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STOCKYARD HILL WIND FARM

EMI Assessment

Stockyard Hill Wind Farm Pty Ltd

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EXECUTIVE SUMMARY

Stockyard Hill Wind Farm Pty Ltd ("SHWFPL") (a subsidiary of Origin Energy) is developing a wind farm project in southwest Victoria, known as the Stockyard Hill Wind Farm ("SHWF").

Planning Permit No. PL-SP/05/0548 (Pyrenees Planning Scheme) ("the Permit") was issued by the Minister for Planning in October 2010 to enable the use and development of the SHWF Wind Energy Facility ("WEF").

SHWFPL has now decided to progress the preparation of an application to amend the Permit to seek approval for taller turbines to achieve more efficient generation of energy. Additionally, as a result of the proposed taller turbines and to ensure the Permit reflects current standards, guidelines, and departments, there are a number of other amendments proposed as part of the application.

Garrad Hassan Pacific Pty Ltd, now trading as DNV GL, has been commissioned by SWHFPL to independently assess the potential electromagnetic interference (EMI) issues associated with the development and operation of the proposed SHWF WEF with the purpose to accompany an application to amend the Permit.

This report summarises the results of an EMI assessment conducted for the site, including the overall impact of the proposed amended WEF and the resulting change in potential impact from the permitted WEF.

Regulatory Requirements

This document assesses the potential risks regarding interference with radiocommunication services operating in the vicinity of the SHWF WEF in accordance with the Victorian Planning Guidelines [1] and EPHC Draft National Wind Farm Development Guidelines [2]. In relation to EMI, these 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.

Approach

SHWFPL has asked DNV GL to assess the potential EMI impacts based upon two layouts provided for the SHWF WEF: a 'permitted' layout consisting of 157 wind turbines as outlined in Table 4 and Figure 1, and an 'amended' layout consisting of 149 wind turbines with a larger turbine type as outlined in Table 5 and also shown in Figure 1.

A hypothetical turbine with a rotor diameter of 104 m and tip height of 132 m has been considered for the permitted WEF, while a turbine with a rotor diameter of 140 m and tip height of 180 m has been considered for the amended WEF. These dimensions represent the maximum overall tip height within the maximum blade/rotor and tower hub height dimensions. There are 236 dwellings that have been identified in the vicinity of the SHWF WEF, as outlined in Table 6, 37 of which are participant dwellings as defined in Section 2.1.

Information relating to telecommunication licences in the vicinity of the SHWF WEF has been obtained from the Australian Communications and Media Authority (ACMA) [3], with other relevant information obtained from publically-available sources as required. Services considered include

fixed point-to-point links, fixed point-to-multipoint links, emergency services radiocommunications, meteorological radars, trigonometrical stations, Citizen's Band radio and mobile phones, wireless internet, satellite television and internet, and broadcast radio and television.

The assessment methodology employed throughout this study has been informed by the methodology outlined in the relevant planning guidelines and various standard industry practices. For point-to-point microwave links, typically used for line-of-sight transmissions between two sites, an exclusion zone has been established around each signal path based on the operating frequency, distance along the link, and turbine blade length. Turbines located within the calculated exclusion zone have the potential to interfere with that signal. Similarly, turbines that intersect the line-of-sight for satellite television and internet signals at dwellings in the vicinity of the WEF may interfere with those services. For terrestrial television broadcasts, dwellings that have increased potential to experience interference to broadcast signals have been identified based on the regions around each turbine in which forward scattering and back scattering of signals is likely to occur.

In many cases, however, assessment of the potential EMI impacts on radiocommunication services requires additional information from the service operators. DNV GL has contacted the operators of services in the vicinity of the SHWF WEF to inform them of the proposed amendment to the WEF and seek feedback regarding the potential for interference to their operations and services.

Assessment Findings

The results of this assessment, including the expected EMI impacts for the permitted and amended SHWF WEF, the anticipated change in impact, and feedback obtained from stakeholders, are summarised in the following table.

Turbines at the WEF are located within the calculated exclusion zones for several fixed point-to-point links passing over the WEF boundaries, and therefore have the potential to cause interference to those links. Interference is also possible for satellite television and internet signals, but the signals that are likely to be intercepted by turbines in both the permitted and amended WEF are from satellites that either do not provide internet to customers in Australia or do not provide television services designed for Australian audiences.

Although base to mobile station style communications such as television and radio broadcasting and commercial and private mobile telephony services are generally unlikely to be affected by WEFs, interference may be experienced in areas of poor or marginal reception. If interference to television and radio reception is increased as a result of the SHWF WEF, a range of options are available to rectify difficulties as required by Condition 38 of the Permit which states that "the wind facility operator must undertake measures to mitigate the interference and return the affected reception to pre-construction quality" if a post-construction survey of signal strength finds any increase in interference to television or radio reception caused by the WEF.

Summary of EMI assessment results for the proposed SHWF WEF

Licence or Service Type	Assessment Findings		Anticipated Change in Impact	Stakeholder Feedback (to date)
	Permitted WEF	Amended WEF		
Fixed point-to-point links	Four links crossing WEF boundary:			
	St John Ambulance Australia			
	Turbines T63, T65, T67 in exclusion zone; link crosses above turbines	Turbines M2, M3, M4 in exclusion zone; link crosses at turbine level	Increased potential for interference	Potential for interference if turbines are within 200 m of link path
	Optus Mobile #1			
	Turbine T37 in exclusion zone; link crosses at level of turbines	No turbines in exclusion zone	Decreased potential for interference	Minimal impact (amended WEF)
	Optus Mobile #2; Aussie Broadband			
	No turbines in exclusion zones	No turbines in exclusion zones	None	No concerns raised
Fixed point-to-multipoint links	Six base stations within 20 km of WEF boundary: Aussie Broadband (one site) Central Highlands Water (three sites) Powercor Australia (two sites)		None	No concerns raised
Emergency services	Point-to-point links: one St John Ambulance Australia link crossing boundary (see above) Mobile telephony systems: unlikely to be affected		None	No concerns raised
Meteorological radar	Unlikely to be affected		See stakeholder feedback	No concerns raised
Trigonometrical stations	Unlikely to be affected		None	No concerns raised
Citizen's Band radio	Unlikely to be affected		None	-
Mobile phones	Unlikely to be affected, may experience interference in areas with marginal coverage		See stakeholder feedback	No concerns raised
Wireless internet	Available services: Aussie Broadband, Telstra, NBN		See stakeholder feedback	No concerns raised
Satellite television and internet	No signals intercepted	Signals from five satellites intercepted at dwellings B145 and B148	Increased potential for impact at two dwellings	-
Radio broadcasting	AM signals: unlikely to be affected FM signals: may experience interference in close proximity to turbines.		None	-
Television broadcasting	May experience interference in areas with poor or marginal reception		Increased potential for impact due to increased turbine dimensions	
	Ballarat tower: 'good' coverage across site			
	72 dwellings in potential interference zone	75 dwellings in potential interference zone	Increased number of dwellings	-
	Bendigo tower: 'variable' coverage in northeast			
	67 dwellings in potential interference zone	65 dwellings in potential interference zone	Decreased number of dwellings	-

Conclusions

This EMI assessment has found that the SHWF WEF has the potential to impact on a number of radiocommunication services in vicinity of the WEF. Specifically, the turbines at the SHWF WEF may interfere with digital television broadcast signals received from the Ballarat and Bendigo broadcast towers at houses surrounding the WEF, particularly in areas where the residents currently experience poor or marginal reception. Interference with fixed point-to-point links passing over the proposed SHWF WEF boundaries is also possible.

While the SHWF WEF may cause interference to fixed point-to-multipoint links, emergency services, and wireless internet services in the vicinity of the WEF, it is not possible to determine the likely impacts without obtaining further information from the operators of those services. DNV GL has consulted with all organisations operating services that may be affected by the development and operation of the SHWF WEF to seek feedback regarding any potential EMI-related impact the WEF could have on their operations and services. To date, no concerns have been raised.

This assessment also found that the amended WEF is expected to result in a similar overall level of interference to fixed point-to-point links passing over the WEF boundary compared to the permitted WEF. However, the impacts of the amended WEF are likely to be different to those for the permitted WEF for terrestrial television broadcast services and satellite television and internet signals. For other services considered in this assessment, either impacts are considered to be minor or impact changes have been assessed through consultation with the service operators.

1 INTRODUCTION

1.1 Project Background

Stockyard Hill Wind Farm Pty Ltd ("SHWFPL") (a subsidiary of Origin Energy) is developing a wind farm project in south-west Victoria, known as the Stockyard Hill Wind Farm (SHWF).

The project has three components – a wind energy facility ("WEF"), a grid connection (approximately 75 km of overhead power lines and a terminal station), and a quarry. This document relates to the WEF component of the project.

Planning Permit No. PL-SP/05/0548 (Pyrenees Planning Scheme) ("the Permit") was issued by the Minister for Planning on 26 October 2010 to enable the use and development of the SHWF WEF.

SHWFPL has now decided to progress the preparation of an application to amend the Permit under Section 97I of the *Planning and Environment Act 1987*.

The primary driver for the amendment application is to seek approval for taller turbines to achieve more efficient generation of energy.

The application to amend the Permit must consider the anticipated difference in environmental, social, and economic impact (whether an increase or decrease from the permitted project) as a result of the proposed amendments.

1.2 Purpose of Document

This document was prepared with the purpose to accompany an application to amend the Permit, including the assessment of the potential electromagnetic interference (EMI) issues associated with the development and operation of the proposed SHWF WEF.

SHWFPL has commissioned Garrad Hassan Pacific Pty Ltd, now trading as DNV GL ("DNV GL"), to carry out an independent assessment of EMI related impacts associated with the proposed SHWF WEF. This document provides an assessment of the overall impact of the proposed amended WEF, whilst also describing the resulting change in potential impact from the permitted WEF where applicable.

In accordance with the Policy and planning guidelines for development of wind energy facilities in Victoria (Victorian Guidelines), published by the Victorian Department of Planning, Transport, and Local Infrastructure in January 2016 [1] and the National Wind Farm Development Guidelines – Public Consultation Draft" (Draft National Guidelines) published by the Environmental Protection and Heritage Council (EPHC) in July 2010 [2], this assessment investigates the impact of the SHWF WEF on:

- Fixed point-to-point links,
- Fixed point-to-multipoint links,
- Radiocommunications assets belonging to emergency services,
- Meteorological radars,
- Trigonometrical stations,
- Citizen's Band (CB) radio and mobile phones,

- Wireless internet,
- Satellite television and internet, and
- Broadcast radio and television.

2 THE PROJECT

2.1 WEF Site

The WEF site is located in the Pyrenees Shire, approximately 150 km west northwest of Melbourne and approximately 35 km west of Ballarat. The closest townships to the WEF site include Beaufort (approximately 4.5 km north of the site) and Skipton (approximately 4 km south of the site).

The site comprises approximately 155.3 km^2 (approximately 45.8 km^2 less than the permitted project) and is generally bound by Eurambeen-Streatham Road and Beaufort-Carranballac Road to the west, Stockyard Hill Road and Mt Emu Settlement Road in the south, Mount Emu Creek in the east and Ballrogan Road, Long Gully Road, and Dalgleishs Road in the north. Skipton Road bisects the subject site.

There are 236 dwellings that have been identified in the vicinity of the SHWF WEF. The coordinates of these dwellings are presented in Table 6, and the dwellings and site boundaries considered in this assessment are shown in Figure 1[1]. Any dwelling located on land listed in the Address of Land in the Permit, or where the landowner has a written agreement with SHWFPL relating to their land and dealing with noise or shadow flicker from the permitted wind turbines, is identified in Table 6 as a participant dwelling. Any dwelling that is currently owned by SHWFPL or under option to be purchased by SHWFPL is identified as a proponent dwelling.

