponent.

Should investigations determine that the cause of the interference is genuinely attributable to the presence of the Liverpool Range Wind Farm; the proponent will put in place mitigation measures at each of the affected receivers in consultation and agreement with the residents.

Notwithstanding the above, specific mitigation measures available are:

¹¹ Connell Wagner Glen Innes Wind Farm Environmental Assessment – Telecommunications interference October 2008

¹² Lawrence Derrick & Associates Bannister Wind Farm – Investigation of possible impacts on broadcasting and Radio communication Services September 2003

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- ▶ Modification to, or replacement of receiving antenna;
- ▶ Provision of a land line between the affected receiver and an antenna located in an area of favourable reception;
- ▶ Improvement of the existing antenna system, or;
- ▶ Installation of a digital set top box.

In the event that interference specifically attributable to the wind farm cannot be overcome by other means, negotiating an arrangement for the installation and maintenance of a satellite receiving antenna with the affected landowner may be considered.

4 Mobile phone services

4.1 Existing services and facilities

This section covers GSM services. High frequency point to point communications links used for mobile transmission networks are discussed in Section 5. Figures below show the existing local mobile phone coverage from the three providers at the time of writing.¹³

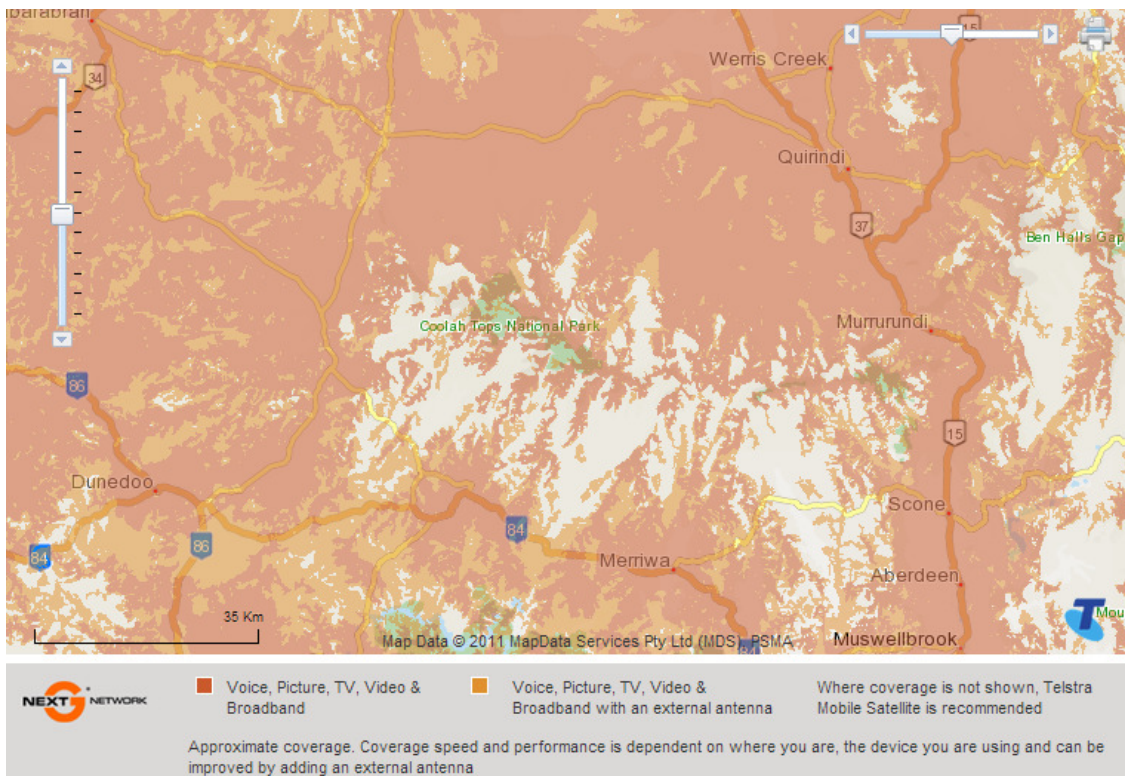


Figure 4-1 – Telstra 3G Network Coverage

¹³ Source: company websites

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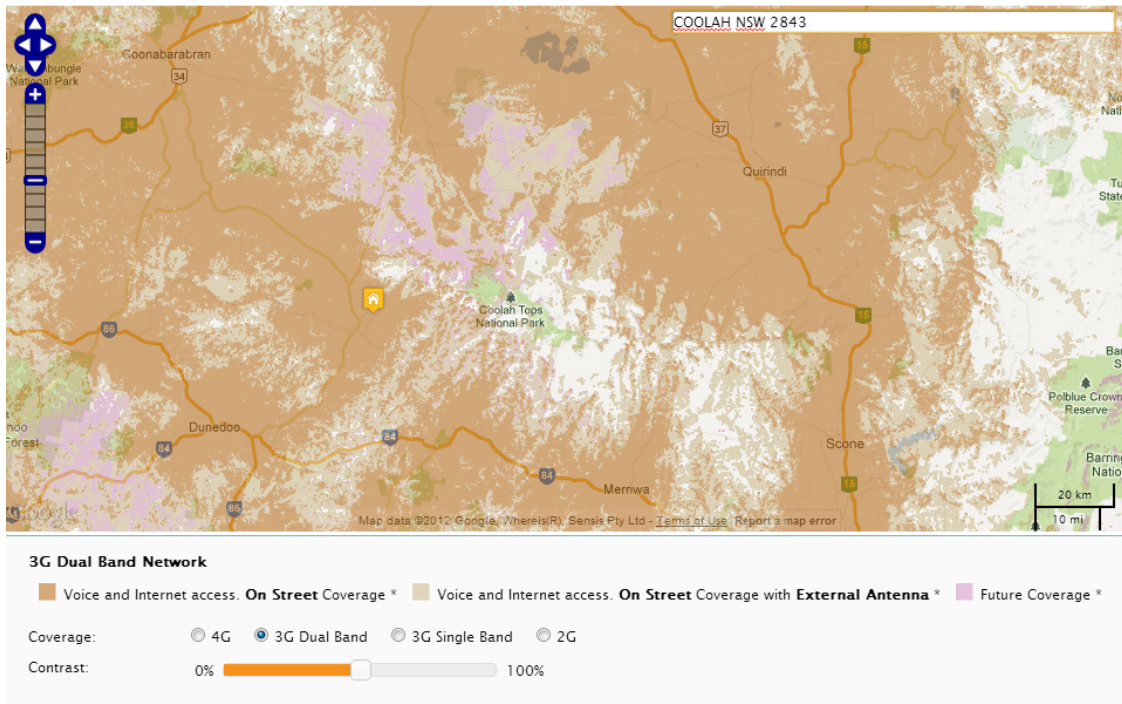


