Berrybank Wind Farm

Expert Witness Statement of Trenton Gilbert

(Expert witness retained by Berrybank Development Pty Ltd)

Shadow Flicker, Electromagnetic Interference, and Electromagnetic Fields

1 Name and address

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2 Area of expertise

- I hold the degrees of Bachelor of Engineering (Aerospace) and Doctor of Philosophy (Aerospace Engineering).
- My qualifications and experience are detailed in Annexure A.
- I have been involved with technical analyses for over 10 GW of proposed wind energy installations, including shadow flicker assessments for over 5 GW of proposed wind energy installations and electromagnetic interference (EMI) assessments for over 3 GW of proposed wind energy installations.
- I have significant experience in using appropriate software applications to model shadow flicker hours associated with wind farm projects and in assessing the potential electromagnetic interference impacts associated with wind farm projects.

3 Scope

3.1 Instructions

I have been commissioned by Herbert Smith Freehills on behalf of Berrybank Development Pty Ltd (**Berrybank Development**) to address the shadow flicker and EMI impacts of the proposed Berrybank Wind Farm and the changes to the wind farm layout and turbine dimensions proposed in the Amendment Applications. I have also been commissioned to act as an independent expert in relation to concerns raised in submissions received in respect of the Amendment Applications regarding:

- shadow flicker impacts
- EMI impacts on television, radio, mobile phone, and internet reception
- electromagnetic field (EMF) impacts.

I originally received the following written instructions from Herbert Smith Freehills:

> *"Your report should address the matters relating to electromagnetic interference as it is relevant to the Amendment Applications. It should also consider the potential for, and likely effectiveness of, any mitigation measures that may be available should nearby residents experience impacts to television and radio reception.*
>
> *…we expect that a number of submissions will be received in respect of the Amendment Applications… we request that you consider those submissions and respond to any relevant matters in your witness statement."*

In further communications with Herbert Smith Freehills, I received verbal instructions to also address matters relating to shadow flicker, as it is relevant to the Amendment Applications, and to respond to any matters relating to shadow flicker or EMF in the submissions received in respect of the Amendment Applications.

My opinions as to the likely shadow flicker, EMI, and EMF impacts of the proposed Berrybank Wind Farm are based on my experience in predicting and assessing the shadow flicker, EMI, and EMF impacts for proposed wind farms.

I have been provided with a copy of Planning Panel Victoria's Guide to Expert Evidence, and I am aware of my obligations as set out in those Guidelines.

3.2 Process and methodology

Shadow flicker and EMI assessments for the Berrybank Wind Farm site were initially conducted by Garrad Hassan Pacific Pty Ltd (now DNV GL) at the request of Robert Luxmore (for shadow flicker) and Environmental Resources Management Australia Pty Ltd (for EMI) on behalf of Union Fenosa Wind Australia Pty Ltd (**UFWA**) in 2009. The findings of those analyses are contained in Garrad Hassan Pacific report 45042/PR/001 Issue D [i] (the **Previous Shadow Flicker Assessment**) and Garrad Hassan Pacific report 45042/PR/02 Issue B [ii] (the **Previous EMI Assessment**).

DNV GL also conducted revised shadow flicker and EMI assessments for the Berrybank Wind Farm at the request of UFWA on behalf of Berrybank Development in December 2015 and April 2016 to account for proposed changes in the turbine layouts, hub heights, and rotor diameters. The findings of those analyses are contained in DNV GL report 170491-AUME-R-01 Issue B [iii] (the **Shadow Flicker Assessment**) and DNV GL report 170493-AUME-R-01 Issue C [iv] (the **EMI Assessment**), which were submitted by Berrybank Development as part of the Amendment Applications for the wind farm.

My role in the preparation of the Shadow Flicker and EMI Assessments was to oversee and check the analyses and approve the final reports.

I have drawn on my experience with wind energy projects (as detailed in Annexure A) to review the Shadow Flicker and EMI Assessments in order to address the issues discussed in this Statement.

3.3 Materials reviewed

In carrying out the work required to prepare this Statement, I have considered the following:

- Garrad Hassan Pacific report 45042/PR/001 Issue D (the **Previous Shadow Flicker Assessment**) [i]
- Garrad Hassan Pacific report 45042/PR/02 Issue B (the **Previous EMI Assessment**) [ii]
- DNV GL report 170491-AUME-R-01 Issue B (the **Shadow Flicker Assessment**) [iii]
- DNV GL report 170493-AUME-R-01 Issue C (the **EMI Assessment**) [iv]
- planning permit no. 20092820 (**Golden Plains Planning Permit**) [v] and planning permit no. 20092821 (**Corangamite Planning Permit**) [vi] (together, the **Planning Permits**)

- Lawrence Derrick & Associates “Berrybank Wind Farm – Pre-construction TV/Radio Reception Survey” (the **Pre-construction Reception Survey**) [xxii]
- submissions received in relation to the Amendment Applications
- Environment Protection and Heritage Council “National Wind Farm Development Guidelines – Draft” (**Draft National Guidelines**) [vii]
- Victoria State Government Department of Environment, Land, Water and Planning “Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria” (**Victorian Planning Guidelines**) [viii]
- cloud cover maps available on the Australian Government Bureau of Meteorology (BoM) website [ix]
- information contained in the Australian Communications and Media Authority (ACMA) database [x]
- information available on the Australian Government “mySwitch” website [xi].

3.4 Persons assisting with this work

In carrying out the work required to prepare this Statement, I have been assisted by Naomi Brammer, also an employee of DNV GL. Naomi Brammer’s qualifications and experience are set out in Annexure B.

4 Findings

The Shadow Flicker and EMI Assessments have been submitted by Berrybank Development as part of its Amendment Applications for the proposed Berrybank Wind Farm and I adopt them as the basis for my Statement and evidence. A summary of my findings is contained within this Statement.