The SHWF WEF includes a combination of flat and undulating terrain with hills. The land at the site is mainly used for wheat farming and sheep grazing. There are extensive areas of forestry in the far north of the site, as well as some smaller patches in the east and south. Topography in the general region is dominated by the mountains of the Great Dividing Range which lie to the north and west of the site, with the westernmost part of the Great Dividing Range, the Grampians National Park, lying approximately 60 km to the west of the site.

The northern sections of the site contain the highest concentration of hills with elevations varying from approximately 330 m to 430 m above mean sea level (AMSL). The central and southern areas of the site contain flatter terrain; however, there are some isolated hills. The centre of the site contains the topographical feature known as Stockyard Hill which is a circular area of elevated land containing a depressed area in the centre known as Black Lake. The south-eastern section of the site contains some notable areas of elevated topography including Monmot Hill and Nanimia Hill. Elevations across the central and southern areas of the site are very similar to the northern area, varying from approximately 320 m to 440 m AMSL. Significant areas of state forest are located to the immediate north of the site and approximately 12 km to the southeast.

2.2 Permitted and Amended WEF

The Permit was issued by the Minister for Planning in October 2010 to enable the use and development of the SHWF WEF, including up to 157 turbine sites (with a maximum tower height of 80 m, maximum blade length of 52 m, and a maximum tip height of 132 m). The Permit is subject to 48 conditions, including the following (which relate to Television and Radio Reception and Interference):

[1] It should be noted that DNV GL has not carried out a detailed and comprehensive survey of house locations in the area and is relying on information provided by SHWFPL [36].

36. *A pre-construction survey must be carried out to the satisfaction of the Minister for Planning to determine television and radio reception strength at selected locations within 5km of any wind turbine including non-stakeholder dwellings. The location of such monitoring is to be determined to the satisfaction of the Minister for Planning by an independent television and radio monitoring specialist appointed by the operator under this permit.*
37. *If, following commencement of the operation of the wind energy facility, a complaint is received regarding the wind energy facility having an adverse effect on television or radio reception at the site of any dwelling in the area which existed at the date of the pre-construction survey, a post-construction survey must be carried out at the dwelling.*
38. *If the post-construction survey establishes any increase in interference to reception as a result of the wind energy facility operations, the wind energy facility operator must undertake measures to mitigate the interference and return the affected reception to pre-construction quality at the cost of the wind energy facility operator and to the satisfaction of the Minister for Planning.*

The amendment is proposed to enable physical changes to the project and amendments to the permit conditions. The amendments to the Permit which relate to EMI include:

- Turbine dimensions – a maximum hub height of 120 m and rotor diameter of 140 m, and overall tip height not exceeding 180 m.
- Layout – ultimate design for up to 149 wind turbine locations, consisting of the following changes:
    - relocation of 3 turbines onto 3 new titles within the centre of the WEF site (adjoining existing permitted address of lands);
    - addition of 4 new turbine locations within the existing permit address of lands; and
    - deletion of 12 turbine locations.

No amendments are proposed to Condition 36, 37, or 38 of the Permit.

A map of the site is shown in Figure 1, and the coordinates of the permitted and amended turbine coordinates are presented in Table 4 and Table 5 respectively.

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*".

The Victorian Guidelines also refer to the National Wind Farm Development Guidelines regarding assessment of potential EMI impacts. 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 spanning over the different stages of wind farm development.

The main purpose of the Draft National Guidelines is to provide detailed methodologies to assess issues related to wind farms including community consultations, shadow flicker, noise monitoring, EMI, impacts on landscapes, and flora and fauna. Other issues that are covered to a lesser extent in the draft guidelines include aircraft safety, blade glint, risk of fire and indigenous heritage.

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 GL considers that the recommendations of the Draft National Guidelines meet, if not exceed, the recommendations of the Victorian Guidelines, and it is noted that the Victorian Guidelines refer directly to the Draft National Guidelines. Therefore the Draft National Guidelines have been used to inform the methodology adopted for this assessment.

4 APPROACH AND ASSESSMENT

If not properly designed, wind farms have the potential to interfere with radiocommunications services. Two services that are most likely to be affected include television broadcast signals and fixed point-to-point microwave signals. Terrestrial broadcast signals are commonly used to transmit domestic television, while microwave links are used for line-of-sight connections for data, voice and video. The interference mechanisms are different for each of these and, hence, there are different ways to avoid interference.

SHWFPL has commissioned DNV GL to complete this assessment based upon two layouts provided for the SHWF WEF: the 'permitted' layout consisting of 157 wind turbines as outlined in Table 4, and an 'amended' layout consisting of 149 wind turbines with a larger turbine type as outlined in Table 5.

For the purpose of the EMI study, a hypothetical turbine with a rotor diameter of 104 m and a tip height of 132 m has been considered for the permitted WEF, and a hypothetical turbine with a rotor diameter of 140 m and a tip height of 180 m has been considered for the amended WEF. These dimensions represent the maximum tip heights and rotor diameters under consideration for the permitted and amended WEFs.

The results generated based on these turbine configurations 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 140 m or less for the amended layout or 104 m or less for the permitted layout;
- an upper tip height of 180 m or less for the amended layout or 132 m or less for the permitted layout; and
- a lower tip height of 40 m or greater for the amended layout or 28 m or greater for the permitted layout.

The Draft National Guidelines recommend that a radial distance of 50-60 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 telecommunication towers within approximately 75 km of the proposed SHWF WEF site, and then assess the telecommunication licences attached to these towers. This is to reduce the likelihood that telecommunications links crossing the site are inadvertently excluded from the assessment.

In order to conduct the EMI assessment, information regarding radiocommunications licences in the vicinity of the SHWF WEF has been obtained from the Australian Communication and Media Authority (ACMA) Register of Radiocommunications Licences (RRL) database [3]. Data contained in the RRL is currently being transitioned from the existing RADCOM system to the new SPECTRA system. Both the RADCOM and SPECTRA datasets have been considered in this assessment in order to identify all potentially affected services in the vicinity of the SHWF WEF; consequently, some licences may be duplicated in the results.

Other services with the potential to experience interference from the SHWF WEF have also been identified, and the potential for interference to those services discussed, including meteorological radars, trigonometrical stations, CB radio and mobile phones, wireless internet, broadcast radio, satellite television and internet, and broadcast television.

DNV GL has also consulted with organisations operating services that may be impacted by the development and operation of the SHWF WEF, to disseminate basic information on the WEF 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 15.

4.1 Telecommunication Towers

An image of the ACMA database dated 30 November 2015 was used for this assessment [3]. From the database, there are 620 telecommunication towers within a nominal 75 km of the SHWF WEF based on the amended WEF site boundary. The locations of these telecommunication towers relative to the SHWF WEF are shown in Figure 2.

4.2 Fixed Licences of Point-to-Point (Microwave) Type

4.2.1 Diffraction

Wind turbines can potentially cause interference, or diffraction, of point-to-point microwave signals and in some cases, point-to-point UHF signals. It is possible to design around this issue as the path and interference zone of these signals are well known. The frequency of common microwave signals varies from approximately 1 GHz to 30 GHz. For this analysis, DNV GL has used a wider and more conservative frequency range of 0 to 50 GHz. Point-to-point links are often used for line-of-sight connections for data, voice and video. Such links often exist on mobile phone and television broadcast towers.

The criteria used for avoiding diffraction effects of point-to-point signals are normally based on an exclusion zone of circular cross-section around the direct path from the transmitter to the receiver (often called boresight) [2] [4] [5]. This exclusion zone is defined in terms of Fresnel zones. The *n*th Fresnel zone is comprised of all points for which, if the radio signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional length compared to the straight transmitter-receiver path equals $\frac{n-\lambda}{2}$, where λ = wavelength.

To avoid interference to point-to-point signals, wind turbines, including the blades, should be kept outside the second Fresnel zone. The radius of the second Fresnel zone varies along the length of the signal, and is given by:

$$R_{F2} = \sqrt{\frac{2\lambda d_1 d_2}{D}}$$

Where d_1 is the distance from the transmitter

d_2 is the distance from the receiver

D is the distance from the transmitter to receiver, i.e. $d_1+d_2 = D$

The registered communications licences for each tower according to the ACMA database were analysed to determine the transmission paths of licenced links that may experience interference from wind turbines.

Each individual link is given a unique identifier or "Assignment ID" so that it can be readily distinguished. For links in the RADCOM dataset, which contains data for broadcast licensing services and 900 MHz public telecommunication services licences [3], the Assignment ID is taken as the hyphenated combination of the Access ID and Device ID. For links in the SPECTRA dataset, which contains data for all other licences [3], the Assignment ID is 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 paths resulting from the towers analysed 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 Country Fire Authority (CFA) towers.

A review of the ACMA database shows that there are four links passing over the proposed SHWF WEF site (operated by Aussie Broadband, Optus Mobile, and St John Ambulance Australia). The links are shown in greater detail in Figure 4 and Figure 5.

References [2] [4] [5] state that turbines should be located outside of either the first or second Fresnel zone in order to avoid interference to that link. For each of the identified links around the site, an exclusion zone has been established based on their operating frequencies, the second Fresnel zone, plus the blade length for turbines with a 104 m rotor diameter for the permitted layout and a 140 m rotor diameter for the amended layout. The potential exclusion zones are also shown in Figure 4 and Figure 5.

It is common practice to have multiple Assignment ID's for the same physical link to cover practicalities such as licensing for sending and/or receiving signals. Accordingly, the Fresnel zone setback has been calculated on the Assignment ID with the lowest frequency. Details of the links are provided in Table 7.

The Draft National Guidelines recommend consultation with the relevant operator is required during the preparation of a planning permit application (and in this instance an application to amend a planning permit) if a turbine is within 2 km of a telecommunication site or if a turbine is located within the second Fresnel zone of a point-to-point link. There are three turbines in the permitted layout that are located within the interference buffer zone for the point-to-point link operated by St John Ambulance Ambulance that passes over the SHWF WEF site. A fourth turbine from the permitted layout is located within the interference buffer zone for one of the point-to-point links operated by Optus Mobile.

For the amended layout, three turbines are again located within the exclusion zone for the link operated by St John Ambulance Australia, and two turbines (turbines J3 and J4) are very close to the exclusion zone for the link operated by Optus Mobile. The turbines located within or near the second Fresnel zone for each point-to-point link crossing the proposed SHWF WEF site are summarised in Table 1 below.

Table 1 Details of turbines located within or near the second Fresnel zones for point-to-point links crossing the proposed SHWF WEF

Link No.	Assignment ID's for Minimum Frequency	Operator	Turbines Within Exclusion Zone (permitted layout)[1]	Turbines Within Exclusion Zone (amended layout)[1]
1	871416, 871417	Aussie Broadband Pty Limited	None	None
2	879502, 879503	Optus Mobile Pty Limited	T37	None (J3 within 10 m, J4 within 40 m)
3	1292842, 1292843	Optus Mobile Pty Limited	None	None
4	948841, 948842	St John Ambulance Australia Incorporated	T63, T65, T67 (T66 within 40 m)	M2, M3, M4 (M5 within 21 m)

Note 1. Distances between turbine locations and the edges of the calculated exclusion zones have been measured perpendicular to the signal path using a geographic information system (GIS) application.

DNV GL has contacted the operators of these links to determine the likelihood that the proposed SHWF WEF will cause interference to their operations and services.

The response received from Optus Mobile indicates that they expect the amended SHWF WEF to have very minimal or negligible impact on the fixed point-to-point link passing over the northeast corner of the WEF site (link number 2 in Table 1 and Table 7). Optus Mobile has also indicated that they do not expect the SHWF WEF to have any impact on the fixed point-to-point link passing over the northwest corner of the WEF site (link number 3 in Table 1 and Table 7).