Figure 4-2 – Optus 3G Network Coverage

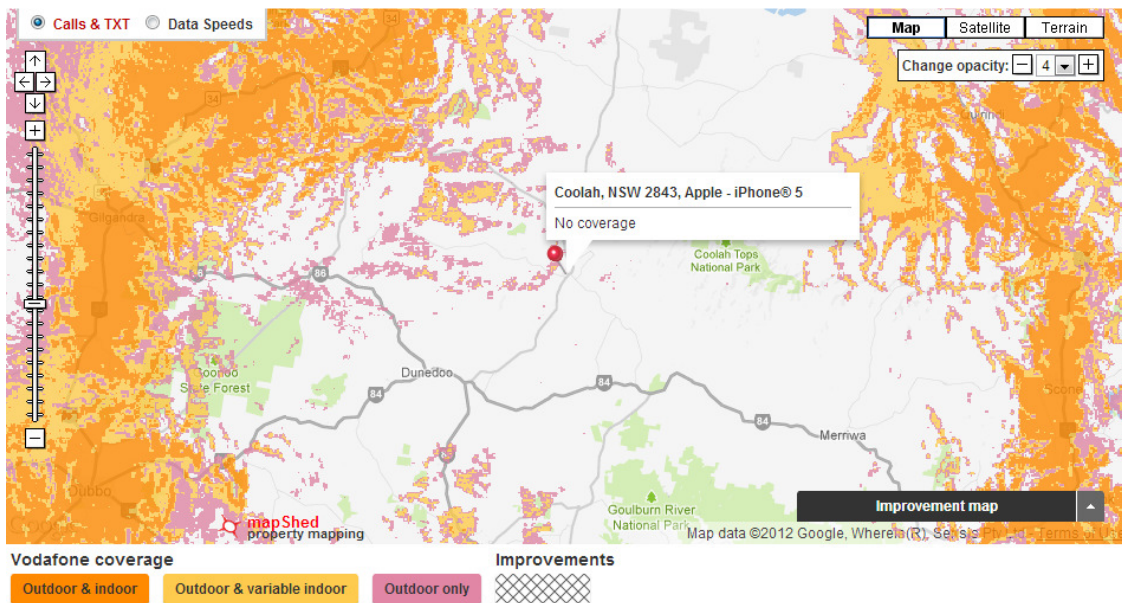


Figure 4-3 – Vodafone 3G Network Coverage

4.2 Interference and impact analysis

A mobile phone network consists of a system of adjoining zones called ‘cells’, which vary in size with a radius of 2 - 10 km. Each cell has its own base station that sends and receives radio signals throughout its

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specified zone. Mobile phone antennas need to be mounted clear of surrounding obstructions such as buildings to reduce 'dead spots' and allow the base station to effectively cover its intended cells.¹⁴

Mobile phone coverage is available in some of the area around Coolah and Cassilis but it is worse further away from these towns and the main highways and where topography limits coverage, especially in the vicinity of the wind farm to the north east.

Advice obtained from mobile phone service providers indicates that mobile phone services in these rural areas are mainly focussed on the main transport routes. In view of the separation distance between the base antennas and turbine structures and the wind farm location relative to areas of existing coverage, transmission of mobile phone signals may not be significantly affected by the operating wind farm.¹⁵

The ACMA RADCOM database identified three mobile phone companies as using base stations within the vicinity of the proposed wind farm. Telstra, Optus and Vodafone were contacted by EPURON regarding potential impacts and asked to provide feedback as to any potential conflicts with their existing networks. No objections were received.

4.3 Mitigation measures

No additional mitigation measures are required.

¹⁴ URS Crookwell II Wind Farm Environmental Impact Statement ,

¹⁵ ibid

5 Radio communication services

5.1 Existing services and facilities

The ACMA issues radio communications licenses in accordance with Part 3.5 of the Commonwealth Radiocommunications Act 1992. The ACMA issues licenses to use specific segments of the radio broadcasting frequency spectrum for different purposes and maintains a register (the ACMA RADCOM Database) of all the licenses issued.

The register allows the ACMA to create a 'density' classification of areas across Australia as high, medium or low depending on the number of licenses in operation in a particular area. According to the ACMA RADCOM database, the area in the vicinity of the proposed wind farm is classified as a "Low Density Area".

License holders operate a range of radio communications services, including fixed link microwave communication and mobile communication systems within a 25km radius of the proposed wind farm. Multiple license holders use some sites, while sole users employ others. Radio communications sites within a 25km radius are listed below.

Each license holder has been contacted and asked to provide independent comment on the wind farm development with respect to possible impacts to communication links. The Proponent will work with organisations to resolve issues, should any be identified.

Table 5-1 - Radio communication license holders within 25km of the Liverpool Range Wind Farm site

ACMA Licence Holder	ACMA Site ID No.
Ambulance Service of NSW	201640
Australian Broadcasting Corporation	6202, 11281
Australian Communications and Media Authority	137123
Coolah Community UHF Users Group	11282
Department of Finance and Services	11022, 11281, 11282, 54746, 201640
Electrostar Pty Limited	11282
Essential Energy	6202, 11283, 201640
Fire and Rescue NSW	11279
Hello Radio Pty Ltd	54514
Liverpool Plains Shire Council	201640
NBN Ltd	6202
NSW Police Force	6202, 11283, 201640
NSW Rural Fire Service	11282, 11283, 54746, 201640
NSW Volunteer Rescue Association Inc	6201, 11280
OFFICE OF ENVIRONMENT AND HERITAGE	54746
Optus Mobile Pty Limited	9012296, 9013052,9014793
Paspaley Pearls Properties Pty Ltd	11282

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ACMA Licence Holder	ACMA Site ID No.
Prime Television (Southern) Pty Limited	11281
Singtel Optus Pty Limited	201640, 9012296, 9013052
Soul Pattinson Telecommunications Pty Limited	11022
SPECIAL BROADCASTING SERVICE CORPORATION	11281
Talbragar Broadcasters Incorporated	48392
Telstra Corporation Limited	7011, 11022, 11284, 132138, 133163, 205756, 9012347
Warrumbungle Shire Council	11283, 137597
WIN Television NSW Pty Limited	11281

5.2 Interference and impact analysis

A fixed link microwave radio transmission is a point to point transmission path typically between two elevated topographical features. The transmission path may become compromised if a wind farm is located within the direct line of sight or what is known as the 'Fresnel Zone' around the line of sight between the sending and receiving antennae.

