

**IN THE MATTER** of the Resource  
Management Act 1991

**AND**

**IN THE MATTER** of a Board of Inquiry  
appointed under s146 of  
the Resource  
Management Act 1991 to  
consider an application  
by Mighty River Power  
Limited for resource  
consents to construct,  
operate, and maintain a  
wind farm at Turitea

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**STATEMENT OF EVIDENCE OF DAVID RUSSELL BLACK IN SUPPORT OF RESOURCE  
CONSENT APPLICATION BY MIGHTY RIVER POWER LIMITED**

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## 1. INTRODUCTION

### Qualifications and Experience

- 1.1. My name is David Russell Black. I am currently Honorary Senior Lecturer in Environmental Medicine at the School of Population Health of the University of Auckland's Faculty of Medical and Health Sciences. I am also a founding director and am currently Principal Consultant of Enviromedix, the New Zealand Institute of Occupational and Environmental Medicine. My clinical practice is based at Auckland Medical Specialists in Epsom, Auckland.
- 1.2. My qualifications are BHB (Bachelor of Human Biology) and MBChB (Bachelor of Medicine and Bachelor of Surgery) from the University of Auckland, which qualifies me as a medical practitioner. I hold a Diploma of Industrial Health (DIH) from the University of Otago. I am a Fellow of the Australasian Faculty of Occupational and Environmental Medicine of the Royal Australasian College of Physicians (FAFOEM) which qualifies me as a Specialist Physician, currently vocationally registered in Occupational Medicine in New Zealand. I am also a Member of the Australasian Radiation Protection Society (MARPS) and am a Member of the Royal Society of New Zealand (MRSNZ). In June 2008 I was elected as a Director of the Bioelectromagnetics Society.
- 1.3. I have been working as an academic at the University of Auckland since 1990. Prior to this I was at the University of Otago from 1986. Between 1989 and 1997 I was employed by Air New Zealand Limited, firstly as their Regional Medical Officer (Northern) and finally as Chief Medical Officer. I remain an active, fully registered specialist medical practitioner in good standing with the New Zealand Medical Council and am recognised by my colleagues and the New Zealand and Australian Environment Courts as an expert in Occupational and Environmental Medicine. I remain active in clinical specialist practice from my rooms in Epsom.
- 1.4. I have considerable experience in health and safety aspects of the electricity generation, distribution and supply industry as well as the telecommunications industry. I have also recently worked on the Te Uku Wind Farm project for WEL Networks Limited, the Mill Creek Wind Farm project for Meridian Energy Limited, the Waitahora Wind Farm project for Contact Energy Limited and the Project Central

Wind for Meridian Energy Limited. I have two decades of experience in applying the evidence based principles of public health protection to the interface between health and technology, including work in standards setting in New Zealand, Australia and the USA. My work has always specialised in clinical medicine and the physical environment, in which I have extensive practice as well as 25 years of postgraduate teaching experience.

- 1.5. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses in the Environment Court. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is within my area of expertise. I have endeavoured to be accurate and to cover all relevant matters relating to the topic on which I am giving evidence. I am not aware of any matters which might adversely affect my conclusions which I have not included. The assumptions on which my evidence is based are not, in my view, unlikely or unreasonable assumptions and, therefore, my evidence complies with Section 5.3 of the Environment Court's Code of Conduct for Expert Witnesses.

#### **Involvement in Turitea Wind Farm**

- 1.6. After the preliminary design of the Turitea Wind Farm, I was consulted by Mighty River Power Limited (Mighty River Power) and asked to provide an assessment of potential health effects which could arise from this proposal. I was given a wide brief and provided with detailed information about the proposal.
- 1.7. I visited the site in October 2008. During this visit, I inspected the specific site proposed for the turbines and associated works and transmission lines. I familiarised myself with the physical characteristics of the environment and the nature of the surrounding communities. I am aware of the recent deletion of nine turbine zones and have taken this into account in my evidence. I have considered any conceivable, even theoretical influence, of the proposed wind farm on the surrounding area, which might result in any issues affecting the health and wellbeing of people living or working in the area.

#### **Purpose and Scope of Evidence**

- 1.8. The purpose of my evidence is to summarise my conclusions from the perspective of a medical officer with public health responsibility for the community.

1.9. In that regard, this evidence will:

- Briefly describe the key elements of the proposal relevant to this evidence (section 2);
- Provide an overview of health related concerns commonly raised in relation to wind farms (section 3);
- Put my evidence into context by: providing and describing the geographical environment; providing some background to the operation of wind turbines and electricity systems; describing the characteristics of electromagnetic fields; and describing the International Non-ionizing Radiation Committee (ICNIRP) guidelines for electromagnetic safety (section 4);
- Outline the key issues relevant to the consideration of public health effects (section 5);
- Outline the key issues relevant to occupational safety (section 6);
- Address the issues raised in specific submissions made on the Turitea Wind Farm proposal (section 7); and
- Give my conclusions and recommendations (section 8).

## **2. KEY ELEMENTS OF THE TURITEA WIND FARM PROPOSAL**

2.1. This application relates to a proposal by Mighty River Power to construct a “wind farm” of up to 122 wind turbine generators located within the Turitea Reserve and on adjacent rural properties within the central North Island.

2.2. These turbines will have the following maximum specifications:

- i) Three blades
- ii) Maximum height (ground to blade tip) of up to 125 m
- iii) Maximum hub height of up to 80 m
- iv) Maximum blade length of up to 45 m

- 2.3. The wind farm will have a total nominal power capacity of up to 336 megawatts (MW) and the total annual energy output is estimated to be up to 1325 gigawatt hours (GWh).
- 2.4. Each turbine will be accompanied by an external (or possibly internal) transformer at the turbine base.
- 2.5. The proposed wind farm will include two 33/220 kV electricity substations, internal (on-site) over-ground and underground 33 kV transmission lines connecting the turbines to the substations, an internal 220 kV transmission line connecting the two substations, an external (off-site) overhead 220 kV transmission line connecting the wind farm to the National Grid and three wind monitoring masts of up to 80 m in height. The full details of the proposal are contained in the AEE and associated information, including the updated layout information and s92 Consolidated Responses document (January 2009).

### **3. HEALTH RELATED CONCERNS**

- 3.1. Health related concerns commonly raised in relation to wind farms often relate to visual impacts, noise and vibration, electromagnetic fields as well as the potential for disruption to the natural environment during construction and operation.
- 3.2. Visual concerns relating to landscape effects are outside my area of expertise and are addressed by the landscape architect Mr Wyatt. I have, however, researched other visual-related concerns (including blade flicker, glare and blade glint) in some detail and have addressed them below.
- 3.3. The other main area of general concern in my evidence is related to noise and vibration, including subsonic energy (sound waves below the frequency of audible sound). With regard to low frequency noise and vibration, I rely on the evidence of Mr Hegley in quantifying the magnitude of this energy and offer the results of my own research on these issues.
- 3.4. At the outset, it is my conclusion that, although all of these are reasonable issues to raise, none of them have characteristics or are of a magnitude which will have any impact on the local community. My rationales for these conclusions are detailed below.

## 4. CONTEXT

- 4.1. In this section, I will address aspects of the local environment and the technology to be used which are relevant to my later analysis in relation to health and safety issues.

### **Geographical Environment**

- 4.2. The proposed Turitea Wind Farm site lies in a sparsely populated area approximately 10 kilometres south-east of the Palmerston North city centre. There are a few very small rural settlements in the area. The nearest residential area is the Ngahere Park subdivision, on Turitea Road to the north-west of the wind farm site. The nearest settlement is Makomako, approximately 1.75 kilometres to the east of the site. The nearest larger towns are Pahiatua further to the east and Linton to the west. The nearest city is Palmerston North City. The Turitea Wind Farm and its associated work and transmission lines are located within the jurisdictions of Manawatu-Wanganui Regional Council (Horizons), Palmerston North City Council (PNCC) and Tararua District Council.
- 4.3. The Turitea Wind Farm turbines will be positioned within the Turitea Reserve and on adjacent rural properties lying along the ridgelines of the northern Tararua Ranges. Most of the turbines will be positioned along a 14 kilometre section of the main ridgeline, which is exposed to prevailing north-westerly winds.
- 4.4. The proposed Turitea Wind Farm site covers both pastoral farm land (such as cattle and sheep) and the Turitea Reserve (owned and administered by the PNCC). Inside the Turitea Reserve, the proposed Turitea Wind Farm site includes areas within the Turitea Water Supply Catchment, Tararua State Forest Park and Brown's Flat. No turbines will be positioned in the Forest Park and no turbines or works are proposed within the Water Structures Area, Harding's Park or any areas within the Reserve in close proximity to the water reservoirs.
- 4.5. The land surrounding the proposed Turitea Wind Farm site is used for mixed purposes. To the east and west, the land is used for pastoral farming and a few small pine plantations. The site is bounded on the north by Pahiatua Aokautere Road and on the south by Harding's Park. The site is also proximal to several existing wind farms; Te Apiti, Tararua 1, 2 and 3, and Te Rere Hau to the north, and the consented Motorimu Wind Farm to the south.

- 4.6. The external 220 kV transmission line will cross approximately 5.2 km of farm land to connect the Turitea Wind Farm to an existing substation at Linton. The proposed alignment for the transmission line runs north from the proposed new substation at Browns Flat, through private property and across Greens Road. It then passes through an area of pine plantation, veers to the north-west and enters the Linton Substation at Harts Road. The line does not approach or traverse any populated areas.