Feedback received from St John Ambulance Australia indicates that they are of the understanding that any turbine within 200 m of the direct transmission path for a fixed point-to-point link has the potential to cause interference to that link. DNV GL has assessed the locations of turbines in the permitted and amended WEF relative to the transmission path for the point-to-point link operated by St John Ambulance that passes over the SHWF WEF site (link number 4 in Table 1 and Table 7), to determine if any turbine rotor will pass within 200 m of the link path. This assessment has taken into account the turbine blade length of 52 m for the permitted layout and 70 m for the amended layout. It has been determined that all three turbines identified within the calculated exclusion zone for both the permitted and amended WEF in Table 1 are also located within 200 m plus the turbine blade length of the direct transmission path for the link and therefore have the potential to cause interference. It is recommended that SHWFPL undertakes further engagement with St John Ambulance Australia prior to the construction of the SHWF WEF, to establish an understanding of how any impact to this fixed point-to-point link may be mitigated in the event that interference is encountered following construction of the WEF.

To date, no formal response has been received from Aussie Broadband. A preliminary assessment was also carried out to determine if the links pass over the SHWF WEF at a height that is well above the highest point of the turbines (maximum tip height of 132 m for the permitted layout, and 180 m for the amended layout). This was achieved by examining the elevation and tower heights at each end of the link, as well as the approximate elevation of the areas within the SHWF WEF boundaries over which the link crosses. It was determined that the Aussie Broadband and Optus Mobile links do cross the site at a height which has the potential to intersect with turbine blades for both the permitted and amended layouts. However, although the St John Ambulance link does not cross the site at a height which has the potential to intersect with turbines in the

permitted WEF, it may intersect with turbine blades for the larger turbines proposed for the amended WEF.

4.2.2 Near field effects and scattering

The Draft National Guidelines [2] mention the possibility of interference to point-to-point links from two additional mechanisms, near field effects and scattering.

According to the Draft National Guidelines, near field effects are usually limited to approximately 720 m from a communication tower and it is recommended that consultation is required if a turbine is within 1 km of a telecommunication site. The Draft National Guidelines also state that scattering is best avoided by placing wind turbines more than 2 km from a communication tower.

All communication towers associated with point-to-point links are greater than 2 km from the SHWF WEF, with the closest telecommunication tower (Site ID 9009153) located approximately 2.5 km from the site boundary or 3.6 km northeast of the nearest wind turbine in both the permitted and amended layouts (turbines T192 and Q5 respectively). It is not expected that this tower will experience interference due to near field effects or scattering.

However, the closest telecommunication tower of any type is associated with a private mobile telephony system operated by the CFA (Site ID 46001), and is located only 60 m from the proposed site boundary or 1.0 km southwest of the nearest turbine in the permitted layout (turbine T59) and 1.2 km southwest of the nearest turbine in the amended layout (turbine J6).

DNV GL has contacted the CFA as part of the consultation process described in Section 4.5 to seek feedback regarding any potential impact the SHWF WEF could have on their operations and services, including possible interference to signals from this communication tower caused by near field effects or scattering. The response received from the CFA indicates that they do not expect the SHWF WEF to have any adverse impact on their operations and services.

4.3 Fixed Licences of Point-to-Multipoint Type

Fixed licences of the point-to-multipoint type are a variation of the point-to-point type. The difference between them is administrative. A point-to-point licence permits communication between two static sites, where the locations of the sites are detailed in the licence register. A point-to-multipoint licence allows communication between one or more static sites and multiple points or between the points. The point-to-multipoint type is usually licensed for a defined operational area.

Administratively, the ACMA database details the location of the static station for a fixed licence of the point-to-multipoint type. Hence, the location of the transmission vectors is not readily identifiable. A review of fixed licences of point-to-multipoint types was undertaken and 192 Assignment ID's were identified within approximately 75 km of the proposed site. These licences are shown in Figure 6. The details of the licence holders as per the two available ACMA datasets are provided in Table 8.

There are five point-to-multipoint base stations listed in the ACMA database within 20 km of the SHWF WEF boundary. These stations are owned by Aussie Broadband (Site ID 9009153), Central Highlands Water (Site ID 9004396, 9001492, and 204824), and Powercor Australia (Site ID 304700). Since it is not possible to determine if there are any potential impacts without knowing the locations of each station in the multipoint network, DNV GL has contacted the operators of

these stations as part of the consultation process to seek feedback on whether their services are likely to be affected by the SWHF WEF.

The response received from Powercor Australia indicates that they do not foresee any potential for interference to their point-to-multipoint systems arising from the SHWF WEF. Powercor Australia has also advised that the Mt Mercer base station (site ID 9017014) identified in the ACMA database is no longer operational and has been replaced by a new base station at Linton (site ID 9026481, GDA94 latitude -37.706316, GDA94 longitude 143.538273). This new site is approximately 11 km from the SHWF WEF, and increases the total number of point-to-multipoint base stations within 20 km of the WEF boundary to six.

To date, no formal response has been received from Aussie Broadband or Central Highlands Water.

There are a number of point-to-multipoint stations at a distance of greater than 20 km from the site. Although it is unlikely that stations at this distance will be servicing customers in the vicinity of the site, DNV GL has also contacted the operators of all stations within 60 km of the centre of the SHWF WEF to seek feedback on any potential impact that the WEF could have on their services. Responses have been received from several operators, as summarised in Table 15, and no concerns have been raised to date.

4.4 Other Licence Types

A review of the ACMA database for other licences was conducted. These licences are shown in Table 9 and Figure 7.

Many of the licences identified can be broadly described as base to mobile station style communications, including radio broadcasting and commercial and private mobile telephony. 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. Should reception difficulty be encountered, the amelioration method consists of the user simply moving to receive a clearer signal.

A number of broadcasting licences have been identified. These are likely to consist of radio and television broadcasting services, and are 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 GL understands that potential impacts to these services have been considered as part of an aviation impact study.

4.5 Emergency Services

A review of the ACMA database was conducted to identify emergency services with licences for radiocommunications assets operating in the vicinity of the SHWF WEF. The groups identified are listed in Table 10 along with their contact details. While the potential for interference to a point-to-point link operated by St John Ambulance Australia and a private mobile telephony tower operated by the CFA has already been identified in Sections 4.2.1 and 4.2.2 respectively, DNV GL has contacted the operators of all stations within approximately 60 km of the centre of the SHWF WEF to seek feedback regarding any potential impact that the WEF could have on their operations and services. Responses have been received from several operators, as summarised in Table 15, and no concerns have been raised to date.

4.6 Aircraft Navigation Systems and Radar

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

4.7 Meteorological Radar

The Bureau of Meteorology (BoM) operates a network of weather stations across Australia and uses radar instruments for measuring wind speeds in the upper atmosphere (known as "wind finding" radar), and determining rain and storm activity (known as "weather watch" radar).

The "wind finding" radar uses radar echoes from a target to determine the wind speeds and direction. The radar target is attached to a balloon and tracked by the ground radar. The "weather watch" radar, or "weather surveillance" radar, consists of a rotating antenna located on a building, and kept free from any physical obstruction. The antenna is used to direct a thin beam of radio energy upward into the atmosphere which is then reflected back by a cloud mass. The location of the cloud is then determined by the direction and travel time of the reflected beam.

Wind profile measurements are used to ensure the safe and economical operation of aircraft and provide an important source of data for the BoM's general weather forecasting system. "Weather watch" radars monitor weather situations and are able to indicate the possibility of severe storms out to as distance of 250 km or more. Hence, whilst the uninhibited operation of meteorological radars may not be as critical as aviation radar, there are implications for public safety if severe weather is not predicted or if its approach is masked due to EMI.

Wind farms located at distances greater than 5 km from a BoM weather station are unlikely to affect wind finding operations [2]. Generally, the optimal coverage area for "weather watch" radar extends approximately 200 km from the radar installation at a height of approximately 3000 m [6] [7], and approximately 100 km at a height of 1000 m [7]. Theoretically, wind farms can impact upon weather watch radar when located within several hundred kilometres of a radar station, however, due to the curvature of the earth, and intervening terrain, the range at or near ground level is generally less.

According to the Draft National Wind Farm Development Guidelines, consultations with operators of weather stations within 250 nautical miles (463 km) of the proposed SHWF WEF should be undertaken [2]. It has been identified that the BoM operates seven weather stations within that range with the closest station, "Melbourne", located approximately 117 km east southeast of the SHWF WEF site. The locations of these stations are shown in Figure 8 and the details of each station can be found in Table 11.

It is not expected that the SHWF WEF will cause interference with BoM radar installations, as given the distance between the site and radar installations, and the nature of the intervening terrain, it is likely that radar signals will be intercepted by terrain before they are able to be influenced by the WEF.

DNV GL has contacted the BoM regarding the SHWF WEF, in accordance with the recommendations of 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 they do not expect the SHWF WEF to have any impact on their radar installations and services.

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 GPS antennas and Electronic Distance Measuring (EDM) devices. EDM devices measure the distance from the trig point to the target object by means of a beam of known velocity which is reflected back to the unit from the target object. Most EDM devices require the target object to be highly reflective and, accordingly, a reflective prism is placed on the target object being surveyed. The effective range of EDM devices depends on the wavelength bands used. Light wave and infrared systems have an effective range of 3 to 5 km while microwave systems can measure distances up to 150 km. However, such systems are not limited by the line of sight or affected by visibility [8].

The Global Navigation Satellite Systems (GNSS) Network is comprised of permanent stations which provide the geodetic framework for the spatial data infrastructure in Australia and its territories. The GNSS network also provides information to the International GNSS Service. Eight stations from the GNSS database in Australia form the Australian Fiducial Network (AFN) [9] [10]. The AFN stations are equipped with EDM devices and GPS receivers and transmit data to Geoscience Australia via phone lines, internet and/or satellite [10].

The closest AFN GNSS station is located at approximately 25 km south of the SHWF WEF, at Colac. Due to the relatively small distance between the SHWF WEF and the GNSS station, DNV GL has contacted Geoscience Australia to seek feedback regarding the potential for the WEF to cause interference to the GNSS network.

DNV GL has also undertaken a review of the Primary Geodetic Network of Australia [11] and it has been observed that the SHWF WEF 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 second-order triangulation network and so forth, with the degree of accuracy decreasing for subsequent networks.

According to the database from Geoscience Australia [12], there are 13 trig points within 20 km of the SHWF WEF site boundary. The details of all 13 trig points are provided in Table 12 and illustrated in Figure 9.

Although it is unlikely that the trig points in close proximity to the SHWF WEF host EDM devices or other equipment that is likely to be subject to EMI, DNV GL has contacted Geoscience Australia and the Victorian Department of Environment, Land, Water and Planning (DELWP) to inform them of the proposed amendment to the SHWF WEF, and seek feedback regarding whether interference to their systems is possible.

The response received from DELWP indicates that they do not expect the SHWF WEF to have any impact on their geodetic assets, which includes a state-wide network of 124 GNSS Continuously Operating Reference Station (CORS) sites. The closest Victorian GNSS CORS site is located approximately 2 km east of the SHWF WEF, at Mt Emu [13]. However, the DELWP has confirmed that the WEF is sufficiently far from this GNSS CORS site to ensure that it will not have any impact on the operation of the Victorian GNSS network.

The response received from Geoscience Australia also indicates that they do not foresee any potential for impact to their geodetic assets, equipment, facilities, or services arising from the SHWF WEF.

4.9 Citizens 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 communications activities, telemetry, and telecommand applications. The radio service operates on two frequency bands, namely the High Frequency (HF) band at between 26.965 MHz and 27.405 MHz, and the Ultra High Frequency (UHF) band at between 476.425 MHz and 477.400 MHz.