The potential impact zone will vary with the distance between the transmitter and receiver, frequency of transmission and the location of any particular point along its path. Communications are only likely to be affected if a wind farm is in the line of sight between two sending and receiving antennae or within a zone of the line of sight of these antennae.

Where a potential exists for interference to line of sight links, an obstruction analysis can be undertaken to ensure that no part of a wind turbine assembly will enter the Fresnel Zone of the microwave link. The maximum extent of the Fresnel zone occurs at the midpoint along the path of the microwave link.

If wind turbines are within 500m of omnidirectional or point to point broadcast towers, there exists the possibility of EMI from near field scattering effects.

5.3 Radio communication links

EPURON has identified and mapped all point to point radio communication links existing in the vicinity of the proposed Liverpool Range Wind Farm site. Table 2 lists the eight radio communication links that travel in close vicinity to the location of proposed wind turbines, and Table 5-3 lists radio communication towers within 500m of wind turbines. Figure 5-1 shows an aerial overview of the location of all fixed radio communication links in the vicinity of the Liverpool Range Wind Farm, the two radio communication towers referred to in Table 5-3 are found in the north-west.¹⁶

Table 5-2 – Point to point radio communication links in the vicinity of the Liverpool Range Wind Farm

LINK ID	CLIENT NO	LICENSEE	LICENSE NO	FREQUENCY (Hz)
255024	5832	NSW Rural Fire Service	1427518	460350000
255024	5832	NSW Rural Fire Service	1427518	450850000
257595	5832	NSW Rural Fire Service	1229825	460775000
257595	5832	NSW Rural Fire Service	1229825	451275000

¹⁶ Based on data contained in the ACMA RADCOM database, June 2012

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328352	1141565	Electrostar Pty Limited	1566428	414100000
328352	1141565	Electrostar Pty Limited	1566428	404650000
367069	5832	NSW Rural Fire Service	1204074	451125000
367069	5832	NSW Rural Fire Service	1204074	460625000

Table 5-3 - Radio communication towers within 500m of wind turbines

SITE ID	SITE NAME	EASTINGS (MGA 94)	NORTHINGS (MGA 94)	ZONE (MGA 94)	TURBINES WITHIN 500m
11,282	Prime Comms Site Adj Oakey Trig Station Turn off 9km North of COOLAH	769,000	6,491,150	55	2
48,392	Three Rivers Radio Mast Adj Oakey Trig Station MT OAKY	768,980	6,490,500	55	3

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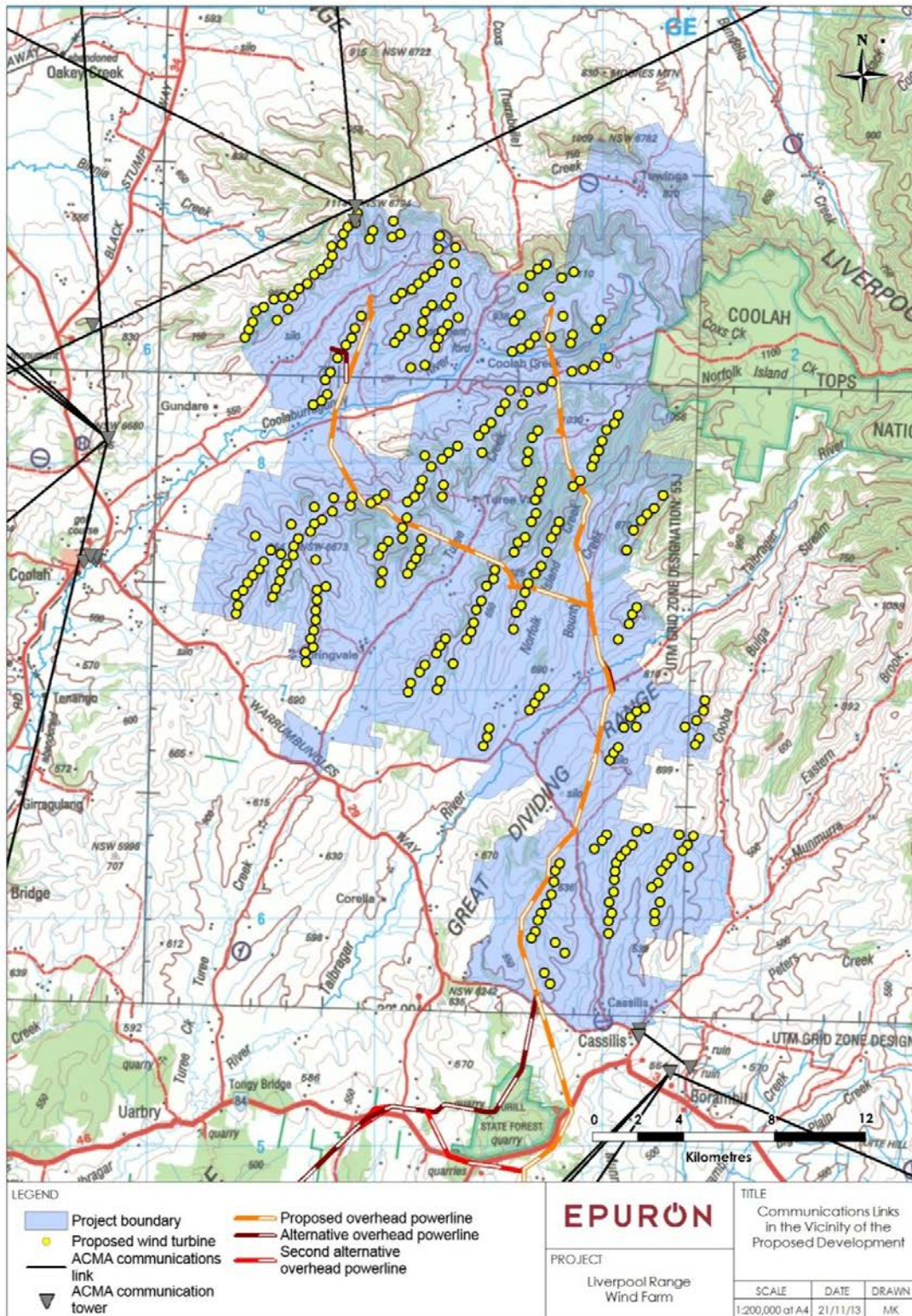


Figure 5-1 Point to point radio communication links in the vicinity of the Liverpool Range Wind Farm

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In order to ensure that obstruction to the signal transmission path does not occur, calculations of the 2nd order Fresnel zone of the point to point communications links in close vicinity to the wind turbines were undertaken.