### **Wind Generation Technology**

- 4.7. The principle of wind generation is to convert the kinetic energy in the wind into electrical energy. This is done by the use of a “turbine” which consists of a generator driven by three blades. The turbine units are computer-controlled to face into the wind and to set the pitch of the blades. The head of the turbine comprising the generator, hub and blades in a unit known as a “nacelle”.
- 4.8. The turbine nacelles are mounted atop robust towers equipped with internal access and are connected to each other in parallel circuits providing the energy to a substation. The turbines generate at a low voltage, typically in the order of 690 V which is “stepped up” at the substations for efficient despatch to users by conventional transmission lines.
- 4.9. When turbines are started, they are run up to speed before connection to ensure synchronisation with minimum effect on the quality of generated electricity.

### **Interaction and Effects of Wind Turbines on the Immediate Environment**

- 4.10. When a turbine is operating, the moving air of wind is intercepted by the turbine blades. As the air approaches, it is generally flowing in a relatively laminar (smooth layered) fashion and the flow is split around the blade. The setting of the pitch of the blade varies the “angle of attack”.
- 4.11. The difference in airflow paths causes differential pressures on either side of the turbine which imparts a force on the blade normal to the direction of air flow, thus rotating the turbine. Past the blade, the flow of air becomes laminar again, although there will inevitably be some turbulence around the trailing, and to a lesser extent the leading edges of the blade. This turbulence creates some friction which vibrates the air across a broad spectrum of low frequencies and may be audible as noise

carried downstream from the turbine. As each blade passes the supporting tower, the turbulent airflow will encounter the structure which will also result in scattered turbulent flow which will generate noise to some degree [1].

- 4.12. Thus there are two wind related sounds from a wind turbine. Firstly, the continuous sound of turbulent air and, secondly, the sound of distorted air passing the tower.
- 4.13. The whole turbine is a rotating machine, running on bearings. In general, such machines have the potential to generate noise from the bearings as well as noise of electrical origin from the windings and magnetic material used in the armature and stators. However, such noise is practically eliminated in modern, well maintained turbines.
- 4.14. Thus, there are a number of potential sources of noise in a wind driven generator. All of these can be mitigated to a greater or lesser extent and considerable research and development has been undertaken in minimising unwanted effects in wind generator turbines.
- 4.15. There is nothing added to or taken from the air passing over a turbine generator. The electrical elements are totally enclosed, there is no opportunity for ionisation of air or electrical discharge such as corona. The mass of air approaching the turbine is identical to the mass leaving it. However, the pressure immediately downstream of the turbine must be reduced compared with the surrounding air since the energy which maintains the force of travel of the moving mass of air has been reduced.
- 4.16. From first principles, it would be expected that this effect will be greatest immediately behind the turbine and that the surrounding air will move to equalise the pressure and density of the moving mass. This effect can be accurately mathematically modelled for various wind speeds and atmospheric pressures. Any residually detectable effects exist downwind from the prevailing north westerly for a limited distance.
- 4.17. The air quality behind the turbines is identical to that approaching them, the only changes being pressure and turbulence. At a distance of one kilometre away, the only detectable effect might be some degree of perceptible sound.
- 4.18. Although the speed of the generator and thus the hub of the blades is relatively slow (6-18 rpm) the maximum blade length will be 45 metres and thus the linear velocity

of the tips is relatively fast, in the order of 70 metres per second. However, from any viewing distance, including immediately adjacent to the structure, all parts of the turbine are seen by the naked eye as a resolvable moving object, they are not perceived as a blur or flicker.

### **New Zealand Electricity Mains Systems – Background**

- 4.19. Electricity mains systems in New Zealand use alternating electric current at 50 Hz. This is carried for long distances around New Zealand from the generating source to regional substations by HV lines running at 220 kV or 110 kV and this is further stepped down by local substations. These substations are found frequently within communities and need to be placed relatively close to the ultimate destination of the energy to maintain security of electricity supply and to minimise losses which increase as the voltage of lines decreases. These losses are proportional to the length of lines feeding consumers from the substation.
- 4.20. The next level of step-down is transformers which are generally situated in suburban streets, usually mounted on the ground beside the road or in overhead reticulation systems on power poles. Electricity is distributed to the consumer at low voltage 240 V power. The amount of electric current flow is measured in Amps.
- 4.21. The Turitea Wind Farm proposal includes two step-up substations to transform the 33 kV electricity from the turbines into 220 kV for connection and supply to the National Grid, 33 kV underground and over-ground transmission lines to connect the turbines to the substation, a 220 kV transmission line to connect the two substations and a 220 kV transmission line to connect the substations to the National Grid (via the Linton Substation).

### **Electric and Magnetic Fields**

- 4.22. When an electric current flows in a conductor (which is a substance capable of carrying electric current such as a metal wire or wet living tissue), there are effects which occur in the space surrounding that conductor which will be only apparent if another conductor enters that space. These effects are known as electric fields which have components which are thought of as electromagnetic fields (electric field or  $E$ ) or magnetic field ( $H$ ).

- 4.23. The  $E$  field can be directly measured in the space surrounding a conductor in volts (V) or kilovolts (kV) per metre ( $V\ m^{-1}$  or  $kV\ m^{-1}$ ). The  $E$  field is present whenever a conductor is charged. The strength of the  $H$  field is directly related to current flow and is expressed in amperes per metre ( $A\ m^{-1}$ ).
- 4.24. In practise, of most interest for potential health effects is the density of the magnetic field strength (magnetic flux density ( $B$ )). The modern unit used for magnetic flux density is the Tesla, and in practise fields usually encountered are in millionths of this (microTesla abbreviated as  $\mu T$ ).
- 4.25. Although there are electric and magnetic fields around power conductors, there is no significant radiation of the type arising from a radio antenna. That only occurs at much higher frequencies. Electric and magnetic fields at the frequency of mains electricity (50 Hz) fields are not the same as radiation. Radiation is a phenomenon which occurs at much higher frequencies when electric and magnetic fields combine to form a wave.

#### **Electric and Magnetic Fields and Wind Turbines**

- 4.26. Electrical energy generated by a turbine is transmitted down conductors inside the tower and underground by buried cables. The steel structure of the tower is electrically conductive as is the ground. Together, these would be expected to form an effective shield for electric fields. Consequentially, electric fields are unlikely to be encountered in the space around wind turbine generators or their associated underground cables.
- 4.27. Magnetic fields, however, are not screened by conductors and therefore will be detectable adjacent to both the wind turbine generators and above the conductors.
- 4.28. However, magnetic field strength falls off very rapidly with distance from a conductor – in this case the turbine and associated cables. The manner in which magnetic field strength falls off with distance from a conductor carrying an electric current is complex, however, in all cases the fall-off in magnetic flux density away from the conductor is rapid. That means that any electric or magnetic fields which do arise from this equipment fall off in strength very rapidly so that at a distance of a few metres they fall well within relevant safety guidelines.

### **Electric and Magnetic Fields and Substations**

- 4.29. Electric fields at the two proposed Turitea Wind Farm substations will be effectively screened by the shielding of the underground cables, the design of the transformers and of the substation construction.
- 4.30. Magnetic fields will be relatively contained in the substation facilities and due to the rapid fall off, only very low levels, if any, are expected at the boundaries of the two substation sites.

### **Electric and Magnetic Fields and Transmission Lines**

- 4.31. Electrical energy generated at the Turitea Wind Farm will be supplied to the New Zealand National Grid. A new overhead 220 kV transmission line will be constructed to connect the two substations and a second 220 kV transmission line will connect the proposed Browns Flat substation to the existing Linton Substation. The substations are to be fed by 33 kV underground or over-ground lines from the turbines.
- 4.32. Electric fields from underground cables will be effectively screened by conductive ground and earthed cable armouring sheaths. Thus, for underground cables, only magnetic fields that are found above ground need to be considered.
- 4.33. However, when electricity is transmitted by overhead lines, the lines are not shielded. Therefore both electric and magnetic fields are found around the conductors and need to be considered. Some reduction of potential exposure below the lines can be achieved by placing conductors so that field effects cancel (reverse phasing). However the only attenuating factor for both fields is the distance from the conductor.
- 4.34. The electric and magnetic fields from the proposed transmission lines will comply with the public exposure reference levels described in the ICNIRP Guideline (outlined in sections 4.37-4.41 below).
- 4.35. Under certain weather conditions, a phenomenon called corona discharge will occur in the air around high tension conductors as a result of electric fields. Corona occurs when the electric field surrounding a high tension conductor ionises oxygen and nitrogen in the air, creating a low energy plasma. The current in high tension power

lines is alternating (in New Zealand, at 50 times a second, or 50 Hz), which has an effect on the electric field. This in turn affects the plasma and creates an audible vibration in the air. This is what is heard when high tension power lines sizzle during damp weather and is an inevitable characteristic of high tension electricity conductors in the atmosphere. Corona is also an everyday phenomenon which is utilised in several workplace and household appliances and fixtures, including air conditioners, photocopiers and fluorescent lights.

- 4.36. The noise from this needs to be considered and should not exceed the ruling limits for the area and installation. This is addressed in the evidence of Mr Hegley.