4.1 Shadow flicker

The Draft National Guidelines and Victorian Planning Guidelines have been adopted as the basis for the analysis and results presented in the Shadow Flicker Assessment. Both the Draft National Guidelines and the Victorian Planning Guidelines provide recommendations for maximum shadow flicker durations that limit the impacts of shadow flicker to acceptable levels. In addition, the Draft National Guidelines provide background information, a proposed methodology, and a suite of assumptions for assessing shadow flicker durations in the vicinity of a wind farm.

It is also noted that condition 22 of the Golden Plans Planning Permit and condition 23 of the Corangamite Planning Permit state that *“[s]hadow flicker from the wind energy facility must not exceed 30 hours per annum at the surroundings of any dwelling existing prior to the issue date of this permit”*, however it is noted that this condition does not apply to dwellings on land on which part of the wind energy facility is erected.

The results of the Shadow Flicker Assessment show that, based on the assessment methodology recommended in the Draft National Guidelines, two inhabited dwellings in the vicinity of the Berrybank Wind Farm are predicted to experience annual theoretical shadow flicker durations greater than the recommended limit of 30 hours per year. I have been advised that both these dwellings are the property of stakeholders in the proposed Berrybank Wind Farm. When likely reductions in shadow flicker due to cloud cover and turbine orientation are considered, the predicted actual annual shadow flicker at all dwellings is below the recommended limit of 10 hours per year.

The Previous Shadow Flicker Assessment found that one inhabited dwelling in the vicinity of the Berrybank Wind Farm was predicted to experience annual theoretical shadow flicker durations greater than the recommended limit of 30 hours per year. According to the assessment report, this

dwelling was also the property of stakeholders in the proposed Berrybank Wind Farm. It is noted that these results may be conservative, since reductions in shadow flicker due to cloud cover and turbine orientation were not considered in the Previous Shadow Flicker Assessment.

Based on the results of the shadow flicker assessments, the changes proposed in the Amendment Applications increase by one the number of dwellings that are predicted to experience theoretical shadow flicker durations above the recommended limits. Nevertheless, the dwellings are both stakeholder dwellings, and the predicted shadow flicker durations for the proposed turbine layout and dimensions are compliant with the relevant guidelines when reductions due to cloud cover and turbine orientation are taken into account.

Mitigation

When assessed under the Draft National Guidelines, and considering likely reductions in shadow flicker due to cloud cover and turbine orientation, the predicted annual shadow flicker durations at dwellings in the vicinity of the proposed Berrybank Wind Farm are within the recommended limits. In the event that an individual finds that the annoyance caused by shadow flicker durations below the recommended limits is unacceptable, a range of mitigation options are available to reduce the shadow flicker experienced at the affected dwelling. Mitigation strategies include planting of trees or other vegetation, construction of screening structures, installation of heavy blinds or shutters, or implementation of turbine control strategies that shut turbines down when shadow flicker is likely to be a problem. However the shadow flicker limits in effect, and the conditions in the Planning Permit are intended to keep shadow flicker durations to acceptable levels.

4.2 EMI overview

The results of the EMI Assessment show that, for most radiocommunication services near the Berrybank Wind Farm, the changes proposed in the Amendment Applications are unlikely to cause any increase in the potential for EMI impacts compared to the previous wind farm and turbine configurations. Interference due to near-field effects or scattering of signals from nearby towers, or large-scale interference to television signals, is not expected for either the previous or amended layout. Feedback received from service operators via the consultation process undertaken in conjunction with the EMI Assessment also indicated that there would be no significant change in impact caused by the changes proposed in the Amendment Applications.

4.3 Point-to-point links

The current EMI Assessment identifies the potential for turbines at the Berrybank Wind Farm to cause interference to two fixed point-to-point links crossing the wind farm site. The potential for interference to these links, operated by the Country Fire Authority and Powercor, was not identified in the Previous EMI Assessment because the links did not exist at the time that assessment was conducted. Therefore, the increase in potential for interference to fixed point-to-point links noted in the EMI Assessment is entirely due to the presence of new point-to-point links crossing the wind farm site that were commissioned after the Planning Permits were granted, and not the changes proposed in the Amendment Applications. Point-to-point links can be impacted by the presence of wind turbines, through diffraction, reflection or scattering of the signal if it passes through one or more turbine rotors. Interference is likely to be encountered whether the changes proposed in the Amendment Applications are considered or not. Should impacts to point-to-point links be encountered, the primary mitigation measure available (assuming relocation of the turbines is not possible) would involve re-routing the links around the wind farm.

4.4 Television reception

For terrestrial television broadcasts from the Ballarat broadcast tower, Figure 17 in the EMI Assessment shows regions in which the television signal received at a dwelling is more likely to be affected by forward or back scatter from wind turbines at the Berrybank Wind Farm. This approach was used to identify dwellings that have increased likelihood of experiencing interference to

television reception. Based on this analysis, the changes in turbine layout proposed in the Amendment Applications decrease the number of houses in the potential interference zone for the Ballarat broadcast tower by three dwellings compared to the previous layout.

Nevertheless, the potential for a wind turbine to cause interference to television signals is likely to be proportional to the radar cross section of the turbine, which is typically proportional to the turbine dimensions. Therefore, the increase in turbine size associated with the Amendment Applications may result in an increased potential for interference to television signals.

Mitigation

Although the changes proposed in the Application Amendments may result in increased potential for interference to television signals, a range of mitigation options are available to rectify issues if they arise. These options include adjusting the alignment or height of the television antenna at the affected dwelling, tuning the antenna into an alternative source of the signal, installing a more directional or higher-gain antenna, relocating the antenna, installing a cable or satellite television receiver at the dwelling, or installing a television repeater station to service the affected area.