It is suggested that beyond the 2nd Fresnel zone, the power of a scattered signal from a structure such as a wind turbine would be small enough such that it would not result in significant interference at the receiver.¹⁷

Completion of this Fresnel analysis showed that no turbines were to be located within the 2nd Fresnel zone, in the direct line of sight path of the point to point links. Despite this, there are wind turbines planned within 500m of one omnidirectional radio broadcast tower and one point to point radio communication tower.

Figure 5-2 below shows the proximity of the turbines to the two radio communication towers. Due to the proximity of the wind turbines to the broadcast towers, there is the possibility that near field scattering interference can occur. Epuron is currently in correspondence with the owners and operators of these two radio communication towers (Three Rivers Radio Talbragar) and will ensure that mitigation measures are implemented, at Epuron's expense, so that impact on existing services does not occur. Further qualified study may be required to determine the potential impact on these broadcast towers.

17 D. F. Bacon, A Proposed Method for Establishing an Exclusion Zone around a Terrestrial Fixed Link outside of which a Wind Turbine will cause Negligible Degradation of the Radio Link, Radiocommunications Agency UK Report Ver 1.1, 28 Oct 2002

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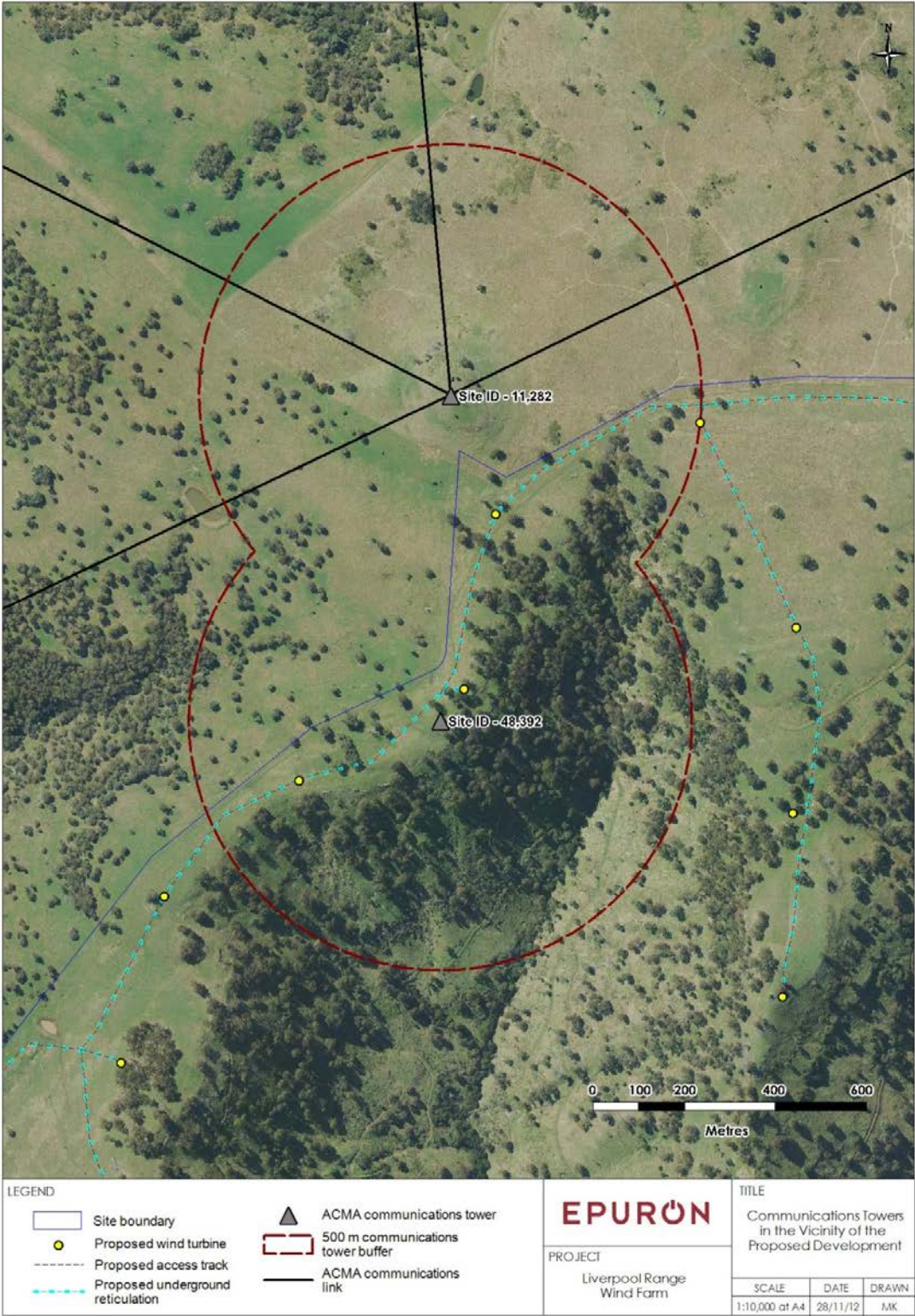


Figure 5-2 – Radio Communication Towers within 500m of wind turbines

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Therefore, based on:

- ▶ The results of the above literature research;
- ▶ Location of turbine layout avoids 2nd order Fresnel zones of all radio communication links, and;
- ▶ Discussion with owners and operators of radio communication towers within 25km of the project;

Interference to the existing point to point communication links from the Liverpool Range Wind Farm is not expected.

EPURON previously contacted all organisations identified as operating radio communication licences (including fixed link communications) within 25km of the Cullerin Range wind farm proposal, which is now operational and without communications issues in the area.

Each license holder was asked to provide independent comment on the wind farm development with respect to possible impacts to communication links. At that time, no organisation within the 25km radius raised concerns.

Optus, Vodafone and Telstra provided general guidelines to assist in the planning of wind farm.

In response to these enquiries, the following comments were noted,

"Provided wind turbines are located well outside the 2nd Fresnel zone of the point to point microwave links, no interference to communications is expected" (pers. comm. Mr. Trong Ho, Optus Mobile)¹⁸

"Clearance criteria is the same for all carriers. Please use the same criteria as proposed by Optus" (pers. comm. Mr. Ganesh Ganeswaran, Senior Engineer / Transmission, AAP Communications Services 22/11/05)¹⁹

"Provided wind turbines are greater than 100m away from Mobile tower (or in the case of directional panel antennae) not in direct line of sight for panel antennas, wind turbines will have minimal effect on existing coverage." (pers. comm. Mr. Ivan D'Amico, Area Team Manager (Country) - NSW&ACT, Telstra Services, Wireless Access Solutions, Mobile Coverage Delivery)¹⁹

The above suggestions have been considered in the planning of the Liverpool Range Wind Farm proposal.