**International Commission for Non-ionising Radiation Protection (ICNIRP)  
Guidelines for Protection against Electric and Magnetic Fields**

- 4.37. From an international health protection viewpoint, the control of non-ionising electromagnetic energy (generically called non-ionising radiation) has been delegated to the International Commission for Non-ionising Radiation Protection (ICNIRP). In 1998, ICNIRP published a definitive guideline [2] which has subsequently formed the basis for most international standards.
- 4.38. The ICNIRP Guideline dates back to work begun by the International Radiation Protection Association (IRPA) who formed a working group on non-ionizing radiation (NIR) to examine the area of protection against the various types of NIR in Paris in 1977. This group evolved to become the International Non-ionizing Radiation Committee (INIRC) and, together with the World Health Organisation (WHO), the ICNIRP developed a number of health criteria documents as part of WHO's environmental health criteria (EHC) programme, sponsored by the United Nations Environmental Programme (UNEP). These documents have evolved and become an unsurpassed international resource for standards setting. The current ICNIRP guideline, published in 1998 is based on the 1993 Environmental Health Criteria No.137 [3]. The next revision of the ICNIRP guideline for extra low frequency (ELF), will be based on the recently published EHC 238 2007 [4]. EHC 238 is available now and so the approach expected in the next ICNIRP Guideline is already clear.
- 4.39. New Zealand and Australia have not formally adopted standards for exposure to low frequency fields although both countries have published standards for radio frequency fields above 3 kHz. However, the ICNIRP Guideline has been adopted by

the New Zealand Ministry of Health and is generally and widely accepted as providing useful and evidence based thresholds for public health protection.

- 4.40. The ICNIRP Guideline is entirely relevant to this matter and in my view, the approach to protection thresholds for general public exposure in this document should be regarded as definitive in this matter. The Ministry of Health adopts this view. In their publication *“Electric And Magnetic Fields And Your Health”* the National Radiation Laboratory (NRL) say:

*“In common with nearly all countries, there are no Regulations or Standards in New Zealand setting out exposure limits for low frequency magnetic fields. The National Radiation Laboratory recommends the use of guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These guidelines are based on a careful examination of the research data on the health effects of exposure to low frequency magnetic fields, and include margins for safety. They were first proposed in 1990, and reconfirmed in 1993 and 1998 after consideration of more recent research results” [5].*

- 4.41. Page 2 of the ICNIRP Guideline describes the basic approach which the Guideline takes to protection. The terms “Basic Restrictions” and “Reference Levels” are defined - these are the parameters most closely equating with actual biological or health effects. Reference levels are given for a range of frequencies, for both the general public and at an occupational level. *B*-field and *E*-field limits are calculated from ICNIRP’s table 7 on page 18 of the Guideline. The relevant parts of this table are reproduced below.

**Reference Levels for the General Public at 50 Hz (ICNIRP 1998):**

<b>Public Levels at 50 Hz (ICNIRP)</b>		
<i>E</i> -field strength ( $V m^{-1}$ )	<i>H</i> -field strength ( $A m^{-1}$ )	<i>B</i> -field ( $\mu T$ )
$250/0.05 = 5000 V m^{-1}$	$4/0.05 = 80 A m^{-1}$	$5/0.05 = 100 \mu T$

## Reference Levels for Occupational Exposure at 50 Hz (ICNIRP 1998):

Occupational Levels at 50 Hz (ICNIRP)		
<i>E</i> -field strength ( $V\ m^{-1}$ )	<i>H</i> -field strength ( $A\ m^{-1}$ )	<i>B</i> -field ( $\mu T$ )
$500/0.05 =$  $10,000\ Vm^{-1}$	$20/0.05 = 400\ Am^{-1}$	$25/0.05 =$  $1000\ \mu T$

## 5. ISSUES RELEVANT TO PUBLIC HEALTH CONSIDERATIONS

5.1. This section of my evidence addresses potential issues relating to wind farms which are relevant to public health considerations, namely:

- i) Air quality;
- ii) Water quality;
- iii) Visual effects;
- iv) Auditory effects;
- v) Electromagnetic effects; and
- vi) Electrical safety.

### Air Quality

5.2. As described in section 4.10, the laminar flow of wind past a turbine is interrupted and disturbed by the presence and operation of the turbines. However, the flow reassembles downstream and within a relatively short distance (less than a kilometre) from the turbine any change in air pressure or flow is insignificant. There is no change in the gaseous mixtures of air and no added contaminants to air from the turbines or other aspects of the proposed Turitea Wind Farm. All electrical equipment is enclosed, so there is no ionisation of air anywhere in the generation facility.

- 5.3. Ionisation of air or corona discharge will occur around the high tension transmission lines, but other than a degree of audible noise, there are no established biological or health effects from corona. Theories have been advanced to the contrary but these have not been confirmed or pursued and are not regarded as indicating any need for control by the WHO.

### **Water Quality**

- 5.4. During the construction phase of the Turitea Wind Farm, its substations and transmission lines, there will be human activity and earthmoving in areas previously undisturbed, or only disturbed by farming activities. This does have the potential to cause transient changes in water quality, which needs to be controlled.
- 5.5. The relevant waterways which cross within the Turitea Wind Farm site have been identified and are as follows:
- i) Turitea Stream (includes the Turitea Water Supply Catchment);
  - ii) Kahuterawa Stream;
  - iii) Otangane Stream;
  - iv) Tainui Stream;
  - v) Matarua Creek; and
  - vi) Unnamed tributaries of the Manawatu River.
- 5.6. The Turitea Water Supply Catchment is the main source of potable water for Palmerston North. The Catchment consists of two dams on the Turitea Stream. I have searched the Ministry of Health's Drinking Water Quality Database [6] for the other waterways within the Turitea Wind Farm site and none were listed as a source of community drinking water.
- 5.7. From a public health perspective, it is essential that any hazardous run-off from construction is contained and is not allowed to contaminate any of the waterways used for public water supply.
- 5.8. The issue of water quality has been addressed by Mighty River Power through the commission of Beca Carter Hollings & Ferner Ltd (Beca) to provide a Water Quality

Monitoring Plan (WQMP) [7]. The WQMP focuses on the Turitea Water Supply Catchment and includes methods for water quality identification, protection and monitoring. This will be used to assist in the development of a Construction Environmental Management Plan (CEMP) which will incorporate the ideas from the WQMP and “*describe in detail the construction methodologies, monitoring and incident actions that will be applied by the contractor to avoid, remedy or mitigate effects on the environment*”. It will also be used for the development of an operational phase environmental plan.

- 5.9. I have read the WQMP. It addresses the different possible sources of water contamination; sediment (including run-off and dust), hydrocarbons (including lubricant, fuel and oil leaks), toilet/washroom facilities (bacterial), cement, detergents, rubbish/debris and increases in nutrient concentration (through vegetation contamination). The potential sources of and effects of each of these contaminations have been identified. Recommendations are then given for methods and frequency of water quality monitoring (including provisions for extra inspections following rainfall or other specific events) and actions to be taken in the event of contamination. The report also recommends independent specialists be employed to carry out additional inspections. Protection measures for both the construction phase and the operational phase are also discussed.
- 5.10. I have also read the Water Ecology report by Brian T. Coffey and Associates Limited (August 2008) and the Construction Effects report by Beca (July 2008) as well as the additional responses in the recent s92 Consolidated Responses document. Together, these outline clear methods and measures to monitor water quality and to avoid, remedy or mitigate water contamination.
- 5.11. It is my opinion that the recommendations contained in these documents, if implemented, should provide adequate protection against effects of water contamination from a public health perspective.
- 5.12. I note that the deletion of nine of the proposed turbine zones will further reduce the potential for the project to affect water quality. This is based on a letter from Mr W. Shaw of Wildlands Consultants Ltd., dated January 2009. Mr Shaw’s assessment is that the removal of these zones will mean a proposed stream crossing (over a stream that drains into the Turitea water supply lake) will no longer be required and

that the streams and wetlands around Browns Flat will also be avoided, causing a “*reduced potential for effects on streams and downstream effects*”.

- 5.13. Once construction is complete and the wind farm operational, neither the turbines nor the transmission line will have any impact on water quality, provided adequate protection measures continue to be maintained.

### **Visual Effects**

- 5.14. The turbines will become a noticeable aspect of the landscape on the skyline from some viewpoints. Visual and landscape effects are addressed by Mr Wyatt, however I will comment on the health aspects of blade flicker. A common concern raised in respect of wind farms is that the rotating blades may cause “flicker” and that there is a known causal relationship between flicker and photosensitive epilepsy.
- 5.15. Visual flicker is an accepted cause of epilepsy, particularly in children and there have been some well-documented cases of this occurring, for example, as a result of particular characteristics of electronic games and television programmes [8]. The characteristics of this effect are well described in the scientific literature with regard to the area of visual field which must be affected and in turn the neurophysical amplitude of the flicker signal as well as frequency and colour characteristics of the flicker [9].
- 5.16. In essence, epilepsy can be precipitated in a few susceptible individuals when the light falling on a substantial part of their vision, at least a quarter of the visual field, is interrupted in a regular pulsating fashion at a particular rate. The effect is also greater at certain colours, generally red.
- 5.17. None of these characteristics are present in viewing the Turitea Wind Farm from any angle and the possibility of epileptogenic flicker effect can be confidently excluded. There is the potential for a flickering effect if the light is behind the turbines but since the velocity of the blades varies along the length, there is never a clear pulse effect. Furthermore, the contrast of the flicker image is low and diffuse as the turbine blades are illuminated by skylight. There is no source of intense red light energy analogous to that associated with epilepsy. Finally, and most importantly, at the viewing distances from the community the turbine blades occupy only a very small part of the viewer’s visual field. I consider that there is no risk of epilepsy from this proposal.