It is also noted that conditions 23, 24 and 25 in the Golden Plains Planning Permit, and conditions 25, 26 and 27 in the Corangamite Planning Permit require completion of pre-construction television and radio reception surveys, and establish procedures to be invoked should interference be encountered. These conditions are intended to protect the television reception of residents in the vicinity of the wind farm.

4.5 Radio reception

The potential for interference to AM and FM radio signals is also likely to be proportional to the turbine dimensions, and may therefore be increased by the changes proposed in the Amendment Applications. Broadcast radio signals are generally not susceptible to interference from relatively small physical obstructions such as wind turbines. However, FM radio signals may be affected in the immediate vicinity of a wind turbine, or in low coverage areas if the direct line-of-sight between the transmission tower and a receiver is blocked by a turbine located within approximately 4 km of the transmitter. Figure 15 in the EMI Assessment indicates that there are no AM or FM radio transmitters within 4 km of turbines at the Berrybank Wind Farm and so it is unlikely that the turbines will cause large-scale interference due to signal obstruction.

Mitigation

In most cases, radio interference problems can be easily resolved by installing a high-quality antenna or amplifier at the affected residence.

It is also noted that conditions 23, 24 and 25 in the Golden Plains Planning Permit, and conditions 25, 26 and 27 in the Corangamite Planning Permit require completion of pre-construction television and radio reception surveys, and establish procedures to be invoked should interference be encountered. These conditions are intended to protect the television reception of residents in the vicinity of the wind farm.

5 Response to key submissions

5.1 Shadow flicker impacts: Berrybank WF Objections (3), (5), (6), (7), (8), (9), and (10)

Berrybank WF Objections (3), (6), (9), and (10) express concerns about the shadow flicker impact of the Berrybank Wind Farm, and the changes proposed in the Amendment Applications, including the effects of shadow flicker on human health, animals, and farming operations. Berrybank WF Objection (5) specifically expresses concerns about shadow flicker causing shading of land that “will prevent seed germination and result in subsequent loss of income from grain growing”.

Further concerns have been raised by Berrybank WF Objection (8) regarding the accuracy and relevance of the Shadow Flicker Assessment.

Dwellings and outdoor locations

Regarding shadow flicker impacts at dwellings in the vicinity of the wind farm, reference is made to Section 4.1 above. There are no requirements under either the Victorian Planning Guidelines or the Draft National Guidelines to assess shadow flicker durations at locations other than in the vicinity of dwellings, although it is noted that the Victorian Guidelines recommend assessing shadow flicker durations within the “garden fenced area” in the vicinity of a dwelling.

Berrybank Objection (9) notes that although planting screening vegetation close to the windows of dwellings will reduce the shadow flicker experienced by people indoors, it will have no effect on the shadow flicker experienced by people who are working outdoors on farming properties. The effects of shadow flicker are generally most noticeable for an observer indoors. This is because light levels indoors are lower, and the shadow cast by a wind turbine blade has the potential to intercept the only light source in the room. When an observer is outside, they are also exposed to ambient or diffuse light as well as direct sunlight. This means that if shadow flicker (also described as “passing shadows” when experienced outdoors [xii]) does occur, the variations in light level are typically lower in amplitude and are therefore less likely to cause annoyance. Moreover, the Victorian Planning Guidelines and the Draft National Guidelines do not set shadow flicker limits for outdoor locations and there is no requirement under either Guidelines to assess the shadow flicker durations at locations other than in the vicinity of dwellings.

Human health

Shadow flicker caused by wind turbines is generally not considered to have an impact on human health. Peer reviewed research conducted by the National Health and Medical Research Council (NHMRC) indicates that there is no scientific evidence linking shadow flicker with adverse health effects [xiii]. Other studies have also concluded that shadow flicker from wind turbines is unlikely to affect human health [xiv].

Historically, the primary health concern raised regarding shadow flicker has been the risk of inducing seizures in people with photosensitive epilepsy [xiv]. Several studies suggest that shadow flicker at frequencies greater than 3 Hz poses a potential risk of inducing epileptic seizures in susceptible people [xv,xvi]. For a wind turbine with three blades, this translates to a maximum rotational speed of 60 revolutions per minute. Modern wind turbines rotate at speeds of 6 to 20 revolutions per minute, corresponding to shadow flicker frequencies of 0.3 Hz to 1.0 Hz, which is well below the threshold frequency for photo-induced epileptic seizures.

Both the Draft National Guidelines and the NHMRC acknowledge that, if not properly managed, annoyance caused by shadow flicker could cause indirect health effects such as stress [vii,xiii]. In general, however, experimental studies have demonstrated that shadow flicker at frequencies below 2.5 Hz is unlikely to cause annoyance or disturbance to most observers [xii]. A laboratory investigation into the effects of exposure to simulated shadow flicker found that continuous exposure over a period of 60 minutes could cause stress effects and a temporary reduction in cognitive performance [xvii]. The annual shadow flicker limits recommended in the Draft National Guidelines are designed to prevent the risk of annoyance and potential stress caused by both short-term continuous exposure to shadow flicker and long-term intermittent exposure.

Animals and crops

Berrybank Objection (10) raises concerns about the effects of shadow flicker on domestic animals. To the best of my knowledge, no formal scientific studies have shown any evidence of on-going adverse impact on domestic animals caused by exposure to shadow flicker. Studies aimed at assessing the impact of shadow flicker on domestic horses have found that although some horses may exhibit minor behavioural changes upon initial exposure to shadow flicker, most become accustomed to the phenomenon and stop showing any response after only a short period of time [xviii,xix].