The 27 MHz CB radio service was legalised in Australia in the 1970s as a temporary move to switch to UHF CB over the following five years. 27 MHz CB transmit signals in either AM or SSB (Single Side Band) transmission mode. The actual range over which the signal is transmitted depends on the antenna used, the terrain and the interference levels. Over the last decade, the use of 27 MHz CB radio service has declined and has been replaced by UHF CB radio service.

The UHF CB radio service is unique in Australia and uses the FM transmission mode. It provides clear communication over 5-20 km and is less susceptible to power line noise. However, the UHF CB radio service requires "line-of-sight" and is easily hindered by hilly terrain and forested areas. If located on a hilltop, CB radio signals can be transmitted over at least 50 km. Repeater stations are set up on hilltops by community groups and commercial organisations to transmit signals from one channel to another.

No individual or organisation owns or has the right to use a channel exclusively. However, out of the 40 channels available, some of them will be allocated to emergency, telemetry or repeater inputs.

Since users of CB radio service do not require a licence, there is no record of users of the service and their locations and the channels are shared among the users and the repeater stations without a right of protection from interference. The impact of the SHWF WEF on CB radio service is expected to be minimal. In the event of interference from the wind turbines, simple steps such as moving a short distance until the signal strength improves would help to mitigate the impact.

4.10 Mobile Phones

Mobile phone networks typically operate at frequencies of either between 700 and 900 MHz, or between 1800 and 2600 MHz, however some new services may operate at up to 3500 MHz. At such frequencies, signals are likely to 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, although there is little evidence of this in the literature.

A review of mobile phone towers in the vicinity of the proposed SHWF WEF has been carried out. The locations of these towers are shown in Figure 10. The nearest mobile phone tower is located approximately 3.6 km to the south of the SHWF WEF boundary.

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

Figure 11 shows the Optus network coverage for the SHWF WEF area [14]. The map shows outdoor 3G coverage at most locations in the vicinity of the WEF, with some areas requiring an external antenna to receive 3G coverage. Some locations, particularly to the southwest of the WEF, may receive outdoor 4G coverage.

Figure 12 shows the Telstra network coverage for the SHWF WEF area [15]. The map also shows 3G coverage in the vicinity of the WEF, although an external antenna is required to receive coverage in some areas. Additionally, areas to the north and south of the WEF, around Beaufort and Skipton, may receive either 4G or 4GX coverage.

Figure 13 shows the Vodafone network coverage for the SHWF WEF area [16]. Most locations in the vicinity of the WEF have only outdoor coverage, although some locations have both outdoor and limited indoor coverage. Areas to the north of the WEF, around Beaufort, receive good outdoor and indoor coverage.

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.

DNV GL has contacted Optus, Telstra, and Vodafone to inform them of the proposed amendment to the SHWF WEF and to seek feedback on any potential impact that the WEF could have on their services. Responses have been received from both Optus and Telstra, and no concerns have been raised to date.

In cases of marginal network coverage, simple procedures are available to mitigate interference, such as moving a short distance to a new or higher location until the signal improves, or using an external antenna to improve the signal.

4.11 Wireless Internet

Aussie Broadband Pty Ltd holds point-to-multipoint licences in the vicinity of the SHWF WEF, with one base station located 2.4 km northwest of the southern section of the WEF site. As the locations of Aussie Broadband customers are not known, it is not possible to determine whether there is the potential for interference to this service, however it is possible that stations at these distances may be servicing customers in the vicinity of the proposed SHWF WEF. Aussie Broadband has been contacted by DNV GL to seek feedback regarding the potential for interference to their services, but no formal response has been received to date.

Additionally, residents in the vicinity of the SHWF WEF are likely to utilise Telstra wireless broadband services. Telstra's wireless broadband service utilises the same network as Telstra's

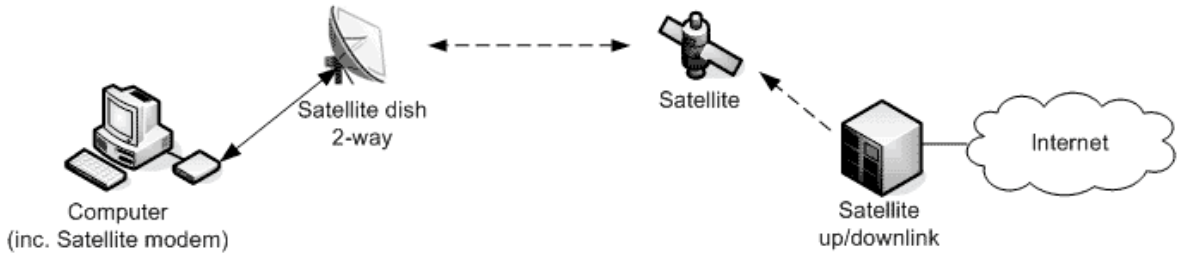
mobile phone service, and therefore the comments made in Section 4.10 are applicable here. Specifically, the presence of wind turbines is unlikely to cause any interference. However should interference occur, the simple mitigation options given in Section 4.10 may be applicable.

The NBN (National Broadband Network) website [17] indicates that the network is available as a fixed wireless service to the east and southeast (Ballarat and surrounds), southwest (Streatham), and northwest (Ararat) of the SHWF WEF site. Work has also commenced to install the NBN as a fixed wireless service in areas further to the south and west of the site. It is therefore likely that some residents, particularly to the southeast of the SHWF WEF, are currently accessing the internet via the NBN and that the network will also be available to other residents in the vicinity of the WEF in the near future. NBN Co has been contacted as part of the consultation process to seek feedback on whether there is potential for the SHWF WEF to cause interference to their services. The response received from NBN Co indicates that they do not expect the SHWF WEF to have any adverse impact on their services.

4.12 Satellite Television and Internet

In some rural or remote areas, television and internet access can be provided through satellite only. Satellite television is delivered via a communication satellite to a satellite dish connected to a set-top box. The satellite transmits television signals to the user's antenna at two frequency bands; the C band at between 4 GHz and 8 GHz, and the Ku band at between 12 GHz and 18 GHz. Signals in the C band are susceptible to interference due to radio relay links, radar systems and other devices operating at a similar frequency while signals in the Ku band are most likely to be affected by rain which acts as an excellent absorber of microwave signals at this frequency. DNV GL understands that there are currently 20 satellites that can provide television to the east coast of Australia [18].

In the case of satellite internet, the user's computer is connected to a satellite modem which is in turn linked to a satellite dish/antenna mounted on the building roof. When the user accesses the internet, a request is sent to the operation centre of the satellite internet provider via the satellite antenna. Data is then sent back to the user's computer via the same path as shown in the figure below.



2-way Connection to the Internet via Satellite [19]

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

A number of satellites transmit television signals that can be received in Australia. DNV GL has analysed the line-of-sight for satellites which provide any television services to eastern Australia. Although only a small number of satellites are likely to be providing television services intended for Australia (e.g., Optus C1, D1, and D2), all viewable satellites have been considered.

The analysis has shown that no satellite signals to houses in the vicinity of the WEF are expected to be intercepted by turbines in the permitted layout. However, signals from the Apstar 7, Thaicom 5, Insat 2E, Measat 3, and NSS-6 satellites may be intercepted by turbines in the amended layout for two house locations, both of which are participant dwellings (dwellings B145 and B148). However it is DNV GL's understanding that these satellites do not transmit programming designed for Australian audiences [20], and as such it is unlikely that residents in the vicinity of the SHWF WEF will be receiving television signals from these satellites.

The main satellites for providing satellite internet in Australia are the IPSTAR and Optus D2 satellites. From the SHWF WEF site, the IPSTAR and Optus D2 satellites have elevations of approximately 39.8° and 45.5° respectively [21]. Therefore it is unlikely that the permitted or amended SHWF WEF will impact upon the line-of-sight from these satellites to any house.

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 of between 520 kHz and 1610 kHz, while FM radio operates in the very high frequency band (VHF) between 87.5 MHz and 108 MHz. The locations of the AM and FM broadcast transmitters in the vicinity of the SHWF WEF are shown in Figure 14.

4.13.1 AM Radio

Amplitude Modulation, or AM, radio signals are diffracted by the ground as they propagate, such that they follow the curvature of the earth, and are also reflected or refracted by the ionosphere at night. This means that AM radio waves are able to travel significant distances under the right conditions. Due to their long wavelength, they can readily propagate around 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.

As AM radio signals are able to propagate around obstructions such as turbines, it is expected that the SHWF WEF 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 [22]. Any interference problems are likely to be easily resolved through the installation of a high quality antenna and/or amplifier.

4.13.2 FM Radio

Frequency Modulation, or FM, radio signals are suited to short range broadcasting. Unlike lower frequency signals (such as AM signals), they are not reflected or refracted off the ionosphere. The waves are slightly refracted by the atmosphere and curve back towards the earth, meaning they can propagate slightly beyond the visual horizon, however they may be blocked by significant terrain features. FM radio stations therefore tend to have only local coverage and this means that signals are less susceptible to interference from distant FM broadcasters. FM signals are also less

susceptible to interference from changes in atmospheric conditions and electrical equipment than AM signals.

FM radio signals are susceptible to interference from buildings and other structures, although they are less vulnerable than higher frequency signals. Reflection or scattering of radio waves by physical structures can reduce signal strength at a receiver or can cause multi-path errors through reception of a reflected signal in addition to the primary signal from the transmitter, resulting in hissing or distortion heard by the listener. FM radio signals received by listeners in the vicinity of the SHWF WEF may be affected by interference caused by the WEF. However, generally interference will only be experienced in the immediate vicinity of a wind turbine [22] and it is unlikely that any permanent FM radio receivers will be located sufficiently close to the WEF to be affected. If interference to FM radio signals is an issue, it is expected that that in most cases this can be easily rectified through the installation of a high quality antenna and/or amplifier in accordance with Condition 38 of the Permit.

4.13.3 Digital Radio

Digital radio services have been introduced in metropolitan licence areas from July 2009. The digital radio services offered use an updated version of the digital audio broadcasting (DAB) digital radio standard, DAB+, to broadcast digital radio to Adelaide, Brisbane, Perth, Melbourne and Sydney [23]. According to the digital radio coverage map available on the ABC website [24], digital radio is not yet available in the SHWF WEF region. Therefore, while there are no digital audio broadcasts in the vicinity of the SHWF WEF, no interference to digital audio will be 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 Victoria are now digital broadcasts [25]. 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 GL has experience in situations where houses were able to receive adequate digital television reception in an area of adequate signal strength where the digital television signal is passing through a wind farm.

The UK telecommunications regulator Ofcom [26], states the following with regard to interference to digital television reception.

"Digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting. However a digital receiver that has to deal with reflections needs a somewhat higher signal level than one that has to deal with the direct path only. This can mean that viewers in areas where digital signals are fairly weak can experience interruptions to their reception should new reflections appear… reflections may still affect digital television reception in some areas, although the extent of the problem should be far less than for analogue television".

DNV GL has drawn two conclusions from this report:

- Firstly that digital television is very robust and does not suffer from ghosting. In most cases digital television should not be susceptible to interference from wind farm developments.

- Secondly, that areas of weak digital television signal can experience interruptions to their reception should new reflections appear, such as those from nearby wind turbines.

The Broadcast Transmitter Database [25] was examined to identify broadcasters nearby to the proposed SHWF WEF, with those found shown in Figure 14. The main television transmitter used by residents in the vicinity of the SHWF WEF is the Ballarat transmitter at Lookout Hill. However, it is also possible that residents to the north and east of the site receive television signals from the Bendigo transmitter.

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

- proximity of wind turbines to television broadcast tower;
- proximity of wind turbines to receivers (houses);
- location of wind turbines in relation to houses and television broadcast towers;
- the rotor blade material, rotor speed and rotor blade direction (always into the wind);
- type of receiving antenna (e.g. directional and height);
- location of the television receiver in relation to terrain and other obstacles; and
- frequency and power of the television broadcast signal.