## **Auditory Effects**

- 5.18. Any noise from the Turitea Wind Farm would result largely from air movement over the turbine blades and past the supporting structures. With the separation distance of the Turitea Wind Farm to the public, there will generally be insignificant noise from the modern wind turbine generators which will be used [10].
- 5.19. Noise from the airflow effects have been calculated by Mr Nevil Hegley at each of the closer dwellings to the Turitea Wind Farm and to other sites of interest. His report [11] shows that noise levels at these residences are of a magnitude which is insignificant from a public health point of view and will not be more than the noise limits prescribed by the New Zealand Standard *NZS6808:1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators* [12]. The noise levels will also be well within the limits allowed by the Palmerston North and Tararua District Plans. In my view, those noise levels are entirely acceptable for a residential area. For example, these levels are much less than the sound of the wind in the trees and would not be noticed by most people.
- 5.20. Mr Hegley's report also concludes that construction noise will, at all times, be within the requirements of New Zealand Standard *NZS6803:1999 Acoustics – Construction Noise* [13].
- 5.21. Mr Hegley has determined that the auditory effects of the Turitea Wind Farm will be less than minor. Mr Hegley's report provides more details. To the extent that noise effects exist they are an issue of amenity, not public health.
- 5.22. Subsequent to the writing of Mr Hegley's report, nine of the originally proposed turbine zones have been deleted. As a result, Mr Hegley has recalculated the predicted noise levels and provided a letter to Mighty River Power (dated January 2009) describing the resulting noise reductions. This letter concludes that the removal of the nine turbine zones causes "*a noticeable reduction in the noise level at some sites, a small reduction at some sites and no change at all a [sic] number of sites*". Therefore, the removal of the nine turbine zones has no noticeable effect on my conclusions relating to the impact of noise from the wind farm on public health.

### Vibro-acoustic disease

- 5.23. I am aware that Vibro-acoustic disease (VAD) is often raised as a concern in the context of wind farm proposals, although it has not been raised to date for the Turitea Wind Farm. VAD is a multi-systemic entity caused by occupational or chronic exposure to large pressure amplitude low frequency (LPALF) noise (greater than 90 dB sound pressure level (SPL) at frequencies under 500 Hz). The clinical picture described for this controversial disorder involves extra-auditory pathology, such as neurological disturbances, respiratory disorders and cardiovascular problems.
- 5.24. VAD has also been observed in some workers in industrial settings at levels of pressure literally millions of times higher than those expected at the Turitea Wind Farm. I am aware that VAD has been raised in the context of wind turbines but only in the immediate proximity of the machines and even then a cause and effect relationship has never been established. At the separation distances applying at the Turitea Wind Farm, I consider that VAD is not an issue which should cause any concern [14].
- 5.25. Vibration through the ground requires a source of high energy pulses which do not and could not arise from wind turbines under any conditions other than a fault which would require immediate shut down and rectification. The extent to which vibration in air could be generated is very minor and of no consequence.

### Tinnitus

- 5.26. Tinnitus is the perception of sound in the absence of corresponding external sound. Tinnitus can be perceived in one or both ears or in the head. It is usually described as a ringing noise, but in some patients it takes the form of a high pitched whining, buzzing, hissing, humming, or whistling sound, or as ticking, clicking, roaring, like "locusts", tunes, or beeping. It has also been described as a "whooshing" sound, as of wind or waves. Tinnitus can be intermittent or it can be continuous. Tinnitus is not itself a disease but a symptom resulting from a number of underlying causes.
- 5.27. The sound perceived may range from a quiet background noise to one that can be heard even over loud external sounds. The term "tinnitus" usually refers to more severe cases. Heller and Bergman conducted a classic study in 1953 using 80

tinnitus-free university students placed in an anechoic chamber. They found that 93% of them reported hearing a buzzing, pulsing or whistling sound [15].

- 5.28. Tinnitus is often caused by noise induced damage to hearing. Such damage could not be caused by this proposed wind farm. The sound pressure levels are too low by a factor of more than 30 dB (thousands).

### **Electromagnetic Effects**

#### Biological Effects of Electric and Magnetic fields

- 5.29. Electric fields at 50 Hz generally have a surface effect on the human body and at sufficient levels this can be felt as causing movement of hairs at low levels and electric stimulus at higher levels. Where electric fields can be carried into conductive tissue, they can be the source of internal electric fields which can cause stimulation of electrically sensitive tissue such as nerves and muscle. Safety standards are thoroughly established to prevent these effects which are well understood and characterised.
- 5.30. Magnetic fields are capable of entering the body and are resolved by conductive tissue to internal electric fields which are similarly capable of causing electric stimulus. The first effect of internal electric fields, that is the effect at the lowest level, is generally regarded as stimulation of the retinal photoreceptors in the eyes and is perceived as flashing in visual fields. This is not necessarily regarded as an adverse effect and it may be regarded as no more than perception. Nonetheless, this biological effect is generally prevented by exposure standards for magnetic and electric fields.
- 5.31. Electrically conductive objects within electric and magnetic fields can also become charged with the potential to cause electric shocks if touched.
- 5.32. The possibility that there may also be effects at levels below perception has been investigated and debated in detail over many decades and is the subject of literally thousands of papers published in the scientific peer reviewed literature. However, no such effects have been established. To the extent that they remain possible, any risk is very low and might occur only where there is sustained significant exposure.

### Possible Low Level Effects of Extra Low Frequency Magnetic Fields

- 5.33. Several decades ago, some researchers in the United States published a paper which suggested the possibility that there could be an association between small excesses in the rates of certain cancers and electric and magnetic fields from power distribution systems [16]. Since that time, there have been many attempts to replicate this research. The results have been inconsistent and inconclusive but the matter has never been entirely settled. In the late 1990s, the eminent British epidemiologist, the late Sir Richard Doll was asked to head a review to attempt to make sense of the literature which by this time was substantial. This work was overseen by the British National Radiation Protection Board (NRPB) and was ultimately published in a very thorough publication [17].
- 5.34. Following that publication, the International Agency for Research on Cancer (IARC), which is the international organisation responsible for the classification of environmental agents in terms of the likelihood that they are a cause of cancer, delivered their findings, after years of deliberation, that extra low frequency (ELF) fields would be placed into category 2B, indicating that they are possibly carcinogenic (see Appendix A attached) [18]. That finding was preceded by other work and advice from ICNIRP including a separate review of epidemiology. This will remain the position for the foreseeable future and applies to magnetic fields arising from electric currents whether they are from distribution systems or household wiring where there is a continuous exposure in excess of 0.4  $\mu\text{T}$ .
- 5.35. That category also applies to a range of other common objects and substances such as coffee and pickled vegetables. However the classification is not saying that they are carcinogens, only that unsettled research exists.
- 5.36. In 2001 an NRPB report [19] identified an apparent difference in epidemiological data in the incidence of leukaemia in children exposed at levels above and below about 0.3-0.4  $\mu\text{T}$ . Whilst this effect is far from confirmed, it did move Sir Richard Doll to regard the lower levels of magnetic fields (below 0.4  $\mu\text{T}$ ) and all electric fields as no longer featuring in the debate.
- 5.37. It remains widely believed that these reported associations are caused by compounding factors (in other words the presence of something else which goes along with the presence of power), but that cannot be confirmed either, so research

will continue and will be monitored by ICNIRP. However, the extent of the effect, if any, is of a magnitude such that, even if it were to be confirmed, would probably not alter the way in which electricity is used on a cost benefit basis [20].

- 5.38. Nevertheless the existence of unsettled research does mean that the possibility of magnetic fields as a contributor to childhood leukaemia remains. However, at the worst case, this could only be an extremely rare risk which would be responsible for less than one of the 40 or so cases of childhood leukaemia seen in New Zealand every year. These cases would, according to the work of Doll *et al* and the ICNIRP advice accepted by IARC, occur only when average continuous exposure exceeds 0.4  $\mu$ T. This can happen in industrial and residential settings, although it is unusual in New Zealand.
- 5.39. Magnetic flux density is proportional to current and falls off very rapidly with distance. The more likely circumstances of such exposure is in buildings with high current carrying conductors in the walls. Such conditions are possible in low voltage installations and probably more so in countries which use 110 V rather than 230 V, since more current is required at a lower voltage for equivalent power.
- 5.40. I have not identified any circumstances or conditions even approaching them where such levels could encroach on the living spaces anywhere around the proposed turbines or power lines for the Turitea Wind Farm. For that reason, in my opinion, the unsettled science with regard to low level health effects is not an issue at all for consideration in respect of the Turitea Wind Farm.

#### Electric and Magnetic Fields and the Turitea Wind Farm, Substations and Transmission Lines

- 5.41. Electric and magnetic fields from the Turitea Wind Farm turbines will comply with the ICNIRP Guidelines [2]. As described in section 4, the turbines' metal housing will act as a shield for electric fields and magnetic field strength will fall off rapidly with distance from the turbines. At all areas of public access, these fields will be well within the public exposure reference levels in the ICNIRP guidelines.
- 5.42. Electric and magnetic fields from the two Turitea Wind Farm substations will, by nature of the design of the stations, be contained within the station sites. Field strengths will be of a magnitude similar to other substations and will easily comply with the ICNIRP Guideline [2].

- 5.43. Conductors between the turbines and the Turitea Wind Farm substations and the proposed overhead 220 kV transmission lines will also have associated electric and magnetic fields. These fields will be of a magnitude typically found around other high tension power distribution lines and will comply with the public exposure reference levels in the ICNIRP Guideline [2]. Electric and magnetic fields surrounding the 220 kV transmission line have been modelled by Beca. Beca's calculations show that electric field strengths at 30 metres are always of the order of, or less than 100 volts per metre (V/m) and magnetic field strengths at 30 metres are less than 5  $\mu$ T.
- 5.44. Compliance with the ICNIRP Guidelines will eliminate any adverse biological or health effects.
- 5.45. Specifically, around the area of the wind farm, which has controlled access levels, electric and magnetic fields should not exceed the ICNIRP occupational reference levels.