Results of more general investigations into the effects of wind farm development and operation on the behaviour of wild and semi-domestic mammals, specifically elk and reindeer, suggest that the presence of wind farms does not displace animals from surrounding habitats or impact their dietary quality [xx]. Additionally, no systematic differences in the measured behaviour patterns of the animals that could indicate either fear or stress were observed as a consequence of exposure to wind turbine operation [xxi].

Berrybank Objection (5) raises concerns about the effects of shadow flicker and shading on seed germination of grain crops. The theoretical shadow flicker durations presented in the Shadow Flicker Assessment predict the total amount of time in each year that moving shadows caused by the passage of the wind turbine blades between the sun and the ground may occur at a particular location. Since the turbine blades account for less than 0.8% of the total swept area of the rotor, the annual static shading experienced at any given location is expected to be considerably less than the predicted shadow flicker duration.

Based on these considerations, I have estimated the likely static shading effect that will be caused by turbines at the proposed Berrybank Wind Farm. Figure 1 shows the percentage of total annual daylight hours that may be affected by static turbine shading at locations in the surrounding area. The maximum shading effect occurs at the base of each turbine, where static shading may be experienced for up to 0.25% of the total annual daylight hours or approximately 11 hours per year. Most locations outside the immediate vicinity of the turbines are likely to experience static shading for less than approximately 0.12% of the annual daylight hours, or around 5 hours per year, and so it is unlikely that shading from the wind farm will have any discernible impact on grain crops.

Accuracy and relevance of the Shadow Flicker Assessment

Berrybank WF Objection (8) asserts that the cloud cover data used to predict the actual annual shadow flicker duration in the Shadow Flicker Assessment is not representative of cloud cover experienced in the Berrybank region. The Shadow Flicker Assessment relies on monthly cloud cover data recorded by the BoM at Ararat, Ballarat, and Colac to provide an estimate of the likely reduction in shadow flicker due to cloud cover. Monthly cloud cover maps available on the BoM website suggest that these three stations are reasonably representative of cloud cover in the Berrybank region throughout most of the year [ix]. Small seasonal differences are observed, which suggest that the cloud cover at Ararat and Ballarat is less than at Berrybank during the Summer months while the cloud cover at Colac is greater than at Berrybank during Autumn. However, these deviations have been minimised in the Shadow Flicker Assessment by averaging the monthly cloud cover data from all three stations. In the absence of reliable on-site cloud cover data, it is my opinion that the use of cloud cover data from the Ararat, Ballarat, and Colac BoM stations provides a reasonable estimate of the cloud cover at Berrybank. Moreover, since the Shadow Flicker Assessment does not consider reductions in shadow flicker caused by turbine shutdown during periods of low wind speed, or shielding from vegetation and structures, the shadow flicker durations predicted using cloud cover data may still be regarded as conservative.

5.2 EMI impacts: Berrybank WF Objections (3), (6), (7), and (8)

Berrybank WF Objections (3), (6), (7), and (8) express concerns about the EMI impact of the Berrybank Wind Farm, and the changes proposed in the Amendment Applications, on television, radio, mobile phone, and internet reception. Berrybank WF Objection (8) also expresses concerns about the accuracy and relevance of the EMI Assessment.

Mobile phone and internet reception

Regarding EMI impacts to mobile phone and internet reception, reference is made to the findings presented in the EMI Assessment, namely that:

- Mobile phone and wireless internet signals are generally not susceptible to interference in areas with good coverage.
- There are some areas with marginal mobile phone coverage which may be susceptible to interference from the wind farm.

- The operators of the mobile phone networks in the area were contacted to seek feedback on any potential impact that the wind farm could have on their services. Responses were received from Telstra and Optus and no concerns were raised regarding impacts to their services.
- The only identified operator of wireless internet services in the area, Aussie Broadband Pty Ltd, was contacted to seek feedback on any potential impact that the wind farm could have on their service. The response received from Aussie Broadband indicated that they do not have any concerns regarding impacts to their services.
- The National Broadband Network (NBN) is currently available in some areas surrounding the wind farm as a fixed wireless service. NBNco typically takes the presence of proposed wind farms into account when it establishes coverage maps for its wireless service. NBNco was contacted as part of the EMI Assessment and stated that they did not believe there would be any adverse impact on their services.

Berrybank WF Objection (8) raises concerns about the mitigation measures for resolving mobile phone reception problems suggested in the EMI Assessment report, and the ability of residents to make emergency phone calls or receive emergency information via mobile phone text messages and radio broadcasts in a timely manner. I acknowledge that the mitigation measures suggested in the EMI Assessment report may not be suitable in all situations. In some cases, it may be possible to achieve better mobile signal strength by moving a short distance from the original location.
In situations where the signal strength is more broadly affected, other mitigation options may be available to improve the mobile phone coverage in that area, such as the installation of new mobile communications infrastructure. Regarding EMI impacts to radio reception, and potential mitigation measures, reference is made to the discussion below and in Section 4.5 above.

Television and radio reception

Figure 17 in the EMI Assessment report indicates that dwellings in the area surrounding the Berrybank Wind Farm site have potential to experience interference to television signals from the Ballarat Tower Hill broadcast tower caused by scatter from turbines at the wind farm. Interference to television broadcasts due to signal scattering is generally more likely in areas where the existing signal is already weak or degraded. According to the Australian Government MySwitch website [xi], the areas around the Berrybank Wind Farm site currently experience good to variable signal coverage from the Ballarat Lookout Hill broadcast tower. Interference to the Ballarat signal may therefore be experienced in the surrounding area as a result of the Berrybank Wind Farm development. As noted above, the increased turbine dimensions proposed in the Amendment Applications may also increase the potential for interference to television signals.

Although the increased turbine dimensions proposed in the Amendment Applications may increase the potential for interference to AM and FM broadcast radio signals, these signals are generally not susceptible to interference from wind turbines. Figure 15 in the EMI Assessment indicates that there are no AM or FM radio transmitters within 4 km of turbines at the Berrybank Wind Farm and so it is unlikely that the turbines will cause interference due to signal obstruction.