5.4 Other radio communication

CB radio

CB radios are not individually licensed, the equipment being subject to class licensing only. Therefore, no records of location or operators of CB radios exist, and the channels are shared without any right of protection from interference. No impact from the wind farm is predicted except perhaps for very local effects to portable or mobile units in the immediate vicinity of the turbines which could be avoided by a small location change of the unit.¹⁹

Wireless broadband

From studies in other areas such as Mahinerangi, NZ²⁰ it is concluded that the minimum separation required between wind turbines and mobile broadband transmitters is approximately 240m. Turbines will be located outside this distance to avoid any impacts on mobile broadband services where possible.

18 Taurus Energy - Cullerin Range Wind Farm Environmental Assessment Report 2006

19 Ibid.

20 Mahinerangi Wind Farm Compatibility with radio services April 2007 - Kordia

5.5 Mitigation measures

As a result of the exclusion zones established in planning the wind farm, the possibility of impacts to existing point to point communication links is reduced. However, in the unlikely event that interference is predicted or observed, the proponent is confident that impacts will be able to be mitigated using the following techniques:

- ▶ Relocation or removal of wind turbine locations prior to construction;
- ▶ Modifications to or relocation of the existing antennae;
- ▶ Installation of a directional antennae to reroute the existing signal;
- ▶ Installation of an amplifier to boost the signal, and/or;
- ▶ Utilisation of onsite optical cable to reroute the original signal.

6 Electric and magnetic fields

6.1 What are electric and magnetic fields?

The existence of electric and magnetic fields (EMFs) has been recognised for decades, and their characteristics have been the subject of thousands of scientific studies around the world. Research conducted over the past 25 years has significantly enhanced our knowledge of EMFs.

Electric fields are produced every time a voltage exists across a conductor. The higher the voltage, the stronger the electric field. Electric fields are strongest closest to the conductor and their level reduces quickly with distance. Most materials act as a shield or barrier to electric fields. The level of electric fields is measured in thousands of volts per metre (kV/m).

Magnetic fields are produced by the flow of an electric current through a conductor. The higher the current, the greater the magnetic field. The strength of magnetic fields is measured in milliGauss (mG). Like electric fields, magnetic fields are highest closest to the conductor and their level reduces quickly with distance. Most materials will not act as a shield or barrier to magnetic fields.

6.2 When do electric and magnetic fields occur?

Electric and magnetic fields (EMFs) occur both naturally and from man-made sources and are not unique to high voltage power lines or wind farms. Natural EMFs are associated with such things as lightning, solar activity or the earth's magnetic field. All living organisms, including humans, have natural electric charges, currents, electric and magnetic fields.

Man-made EMFs occur whenever electricity is being used in any form of electrical equipment or wiring. Most people will be exposed to a wide variety of EMF sources throughout their daily lives. As electricity use is so widespread in modern society, questions about its possible effects on health are important to everyone.

Biological and occupational health research on EMFs began in the early 1960s. Since that time many national and international review panels, such as the World Health Organisation, the US National Institute of Environmental and Health Sciences and the UK National Radiological Protection Board have evaluated the research to assess the likelihood of health effects being associated with exposure to electric and magnetic fields. In Australia, the relevant health authority is the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), an arm of the Commonwealth Department of Health. In response to a recent report, the CEO of this agency said:

"It is also important not to fixate on the location of external power lines, including high voltage transmission lines, as the prime cause of exposure. Exposure to ELF magnetic fields can arise from ground currents, internal household wiring and the use of electrical appliances as much as from exposure to external powerlines."

Government Agencies such as ARPANSA have also monitored international research on the topic, concluding that,

"On balance, the scientific evidence does not indicate that exposure to EMF's found around the home, the office or near power lines is a hazard to human health"²¹

6.3 What are the electromagnetic field implications of wind farms?

There are four potential sources of EMF associated with wind farms. These are:

- ▶ The grid interconnection power line;
- ▶ The wind turbine generators;
- ▶ Any electrical transformers, and;
- ▶ The underground collector network cabling.

The interconnection with the existing grid is usually made above ground and is no different from any other power line used in the existing network. The EMF levels are comparable to typical household appliances which are known to be negligible. The electrical generator windings are close together and surrounded by conductive metal housing so the electromagnetic fields are effectively zero.

The switchyard transformer, which will carry the entire output of the wind farm, is generally located in the central part of the switchyard and the protective fencing means it is not possible for members of the public to come close enough to be exposed to significant EMF.

The collector network, which connects the various turbine generators of a wind farm operates at typical distribution voltages and is buried at least 750mm below ground level. Because of the closeness of the phase conductors within the cables and the screening of the cables, the electromagnetic fields are effectively zero.

The electromagnetic fields associated with generation and export of electricity from a wind farm does not pose a significant threat to public health. Consequently, no serious or adverse EMF or interference issues are anticipated from a wind farm.²²

6.4 Mitigation measures

No mitigation measures are required.

22 http://www.wind.appstate.edu/reports/BP10_EMC&EMF.pdf

7 Conclusion

As wind turbines do not impact on the 2nd order Fresnel zone, conflicts between point to point radio systems and the wind turbines are not expected. There are two radio communication towers within 500m of the wind turbines, and the owners and operators of these towers have been contacted and mitigation methods proposed. Also, mobile radio and other radio communication services in the area are not expected to be impacted by the wind farm or its operation.

Analogue TV transmission is currently planned to be phased out by 2013 and replaced by digital. Digital TV is not susceptible to visible "ghosting" degradation. Any impact of reflections from the turbines would be a minor reduction of coverage at the limit of the service area.

Interference to AM and FM sound broadcasting is not expected.

Overseas experience indicates that electrical interference from wind farm generators and controls is not a problem with established and reputable wind turbine manufacturers and therefore no electrical noise measurements are warranted.