### **Electrical Safety**

- 5.46. Electrical conductors around the Turitea Wind Farm will generally be insulated and buried or elevated. The substations will be totally enclosed and security restricted. There is therefore no risk to lawful public activity from any conductor. Past the substations, uninsulated overhead lines may be used. These will comply with the New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001) [21] which provides a high level of safety equivalent to that found in other electrical facilities in New Zealand.

## **6. OCCUPATIONAL HEALTH**

### **Construction Phase**

- 6.1. During the construction phase many of the required activities will be technically challenging and require highly specialised techniques with associated safety procedures which are outside the scope of this report.
- 6.2. These issues will be addressed by compliance with relevant standards and the Health and Safety in Employment Act.

## **Operational Phase**

- 6.3. Once the wind farm and transmission lines are operational, workers will need to comply with the ICNIRP guidelines for occupational exposure to electric and magnetic fields given in section 2.
- 6.4. These levels remain entirely safe but with a lower safety margin than public exposure levels.

## **7. ISSUES RAISED BY SUBMISSIONS**

- 7.1. I have reviewed all of the submissions lodged on the application with regard to this project, taking particular notice of concerns which could relate to health effects.
- 7.2. A brief summary of each submitter's individual concerns is included in the table in Appendix B. A list of the submitters (by subject) is included in Appendix C. I will address these issues by subject below.

### **Noise and Subsonic Vibration**

- 7.3. Several submitters raised concerns over noise and its potential effects on public health. Mr Hegley has addressed the absolute magnitude of noise to be expected from the turbines in operation and I have previously described in my evidence the origins of these sounds.
- 7.4. There will be audible noise carried downstream from the turbines. However this is of a known character and predictable magnitude which has been evaluated by Mr Hegley. It is accepted that where there were doubts about noise levels reaching into some living areas, as a result assessments were made, and the proposal amended, resulting in the removal of a number of initially proposed zones.
- 7.5. As I have discussed in my evidence, audible noise at low levels has potential effects on amenity but will only cause direct health effects at much higher levels, none of which are encountered in this proposal, even prior to the removal of proposed turbines.
- 7.6. Several submitters have raised concerns about sleep disturbance as a result of noise and/or vibration. Lynette Bebb raised concern over the potential for this leading to depression. I certainly accept that sleep disturbance can be at least an

aggravating factor in depression and that features of a proposal such as this which are likely to cause sleep disturbance should be regarded as undesirable or unacceptable.

- 7.7. Some health authorities, including the WHO have become interested in the effects of noise on health and wellbeing. However, this is in the context of significant issues such as traffic and aircraft noise and these concerns are advanced as evidence for providing effective curfews against significant noise nuisance particularly during hours where people are sleeping.
- 7.8. In that regard, the WHO published a document entitled “Guidelines for Community Noise” [22]. These guidelines aim to “*consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professional trying to protect people from the harmful effects of noise in non-industrial environments.*” In this report, guidelines for noise levels are set based on the lowest levels of noise which would have a critical effect on health for the general population. For sleep disturbance, the report gives the guideline of 30 dB LAeq,8h and 45 dB LAmax. For interference with communication, the guideline gives background levels of 35-45 dBA for easily understood speech, and 65 dBA for speech with “more vocal effort”.
- 7.9. Through the evolution of the design of the Turitea wind farm, levels of noise, or any other physical factors which could cause sleep disturbance have been eliminated. Mr Hegley’s calculations support this, showing that no residence not forming part of the project is expected to experience (outdoor) noise levels above 45 dBA, under worst-case conditions. Most properties will experience noise levels well below this.
- 7.10. I have no doubt that compliance with the New Zealand standard, as is proposed in this case, will eliminate any risks associated with the effects of noise on wellbeing, including potential sleep disturbance. Given that a modern building will attenuate sound by approximately 15 dBA, Mr Hegley’s modelling suggests that neither the levels recommended by the WHO guidelines or NZS 6808 will be exceeded. Noise at these levels is insignificant from a public health point of view.
- 7.11. Imogen Watson’s submission says that the WHO recommends a 1.6 km buffer distance between wind turbines and residences to avoid hazards from noise. However, the WHO does not recommend any specific buffer zones for wind farms.

As already discussed, it does have guidelines for community noise which have been taken into account in both my assessment of the health effects and the assessments of Mr Hegley.

- 7.12. Beverly Hall has raised the possibility of harmonic vibrations from the turbines affecting the human nervous system. Harmonics are exact multiples of a fundamental frequency and given that the sound produced by the moving blades will not be strictly sinusoidal, there will be harmonics in the overall makeup of the transmitted sound. However this, if anything is a benefit as it means the sound energy is distributed over a wider spectrum and the resultant sound approaches that of “white noise” which is sound with characteristics frequently found in nature and generally readily accepted. Therefore, whilst I accept that there will be harmonics, this should cause no particular concern. Mr Hegley could provide more details with respect to the physics behind this issue.
- 7.13. Many people have also mentioned concerns about subsonic or infrasonic vibration which, in this context, could only be very low frequency sound conveyed as vibration in air, on the basis that it is not plausible that vibration through the ground, even if there was any, could reach populated areas from the remote and elevated positions proposed for the Turitea turbines.
- 7.14. The human ear is less sensitive to low frequency noise than high frequencies, although this is compensated for in measurements by providing additional weighting to low frequencies, such as in the dBA system. This relationship is complex because the overall human hearing response at low frequencies varies markedly with amplitude. However, the ear remains by far the most sensitive transducer of variations in air pressure and so human perception of sound-type energy (i.e. variations in sound pressure level) is much lower in the subaudible or subsonic region.
- 7.15. Some submitters such as Alan Thornton have raised this issue particularly in the context of disorders and diseases associated with vibration. However, as I have explained in sections 5.23-5.25 of my evidence, these diseases are altogether different and are either localised effects at very high magnitude (such as Hand Arm Vibration Syndrome (HAVS) or Whole Body Vibration (WBV)) which require very high levels of energy – much higher than could ever be transmitted from a wind

turbine, or for that matter would be tolerated by the continued operation of the machine.

- 7.16. Karine and David Chagne raised the issue of low frequency noise affecting cardiovascular conditions, although they admit that they could not find any research articles to support this concern. I too have heard these concerns particularly in the context of Dr Alves-Pereira. It has been advanced in some medical publications but not with any powerful evidence of causation. There is no reasonable biological plausibility for such an effect and therefore it cannot be regarded as either a reasonable hypothesis or as either established nor expected to occur.
- 7.17. Concerns about diseases resulting from subsonic vibration do not extend below levels of 85 dB and even at that level are only tentative. The threshold for acute damage from noise is 140 dB.
- 7.18. Any significant vibration requires a source of high energy pulses which do not and could not arise from wind turbines under any conditions other than a fault, which would trigger immediate shut down and require rectification. It is intrinsic to the design and operation of the machines that they run smoothly against the continuous and even or gently varying load presented by the generating equipment.
- 7.19. Mark and Sharon Malone raised concern over the “seismic effects” of turbines. By this they are referring to transmission of energy through the structure of the turbine to the earth. As I have covered in my evidence and as is also discussed by Mr Hegley, this cannot occur to any significant level and the extent to which energy can be transferred through seismic effects will be negligible.
- 7.20. Maurice King says that experts will negate each other with opposing opinions on issues such as sound and subsonic vibration. That is not correct. This is not an area of biophysics where there are genuinely unsettled opinions. The magnitude of vibrations which causes health effects is clearly understood and is reported consistently in the scientific literature. The level of vibration which could be expected from the turbines is part of the specifications of the equipment and is thousands of times lower than the levels at which health effects might be expected. Therefore such a debate could only occur if one party did not follow evidence-based science and that is straightforward to establish.

### **Cumulative Effects of Noise**

- 7.21. Mr Christopher Barker raises concern over the cumulative effects of low frequency noise resulting from the proposed Turitea wind farm, when combined with other nearby (proposed) wind farms.
- 7.22. As I have discussed, there will be some low frequency energy transferred through the air which will be of a similar magnitude to the adjacent audible sound and of no biological significance. However, the consideration of cumulative effects is a valid point which needs to be considered. From a purely physical point of view, there will not be literal addition as such of the two energy sources, because for this to occur they would need to be of identical character and in phase. Having said that, if they were nearly in phase and drifted in and out of synchronicity, sound of an unexpected character could conceivably occur. This is therefore a matter which will need to be considered by Mr Hegley.
- 7.23. However, the low absolute magnitude of the energy from this wind farm or those adjacent makes any significant or noticeable effect unlikely from first principles.

### **Noise and Hearing**

- 7.24. Mr Victor Bebbs suggests that there is scientific acceptance of adverse effects on children's hearing from wind turbines.
- 7.25. There is no such validated research in the literature and it is not plausible that this could occur. Effects on hearing, scientifically known as Permanent Threshold Shift (PTS) are caused by sustained high levels of sound energy in excess of about 75 dBA averaged over daily exposure. Even at this level, hearing damage over a lifetime would be most unlikely to occur. The levels from the proposed Turitea wind farm are well below that as I have indicated by more than 30 dB, which provides a large safety margin.