The Planning Permits for the Berrybank Wind Farm includes a number of conditions that are intended to protect television and radio reception at dwellings in the vicinity of the wind farm. These include conditions 23, 24 and 25 in the Golden Plains Planning Permit, and conditions 25, 26 and 27 in the Corangamite Planning Permit

Pre-construction reception surveys

Condition 23 in the Golden Plains Planning Permit and condition 25 in the Corangamite Planning Permit state that “[a] pre-construction survey must be carried out… to determine television and radio reception strength at selected locations within 5kms of any wind turbine” in the absence of the wind farm. It is my understanding that these conditions will not be changed by the Amendment Applications, and the survey helps to understand the existing television and radio reception prior to construction. The Pre-construction Reception Survey for the Berrybank site was conducted in 2012 [xxii]. Although the Pre-construction Reception Survey was conducted before the completion

of the changeover from analogue to digital television, the report notes that, at the time of the survey, all residents in the survey area were receiving digital television signals.

Mitigation and post-construction reception surveys

If interference to television signals from the Ballarat broadcast tower is experienced at dwellings on account of the Berrybank Wind Farm, and no alternative broadcast signal is available, it may be possible to improve the reception at affected dwellings by adjusting the height or location of the existing antenna or installing a more directional or higher-gain antenna. Further mitigation options include installing cable or satellite television receivers at the affected dwellings, or installing a television repeater station to service the area. Interference to radio signals, if experienced, can usually be resolved by installing a high-quality antenna or amplifier at the affected residence.

Conditions 24 and 25 in the Berrybank Planning Permit state that a post-construction survey must be carried out at any dwelling where a complaint has been made regarding television or radio reception, and appropriate measures must be undertaken by the wind farm operator to mitigate interference if the complaint is substantiated. Specifically, those measures must “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”. It is my understanding that these conditions and obligations will not be changed by the Amendment Applications, and will help to ensure that television and radio reception at dwellings is protected after construction of the wind farm.

Accuracy and relevance of the EMI Assessment

Berrybank WF Objection (8) claims that the EMI Assessment incorrectly states that mobile phone reception is available in the wind farm area, and asserts that mobile phone services offered by Optus, Telstra, and Vodafone near the site are either very poor or not available. The EMI Assessment prepared by DNV GL used publicly-available coverage maps to assess the likely availability of mobile phone services near the wind farm. Confirmation of service availability was not sought from the service providers, and DNV GL staff did not visit the site to assess the mobile phone signal strength in the area. The network coverage maps reproduced in Figures 12, 13, and 14 in the EMI Assessment suggest that most areas in the vicinity of the wind farm site are able to receive 3G or 4G mobile phone signals from the Optus and Telstra networks, and 3G only signals from the Vodafone network, without the need for an external antenna while outdoors. However, it is possible that residents may experience reduced mobile phone reception while indoors due to attenuation of the signal as it passes through the walls of the building. I have not personally assessed the availability of mobile phone services in the vicinity of the proposed Berrybank Wind Farm site am therefore unable to verify the availability of mobile phone services in the area.

Berrybank WF Objection (8) also raises concerns that the EMI Assessment is based on out-dated information regarding television signal strength and the use of set top boxes to receive digital signals, and claims that the EMI Assessment states that this information was determined from an on-site survey of dwellings in the vicinity of the wind farm. Objection (8) may be referring to the Previous EMI Assessment, which was undertaken before the changeover from analogue to digital television was completed, as there is no mention of either set top boxes or a site visit to assess television signal strength in the current EMI Assessment. Alternatively, Objection (8) may be referring to the Pre-construction Reception Survey for the Berrybank site [xxii], which states that “All residents in the survey area have converted to digital TV receptions with the use of either digital set top boxes… or digital TV sets”. The EMI Assessment that was submitted as part of the Application Amendments for the proposed Berrybank Wind Farm was completed after the changeover from analogue to digital television and considers the potential impact of the wind farm on digital television signals. Television signal strengths reported in the EMI Assessment were determined from online coverage maps available on the “mySwitch” website [xi], and DNV GL staff did not conduct an on-site survey as part of the current assessment.

5.3 EMF impact: Berrybank WF Objections (2), (7), and (8)

Berrybank WF Objections (2) and (7) express concerns about the EMF impact of the Berrybank Wind Farm, and the changes proposed in the Amendment Applications, particularly with respect to

the effects on human health. In addition, Berrybank WF Objection (8) expresses concerns about the effect of EMF on mobile phone reception.

Human health

EMF associated with the generation, distribution, and use of electricity is classified as extremely low frequency (ELF) EMF. Guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommend that public exposure to ELF EMF at a frequency of 50 Hz be limited to an electric field strength of 5 kV/m and a magnetic flux density of 200 μT [xxiii]. These limits are based on extensive reviews of the current scientific knowledge of the direct and indirect effects of EMF on the human body, and are designed to provide protection against all established adverse health effects from EMF exposure. Acute exposure to ELF EMF at high levels can affect the function of the nervous system by causing electrostimulation of nerves and muscles, or can induce faint flickering light sensations called phosphenes at the edges of the visual field [xxiii, xxiv]. Despite a weak association between prolonged exposure to higher than normal ELF magnetic fields and childhood leukaemia, there is no established evidence that prolonged exposure to ELF EMF is associated with any chronic health effects [xxiii, xxiv].

According to the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the background EMF in most Australian homes associated with electrical wiring and household appliances has a magnetic flux density of around 0.1 μT and an electric field strength of up to 20 V/m [xxiii]. The EMF at ground level directly underneath an overhead powerline may be up to 20 μT and around 100 V/m to 10 kV/m [xxiii]. However, EMF strength decreases rapidly as the distance from the source increases. At a distance of 50 m from a high voltage power line, or 5-10 m from a substation or transformer, the magnetic field is generally no higher than typical background levels [xxv].

