IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of a notice of requirement issued by **WEL NETWORKS LIMITED** pursuant to section 168(2) of the Act for designations (3) to authorise the implementation of the Western Network Upgrade Project

STATEMENT OF EVIDENCE OF DAVID RUSSELL BLACK

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 and MBChB 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 Upper North Island Grid Upgrade project for Transpower New Zealand Limited and the Coroglen to Kaimarama transmission line proposal for Powerco 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.

Involvement in project

1.5 After the design of the Western Network Upgrade Project ("WNUP"), I was consulted by WEL Networks Limited ("WEL") 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.

1.6 I have visited the site of the WNUP on at least five occasions between 2006 and 2008. During these visits, I inspected the route proposed for the transmission lines and familiarised myself with the physical characteristics of the environment and the nature of the surrounding communities. I have considered any conceivable, even theoretical, influence of the proposed transmission line and substations 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

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

1.8 In that regard, this evidence will:

a) Briefly describe the key elements of the proposal relevant to this evidence (section 3);

b) Put my evidence into context by: providing and describing the geographical environment; providing some background to the operation of electricity systems; describing the characteristics of electromagnetic fields; describing the characteristics of electromagnetic fields in regards to transmission lines and electricity substations; describing the ICNIRP Guideline for electromagnetic safety; and discussing the biological effects of electric and magnetic fields (section 4);

c) Outline the key issues relevant to the consideration of public health effects (section 5);

d) Outline the key issues relevant to occupational safety (section 6);

e) Address the issues raised in specific submissions made on WNUP (section 7);

f) Comment on the Officers report and proposed conditions (section 8);

and

g) Give my conclusions and recommendations (section 10).

1.9 A summary of my evidence is contained in Section 2.

Expert witness code of conduct

1.10 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note 2006 [2006] NZRMA 357. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2. SUMMARY

2.1 My detailed evidence follows. At the outset, the key conclusions in relation to the potential health effects of the proposal can be summarised as follows.

Key elements of proposal

2.2 The key elements of the proposal relevant to my evidence include:

(a) A high voltage transmission line which will convey electricity from the Wind Park substation to the Te Kowhai substation;

(b) 240 steel or concrete poles which will carry three 110 kV conductors, an earth wire and a fibre optic cable; and

(c) A 110 kV / 220 kV electricity substation at Te Kowhai and a 33 kV / 110 kV substation at the proposed Te Uku Wind Park.

2.3 The proposed transmission line will traverse 25 km of farmland and road (including Waipa River) from the Te Uku Wind Park to Te Kowhai. The line route will never be closer than 30 metres to any occupied building.

2.4 The Proposed Te Kowhai substation will be located beside an existing Transpower substation on a 16 hectare, fully fenced site. The proposed Wind Park substation will be located with the Te Uku Wind Park on the Wharauroa Plateau on farm land.

2.5 Electricity is carried from the generating source to regional substations by high voltage lines (110 kV or 220 kV) and is stepped down through local substations at 33 kV (which need to be located close to the destination of the energy and are therefore after found in communities). The electricity is then stepped down by transformers normally located in suburban streets.

Electric and magnetic fields

2.6 Electromagnetic fields (EMFs) are comprised of electric fields (*E*) and magnetic fields (*H)*. *E* fields exist when a conductor is charged and *H* fields exist when current is moving through a conductor. The most interest for potential health effects is the density of the magnetic field strength (magnetic flux density (*B*)). *E* fields can be shielded by most building materials but, *H* fields cannot. Both field strengths fall off very rapidly with distance from a conductor.

2.7 No significant radiation arises around power conductors at the frequency of mains electricity (50 Hz). Radiation is a phenomenon that only occurs at much higher frequencies when electric and magnetic fields combine to form a wave.

2.8 As over head lines are not shielded, both electric and magnetic fields are found around the conductors. Some reduction can be achieved by reverse phasing but distance is the only attenuating factor. Within a few metres from a conductor, magnetic flux density and electric fields fall well within safety guidelines.

2.9 Under certain weather conditions, corona discharge will occur in the air around high tension conductors as a result of electric fields, creating an audible vibration.

2.10 The International Commission for Non-ionising Radiation Protection ("ICNIRP") published a definitive guideline in 1998 which forms the basis for most international standards. The ICNIRP Guideline has been adopted by the New Zealand Ministry of Health and in my view its approach to protection thresholds for general public exposure should be definitive in this matter.

2.11 The ICNIRP Guideline provides the reference levels (i.e. chosen in order to eliminate all known biological or health effects by a wide safety margin) for magnetic flux density at 50 Hz of 100 µT for general public exposure and 500 µT for occupational exposure.

2.12 EMFs can have biological effects on the human body, including stimulation of electrically sensitive tissue (e.g. nerves and muscle). These effects are well understood and the ICNIRP Guideline is designed to prevent these effects. The probability that there may be effects at levels below perception has been investigated over many decades, but no such effects have been established.