### **Water Quality**

- 7.26. Many submitters raised concerns over contamination of the Palmerston North water supply from construction dust, silt, sediment and debris.
- 7.27. I have discussed water quality in sections 5.4-5.13 and am aware that the Turitea Stream and the downstream Turitea Water Supply Catchment are a source for

community drinking water. As discussed in my evidence, from a public health perspective, it will be an essential requirement that any hazardous run-off and airborne pollution from construction is contained and is not allowed to contaminate any water destined for supply to the public. As described, the WQMP, Water Ecology Report and Construction Effects Report (and supplementary information) include methods for prevention and mitigation to prevent hazardous waste and other materials from contaminating the public water supply. As long as these measures are adhered to, there should be no risk to public health through loss of water quality as a result of the Turitea wind farm.

- 7.28. Philip Pearce raised concerns about the potential for contamination of the water reserve with infectious diseases when workers come in and out of the area, noting that hunters require a medical certificate to enter this protected region. That is a valid concern and will need to be addressed both during the construction phase and on an ongoing basis. Whilst management of this matter is ultimately a matter of administration for the local authority, the policy and approach to the protection of public health is a matter the District Health Board.
- 7.29. Dessiree Allen, Danna Morgan and John Adams raised concern over the possibility of contamination of personal tank or roof water supplies from construction and traffic dust and debris. Mr Adams is particularly concerned due to the proximity of his residence to the proposed substation and concrete batching plant.
- 7.30. This is a reasonable concern and will need to be mitigated / controlled. Mighty River Power has considered the issues of construction dust (including dust from the concrete batching plant) and dust suppression on gravel roads in the Construction Effects Report by Beca. These issues will be addressed in detail in the CEMP, which Mighty River Power will be required to prepare and any construction workers will be required to adhere to. The CEMP will include identification of dust sources and measures to control this dust. If this control is not adequate to protect personal water supplies such as those from roofs, Mighty River Power will be expected to provide safe potable water to affected residences until the problem is rectified.

### **Air Quality**

- 7.31. Several submitters are concerned about the effects of construction on air quality, namely regarding the issue of dust and airborne pollution.

- 7.32. As discussed above, the issue of dust pollution has been noted by Mighty River Power and has been discussed in the Construction Effects Report by Beca. Provided the CEMP includes adequate standard construction practise controls for dust suppression, I do not see any risk to public health and safety from this issue.

### **Visual Effects**

- 7.33. Several submitters raised concerns over the issue of flicker. I have addressed this already in my evidence.
- 7.34. Lynette Low's submission raised particular concerns about flicker, noting that she is extremely sensitive to flickering light and has a serious history of epilepsy in her family. Ms Low's submission noted Dr Pierpont's work on wind turbines in the USA. Whilst I entirely understand Ms Low's concern, there is no potentially physiologically effective flicker from these slowly rotating turbines. As I have explained in my evidence, there are reports in the medical literature about epilepsy arriving from flicker, but this effect is clearly from quite specific types of flicker at much higher frequencies than would ever be encountered from a rotating turbine blade.
- 7.35. It is true that some individuals are more sensitive than others to flicker. Most people cannot detect or be affected by flicker at the frequency of mains electricity (50 Hz) although there are a few that can and under some adverse conditions such as disease or medication, sensitivity can be induced. It is also correct to say that such sensitivity can run in families. However, the magnitude of this sensitivity in terms of frequency extends down to no lower than 40 Hz, whereas any potential flicker from these slowly rotating turbine blades is well below that frequency.
- 7.36. Karine and David Chagne also raised the issue of epilepsy and flicker, referring to a recently published paper in *Epilepsia Journal* [23]. The recent publication of this paper is acknowledged and it has been carefully evaluated. The paper does confirm the approach which I have recommended and should provide reassurance that epilepsy could not be caused, worsened or precipitated by any aspect of this proposal.
- 7.37. Jonathan and Debra Perera are concerned about sunlight reflecting from blades into their house. I agree that this phenomenon, known as "blade glint" has been described, and if it occurs can be annoying. Blade glint can be effectively prevented by ensuring that the properties of the blade surface are such that light falling on

them can only be reflected in a diffuse or non-specular manner. The need for this is well accepted and should be part of the design requirement for the blades. In practise, it was a problem with earlier turbines which has now been overcome.

- 7.38. Stephen Lang's submission raised concern over the safety of motorists when approaching moving turbines with the sun shining behind them. The rotating wind turbine blades no doubt have the potential to provide a novel view which could distract driver's attention although the normal discipline of driving should prevent that. I cannot however hypothesise any other physiological or visual effect from the rotating turbine blades which might disturb a driver's perception and have discussed this with the New Zealand Transport Agency.

### **Wind Turbine Syndrome**

- 7.39. The submissions of Martyn Nail, Lynette Low, Lynette Bebb and Victor Bebb mention "Wind Turbine Syndrome". There is no such syndrome accepted in the medical and scientific literature. I am aware that individual workers have coined this phrase but it has no scientific credibility or general acceptance and it is unhelpful to use it. Any ideas based on this "syndrome" should carry no weight.

### **Mental Health Effects**

- 7.40. Several submissions raised concern over effects on mental health from stress and anxiety over the proposed wind farm.
- 7.41. Symptoms such as anxiety or even reactive Affective Disorder have been associated with wind turbine generators. However these effects are a consequence of the interaction between the individual's attitude to, or perception of, the perceived offending stimulus and perhaps their underlying psychological state. These effects occur when an individual becomes distressed by a noise or sensation which triggers their awareness of the presence of the facility and escalating concern about harm. Anxiety then builds and a cue to the presence of a facility (such as visual or audible stimuli) becomes sufficient to trigger anxiety and distress.
- 7.42. Neither anxiety or reactive Affective Disorder can be directly taken into account in deciding whether an effects-based decision in resource consent is appropriate, although a decision does have to be made as to whether such perceived concern is reasonable or not. If it is unreasonable, notwithstanding distressing, to the individual

and not within their control the best mitigation for this effect is correction of misinformation and misapprehension about direct physiological effects which are often the true cause for distress.

### **Transmission Lines**

- 7.43. Dessiree Allen's supplementary submission raises concern over health effects from high voltage transmission lines. However, this facility is positioned in immediate proximity to the North Island Grid and will therefore supply the national distribution system directly from the substation linking the turbines. As a result, there will be no need for any extended transmission line.

### **Other Concerns**

- 7.44. Timothy Adams' submission states that there are "*insufficient studies of the health effects from wind generation facilities of this size so close to so many people*". I understand that point of view. It is true that we are extrapolating expected effects from knowledge of the underlying biophysical principles which apply, although these are very clear and well understood. I can agree that the rapid development of this industry in New Zealand would provide a good opportunity for confirmatory research and expect that this will be done. However, that does not imply uncertainty with respect to the health protection measures that are taken, but an opportunity for New Zealand researchers to document our experiences for the benefit of the literature as a whole.
- 7.45. The submissions of Michael Wild and Margaret McKenzie, Helen Sneddon and the Palmerston North Green Party raise concern over the risk of health issues during construction of the proposed substations as a result of PCBs. PCBs (or polychlorinated biphenyls) are a class of organic compounds historically used as dielectric (insulating) fluids in the transformers and capacitors of equipment used for electricity transmission. However, the environmentally damaging effects of these chemicals have been known for decades and they are now never used in new substations. The extent to which they remain a problem relates to disposal from decommissioned equipment. There will be no PCBs used in the construction of either these wind turbines or the associated substation.
- 7.46. The submissions of Mohammad Zaidan, Huid Morrell and Ismail Mustafa raised concern over the health effects of "waves" coming from the turbines. Such "waves"

would have to be either propagating through a medium (in this case the atmosphere) or electromagnetic waves which do not require any medium and propagate on their own account through space. As discussed by Mr Hegley and in my evidence, sound energy will be carried downstream and such energy does constitute waves in air - that is to say cyclic variation in air pressure which, in the audible range, is perceived as sound. It is also acknowledged that there may be some subsonic energy below the frequency of audible sound which are also waves but are not of any biological or health importance. Electric fields will be generated in any conductors in the turbines and other equipment, but these will be entirely screened by the turbine structures and underground cabling methods. There may also be magnetic fields which will pass through this screening but are of low magnitude and entirely within the relevant ICNIRP Guideline limits. Neither the electric nor the magnetic fields are themselves, or will combine to form, a radiated wave. Therefore, this is not a source of waves which should concern these submitters. There are no other plausible waves generated by this proposed facility.

- 7.47. Several submissions raised concern over the issue of health and safety, without describing any specific area of concern. It is because the applicant is concerned about any possibility of an effect on public health that extensive research and assessment regarding the probability of such effects has been undertaken. It is entirely reasonable for the community to expect this to have been undertaken and done to a standard to which they are entitled to rely on. It is however, unreasonable to expect such research to be discounted on the basis of not considering effects which have never been established nor suspected. Therefore, general unspecified concerns have to be discounted.

## **8. CONCLUSIONS AND RECOMMENDATIONS**

### **Suggested Approach for Effects Identified:**

- 8.1. *Air quality:* No effect. No mitigation indicated.
- 8.2. *Water quality:* Control discharges of sediment and dust into waterways as described in the WQMP. In particular, prevent any discharge into the Turitea Water Supply Catchment. Identify domestic use of waterways downstream of activities (if any).
- 8.3. *Visual effects:* Avoid casting significant flicker shadows on any dwelling place, workplace or school. No such instances are envisaged in the present design.