EMF strengths associated with the proposed Berrybank Wind Farm are expected to be well within the limits recommended by the ICNIRP guidelines at nearby dwellings and in areas that may be frequented by people, and are therefore unlikely to pose any risk to human health. Electrical components used in wind farms are typical of similar equipment used in other installations and do not pose a unique risk. Wind turbines such as those proposed for the Berrybank Wind Farm are designed, constructed, and operated in accordance with international and local standards and accepted industry practices, which limit the ELF EMF strengths to acceptable levels. Scientific studies have found that the EMF associated with operating wind farms is indistinguishable from background levels at 2 to 3 m from the wind turbines, and well below both the ICNIRP guidelines for public exposure and the EMF produced by many common household appliances [xxvi, xxvii].

It is noted that the 500 kV Moorabool-Heywood transmission line currently runs across the south-eastern boundary of the Berrybank Wind Farm site, while the 220 kV Ballarat-Terang transmission line is located approximately 4 km northwest of the site. Considering the close proximity of the wind farm to existing sources of ELF EMF, and the low EMF strengths expected at dwellings from those sources, any increment to the existing EMF levels that can be ascribed to presence of the wind farm is not likely to be significant. Moreover, the changes proposed in the Amendment Applications are not likely to significantly increase the EMF associated with the wind farm.

Mobile phone reception

Berrybank WF Objection (8) claims that mobile phone signals received in Berrybank are subject to interference from the 500 kV Moorabool-Heywood transmission line located between Berrybank and Cressy, and raises concerns about the effect of EMF from the proposed Berrybank Wind Farm on mobile phone reception. The main way that a wind farm can interfere with telecommunications signals is through the physical presence of the turbines causing signal obstruction or scattering, rather than through EMF produced by the turbines and associated electrical equipment. Although it is possible that mobile phone users could experience some interference in very close proximity to high voltage power lines, or other electrical equipment, I am not aware of any conclusive evidence that EMF can cause a reduction in mobile phone reception at greater distances.

As noted above, the Berrybank Wind Farm site is located between the 500 kV transmission line to the southeast and a 220 kV transmission line to the northwest. EMF strengths associated with the proposed wind farm are likely to be indistinguishable from background levels at nearby dwellings

and in areas that may be frequented by people. The presence of the wind farm and the changes proposed in the Amendment Applications are therefore not expected to significantly increase the EMF in the surrounding area compared to the current situation.

5.4 General: Berrybank WF Objection (8)

Berrybank WF Objection (8) claims that the reports submitted as part of the Amendment Applications date back to 2009 and are therefore not current. The Shadow Flicker and EMI Assessments submitted as part of the Amendment Applications for the proposed Berrybank Wind Farm were completed in December 2015 and April 2016 respectively, and are based on the most current wind farm and turbine configurations, national and state wind farm development guidelines, and meteorological and telecommunications data available at the time of the assessments.

6 Conclusion

DNV GL has previously conducted Shadow Flicker and EMI Assessments to determine the potential impacts of changes proposed in the Amendment Applications for the Berrybank Wind Farm. The Shadow Flicker Assessment shows that when assessed under the Draft National Guidelines, and considering likely reductions in shadow flicker due to cloud cover and turbine orientation, the predicted annual shadow flicker durations for the amended layout and turbine configurations are compliant with the recommended limits at all nearby dwellings. The EMI Assessment acknowledges that there is the potential for impacts to some services from both the previous and amended layout and turbine configurations, and that for some services the impacts arising from changes proposed in the Amendment Applications may be greater. However in many cases options are available to mitigate potential impacts, if necessary, or the relevant service operators have not raised concerns about the potential impact of the Amendment Applications.

Based on the Shadow Flicker and EMI Assessments, it is my opinion that the changes to the Berrybank Wind Farm proposed in the Amendment Applications could result in increased shadow flicker durations in some locations and increased potential for interference to television and radio broadcasts, particularly in areas of marginal signal strength. Nevertheless, predicted shadow flicker durations for the amended layout and turbine configurations are within the recommended limits at all dwellings when likely reductions due to cloud cover and turbine orientation are taken into account. If shadow flicker does cause annoyance, a range of mitigation options are available. In the case of television and radio signals, several mitigation options are also available to resolve any impacts that may arise.

Concerns have been raised regarding the potential shadow flicker from the proposed Berrybank Wind Farm at dwellings and outdoor locations, and the effects of shadow flicker on human health, animals, and crops. The Shadow Flicker Assessment has shown that the predicted annual shadow flicker durations at all dwellings near the wind farm, considering likely reductions in shadow flicker due to cloud cover and turbine orientation, are within the recommended limits. There are no requirements under either the Victorian Planning Guidelines or the Draft National Guidelines to assess shadow flicker at locations other than in the vicinity of dwellings, and shadow flicker is generally not expected to cause annoyance for observers outdoors. Although shadow flicker has the potential to cause annoyance to observers in the immediate vicinity of a wind farm, exposure to shadow flicker caused by wind turbines is generally not considered to adversely affect human health. Investigations into the impacts of wind farms on animal behaviour suggest that animals quickly adapt to the presence of turbines and exhibit no on-going adverse reactions. Areas outside the immediate vicinity of the turbines are expected to experience static shading for less than 0.12% of the annual daylight hours and so it is unlikely that shadow flicker and shading from the wind farm will have any discernible impact on the germination of grain crop seeds.