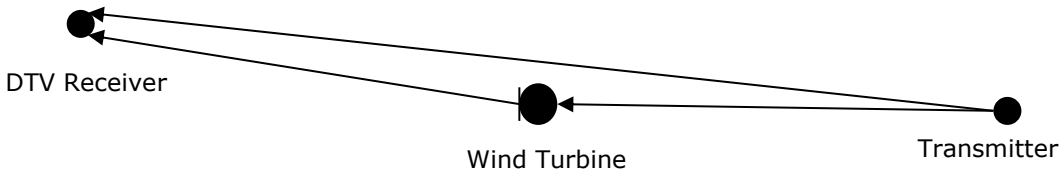
4.14.1 Large Scale Interference

For broadcast signals, large scale interference can generally be avoided by placing the wind turbines distant from the broadcast tower. Broadcast towers may be either relay or primary transmitters. Relay television transmitters are more commonly found in rural areas. Primary television 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 television transmitters, while a clearance of at least 6 km is recommended for primary television transmitters [5]. The closest digital television transmitter to the SHWF WEF is the Ballarat transmitter at Lookout Hill, which is approximately 40 km away, and so neither the permitted or amended WEF is expected to cause large scale interference.

4.14.2 Forward and Back Scatter

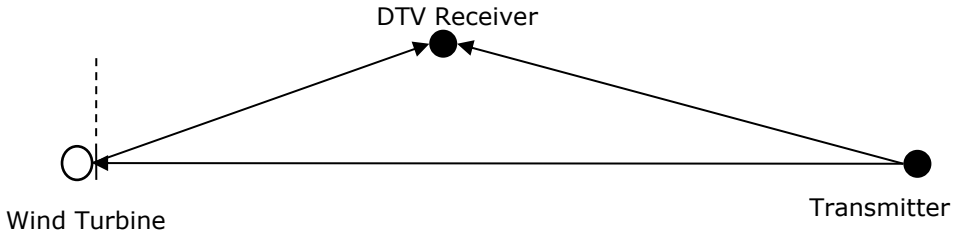
Wind turbines cause interference to television signals by introducing reflections that may be received by the antenna at a dwelling, in addition to the signal received directly from the transmitter, which causes multipath errors. A wind turbine has the potential to scatter electromagnetic waves carrying television 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 [27]. 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 DTV 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).



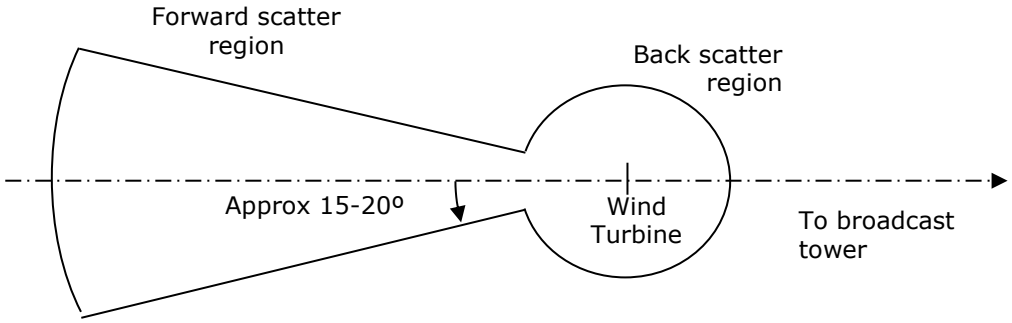
Back Scatter Signal Path

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 [27].

According to Ofcom [26], the forward scatter region does not typically extend further than 5 km for the worst combination of factors [5] [28]. Interference may extend beyond 5 km if the houses are screened from the broadcast tower, but do have line-of-sight to the wind turbines [26]. 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 house delayed relative to the source signal from the broadcast tower. The back scatter region generally does not extend further than 500 m [5] [29], 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, digital television signals are transmitted using the DVB-T (Digital Video Broadcasting – Terrestrial) standard. The International Telecommunication Union (ITU) Recommendation BT.1893 [30] 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 [31] 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 [31].

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 SHWF WEF are discussed in section 4.14.4.

4.14.3 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 [32]. 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 [30], was found to be the most inaccurate, and does not provide signal estimations in the forward scattering zone of the blades. Additionally, DNV GL notes that it only applies to a single wind turbine rather than a wind farm as a whole. Due to the lack of an accurate scattering model, DNV GL has not performed detailed scatter calculations to predict DTV interference.

As an alternative, it is common practice to identify those dwellings or areas that are most likely to experience potential television interference based on likely forward and back scatter regions. 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 [26]. 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 SHWF WEF, and hence have an increased likelihood of experiencing interference to television signals, are described in section 4.14.4.

4.14.4 Potential impacts for dwellings

Dwellings that have increased potential to receive back-scattered or forward-scattered signals from a turbine in the SHWF WEF (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 Figure 15 to Figure 18 and Table 13 and Table 14. The dwellings that are most likely to be susceptible to interference include those within the possible interference zones, as summarised in Table 2 below. 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.

Table 2 Number of dwellings located within potential interference zones for digital television broadcast towers in the vicinity of the Stockyard Hill Wind Farm site

Digital Television Broadcast Tower	Number of Dwellings Within Potential Interference Zone (permitted WEF)	Number of Dwellings Within Potential Interference Zone (amended WEF)
Ballarat (Lookout Hill)	72 (25 participant dwellings, 2 proponent dwellings)	75 (26 participant dwellings, 2 proponent dwellings)
Bendigo (Harcort North)	67 (21 participant dwellings, 2 proponent dwellings)	65 (21 participant dwellings, 2 proponent dwellings)

According to the Australian Government mySwitch website [29], the area around the SHWF WEF is able to receive digital television signals from the Ballarat and Bendigo broadcast towers. The coverage maps (reproduced in Figure 15 to Figure 18) suggest that the majority of the area surrounding the SHWF WEF receives 'good' coverage from the Ballarat tower, but only the northeastern part of the site receives 'variable' coverage from the Bendigo tower.

Although digital television 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 SHWF WEF, it is possible that some areas could be deemed to have marginal reception, and interference could be encountered. If reception difficulties are encountered, there are a number of mitigation options available, and these are discussed in further detail in Section 4.14.5.

The method used here to assess the potential interference to television signals from the SHWF WEF represents a simplified approach which is expected to capture locations where interference is most likely to occur. This simplified analysis is deemed appropriate as the implications of potential television interference are reasonably low given the large range of mitigation options available.

4.14.5 Mitigation options

In the event that television interference is an issue during construction or after commissioning of the SHWF WEF, there are several amelioration options available to ensure compliance with Condition 38 of the Permit:

1. Realigning the householder's television antenna more directly towards their existing transmitter;
2. Tuning the householder's antenna into alternative sources of the same or suitable television signal;
3. The installation of more directional and/or higher gain antenna at the affected house;
4. Relocating the antenna to a less affected position;
5. The installation of cable/satellite television at the affected house; and
6. Installation of 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. 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 [27] DVB-T reception quality may not be substantially affected in the forward scatter region.

The ITU [31] 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 digital television 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 [33].

4.15 Anticipated Change

The amended WEF is expected to result in a similar level of interference to fixed point-to-point links passing over the SHWF WEF boundary compared to the permitted WEF.

For both the permitted and amended WEF, a total of three turbines are located in the exclusion zone for the point-to-point link operated by St John Ambulance Australia that passes over the SHWF WEF site. However, it is noted that although the St John Ambulance link crosses the site at a height that does not have the potential to intersect with turbines in the permitted WEF, the larger turbines proposed for the amended WEF do have the potential to intercept the St John Ambulance link. One additional turbine in the permitted layout is located within the exclusion zone for a second point-to-point link operated by Optus Mobile, and has the potential to intercept the line of sight of that link, but there are no turbines in the amended layout that are located within the exclusion zone for this link.

The proposed turbine locations in the amended layout are also slightly further away from the nearest telecommunication tower compared to the permitted layout, although the turbines are still located within 2 km of the tower and therefore have the potential to cause interference due to scattering. The consultation process undertaken by DNV GL has helped to further assess the impact of the SHWF WEF on the point-to-point links crossing the WEF site, and hence determine the change in impact arising from the proposed amendments.

The analysis has shown that the amended WEF will introduce the potential that satellite signals to two houses will be intercepted by turbines. However, as discussed in Section 4.12, it is considered unlikely that houses in the vicinity of the WEF will be receiving signals from these satellites.

The amended WEF increases the number of houses identified in the potential interference zone for the Ballarat digital television broadcast tower by a total of three, compared to the permitted WEF. Conversely, two fewer houses are identified in the potential interference zone for the Bendigo broadcasting tower for the amended layout compared to the permitted layout. The coverage maps shown in Figure 15 to Figure 18 suggest that the houses affected by both the permitted and amended WEFs are located in areas where the signal from the Bendigo tower is 'variable' or poor and would therefore most likely be receiving signals from Ballarat, which has generally 'good' signal strength across the site.

However, the potential for interference to television signals caused by a wind turbine is likely to be proportional to the radar cross section (RCS) of the turbine, which is typically proportional to the turbine dimensions [30]. Therefore, the increased turbine dimensions associated with the amended SHWF WEF may increase the potential for interference when compared with the permitted WEF. However, the large number of mitigation options available (as discussed in section 4.14.5) mean that it is likely that any potential interference could be rectified.

It is not possible to determine the change in potential EMI impact on other licence types (including point-to-multipoint links), emergency services, and wireless internet services without knowing the location of each station in the network or obtaining further information from the service operators. The consultation process undertaken by DNV GL has helped to determine the relevant link paths and the potential for the SHWF WEF to cause interference to these services, and therefore asses the likely changes in impact arising from the proposed amendments. All responses received to date indicate that the impact of the SHWF WEF on these services is unlikely to be any different for the amended WEF compared to the permitted WEF.

For other services considered in this assessment, including meteorological radar, trigonometrical stations, CB radio, mobile phones, and broadcast radio, either impacts are considered to be minor for both the permitted and amended WEF or impact changes have been assessed through consultation with the service operators. Additionally, it is understood that any changes to the impact of the SHWF WEF on aviation radar and navigation systems arising from the proposed amendments have been identified as part of an aviation impact study.

5 CONCLUSIONS

Broadcast towers and transmission paths around the SHWF WEF were investigated to determine if EMI would be experienced as a result of the development and operation of the WEF, including an assessment of the overall impact of the amended WEF and the change in potential impact from the permitted WEF. The amended WEF will involve the installation of 149 wind turbine generators in the amended layout configuration, compared to the permitted WEF which includes up to 157 wind turbines. DNV GL has considered turbine geometries that will be conservative for turbine configurations with dimensions satisfying all of the following criteria: a rotor diameter of 140 m or less and an upper tip height of 180 m or less for the amended WEF, and a rotor diameter of 104 m or less and an upper tip height of 132 m or less for the permitted WEF.

The results of this assessment, including feedback obtained from relevant stakeholders, are summarised in Table 3 on the following pages. It is noted that the SHWF WEF has the potential to cause interference to point-to-point links crossing the proposed WEF site, as well as to satellite television and internet signals and terrestrial television broadcast signals received at houses in the vicinity of the WEF.

It is anticipated that the amended WEF may increase the potential for interference to one point-to-point link passing over the WEF boundary compared to the permitted WEF, but may decrease the potential for interference to another such link. The amended WEF is therefore expected to result in a similar overall level of interference to fixed point-to-point links as for the permitted WEF.

The amended WEF will introduce the potential that satellite signals will be intercepted by turbines at two house locations; however, it is understood that these satellites either do not provide internet access to customers in Australia, or do not provide television services designed for Australian audiences.