- 8.4. *Noise*: The wind farm should comply with New Zealand Standard NZS6808:1998. The designers have anticipated and incorporated that.
- 8.5. *Electric and magnetic fields*: Exposure will conform to the recommendations of the Ministry of Health and the 1998 ICNIRP guideline.
- 8.6. *Electrical safety*: Comply with NZECP 34:2001, The Health and Safety in Employment Act, and any other relevant statute or regulation.

### **Conclusion**

- 8.7. In my opinion the proposed Turitea Wind Farm and associated substations and transmission lines can be constructed and operated with minimal (if any) effects on the environment around it. Once construction is finished and the wind farm and transmission lines are operating I cannot identify any actual or potential adverse effect on public health or wellbeing unless misunderstanding or misinformation cause unjustified fear or concern and sensitises individuals to the ongoing presence of the wind farm. I consider there are no health related effects that should prevent the granting of consent subject to appropriate conditions.

**DAVID RUSSELL BLACK**

**1 May 2009**

**APPENDIX A**

**International Agency for Research on Cancer (IARC) Classification of Human Carcinogens [18]**

<b>Group</b>	<b>Supporting data required for classification in group</b>	<b>Examples</b>	<b>Number so classified</b>
Group 1: The agent is <i>carcinogenic</i> to humans.	<i>Sufficient</i> epidemiological evidence	Alcoholic beverages, Asbestos, Benzene, Radon, X-rays, Sunlight, Tobacco, Secondhand smoke	95
Group 2A: The agent is <i>probably carcinogenic</i> to humans.	<i>Limited</i> or inadequate epidemiological evidence PLUS sufficient animal evidence	Creosote, Diesel exhaust, PCBs, Sun lamps	66
Group 2B: The agent is <i>possibly carcinogenic</i> to humans.	Limited epidemiological evidence PLUS limited or inadequate animal evidence	Automobile exhaust, Coffee, Pickled Vegetables, Power Frequency Magnetic Fields	241
Group 3: The agent is <i>unclassifiable as to carcinogenicity</i> in humans.	<i>Inadequate</i> epidemiological evidence PLUS inadequate or limited animal evidence OR Does not fall into other groups	Caffeine, Coal dust, Fluorescent lights, Diesel fuel, Electric fields, Mercury, Saccharin, Tea, Static magnetic fields	497

## APPENDIX B

### Brief Summary of All Health-Related Submissions, by Submission Number

Submission Number	Name	Concern
54	Tracy Coyle	Don't want the reserve to be removed / damaged as it is important for health and safety in regards to noise and vibration from the turbines
63	Richard Verdonk	Concerned about proximity to housing and noise, vibration
66	Alan Adamson	Pollution and dust concern, noise and traffic safety
86	Ross Cassells	Are within 40 dBA zone Concerned about low frequency noise Talk of WHO saying that noise is linked to health effects, especially low freq noise Noise and sleep disturbance Cites ISO table 1996-1971 "recommendation for community noise limits to protect health and wellbeing" Rural: daytime upper = 35 dBA, 7-11 pm limit = 30 dBA, night limit = 25 dBA Strobe effect, particularly regarding migraines (wife)
87	Richard Mildon	General health concerns
89	Claire King	Concerns over impact of vibration on health and noise (has a chronic disease)
90	Ms Mayan Schraders	Noise and vibration and health issues
91	Maurice King	Says experts will negate each other with opposing opinions on sound, subsonic vibration, etc.
92	Timothy Adams	Says there are "insufficient studies of the health effects from wind generation facilities of this size so close to so many people". Wants an independent analysis of health effects
131	Chris Teo-Sherrell	General health concerns
135	Jenny Olsson	Concerns over dust contamination of water and air from metal roads, construction and water contamination from waste-water overflow. Noise concerns.
143 Plus additional submission (see 324 below)	Dessiree Allen	Concerned about noise and sleep disturbance (and health effects from this) Concerned about dust getting into the water reserve Concerned about dust / chemicals (from construction vehicles) affecting their tank water
144	Ms Danna Morgan	Concerned about contamination of water reserve Concerned about dust contamination of tank water
147	Arthur Renquist	Concerned about contamination of water reserve
155	Charles Cruickshank	Mental harm due to visual and audible pollution
156	Adam	Noise and stress

	Cruickshank	
163	Rosemary Thornton	Health issues from “strobe affect from the blades of the wind mills”. Says this will be every morning and night on sunny days for proximal residents. Calls the health effects “close to torture”. Adverse health effects from stress Concerned about water contamination
164	Alan Thornton	“Droning noise and land vibrations would be unbearable and cause problems to health. E.g. sleep deprivation, inability to concentrate. Health problems like these are well documented.” Concerned over strobe effect when sun/moon rises behind blades – safety issue for people driving in Palmerston North Water safety due to discharge of contaminants
166	Philip Pearce	Health concern over workers coming in and out of reserve (what do they carry? Eg giardia etc). Said to hunt in reserve need a medical certificate to show you don’t carry any disease that could affect water supply – but will workers need this?
186	Karine & David Chagne	Concerned about: - contamination of drinking water - Annoyance due to noise/visual (cite Pederson & Halmstad (2003) Noise annoyance from wind turbines- a review) plus more papers - Effect of low frequency noise on cardiovascular conditions (but admit they could not find any research articles to support this concern. Say that’s prob because it’s too new) - epilepsy from rotating blades (cite Harding et al., (2008) paper).
197	Dawne Perks	Talks of proven documented cases overseas of sleep deprivation, disorientation, and poor concentration from noise/vibration
218	Imogen Watson	Worried about increased noise and probable health (deterioration) implications Says the UK Noise Association / WHO recommend 1.6 km buffer from residences to avoid such noise hazards Concerned over long term health effects from dust pollution Concerned over diesel storage and water catchment quality
236	Monica Stichbury	Fire / erosion affecting water Noise concerns Flicker Safety implications for aviation and military
258	John Adams	Risk of water supply contamination Risk of fire Concerned over dust and contamination of roof water (near to substation, turbines and concrete batching plant) Flicker Concerned about sleep disturbance from noise

262	Mary Jenkin	General health concerns, particularly vibrations and headaches
294	Carla Piper	Water supply safety Mentions in the Netherlands, not building any more turbines on land due to “increasing health issues from noise and vibrations”. Concerned it will affect her sleeping.
295	Malcolm Frith	Contaminants getting into atmosphere and waterways – loss of drinking water quality Health effects of repetitive noise and vibration (torture)
299	Leigh Dome (Mrs)	14 turbines within 2 km of their home. Concerned about noise, vibration and flicker/strobing Concerned about unpleasant sensations of infrasound and about sleep disturbance Concerned about flicker – gets migraines, says will make them worse Concerned over city water supply
309	Mark and Sharon Malone	Don't mention health specifically but are concerned about noise and “seismic effects” of turbines
324 (additional to sub 143)	Dessiree Allen	Concerned about health impacts of transmission lines
326	Martyn Nail	Health effects: strobing, shadow flicker, sleep disturbance, Wind Turbine Syndrome. Talks of lots of independent studies into health effects and WHO proximity recommendations regarding wind farms due to noise Includes report by Nina Pierpont (recommends 3.04 km set-back in NZ). See below.
328	Edwina Neilson	Noise pollution General health concerns
329	Susan Cassells	Noise, particularly low frequency noise (Are within the 40 dBA zone) - Sleep disturbance. Effect of noise on health Strobe effect – sun/moon will rise behind turbines. Gets migraines from light flicker through trees while driving
332	Wayne Johnson	General concerns
335	Douglas Pringle	Claim their predicted noise level is above 40 dBA and night noise is only 25 dBA. Therefore, effect on health from noise (ref WHO) WHO noise effects on health: sleep disturbance, physiological functions, mental illness, performance, social and behavioural effects (annoyance) Concerned that health matters are not taken into account in NZ noise standard 6808
339	Christopher Barker	Concerned about noise, especially low frequency noise and effects on health and any “cumulative” effects from this combined with other nearby wind farms

		Concerned over contamination of water reserve
348	Bronwyn & Simon Ferry	Concerned about operational noise and vibration, and construction debris
350	Anthony Paewai	General concerns over vibration, noise, water supply
353	Sue & Mason Stewart	Health and well-being effects of noise Health risks to water
357	Rachel James	Concerned of health effects on children (due to proximity). Says that removal of the 9 zones (due to residential proximity) indicates that there ARE health risks (admitted). "Research shows there are a multitude of negative effects on health and well-being caused by living within 2 km of wind turbines". Claims numerous articles show this.
360	Tanya Zander	Noise – believes will cause headaches in child who is prone to them
365	Malcolm & Cheryl Wood	Concerned about potential health effects of audible and inaudible noise
369	Lynette Low	Flicker (says she is extremely sensitive to flickering light) – gets migraines from flicker of sun through trees, police lights. Had a son die of epilepsy, so thinks it's in family. References Dr Pierpont's belief on migraines and Wind Turbine Syndrome Effects on water supply Sleep disturbance from noise
375	Gary Trainer	Health effects of noise Effect on drinking water
383	Prudence Robbie	Health effects of noise Effect on drinking water Says adverse effects of low frequency (inaudible) noise are "undeniable". Adverse health effects due to anger and stress
384	William Frith	Water contamination Noise and health effects
387	Susan Parker	Noise and health effects
389	Margaret Mackie & Darrel Berry	Health effects of low frequency noise
392	Victor Bebb	Health effects of Wind turbine syndrome. Effects on children's hearing (says deaf foundation says they are a threat)
393	Lynette Bebb	Sleep disturbance (leading to depression, which she is prone to) Health effects of Wind turbine syndrome. Noise and flicker
450	Jonathan and Debra Perera	Concerned over "unknown" health impacts. Claim that future health effects of having turbines so close to homes is unknown. Effects of noise and subsonic vibration. Sleep disturbance Worried about sunlight reflections from blades in their