8 Glossary and Acronyms

ABA	Australian Broadcasting Authority
ACMA	Australian Communications & Media Authority
CB Radio	Citizens Band Radio
CDMA	Code Division Multiple Access cellular mobile system
EMI	Electromagnetic Interference
FM	Frequency Modulation
Fresnel Clearance	Clearance to obstructions from the ray line on a radio path which does not produce any additional loss above free space loss
GSM	Global Systems Mobiles
ITU	International Telecommunications Union
LF	Low Frequency
MF	Medium Frequency
TVI	Television Interference
UHF	Ultra High Frequency (300MHz - 3GHz)
UHF Channels	TV Channels 28 - 69 (526 - 820 MHz)
VHF	Very High Frequency (30MHz - 300MHz)
VHF Channels	TV Channels 0 to 12 (45 - 230 MHz)



9 Turbine Co-ordinates

Table 9-1 - Wind Turbine Co-Ordinates

Turbine ID	Easting	Northing	AHD	Turbine ID	Easting	Northing	AHD
C3-1	764,267	6,485,655	858	D3-5	765,928	6,487,403	960
C3-2	764,424	6,485,998	880	D3-6	766,153	6,486,914	920
C3-3	764,606	6,486,331	902	D3-7	766,371	6,487,494	949
C3-4	764,734	6,486,809	940	D3-8	766,621	6,487,807	878
C5-1	764,362	6,474,877	870	D3-9	767,004	6,488,042	872
C5-2	764,716	6,476,944	850	D4-1	767,243	6,482,687	711
C5-3	764,609	6,475,171	850	D4-2	767,611	6,482,866	770
C6-4	763,962	6,473,880	825	D4-4	767,804	6,483,810	790
C6-5	763,851	6,473,510	816	D4-5	767,868	6,483,146	780
C6-6	763,858	6,474,324	842	D4-6	768,013	6,484,128	763
C6-7	764,167	6,474,538	846	D4-8	768,340	6,484,770	780
D2-1	768,529	6,489,772	1020	D5-1	764,872	6,475,454	850
D2-2	768,577	6,490,200	1040	D5-10	766,415	6,476,470	950
D2-3	768,774	6,490,528	1040	D5-11	766,603	6,476,812	913
D2-4	769,109	6,490,703	1060	D5-12	767,367	6,475,892	848
D2-5	769,193	6,491,105	1069	D5-13	767,143	6,477,146	869
D2-7	769,725	6,489,975	1036	D5-14	767,808	6,474,713	840
D2-8	769,873	6,490,338	1040	D5-15	767,303	6,477,485	878
D3-10	767,316	6,488,442	879	D5-16	767,320	6,478,205	866
D3-11	767,619	6,488,667	940	D5-17	768,108	6,477,995	890
D3-12	767,905	6,488,924	940	D5-18	767,644	6,477,650	879
D3-13	768,103	6,489,262	940	D5-19	768,151	6,478,599	883
D3-15	768,071	6,489,664	961	D5-2	765,079	6,475,815	851
D3-16	768,706	6,485,319	777	D5-21	768,879	6,478,264	880
D3-17	768,942	6,485,623	780	D5-22	768,975	6,478,651	888
D3-18	769,077	6,486,050	799	D5-23	769,784	6,478,362	889
D3-2	765,070	6,486,992	918	D5-3	765,379	6,476,318	914
D3-20	769,364	6,486,587	800	D5-4	765,798	6,474,962	891
D3-3	765,517	6,487,338	919	D5-5	765,881	6,475,371	890
D3-4	765,671	6,486,432	900	D5-6	766,101	6,475,679	930

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<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
D5-7	765,853	6,476,132	933
D5-8	766,284	6,477,441	870
D5-9	766,371	6,476,094	942
D6-1	765,620	6,474,610	840
D6-10	767,421	6,474,554	839
D6-11	765,461	6,474,258	788
D6-2	766,913	6,471,836	729
D6-3	766,934	6,471,367	728
D6-4	767,127	6,472,425	732
D6-5	767,243	6,472,045	731
D6-6	767,271	6,472,790	755
D6-7	767,361	6,473,248	770
D6-8	767,356	6,473,655	780
D6-9	767,419	6,474,100	781
E2-3	770,714	6,490,065	1049
E2-4	770,774	6,490,770	1059
E2-5	771,102	6,490,217	1032
E3-10	771,597	6,487,787	920
E3-11	771,893	6,488,024	980
E3-12	772,155	6,488,316	1000
E3-13	772,519	6,488,535	1000
E3-14	772,795	6,488,857	980
E3-15	772,771	6,489,554	1002
E3-16	773,462	6,488,920	980
E3-17	773,523	6,489,630	1040
E3-18	772,809	6,490,126	1003
E3-19	773,547	6,488,078	940
E3-20	773,313	6,487,417	978
E3-21	773,094	6,487,107	979
E3-22	772,491	6,487,064	972
E3-23	772,199	6,486,798	980
E3-24	772,073	6,486,348	960
E3-25	772,026	6,485,906	940
E3-26	773,631	6,486,533	960

<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
E3-27	773,174	6,486,241	960
E3-28	772,938	6,485,936	960
E3-29	772,768	6,485,595	898
E3-30	772,611	6,485,236	860
E3-4	770,832	6,485,440	815
E3-5	770,876	6,487,368	846
E3-6	771,061	6,485,729	880
E3-7	771,164	6,487,616	899
E3-8	771,289	6,486,039	860
E4-1	772,157	6,480,467	910
E4-10	774,793	6,481,632	902
E4-11	771,536	6,484,335	800
E4-12	772,157	6,484,436	840
E4-2	772,939	6,480,332	920
E4-3	773,216	6,480,602	924
E4-5	773,621	6,480,883	917
E4-7	774,529	6,481,346	910
E4-8	774,691	6,480,596	920
E5-1	770,127	6,476,095	863
E5-10	771,190	6,477,293	917
E5-11	771,379	6,477,732	889
E5-12	771,399	6,478,445	889
E5-13	771,407	6,475,263	805
E5-14	771,566	6,475,625	845
E5-15	771,718	6,478,669	888
E5-17	771,777	6,475,943	880
E5-18	771,935	6,479,013	898
E5-19	771,956	6,476,318	912
E5-2	770,076	6,478,547	890
E5-20	772,028	6,476,797	920
E5-21	772,056	6,479,383	897
E5-23	772,438	6,479,983	892
E5-24	772,999	6,479,156	880
E5-26	772,920	6,478,645	890

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<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
E5-3	770,307	6,475,342	799
E5-4	770,314	6,476,427	901
E5-6	770,565	6,476,714	910
E5-7	770,391	6,478,774	900
E5-8	771,190	6,476,835	916
E6-1	771,426	6,470,084	727
E6-10	772,837	6,472,109	780
E6-11	772,835	6,470,561	750
E6-13	773,075	6,472,419	780
E6-14	773,408	6,471,305	779
E6-17	773,994	6,472,394	780
E6-18	774,197	6,472,718	770
E6-2	771,559	6,470,459	734
E6-20	774,309	6,473,134	780
E6-21	774,422	6,473,676	780
E6-22	774,655	6,474,088	789
E6-24	774,874	6,474,745	810
E6-25	770,232	6,474,872	770
E6-4	771,949	6,470,953	760
E6-5	772,167	6,471,265	770
E6-7	772,707	6,470,195	732
E6-9	772,689	6,471,761	793
E7-6	774,748	6,467,705	660
E7-7	774,913	6,468,081	660
E7-8	774,999	6,468,488	649
F3-10	776,773	6,485,385	960
F3-11	777,019	6,485,678	980
F3-12	777,148	6,488,678	1004
F3-14	777,496	6,488,887	1037
F3-18	777,646	6,487,456	1040
F3-19	777,710	6,485,668	1004
F3-24	778,247	6,486,603	1080
F3-25	778,198	6,488,290	1048
F3-27	778,566	6,485,399	1019