Concerns have been raised regarding the potential impacts of the Berrybank Wind Farm on television, radio, mobile phone, and wireless internet reception in the surrounding area. Dwellings near the wind farm have increased potential to experience interference to television signals from the Ballarat broadcast tower, but interference to radio signals is unlikely. The Berrybank Planning Permit states that a pre-construction reception survey must be carried out at locations within 5 km

of the wind turbines, which will ensure that the existing television and radio reception in the vicinity of the wind farm is understood before construction commences. In addition, a post-construction survey must be conducted at any dwelling where a complaint has been made regarding television or radio reception. If interference to television signals from the Ballarat tower is experienced at dwellings in the area, a number of mitigation options are available. Mobile phone and wireless internet signals may be susceptible to interference in areas with marginal coverage, but network operators have not raised any concerns regarding impacts to their services and mitigation options are available to resolve issues if they do arise.

Concerns have also been raised regarding EMF produced by the proposed Berrybank Wind Farm, and the potential effects on human health and mobile phone reception. Although acute exposure to EMF at high levels can cause short-term physical sensations, there is no established evidence that prolonged exposure to EMF arising from the generation, distribution, and use of electricity is associated with any chronic health issues. EMF strengths associated with the proposed Berrybank Wind Farm are expected to be well within the recommended limits in areas that may be frequented by people, and are therefore unlikely to pose any health risks. While interference to mobile phone signals could be experienced in close proximity to operating electrical equipment, I am not aware of any conclusive evidence that EMF can cause a reduction in mobile phone reception at greater distances. Considering that the Berrybank Wind Farm site is located between two existing high voltage transmission lines, the presence of the wind farm and the changes proposed in the Amendment Applications are not expected to significantly increase the EMF in the surrounding area.

Finally, concerns have been raised that the Shadow Flicker and EMI Assessments may not be sufficiently accurate or up to date. The Shadow Flicker and EMI Assessments submitted as part of the Amendment Applications for the proposed Berrybank Wind Farm were completed in December 2015 and April 2016 respectively. Both reports were based on the most current information, guidelines, and data available at the times of the Assessments, and the methodologies used are based on the recommendations of the Draft National Guidelines.

7 Opinion

The opinions that I have expressed in this Statement are based on my qualifications and experience. Subject to any limitations and exclusions outlined above, my opinions are complete and accurate in every respect.

I am satisfied through my inquiries that the opinions I have expressed are reasonable in regard to the impact of shadow flicker, EMI, and EMF in the vicinity of the proposed Berrybank Wind Farm.

8 Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Trenton Gilbert

Date: 8 November 2017

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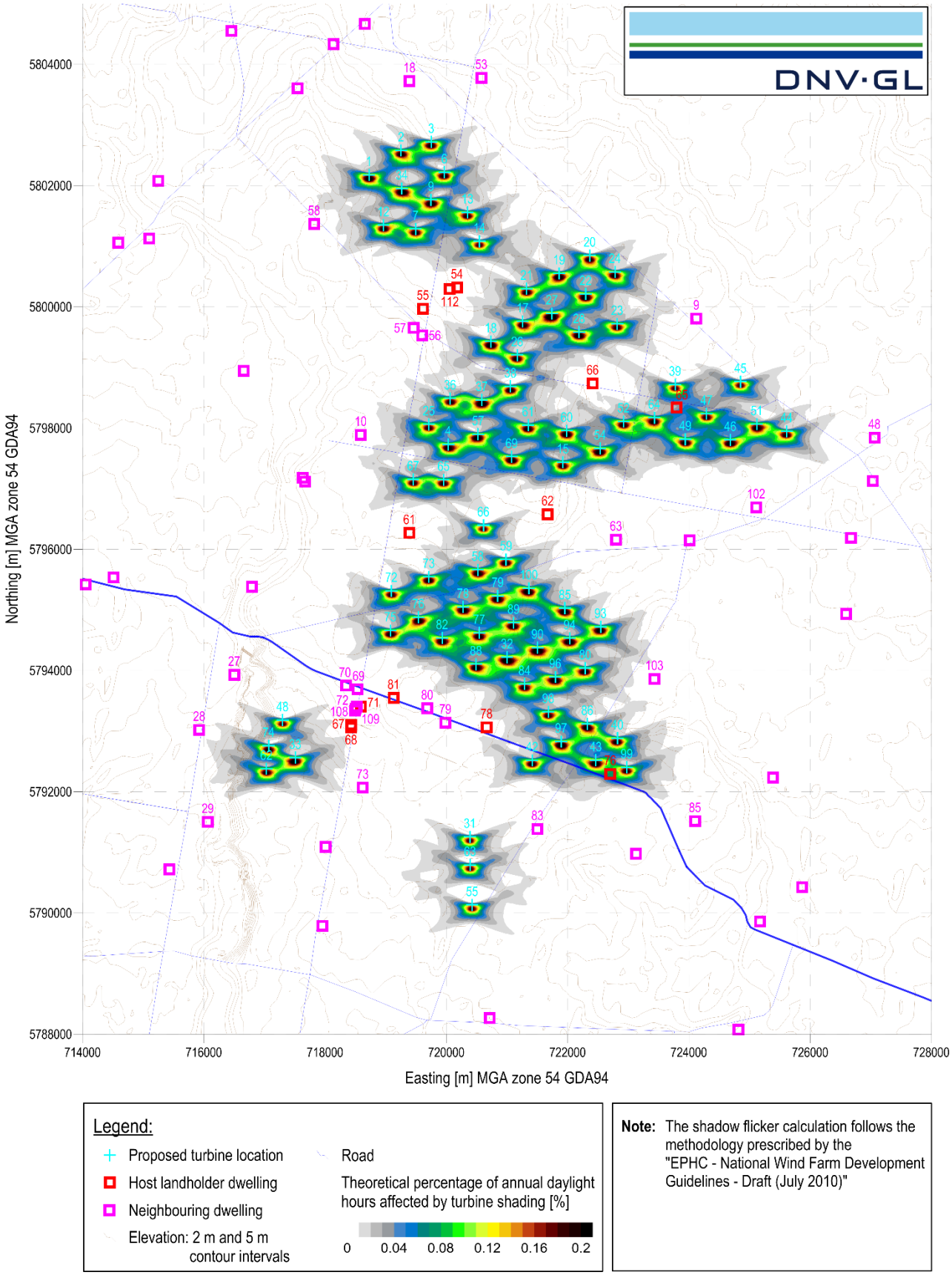