For terrestrial television broadcasts, the amended WEF increases the total number of houses in the potential interference zone for the Ballarat broadcast tower by three but decreases the number of houses in the potential interference zone for the Bendigo broadcast tower by two compared to the permitted WEF. However, the increased turbine dimensions associated with the amended WEF may increase the potential for interference when compared with the permitted WEF.

While it is not possible to determine the effects of the proposed amendments on the potential EMI impacts on point-to-multipoint links, emergency services, and wireless internet services without obtaining further information from the service operators, the consultation process undertaken by DNV GL has helped to determine the potential for the SHWF WEF to cause interference to these services, and hence assess the likely change in impact caused by the amended WEF compared to the permitted WEF. All responses received to date indicate that the impact of the SHWF WEF on these services is unlikely to change as a result of the proposed amendments.

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

Table 3 Summary of EMI assessment results for the proposed SHWF WEF

Licence/Service Type	Assessment Findings		Anticipated Change in Impact	Stakeholder Feedback (to date)
	Permitted WEF	Amended WEF		
Fixed point-to-point microwave links	Four links crossing WEF boundary:			
	St John Ambulance Australia			
	Turbines T63, T65, T67 in exclusion zone; link crosses above turbines – potential for interference	Turbines M2, M3, M4 in exclusion zone; link crosses at level of turbines – potential for interference	Increased potential for interference	Potential for interference if turbines are within 200m of link path
	Optus Mobile #1			
	Turbine T37 in exclusion zone; link crosses at level of turbines – potential for interference	No turbines in exclusion zone	Decreased potential for interference	Minimal to negligible impact expected (amended WEF)
	Optus Mobile #2			
	No turbines in exclusion zone	No turbines in exclusion zone	None	No impact expected
	Aussie Broadband			
	No turbines in exclusion zone	No turbines in exclusion zone	None	None received
Fixed point-to-multipoint microwave links	192 assignments within 75 km of WEF boundary Six base stations within 20 km of WEF boundary: Aussie Broadband (site 9009153) Central Highlands Water (sites 9004396, 9001492, 204824), Powercor Australia (sites 304700, 9026481)		None	No concerns raised
Other licence types	Base to mobile station style communications: unlikely to be affected (see "Emergency services", "Mobile phones", "Radio broadcasting", "Television broadcasting") Aeronautical and radiodetermination: to be considered as part of an aviation impact assessment		-	-
Emergency services	Point-to-point microwave links: one St John Ambulance Australia link crossing boundary (see "Fixed point-to-point microwave links") Base to mobile station style communications: unlikely to be affected		None	No concerns raised
Aircraft navigation systems and radar	To be considered as part of an aviation impact assessment		-	-

Table 3 Summary of EMI assessment results for the proposed SHWF WEF (concluded)

Licence/Service Type	Assessment Findings		Anticipated Change in Impact	Stakeholder Feedback (to date)
	Permitted WEF	Amended WEF		
Meteorological radar	Nearest station: "Melbourne", 117 km from WEF Unlikely to be affected		See stakeholder feedback	No concerns raised
Trigonometrical stations	13 stations within 20 km of WEF boundary Electronic equipment: unlikely to be affected Sight lines to other stations: may be blocked by turbines		None	No concerns raised
Citizen's Band radio	Unlikely to be affected		-	-
Mobile phones	Fair to good coverage across site Unlikely to be affected, may experience interference in areas with marginal coverage		See stakeholder feedback	No concerns raised
Wireless internet	Likely service providers: Aussie Broadband, Telstra NBN: currently available in areas surrounding WEF		See stakeholder feedback	No concerns raised
Satellite television and internet	Services intended for Australia: unlikely to be affected		None	-
	Other services: no signals intercepted	Other services: signals from five satellites intercepted at dwellings B145 and B148	Increased potential for impact at two dwellings (B145, B148)	
Radio broadcasting	AM signals: unlikely to be affected FM signals: may experience interference (low level hiss or distortion) in close proximity to turbines.		None	-
Television broadcasting	Digital signals: may experience interference in areas with poor or marginal reception *Ballarat tower: 'good' coverage across site*		Increased potential for impact due to increased turbine dimensions	
	72 dwellings (25 participant dwellings, 2 proponent dwellings) in potential interference zone	75 dwellings (26 participant dwellings, 2 proponent dwellings) in potential interference zone	Number of dwellings in potential interference zone increased by three	-
	Bendigo tower: 'variable' coverage across northeast of site			
	67 dwellings (21 participant dwellings, 2 proponent dwellings) in potential interference zone	65 dwellings (21 participant dwellings, 2 proponent dwellings) in potential interference zone	Number of dwellings in potential interference zone decreased by two	-

6 REFERENCES

[1] Victorian Department of Planning, Transport, and Local Infrastructure, "Policy and planning guidelines for development of wind energy facilities in Victoria," January 2016.

[2] EPHC, "National Wind Farm Development Guidelines - Public Consultation Draft," July 2010.

[3] Australian Communications and Media Authority (ACMA), "Radiocommunications Licence Data," 30 November 2015. [Online]. Available: http://www.acma.gov.au/Industry/Spectrum/Radiocomms-licensing/Register-of-radiocommunications-licences/radiocomms-licence-data. [Accessed 30 November 2015].

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

[5] S. H. Hall, "The assessment and avoidance of Electromagnetic Interference due to Wind Farms," *Wind Engineering Vol 16 No 6,* pp. 326 - 338, 1992.

[6] Bureau of Meteorology, "Optimal Radar Coverage Areas," 2015. [Online]. Available: http://www.bom.gov.au/australia/radar/about/radar_coverage_national.shtml. [Accessed 12 November 2015].

[7] Bureau of Meteorology, "Radar Frequently Asked Questions," 2015. [Online]. Available: http://www.bom.gov.au/australia/radar/about/radarfaq.shtml. [Accessed 12 November 2015].

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

[9] Geoscience Australia, Australian Government, "Australian Fiducial Network," [Online]. Available: http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/geodetic-datums/gda/afn. [Accessed 7 December 2015].

[10] Land and Property Information, New South Wales Government, "Geodesy and GDA," [Online]. Available: http://www.lpi.nsw.gov.au/surveying/geodesy. [Accessed 7 December 2015].

[11] Intergovernmental Committee on Surveying and Mapping (ICSM), "Fundamentals of Mapping - Survey for Mapping," May 2015. [Online]. Available: www.icsm.gov.au/mapping/surveying1.html. [Accessed 3 December 2015].

[12] GeoScience Australia, "National Geospatial Reference System," [Online]. Available: http://webmap.ga.gov.au/ngrs/. [Accessed 3 December 2015].

[13] The State of Victoria, "CORS Interactive Map," 1996-2016. [Online]. Available: http://gnss.vicpos.com.au/Map/SensorMap.aspx. [Accessed 24 February 2016].

[14] Singtel Optus Pty Limited, "Optus Mobile Network Coverage," [Online]. Available: http://www.optus.com.au/shop/mobile/network/coverage. [Accessed 16 December 2015].

[15] Telstra, "Telstra - Our Coverage," [Online]. Available: https://www.telstra.com.au/coverage-networks/our-coverage. [Accessed 16 December 2015].

[16] Vodaphone Australia, "Network Coverage Checker," 2015. [Online]. Available: http://www.vodafone.com.au/aboutvodafone/network/checker. [Accessed 16 December 2015].

[17] NBN Co, "Check Your Address," 2015. [Online]. Available: http://www.nbnco.com.au/connect-home-or-business/check-your-address.html. [Accessed 7 December 2015].

[18] Aussie Satellite Services, "Available Satellites in Australia," [Online]. Available: http://aussiesatellite.com/DS/shop/cart.php?m=content&page=10. [Accessed 7 December 2015].

[19] Busicom Communications Pty Ltd, 2007. [Online]. Available: http://www.busicom.net.au/bigpond_satellite.htm. [Accessed 7 December 2015].

[20] LyngSat, "Free TV from Australia," [Online]. Available: http://www.lyngsat.com/freetv/Australia.html. [Accessed 7 December 2015].

[21] DP Technologies Ltd, "Satellite Finder / Dish Alignment Calculator with Google Maps," 2012. [Online]. Available: www.dishpointer.com. [Accessed 7 December 2015].

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

[23] Australian Communications and Media Authority (ACMA), "Digital Radio," 1 September 2015.

[Online]. Available: http://www.acma.gov.au/Industry/Broadcast/Spectrum-for-broadcasting/Broadcast-planning/digital-radio-spectrum-for-broadcasters-acma-1. [Accessed 7 December 2015].

[24] Australian Broadcasting Corporation (ABC), "ABC Digital Radio Coverage Maps," 2015. [Online]. Available: http://www.abc.net.au/reception/radio/dr_coveragemaps.htm. [Accessed 7 December 2015].

[25] Australian Communications and Media Authority, "Licenced Broadcasting Transmitters," 1 December 2015. [Online]. Available: http://www.acma.gov.au/Industry/Spectrum/Radiocomms-licensing/Apparatus-licences/list-of-licensed-broadcasting-transmitters. [Accessed 4 December 2015].

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

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

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

[29] Australian Government, "mySwitch," [Online]. Available: http://myswitch.digitalready.gov.au/. [Accessed 16 December 2015].

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

[31] 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.

[32] 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.

[33] Australian Government, "VAST - Viewer Access Satellite Television," [Online]. Available: https://www.myvast.com.au/. [Accessed 16 November 2015].

[34] "SHWF_WF_Permitted Turbine_Pt.shp," SHWFPL, 20 November 2015.

[35] "Layout 12.xlsx," SHWFPL, 15 December 2015.

[36] "SHWF_Dwellings_20160304.xlsx," SHWFPL, 4 March 2016.

[37] Recommendation ITU-R BT.1893, "Assessment of impairment caused to digital television reception by a wind turbine," October 2015.

[38] "Turbine data_165.doc," SHWFPL, 20 November 2015.

[39] "Turbine data_180.doc," SHWFPL, 20 November 2015.