<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
F3-28	778,673	6,485,773	1024
F3-29	778,726	6,488,547	1072
F3-3	776,102	6,486,364	920
F3-35	779,706	6,486,038	1020
F3-37	779,894	6,486,420	1080
F3-4	776,009	6,485,046	860
F3-5	776,352	6,486,655	902
F3-6	776,415	6,485,184	880
F3-7	776,484	6,487,872	920
F3-8	776,788	6,488,401	964
F4-10	777,151	6,481,564	928
F4-12	776,663	6,480,221	896
F4-14	777,770	6,483,715	920
F4-2	775,083	6,481,896	906
F4-22	779,135	6,484,253	940
F4-24	779,511	6,479,984	950
F4-25	779,625	6,480,335	950
F4-26	779,634	6,484,412	1000
F4-28	779,809	6,480,692	946
F4-29	779,960	6,481,127	979
F4-3	775,463	6,482,426	910
F4-31	778,650	6,484,175	911
F4-33	775,913	6,483,306	905
F4-34	776,709	6,483,257	930
F4-4	775,685	6,482,767	900
F4-5	776,474	6,482,738	920
F4-7	776,704	6,480,627	930
F4-8	776,875	6,481,267	930
F4-9	777,331	6,483,435	939
F5-1	775,203	6,475,050	770
F5-10	776,862	6,477,556	908
F5-14	777,048	6,477,913	920
F5-15	777,023	6,475,273	830
F5-16	777,032	6,478,516	920

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<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
F5-17	777,294	6,475,612	820
F5-18	777,199	6,478,879	920
F5-19	777,534	6,476,242	830
F5-2	775,234	6,475,426	780
F5-20	777,322	6,479,313	909
F5-24	777,743	6,476,858	890
F5-25	777,922	6,477,194	871
F5-26	778,065	6,477,548	847
F5-27	778,687	6,479,123	905
F5-29	779,012	6,479,376	917
F5-7	776,086	6,476,221	830
F5-8	776,274	6,476,641	867
F5-9	776,583	6,476,889	844
F6-10	776,175	6,473,575	780
F6-11	776,408	6,473,879	780
F6-12	776,572	6,474,450	810
F6-13	776,727	6,474,836	820
F6-14	777,417	6,470,211	666
F6-7	776,059	6,472,837	760
F7-1	776,773	6,469,273	642
F7-2	776,986	6,469,585	670
F7-3	777,188	6,469,907	670
F8-1	777,133	6,460,050	650
F8-10	779,953	6,463,534	640
F8-2	777,290	6,460,358	649
F8-3	777,514	6,460,741	640
F8-4	777,725	6,461,179	630
F8-6	777,849	6,461,730	627
F8-7	777,904	6,462,206	630
F8-8	778,103	6,462,544	620
F8-9	779,629	6,463,172	640
F9-1	776,846	6,459,250	628
F9-2	777,031	6,459,541	640
F9-3	777,425	6,457,733	610

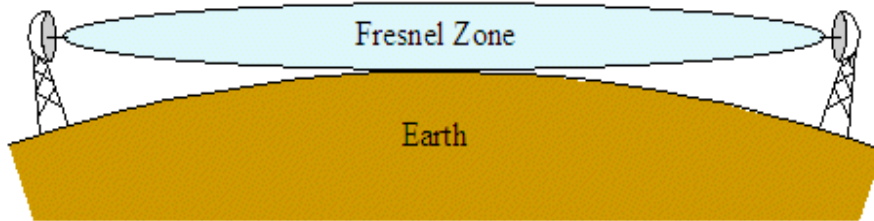
<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
F9-4	777,662	6,457,241	600
F9-5	777,890	6,459,054	640
F9-6	778,329	6,458,606	640
G4-2	780,169	6,481,590	1007
G4-3	780,212	6,484,775	1000
G4-4	780,494	6,481,880	1009
G4-5	780,657	6,482,236	1010
G5-10	782,252	6,478,146	880
G5-12	782,644	6,478,708	880
G5-4	781,047	6,476,314	780
G5-6	781,337	6,477,178	870
G5-8	781,690	6,477,602	864
G5-9	781,943	6,477,891	880
G6-3	780,682	6,472,379	735
G6-4	781,163	6,473,079	840
G6-6	781,283	6,473,492	850
G6-7	781,492	6,473,813	858
G7-1	780,312	6,467,072	740
G7-10	783,615	6,468,558	770
G7-11	784,103	6,468,825	780
G7-12	784,240	6,468,049	730
G7-14	784,066	6,467,762	711
G7-15	784,426	6,469,246	763
G7-16	784,471	6,469,700	772
G7-2	780,477	6,467,375	740
G7-3	780,675	6,467,650	740
G7-4	780,934	6,468,523	757
G7-6	781,209	6,468,977	767
G7-7	781,448	6,468,539	761
G7-8	781,481	6,469,214	780
G7-9	781,848	6,469,371	761
G8-1	780,148	6,463,809	636
G8-10	780,769	6,462,832	646
G8-11	781,000	6,463,107	659

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<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
G8-12	781,295	6,463,343	660
G8-14	781,493	6,463,939	671
G8-15	781,972	6,464,084	679
G8-16	782,137	6,461,473	640
G8-17	782,273	6,459,982	582
G8-18	782,275	6,460,354	590
G8-19	782,430	6,461,682	650
G8-2	780,277	6,460,830	638
G8-20	782,552	6,462,222	650
G8-21	782,790	6,462,499	651
G8-22	783,015	6,462,789	652
G8-23	783,485	6,463,093	661

<i>Turbine ID</i>	<i>Easting</i>	<i>Northing</i>	<i>AHD</i>
G8-24	783,709	6,463,358	669
G8-25	783,351	6,463,802	661
G8-26	783,736	6,462,401	650
G8-27	783,974	6,463,734	661
G8-3	780,383	6,460,362	630
G8-4	780,486	6,461,281	640
G8-5	780,490	6,461,838	634
G8-6	780,584	6,462,549	641
G8-7	780,542	6,462,189	640
G8-9	782,495	6,460,832	570
G9-28	780,253	6,460,030	603
G9-29	780,247	6,459,465	610

10 Fresnel zone calculation



The equation for calculating the Fresnel zone radius for a radio communications link is shown below:

$$F_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}}$$

Where:

- ▶ F_n = The nth Fresnel Zone radius in metres
- ▶ d_1 = The distance from one end in metres
- ▶ d_2 = The distance from the other end in metres
- ▶ λ = The wavelength of the transmitted signal in metres

Using this equation, the 2nd order Fresnel zone was determined for each link that is in the vicinity of the Liverpool Range Wind Farm site perimeter. Table 10-1 below shows the summary of the calculations performed for each radio-communication link. The Fresnel zones were then mapped to ensure that no part of the wind turbines or blades would enter the Fresnel exclusion zones.