		rooms Concerned about drinking water (from Turitea stream) and construction contamination
459	Sarah Sims	Long term effects Noise
467	Glenda Roylands	General Health Concerns
468	Joyce Green	General Health Concerns
469	Caroline van der Haas	General Health Concerns, noise and water
473	Cynthia Hann	Noise – sleep deprivation and effects of “sub-noise”
474	David Alexander	General Health Concerns
479	Palmerston North Green Party	Water quality Health issues during construction of substations due to possible PCB contamination
484	Anthony Andersen	General health concerns
491	Mary-Anne Bailey	Noise, vibration, sleep Water supply
501	Richard and Wendy Day	General health concerns – “unknown” risks
502	Stephen Lang	Stress from view full of moving objects (not relaxing) Safety of access roads (increased traffic) Effects on drivers of approaching moving turbines
508	Isla Lewis	Health problems from noise
513	Tania Buwalda	Road safety & Children General health concerns
514	Allan Ryan & Marianne Tremaine	Noise impact on health and well-being Potential silting of water supply
515	John Flenley	General psychological concerns
518	Ian Lewis	General health concerns
519	John Hall	Shadow/strobing Noise – ill effects from the “harmonic vibrations from the turbines affecting the human nervous system”
527	Beverley Hall	Flicker harmonic vibrations from the turbines affecting the human nervous system Noise (especially at night)
533	Michael & Angela Grassick	Noise Water contamination
536	Rosemary Adams	Sleep Water quality
540	Hiba Mustafah (miss)	General health concerns
541	Mohammad Zaidan	General health concerns (“waves” coming from turbines)
543	Huid Morrell (miss)	General health concerns (“waves” coming from turbines)
546	Michael Wild &	Water quality

	Margaret McKenzie	Health issues during construction of substations due to possible PCB contamination
548	Miss Reem Mustafa	General health concerns
549	Mr Ismail Mustafa	General health concerns (“waves” coming from turbines)
553	Ivan Johnstone	Health issues from noise Potential pollution of drinking water
570	Roger & Carol Thomasen	Soil disturbance affecting water supply Health issues from noise
571	John Rounce	Say they are in a 40-69 dBA noise range Concerned over health effects from chronic noise exposure Concerned over health of horses
580	Nigel & Julia Cooper	Says wind farms have not been around long enough to know real health effects (likens it to Asbestos-not known to be bad until 1990s) Shadow flicker and strobing concerns and possible health concerns. Says he has not heard of any papers to rebut claims of ill health effects. Should not allow, until science says there is no effect. Concerned about sleep disturbance from noise Adverse effects from low frequency noise (cites overseas websites for this). Talks of a guy whose sleep and metabolism were affected.
590	Denis Turnbull	Risk of silt and disease contamination of water supply
595	Katherine Scott	General health concerns eg effect from sleep deprivation and worry
606	Helen Sneddon	Water quality Health issues during construction of substations due to possible PCB contamination
607	Wilhelmus Christiaans & Robyn Harding	Noise and Vibrations – health effects Lightening strike and Forest fire Noise, dust and pollution from construction
619	Harley James	Concerned of health effects on children (due to proximity). Says that removal of the 9 zones (due to residential proximity) indicates that there ARE health risks (admitted). “Research shows there are a multitude of negative effects on health and well-being caused by living within 2 km of wind turbines”. Claims numerous articles show this.
624	Vita von Wedel	General objections. Noise, vibration, flicker
626	Elizabeth & Michael Hendy	Noise Dust and water quality
629	Adrian Cookson	Increased traffic – safety risk Sedimentation and water supply Concerned over health effects of noise – thinks children are particularly prone to adverse effects
657	Ruth Cookson	General health concerns, incl sleep disturbance. Worried about more vulnerable people

## APPENDIX C

### Submitters with Health-Related Concerns, by Subject

Concern	Submitters
Noise / Vibration	Tracy Coyle, Richard Verdonk, Alan Adamson, Ross Cassells (low freq & sleep disturbance) Claire King Mayan Schraders Maurice King Jenny Olsson Dessiree Allen (sleep) Alan Thornton (sleep, concentration) Karine & David Chagne (stress, disturbance & low freq effects on cardiovascular disease) Dawne Perks (sleep deprivation, disorientation, poor concentration) Imogen Watson Monica Stichbury John Adams (sleep disturbance) Mary Jenkin (headaches from vibration) Carla Piper (sleep) Malcolm Frith Leigh Dome (infrasound & sleep disturbance) Martyn Nail (sleep disturbance) Edwina Neilson Susan Cassells (low freq & sleep disturbance) Douglas Pringle (sleep disturbance, physiological functions, mental illness, performance) Christopher Barker (low freq & combined effects of multiple windfarms) Bronwyn & Simon Ferry Anthony Paewai Sue & Mason Stewart Tanya Zander (headaches from noise, esp in child) Malcolm & Cheryl Wood (audible and inaudible noise) Lynette Low (sleep disturbance) Gary Trainer Prudence Robbie (low freq) William Frith Susan Parker (noise) Margaret Mackie & Darrel Berry (low freq noise) Victor Bebb (hearing, esp children) Lynette Bebb (sleep, depression) Jonathan and Debra Perera (noise & subsonic vibration, sleep) Sarah Sims Caroline van der Haas Cynthia Hann (sleep deprivation, subsonic noise) Mary-Anne Bailey (sleep) Isla Lewis

	<p>Allan Ryan &amp; Marianne Tremaine  John Hall (“harmonic” vibrations affecting the nervous system)  Beverley Hall (sleep, “harmonic” vibrations affecting the nervous system)  Michael &amp; Angela Grassick  Rosemary Adams (sleep)  Ivan Johnstone  Roger &amp; Carol Thomasen  John Rounce  Nigel &amp; Julia Cooper (sleep disturbance, low frequency - metabolism)  Katherine Scott (sleep)  Wilhelmus Christiaans &amp; Robyn Harding  Vita von Wedel  Elizabeth &amp; Michael Hendy  Adrian Cookson (esp children)  Ruth Cookson (sleep)</p>
<p>Contamination of catchment water</p>	<p>Jenny Olsson  Dessiree Allen  Danna Morgan  Arthur Renquist  Rosemary Thornton  Alan Thornton  Philip Pearce (workers bringing in transmissible diseases eg giardia into catchment area)  Karine &amp; David Chagne  Imogen Watson (from diesel storage)  Monica Stichbury (from fire, erosion)  John Adams  Carla Piper  Malcolm Frith  Leigh Dome  Christopher Barker  Anthony Paewai  Sue &amp; Mason Stewart  Lynette Low  Gary Trainer  Prudence Robbie  William Frith  Jonathan and Debra Perera  Caroline van der Haas  Palmerston North Green Party  Mary-Anne Bailey  Allan Ryan &amp; Marianne Tremaine  Michael &amp; Angela Grassick  Rosemary Adams  Michael Wild &amp; Margaret McKenzie  Ivan Johnstone  Roger &amp; Carol Thomasen  Denis Turnbull  Helen Sneddon  Elizabeth &amp; Michael Hendy</p>

	Adrian Cookson
Contamination of personal roof / tank water	Dessiree Allen Danna Morgan John Adams (near substation & batching plant)
Flicker / strobe / light effects	Rosemary Thornton Alan Thornton Karine & David Chagne (epilepsy) Monica Stichbury John Adams Leigh Dome (migraines) Martyn Nail Susan Cassells (migraines) Lynette Low (migraines and have epilepsy in family) Lynette Bebb Jonathan and Debra Perera (sunlight effects indoors) Stephen Lang (safety on roads when driving) John Hall Beverley Hall Nigel & Julia Cooper Vita von Wedel
Dust pollution /airborne contamination	Alan Adamson Jenny Olsson Imogen Watson Malcolm Frith Bronwyn & Simon Ferry Wilhelmus Christiaans & Robyn Harding Elizabeth & Michael Hendy
Wind Turbine Syndrome	Martyn Nail Lynette Low Victor Bebb Lynette Bebb
Transmission lines	Dessiree Allen
Substations	Palmerston North Green Party (PCBs) Michael Wild & Margaret McKenzie (PCBs) Helen Sneddon (PCBs)
Stress / mental harm	Rosemary Thornton Charles Cruickshank (from noise/visual) Adam Cruickshank (from noise/visual) Prudence Robbie (stress, anger) Stephen Lang John Flenley Katherine Scott (worry)
General (unspecified) health concerns	Richard Mildon Timothy Adams Chris Teo-Sherrell Mary Jenkin Mark and Sharon Malone Edwina Neilson Wayne Johnson Rachel James Sarah Sims (long-term effects) Glenda Roylands Joyce Green

	<p>Caroline van der Haas  David Alexander  Anthony Andersen  Richard and Wendy Day (“unknown” risks)  Tania Buwalda  Ian Lewis  Hiba Mustafah  Mohammad Zaidan (“waves” coming from turbines)  Huid Morrell (“waves” coming from turbines)  Reem Mustafa  Ismail Mustafa (“waves” coming from turbines)  Harley James (children)  Ruth Cookson (esp “vulnerable” people)</p>
Other	<p>Monica Stichbury – aviation and military safety  John Adams – bush fire  Rachel James – effects on children  Tania Buwalda – children and road safety  John Rounce – effects on horses  Wilhelmus Christiaans &amp; Robyn Harding – lightening strike and bush fire</p>

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