LIST OF TABLES

Table 4 Permitted turbine layout for the SHWF WEF site [34]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
T1	696868	5853108	363	T71	704536	5846907	357
T2	696940	5852658	353	T72	704978	5846874	380
T3	703137	5852595	403	T74	709981	5845071	364
T4	697977	5852393	361	T75	710638	5844993	373
T6	703358	5852221	403	T76	711338	5844676	381
T7	697402	5852197	364	T77	709978	5844414	359
T8	703914	5852120	395	T78	711801	5844214	380
T9	702772	5852079	403	T79	710846	5844106	366
T10	699612	5852021	387	T80	704433	5844074	375
T11	704373	5851985	399	T81	712367	5844039	370
T16	702178	5851857	390	T82	713221	5843935	353
T19	702955	5851498	378	T84	704924	5843925	387
T20	699335	5851479	355	T85	711549	5843735	372
T22	699165	5851229	349	T86	712122	5843643	371
T24	702970	5850998	369	T87	701948	5843413	354
T27	704743	5850634	393	T88	711108	5843206	363
T30	704408	5850488	388	T89	704326	5843181	378
T33	708019	5849599	390	T90	703129	5843074	377
T37	711039	5849388	392	T91	703682	5843074	387
T39	710215	5849187	389	T92	712003	5843027	356
T40	712257	5849155	408	T93	710992	5842642	355
T41	709859	5848959	373	T94	702005	5842614	361
T43	708113	5848895	401	T95	703975	5842584	386
T44	707007	5848842	386	T96	704597	5842272	388
T45	706620	5848796	377	T97	702236	5842078	367
T46	711066	5848788	425	T98	701711	5841977	361
T48	707436	5848739	400	T99	701240	5841808	356
T50	709894	5848580	371	T101	702617	5841384	376
T51	707730	5848580	410	T103	703947	5841234	393
T52	712461	5848570	403	T104	703257	5841109	386
T53	710545	5848561	383	T106	701156	5841036	363
T55	711018	5848407	415	T107	701787	5840921	373
T56	708245	5848375	387	T110	702393	5840813	378
T57	707949	5848373	406	T111	704465	5840771	422
T58	706735	5848344	369	T112	703908	5840683	399
T59	712142	5848334	391	T114	703538	5840538	393
T60	707816	5847982	400	T115	702966	5840440	387
T61	708355	5847951	366	T117	701229	5840325	361
T62	709347	5847730	363	T119	703841	5840174	404
T63	706988	5847683	392	T120	701949	5840148	372
T64	709896	5847674	371	T122	698261	5840040	334
T65	706695	5847427	397	T124	702672	5839840	381
T66	706210	5847386	401	T125	699006	5839809	340
T67	707298	5847319	375	T126	700843	5839741	362
T68	705785	5847306	394	T129	703356	5839589	388
T69	705309	5847200	389	T130	701542	5839580	366
T70	706124	5846908	388	T131	698132	5839579	342

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

Table 4 Permitted turbine layout for the SHWF WEF site (concluded)

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
T132	709657	5839599	357	T201	710814	5833400	358
T135	707737	5839332	364	T202	713599	5833261	374
T136	702230	5839323	371	T203	711328	5833175	420
T138	699985	5839305	356	T204	714854	5833145	343
T141	700575	5839230	365	T205	713165	5833124	398
T142	699342	5839207	350	T206	711830	5833093	404
T147	709017	5839030	359	T207	713877	5832973	361
T148	702781	5838952	381	T208	712890	5832883	398
T149	698237	5839117	339	T209	712436	5832864	412
T151	699851	5838823	353	T210	713448	5832852	378
T154	700519	5838761	364	T211	715370	5832803	350
T155	701240	5838729	362	T212	709619	5832669	340
T156	698666	5838721	346	T213	713943	5832540	362
T157	702175	5838677	369	T214	715999	5832529	349
T163	699236	5838531	350	T215	709211	5832495	337
T168	700233	5838255	354	T216	713462	5832416	369
T169	701018	5838210	354	T217	713058	5832406	380
T173	701717	5838266	358	T219	712599	5832185	373
T177	700362	5837333	333	T220	709670	5831931	338
T179	699904	5837228	329	T223	712047	5831876	364
T182	700861	5836863	331	T225	712595	5831692	364
T188	712785	5834669	368	T226	713177	5831549	363
T191	713251	5834205	362	T229	711479	5831186	352
T192	714223	5834160	350	T232	712488	5830972	351
T193	712655	5834138	385	T233	713258	5830831	355
T194	712261	5833993	384	T235	713814	5830566	355
T195	713665	5833810	363	T238	714641	5830405	353
T196	712709	5833724	394	T239	712357	5830193	337
T197	711241	5833645	374	T240	713134	5830081	347
T198	714421	5833566	348	T241	713824	5829942	347
T199	712328	5833462	414	T242	714525	5829811	342
T200	713064	5833446	397				

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

Table 5 Amended turbine layout for the SHWF WEF site [35]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
A1	701970	5851867	394	F7	697918	5839649	328
A2	702658	5852068	405	G1	702406	5840754	379
A3	702934	5851497	379	G2	702091	5840217	374
A4	703087	5852543	409	G3	701554	5839757	366
A5	703596	5852201	410	G4	701578	5839096	364
A6	704067	5852005	416	G5	701099	5838869	363
A7	704594	5851892	426	G6	700212	5838479	356
A8	699612	5852021	387	G7	699336	5838700	349
A9	699390	5851545	356	H1	702753	5839828	383
A10	698013	5852388	360	H2	702915	5838918	379
A11	697535	5852650	345	H3	702311	5839261	373
A12	696914	5852640	353	H4	702305	5838649	367
A13	696970	5853262	353	H5	701753	5838374	360
A14	702961	5850946	368	H6	700028	5837050	327
A15	704533	5850422	405	H7	700797	5836663	329
B1	702763	5841264	380	I1	703046	5840522	389
B2	703420	5841212	388	I2	703567	5840557	393
B3	703485	5841740	387	I3	703965	5841397	393
B4	703968	5842414	386	I4	704651	5840903	436
B5	704476	5842359	387	I5	704140	5840608	401
B6	704167	5843295	370	I6	703881	5839976	400
B7	704971	5843907	388	I7	703445	5839409	392
C1	702454	5841969	372	J1	710426	5848610	375
C2	702900	5842225	373	J2	710225	5849113	387
C3	703463	5842528	382	J3	711174	5848720	428
C4	703683	5843029	388	J4	711186	5849226	392
C5	703127	5842919	378	J5	712244	5849137	409
C6	702608	5842843	366	J6	712356	5848444	401
C7	701943	5843592	353	K1	709970	5847874	371
D1	702129	5841376	369	K2	709861	5848586	371
D2	701795	5841798	361	K3	709736	5849070	368
D3	701242	5841562	358	K4	708283	5848579	371
D4	699605	5839811	347	K5	708248	5849092	380
D5	699070	5839935	340	K6	708058	5849561	392
E1	701107	5840803	361	L1	709263	5847903	364
E2	701345	5840315	364	L2	708463	5847573	366
E3	700969	5839898	364	L3	708518	5848087	365
E4	700750	5839386	358	L4	707943	5847939	395
E5	699995	5839374	354	L5	707771	5848564	414
E6	698674	5839618	341	L6	707279	5848336	388
E7	698244	5840083	334	L7	706700	5848304	368
F1	701686	5840831	373	M1	707415	5847830	392
F2	700448	5838975	365	M2	707000	5847645	394
F3	699878	5838908	353	M3	707325	5847306	374
F4	699322	5839251	351	M4	706643	5847404	397
F5	698765	5838888	346	M5	706178	5847399	399
F6	698366	5839207	341	M6	705657	5847248	391

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

Table 5 Amended turbine layout for the SHWF WEF site (concluded)

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base Elevation [m]
M7	706020	5846821	381	R6	713443	5834084	361
N1	710101	5844908	365	S1	711819	5832989	395
N2	709880	5844452	360	S2	711409	5833292	412
N3	710626	5844786	372	S3	711050	5833660	365
N4	710355	5844267	361	S4	710612	5833401	352
N5	709710	5839595	356	S5	709511	5832837	336
N6	709035	5838816	358	S6	709045	5832608	334
N7	707918	5839334	363	T1	712356	5832208	373
O1	710924	5844017	365	T2	712485	5831487	361
O2	711505	5843838	373	T3	712393	5830780	348
O3	712086	5843715	372	T4	712323	5830287	341
O4	711783	5843045	356	T5	711536	5830952	347
O5	711274	5843205	364	T6	709467	5831817	336
O6	710958	5842681	356	U1	712846	5832338	380
P1	711386	5844646	380	U2	713076	5830672	352
P2	711996	5844324	381	U3	712910	5830158	346
P3	712567	5844036	366	U4	713649	5830388	352
P4	713180	5844022	354	U5	713936	5829969	349
Q1	712736	5832837	401	U6	714438	5829859	342
Q2	713114	5833173	397	U7	714540	5830355	351
Q3	713566	5833496	372	V1	713303	5832554	377
Q4	713904	5833871	358	V2	713580	5832976	374
Q5	714394	5834054	348	V3	714056	5833144	356
R1	712247	5832704	399	V4	714504	5833560	346
R2	712275	5833249	420	V5	714973	5833364	342
R3	712257	5833760	393	V6	715577	5832941	348
R4	712717	5834028	389	V7	716240	5832587	344
R5	713079	5833676	388				

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

Table 6 Dwellings in the vicinity of the proposed SHWF WEF [36]

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B001	709253	5852775	Non-participant	3.4	3.4
B002	709103	5852574	Non-participant	3.2	3.2
B003	705834	5855618	Non-participant	3.9	3.9
B004	708680	5852063	Non-participant	2.6	2.6
B005	707306	5851747	Non-participant	2.3	2.3
B006	706605	5851433	Non-participant	2.0	2.1
B007	706246	5853633	Non-participant	2.5	2.4
B008	706041	5855885	Non-participant	4.2	4.3
B009	715845	5854392	Non-participant	6.4	6.4
B010	715883	5854127	Non-participant	6.2	6.2
B011	716575	5853899	Non-participant	6.4	6.4
B012	716395	5853862	Non-participant	6.3	6.3
B013	716220	5853816	Non-participant	6.1	6.1
B014	716002	5853835	Non-participant	6.0	6.0
B015	716168	5853731	Non-participant	6.0	6.0
B016	716394	5853765	Non-participant	6.2	6.2
B017	716505	5853830	Non-participant	6.3	6.3
B018	716934	5854121	Non-participant	6.8	6.8
B019	716830	5854001	Non-participant	6.7	6.7
B020	716877	5852934	Non-participant	6.0	6.0
B021	716431	5853147	Non-participant	5.8	5.8
B022	716170	5853289	Non-participant	5.7	5.7
B023	715767	5853144	Non-participant	5.3	5.3
B024	715580	5852470	Non-participant	4.7	4.7
B025	714066	5851837	Non-participant	3.2	3.3
B026	713929	5850701	Non-participant	2.3	2.3
B027	713027	5850072	Non-participant	1.2	1.2
B028	712786	5850338	Non-participant	1.3	1.3
B029	712701	5850234	Non-participant	1.2	1.2
B030	712790	5850384	Non-participant	1.3	1.4
B031	**712833**	**5850699**	**Proponent**	**1.7**	**1.7**
B032	711989	5850969	Non-participant	1.8	1.9
B033	712117	5850655	Non-participant	1.5	1.5
B034	711791	5850931	Non-participant	1.7	1.8
B035	716004	5852745	Non-participant	5.2	5.2
B036	716920	5851343	Non-participant	5.1	5.2
B038	706141	5854178	Non-participant	2.8	2.8
B039	705948	5853269	Non-participant	2.0	1.9
B040	705306	5853644	Non-participant	1.9	1.9
B041	704777	5853649	Non-participant	1.7	1.8
B042	705083	5853659	Non-participant	1.8	1.8
B043	706103	5856227	Non-participant	4.6	4.6

Note 1. Coordinate system: MGA zone 55, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**

Table 6 Dwellings in the vicinity of the proposed SHWF WEF (continued)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B044	701488	5854951	Non-participant	2.9	2.9
B047	717770	5849678	Non-participant	5.4	5.5
B048	717642	5843680	Non-participant	4.4	4.5
B049	716355	5845487	Non-participant	3.5	3.5
B050	715305	5847097	Non-participant	3.2	3.2
B051	714233	5847191	Non-participant	2.2	2.3
B052	715247	5846997	Non-participant	3.2	3.2
B053	*711656*	*5847683*	*Participant*	*0.8*	*1.0*
B054	714501	5847882	Non-participant	2.1	2.2
B055	714636	5848316	Non-participant	2.2	2.3
B056	714412	5849632	Non-participant	2.2	2.2
B057	**709858**	**5848031**	**Proponent**	**0.4**	**0.2**
B058	*709623*	*5846924*	*Participant*	*0.8*	*1.0*
B060	711327	5846673	Non-participant	1.7	1.8
B061	711434	5846970	Non-participant	1.5	1.7
B064	*710107*	*5842201*	*Participant*	*1.0*	*1.0*
B065	710656	5840980	Non-participant	1.7	1.7
B066	711322	5840668	Non-participant	2.0	1.9
B067	*711516*	*5840928*	*Participant*	*1.8*	*1.8*
B068	*711535*	*5840979*	*Participant*	*1.8*	*1.8*
B069	713317	5840575	Non-participant	2.8	2.9
B070	713827	5840711	Non-participant	2.9	3.1
B071	713723	5840190	Non-participant	3.3	3.5
B072	715185	5840037	Non-participant	4.4	4.5
B073	715753	5839898	Non-participant	4.8	4.9
B074	717966	5837255	Non-participant	4.9	4.8
B075	721038	5833146	Non-participant	5.1	4.8
B076	720969	5833283	Non-participant	5.0	4.8
B077	719971	5833062	Non-participant	4.0	3.8
B078	717670	5834191	Non-participant	2.4	2.1
B079	716270	5834805	Non-participant	2.1	1.9
B080	*714306*	*5834879*	*Participant*	*0.7*	*0.8*
B081	714359	5836174	Non-participant	2.0	2.1
B082	*713434*	*5836246*	*Participant*	*1.7*	*2.2*
B083	712039	5835649	Non-participant	1.2	1.8
B084	711563	5835716	Non-participant	1.6	2.0
B085	*709505*	*5834994*	*Participant*	*2.1*	*1.9*
B086	708905	5835003	Non-participant	2.4	2.3
B087	702623	5833807	Non-participant	3.5	3.4
B088	702393	5833547	Non-participant	3.7	3.5