Figure 1: Percentage of total annual daylight hours that may be affected by turbine shading from the proposed Berrybank Wind Farm

Annexure A – Qualifications of Trenton Gilbert

Academic qualifications

Doctor of Philosophy (Aerospace Engineering), RMIT University, Melbourne, 2003

Bachelor of Engineering (Aerospace, Hons I), RMIT University, Melbourne, 1999

Membership of professional associations

Member, Engineers Australia (IEAust)

Associate, Royal Aeronautical Society (RAeS)

Detailed professional experience

Principal Engineer, Head of Section, Developer Support Services (Pacific)
DNV GL (formerly GL Garrad Hassan)
(2014 – Present)

Trenton is a Principal Engineer, and the Head of Section for Developer Support Services in the Pacific Region in the Renewables Advisory Division of DNV GL - Energy. He has a PhD in Aerospace Engineering and a BE in Aerospace.

Trenton has worked on a large number of wind farm projects throughout Australasia and Southeast Asia in support of developers and lenders, and is responsible for the delivery of a range of services including site identification, wind mapping, CFD, feasibility studies, wind monitoring programmes, layout development and optimisation, and technical inputs to environmental and planning assessments, including shadow flicker, electromagnetic interference (EMI) and visual impact assessments.

Trenton has presented evidence as an expert witness on shadow flicker and EMI at wind farm planning hearings, and has also been involved with site inspections, wind data analysis and energy production assessments for multiple wind farm projects.

Senior Engineer, Technical Lead, Development Services (Pacific)
DNV GL (formerly GL Garrad Hassan)
(2011 – 2014)

Senior Engineer
DNV GL (formerly GL Garrad Hassan)
(2008 – 2011)

Aerospace Engineer
DSTO (Defence Science & Technology Organisation)
(2003 – 2008)

DSTO is responsible for conducting and applying research in support of the Australian Department of Defence. Trenton played a key role in a number of projects, including:

- Development, validation and application of aerodynamic, inertial and propulsive models for predicting aircraft loads. These models were used to ensure the accuracy of loads measured on instrumented aircraft for the purpose for of performing aircraft life assessment.
- Involvement in flight testing of instrumented aircraft, and subsequent post-processing, analysis and visualisation of flight test data.

- Development of ground testing and numerical analysis techniques to assist with the prediction of aeroelastic instabilities in highly flexible aircraft.
- Involvement with ground vibration testing, flight flutter testing and subsequent data analysis for the purpose of aircraft envelope expansion.
- Development of parameter identification techniques based on numerical optimisation for use in developing databases for aircraft performance assessment.
- Management of long range research activities in aircraft loading and flight mechanics.

Postgraduate Researcher (PhD)
RMIT University
(2000 – 2003)

Trenton completed his PhD thesis titled “Non-linear Dynamic Modelling of Flexible Manoeuvring Structures”. This research involved the development of a technique based on a non-linear finite element method for modelling highly flexible robotic and aircraft structures in order to predict the loading experienced during manoeuvring.

Engineer (casual)
RMIT University
(2000 – 2003)

Trenton was employed on a casual basis by RMIT University whilst completing his PhD, and was involved in a number of activities, including:

- participation in development of numerical analysis and visualisation software
- assessment of structural flexibility of a trainer aircraft from deflection measurements
- use of data acquisition systems and data processing for aircraft fatigue life assessment
- conducting ground vibration testing and modal analysis of sporting equipment
- lecturing, tutoring, and student assessment in computer programming and dynamics.

Annexure B – Qualifications of Naomi Brammer

Academic qualifications

Doctor of Philosophy (Mechanical Engineering), Monash University, Melbourne, 2014

Bachelor of Engineering (Mechanical Engineering, Hons I), Monash University, Melbourne, 2004

Bachelor of Science, Monash University, Melbourne 2004.

Membership of professional associations

Member, Engineers Australia (IEAust)

Member, Australian Society for Technical Communication (ASTC)

Professional experience

Engineer
DNV GL (formerly GL Garrad Hassan)
(Aug 2015 – Present)

Naomi has been involved in a range of tasks associated with providing technical inputs to environmental and planning assessments, including shadow flicker and electromagnetic interference assessments. She also has experience with wind data analysis, performing energy assessments for wind farm development, and the use of remote sensing data.

Postgraduate Researcher (PhD)
Monash University
(2005 – 2014)

Naomi completed her PhD thesis titled “Exergy-Based Indicators of Environmental Impact: Influence of Methodological Choices”. This research examined the use of exergy, a measure of deviation from the state of the environment, as an indicator to assess and compare the environmental impact of human activities. It showed that recommendations based on these comparisons can change depending on how the indicator or the environment is defined.

Assistant Lecturer and Teaching Associate
Monash University
(2005 – 2012)

Naomi was employed as a lecturer and unit coordinator for several introductory units in thermodynamics, heat transfer, and power cycles for Mechanical, Aerospace, and Chemical Engineering students from 2008 to 2012. Prior to this, she worked as a demonstrator and tutor for laboratory and problem solving classes in thermodynamics, physics, and engineering drafting. During this time, Naomi also assisted in the training of demonstrators and tutors in the Faculty of Engineering, and jointly developed and implemented a new approach to teaching and assessing written communication skills in thermodynamics units.