Table 10-1 - Fresnel Zone Calculations

Link ID	Frequency (MHz)	Licensee	License_No	Length (m)	Midpoint (m)	Max Fresnel Radius (m)
255024	460.35	NSW Rural Fire Service	1427518	36150.93	18075	N/A ²³
255024	450.85	NSW Rural Fire Service	1427518	36150.93	18075	109.67
257595	460.775	NSW Rural Fire Service	1229825	85706.48	42853	N/A ²³
257595	451.275	NSW Rural Fire Service	1229825	85706.48	42853	168.78
328352	414.1	Electrostar Pty Limited	1566428	491264.60	245632	N/A ²³

²³ Obsolete due to same Link ID with lower frequency already analysed. The lower frequency link will have a larger Fresnel radius and is therefore used. This often occurs due to the 'in-going' and 'out-going' nature of radio point to point communications.

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328352	404.65	Electrostar Pty Limited	1566428	491264.60	245632	426.74
367069	451.125	NSW Rural Fire Service	1204074	66488.31	33244	148.68
367069	460.625	NSW Rural Fire Service	1204074	66488.31	33244	N/A ²³

11 Correspondence

License holders identified via the ACMA RADCOM database within a 25 km radius of the wind farm were notified of the project in relation to potential impacts and asked to provide comments. Table 11-1 summarises the organisations that were consulted and their comments received. Their responses are then provided in full.

Table 11-1 Consultation with license holders

<i>Organisation</i>	<i>Response</i>	<i>Comment</i>
Aerial Agricultural Association of Australia	No Response	
Ambulance Service of NSW	No Response	
Australian Broadcasting Corporation	No Response	
Australian Communications and Media Authority	No Response	
Civil Aviation Safety Authority	No Response	
Coolah Community UHF Users Group	No Response	
Department of Defence	No Response	
Department of Finance and Services	No Response	
Electrostar Pty Limited	No Response	
Essential Energy	No Response	
Fire and Rescue NSW	No Response	
Hello Radio Pty Ltd	No Response	
Liverpool Plains Shire Council	No Response	
NBN Ltd	No Response	
NSW Police Force	No Concern	
NSW Rural Fire Service	No Response	
NSW Volunteer Rescue Association Inc	No Response	
OFFICE OF ENVIRONMENT AND HERITAGE	No Response	
Optus Mobile Pty Limited	No Response	
Paspaley Pearls Properties Pty	No Response	

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Ltd		
Prime Television (Southern) Pty Limited	No Response	
Singtel Optus Pty Limited	No Response	
Soul Pattinson Telecommunications Pty Limited	More Information Requested	More Information supplied
SPECIAL BROADCASTING SERVICE CORPORATION	No Response	
Talbragar Broadcasters Incorporated	Concerns Raised	More Information supplied. Further study requested prior to construction.
Telstra Corporation Limited	No Response	
Warrumbungle Shire Council	No Response	
WIN Television NSW Pty Limited	No Response	

NSW Police Force:

Hi All,

Please find below information from Daniel Gilbert from Epuron regarding a proposed wind farm at Coolah.

This proposed Wind Farm in the vicinity of the NSWPF Radio Site at Cassilis (ACMA 6202)

If Newcastle WNS has any feedback or concerns re the proposed Wind Farm then please advise WT Directly.

The proposed site does not seem to be in the direct path of any existing NSWPF RF Links

Regards
David Towells

Talbragar Broadcasters Inc

Hello Daniel

I contacted two people one Mal Penman at Coonabarabran who is on 6842 3025 and Gorden Smith I told them no payment is offered but can they see any difficulties Mal wanted to know heights of us and towers etc . I could not give him them.

Gorden came back with the attached.

Hope this can help.

If you need to contact me do not hesitate.

Regards

Ken Westerman
Three Rivers Radio
Coolah Dunedoo

EPURON

Dear Daniel

This shows where our transmitter & RFS and also Channel 6 UHF CB repeater are located and show the closest proposed Wind Turbines.

This site is No 1 for complete coverage, and as you suggested Epuron may go there...

I will phone you later today...

... Regards

Ken Westerman

Talbragar Broadcasters Incorporated

20 December 2012

Three Rivers FM 95.3 & 96.1

Epuron Pty Ltd
Level 11, 75 Miller Street
NORTH SYDNEY NSW 2060

Reference: Liverpool Range Wind Farm (Mt Oakey Talbragar Broadcasters)

Attention: Daniel Gilbert

Dear Daniel,

ACMA Grid references of our site on Mt Oakey are incorrect we are on the highest hill in this area.

Would you please forward us a copy of your Electromagnetic Interference Assessment Investigation of Possible Impacts on Broadcasting & Radio Services for this Wind Farm if it has been completed.

With incorrect ACMA information and our feed to this transmitter via off air pickup from Dunedoo, which is weak, will be a difficult problem to resolve.

Would it be possible to arrange a meeting with us and possibly the two other organizations with radio equipment that share this site.



Ken Westerman
Technical Officer.

ABN 63 151 690 638

Three Rivers FM 95.3 & 96.1

Phone Dunedoo 6375 1015 Coolah 6377 1654 - Fax 6375 1086
PO Box 1000 Dunedoo NSW 2844
Email talbrag@bigpond.net.au

EPURON

Reference: Liverpool Range Wind Farm (Mt Oakey Talbrager Broadcasters)

Dear Ken,

Thank you for your letter dated 20th of December 2012 in regards to the Liverpool Range Wind Farm. I have attached a copy of the Telecommunications Impact Assessment which was completed and submitted with the Environmental Assessment for the Liverpool Range Wind Farm in 2012.

This assessment was completed using data from the Australian Communications and Media Authority (ACMA) database and incorrect data from ACMA could affect the accuracy of the study. Due to the complexity of the telecommunications at this northern end of the Liverpool Range Wind Farm, a specialist may be required to ensure no disruption to the existing radio communication network.

Epuron would be happy to meet with Talbragar Broadcasters and other related parties in regards to the matter.

Sincerely,

Daniel Gilbert
Epuron Pty Ltd
(02) 8456 7408
d.gilbert@epuron.com.au