Note 1. Coordinate system: MGA zone 55, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**

Table 6 Dwellings in the vicinity of the proposed SHWF WEF (continued)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B089	699411	5833374	Non-participant	3.8	3.6
B090	*706893*	*5836340*	*Participant*	*3.1*	*3.2*
B091	704569	5837080	Non-participant	2.6	2.5
B092	704428	5836948	Non-participant	2.6	2.5
B094	710285	5837274	Non-participant	2.2	2.0
B095	713414	5837411	Non-participant	2.8	3.3
B096	716404	5836000	Non-participant	2.9	2.8
B097	*708404*	*5839745*	*Participant*	*0.8*	*0.6*
B098	708496	5840559	Non-participant	1.4	1.4
B100	718995	5830670	Non-participant	3.5	3.4
B101	718803	5830632	Non-participant	3.4	3.2
B102	*715232*	*5831362*	*Participant*	*1.1*	*1.2*
B103	*714106*	*5831545*	*Participant*	*0.9*	*1.2*
B104	*710991*	*5832179*	*Participant*	*1.1*	*1.2*
B106	706915	5832957	Non-participant	2.3	2.2
B107	706518	5832414	Non-participant	2.7	2.5
B108	706945	5851749	Non-participant	2.4	2.3
B109	706737	5851857	Non-participant	2.3	2.1
B110	705895	5851752	Non-participant	1.5	1.3
B111	706523	5850435	Non-participant	1.6	1.8
B112	*704918*	*5849066*	*Participant*	*1.5*	*1.4*
B113	704757	5848887	Non-participant	1.6	1.6
B114	703278	5849485	Non-participant	1.5	1.5
B115	*703163*	*5849249*	*Participant*	*1.8*	*1.7*
B116	698351	5849121	Non-participant	2.3	2.6
B117	698102	5849512	Non-participant	2.0	2.4
B118	698274	5850428	Non-participant	1.2	1.6
B119	*698409*	*5850995*	*Participant*	*0.8*	*1.1*
B120	*699102*	*5852320*	*Participant*	*0.6*	*0.6*
B121	699081	5853513	Non-participant	1.6	1.6
B122	698915	5853297	Non-participant	1.3	1.3
B123	700927	5853569	Non-participant	2.0	2.0
B124	*695961*	*5853202*	*Participant*	*0.9*	*1.0*
B125	695651	5853628	Non-participant	1.3	1.4
B126	695035	5852103	Non-participant	2.0	2.0
B127	*696999*	*5851953*	*Participant*	*0.5*	*0.7*
B128	694824	5855205	Non-participant	2.9	2.9
B129	693313	5849068	Non-participant	5.1	5.1
B130	693723	5848697	Non-participant	5.1	5.1

Note 1. Coordinate system: MGA zone 54, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**

Table 6 Dwellings in the vicinity of the proposed SHWF WEF (continued)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B131	694024	5848704	Non-participant	4.9	4.9
B132	696638	5846790	Non-participant	5.1	5.5
B133	699038	5847188	Non-participant	4.0	4.4
B135	699823	5845172	Non-participant	2.8	2.6
B136	700331	5845536	Non-participant	2.7	2.5
B138	701579	5846427	Non-participant	3.0	2.9
B139	701437	5846769	Non-participant	3.1	3.2
B140	*706705*	*5846346*	*Participant*	*0.8*	*0.8*
B141	707855	5845963	Non-participant	1.5	1.4
B142	*706409*	*5844807*	*Participant*	*1.7*	*1.7*
B143	*703669*	*5844423*	*Participant*	*0.8*	*1.2*
B144	*703729*	*5844762*	*Participant*	*1.0*	*1.5*
B145	*705091*	*5843052*	*Participant*	*0.8*	*0.9*
B146	*705384*	*5841864*	*Participant*	*0.9*	*1.0*
B148	**703243**	**5842092**	**Proponent**	**0.9**	**0.4**
B149	*701380*	*5842799*	*Participant*	*0.7*	*1.0*
B150	697071	5842569	Non-participant	2.8	2.8
B151	*696932*	*5840842*	*Participant*	*1.6*	*1.5*
B152	695303	5840152	Non-participant	2.9	2.7
B153	696205	5848320	Non-participant	4.1	4.4
B154	692562	5844476	Non-participant	7.2	7.2
B155	691686	5841430	Non-participant	6.7	6.5
B156	690181	5839072	Non-participant	7.9	7.7
B157	696576	5831205	Non-participant	6.9	6.8
B158	696621	5831854	Non-participant	6.3	6.2
B159	694905	5832734	Non-participant	6.7	6.7
B160	702271	5831469	Non-participant	5.6	5.4
B161	702481	5831000	Non-participant	6.1	5.9
B162	702809	5830889	Non-participant	6.3	6.1
B163	703568	5830306	Non-participant	6.0	5.9
B164	703998	5830018	Non-participant	5.8	5.7
B165	705070	5829936	Non-participant	4.9	4.8
B166	705333	5829263	Non-participant	5.0	4.9
B167	702547	5836483	Non-participant	1.7	1.8
B168	*701154*	*5837552*	*Participant*	*0.7*	*1.0*
B169	*699647*	*5837851*	*Participant*	*0.7*	*0.8*
B170	*699004*	*5837890*	*Participant*	*0.7*	*0.9*
B171	*697423*	*5837889*	*Participant*	*1.5*	*1.6*
B172	696587	5838653	Non-participant	1.7	1.7
B173	698026	5833424	Non-participant	4.2	4.1
B174	697305	5834802	Non-participant	3.6	3.5

Note 1. Coordinate system: MGA zone 54, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**

Table 6 Dwellings in the vicinity of the proposed SHWF WEF (continued)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B175	696077	5836315	Non-participant	3.5	3.7
B176	694851	5838023	Non-participant	3.6	3.5
B177	694373	5837127	Non-participant	4.3	4.3
B178	694077	5835604	Non-participant	5.4	5.6
B179	693544	5836855	Non-participant	5.2	5.2
B180	692574	5836989	Non-participant	6.0	6.0
B184	693412	5853729	Non-participant	3.5	3.6
B195	702588	5833533	Non-participant	3.8	3.6
B197	712844	5837841	Non-participant	3.2	3.6
B198	714900	5827679	Non-participant	2.2	2.2
B199	716612	5827718	Non-participant	3.0	3.0
B200	718935	5830768	Non-participant	3.4	3.2
B201	700018	5845000	Non-participant	2.5	2.4
B203	*701684*	*5836682*	*Participant*	*0.8*	*0.9*
B204	712419	5850879	Non-participant	1.7	1.8
B206	706486	5853879	Non-participant	2.8	2.7
B207	706521	5853668	Non-participant	2.7	2.6
B208	706617	5853818	Non-participant	2.9	2.8
B209	706738	5853831	Non-participant	3.0	2.9
B210	706910	5853605	Non-participant	3.0	2.9
B211	706857	5853769	Non-participant	3.1	2.9
B212	707009	5853674	Non-participant	3.1	3.0
B231	709861	5851553	Non-participant	2.4	2.5
B232	710300	5851971	Non-participant	2.7	2.9
B233	710527	5852441	Non-participant	3.1	3.3
B241	711040	5851667	Non-participant	2.3	2.4
B244	701479	5846909	Non-participant	3.1	3.4
B245	*701784*	*5837154*	*Participant*	*1.0*	*1.1*
B277	711867	5822874	Non-participant	7.3	7.4
B278	711166	5823834	Non-participant	6.5	6.6
B279	710813	5824483	Non-participant	5.9	6.0
B281	709264	5827151	Non-participant	4.3	4.4
B282	709091	5827129	Non-participant	4.5	4.5
B283	709129	5827325	Non-participant	4.3	4.4
B284	708874	5827202	Non-participant	4.6	4.6
B285	708881	5827251	Non-participant	4.6	4.6
B286	708633	5827445	Non-participant	4.6	4.5
B287	708681	5827539	Non-participant	4.5	4.4
B288	708749	5827498	Non-participant	4.5	4.4
B289	708814	5827492	Non-participant	4.5	4.4

Note 1. Coordinate system: MGA zone 54, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**

Table 6 Dwellings in the vicinity of the proposed SHWF WEF (concluded)

House ID	Easting[1] [m]	Northing[1] [m]	Status	Distance to nearest turbine (permitted layout) [km]	Distance to nearest turbine (amended layout) [km]
B290	708865	5827610	Non-participant	4.3	4.3
B291	708818	5827722	Non-participant	4.3	4.2
B292	708732	5827862	Non-participant	4.2	4.0
B293	708826	5827885	Non-participant	4.1	4.0
B294	708556	5827971	Non-participant	4.1	4.0
B295	709077	5828092	Non-participant	3.9	3.8
B318	*710635*	*5849884*	*Participant*	*0.6*	*0.9*
B322	*715703*	*5831166*	*Participant*	*1.3*	*1.4*
B328	712415	5850552	Non-participant	1.4	1.4
B329	706914	5854214	Non-participant	3.4	3.3
B332	707013	5853968	Non-participant	3.3	3.2
B334	705741	5853638	Non-participant	2.1	2.1
B335	706403	5852464	Non-participant	2.1	1.9
B337	708961	5835013	Non-participant	2.4	2.2
B343	*697991*	*5838011*	*Participant*	*1.0*	*1.2*
B345	*705393*	*5841802*	*Participant*	*0.9*	*1.1*
B346	696903	5842589	Non-participant	2.9	2.8
B350	699482	5845603	Non-participant	3.3	3.2
B351	699461	5845612	Non-participant	3.3	3.2
B352	699821	5845416	Non-participant	2.9	2.8
B359	696246	5848285	Non-participant	4.1	4.4
B360	698115	5849553	Non-participant	2.0	2.4
B366	705718	5852253	Non-participant	1.4	1.2
B372	710981	5851953	Non-participant	2.6	2.7
B374	707802	5851498	Non-participant	1.9	2.0
B376	709136	5851854	Non-participant	2.5	2.5
B377	709064	5851853	Non-participant	2.5	2.5
B379	710595	5851603	Non-participant	2.3	2.5
B382	718811	5830906	Non-participant	3.2	3.1
B385	699955	5833024	Non-participant	3.9	3.7
B387	715033	5827530	Non-participant	2.3	2.4
B388	714773	5827574	Non-participant	2.3	2.3
B390	714479	5826837	Non-participant	3.0	3.0
B420	707834	5851472	Non-participant	1.9	1.9

Note 1. Coordinate system: MGA zone 54, GDA94 datum
Participant dwellings are indicated by *underlined italic text*
Proponent dwellings are indicated by **bold text**