2.13 Much research has been undertaken to establish whether there is an association between small excesses in the rates of certain cancers and EMFs from power distribution systems, but the results are inconsistent and inconclusive. As a result, extra low frequency ("ELF") EMFs have been placed in Category 2B which signals that they are *possibly* carcinogenic (along with coffee and pickled vegetables).

2.14 The existence of unsettled research means that the possibility of magnetic fields as a contributor to childhood leukaemia remains, but could only be an extremely rare risk. The most likely exposure to magnetic flux density is in

buildings with high current carrying conductors in the walls and many household appliances expose the public to greater levels of magnetic flux density than high voltage conductors. Given that the proposed transmission line does not encroach on any living space, the uncertainty around ELFs and leukaemia is not a relevant consideration.

Issues relevant to public health considerations

2.15 Mr Milton's report has calculated EMFs around the WNUP transmission line having regard to the possible scenarios at maximum load conditions. His conclusions show that the maximum electric field strength (less than 2 kV m^{-1}) and magnetic flux density (less than 20 µT) in areas accessible by the public or adjacent landowners are well below the limits recommended by the ICNIRP Guideline.

2.16 Mr Mitton's evidence has calculated EMFs around the Te Kowhai and Wind Park substations under worst case conditions. His conclusions show that maximum electric field strength (less than 1.45 kV m^{-1} at both substations) and magnetic flux density at 1 metre above ground (less than 15 µT at the Te Kowhai substation and just over 20 µT at the Wind Park substation) are well below the limits recommended by the ICNIRP Guideline.

2.17 There are no biological or health concerns about this proposal and no reason not to proceed on the basis outlined by WEL in their notices of requirement given the proposed design and conditions.

3. KEY ELEMENTS OF PROPOSAL

3.1 This application relates to a proposal by WEL to construct a high voltage transmission line to form part of the WEL distribution network in the Western Waikato. The proposed line will convey electricity from the proposed Te Uku Wind Park generating station to substations at Te Uku (WEL) and Te Kowhai (interfaced with Transpower).

3.2 The line will be carried on approximately 240 single poles made of steel or concrete. The line will be comprised of three conductors, will operate at 110 kV (± 5%) and will carry up to 84 MW. Each pole will also carry an earth wire and a fibre optic cable.

3.3 Additional circuits at 11 kV or 33 kV may also be carried on some sections of the line.

3.4 The height of each pole will generally be 17 metres, although taller poles will be used when topographical features require this.

3.5 This proposal also includes the construction and operation of two electricity substations. The first of these is the Te Kowhai substation, which will be located beside an existing Transpower substation within a 16 hectare site. The proposed 110 kV WNUP transmission lines will feed into the Te Kowhai substation which will convert this to 220 kV for further transmission through the North Island Grid. The substation will include a control room, a toilet, a gantry, 220 kV bus extensions, 110 kV and 220 kV protection, a 110 kV / 220 kV transformer, incoming conductors and a termination support structure. The site will be fenced at a distance of no less than 6.5 metres from the substation, with a locked gate at the entry.

3.6 The second proposed substation is the Wind Park substation which will be located with the Te Uku wind farm on the Wharauroa Plateau. The Wind Park substation will receive 33 kV electricity from the Te Uku Wind Park and will convert this to 110 kV for further transmission. The substation will include a control room, a toilet, a 110 kV gantry, 110 kV and 33 kV protection, a 110 kV / 33 kV transformer, incoming conductors and a termination support structure. The site will be fenced and access controlled.

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 transmission line will descend from the elevated position of the proposed Te Uku Wind Park on the Wharauroa Plateau across farmland, then turn to the north east generally following land contours until it joins Karakariki Road and runs northward on the eastern side of the road reserve. The line then bears to the east, crosses farmland and the Waipa River to reach Te Kowhai. The overall distance covered by the line will be 25 km.

4.3 The transmission line will approach a few small paper roads, for example on the McCauley property, however, relatively few populated areas are approached and none are directly traversed. It is likely that the route will never be closer than 30 metres to any occupied building.

4.4 The proposed Te Kowhai substation will be located within a large 16 Hectare site, which is surrounded and mostly obscured from view by shelterbelt planting. The nearest boundary to the security fence will be at an approximate distance of 567 metres.

4.5 The proposed Wind Park substation will be situated near an existing stockyard on the farm of Mr Vanhoutte. The site is located near the Te Uku Wind Park turbines and the neighbouring land is predominantly used for grazing. There is no public access to this part of the Vanhoutte property.

New Zealand electricity mains systems – background

4.6 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 high voltage lines running at 220 kV or 110 kV and this is stepped down to local substations at 33 kV. 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.

4.7 The next level of step-down is performed by 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.

Electric and magnetic fields

4.8 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 electromagnetic fields ("EMF") which have components which are thought of as electric fields (*E*) and magnetic fields (*H*).

4.9 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 and can be present even when no current is flowing. *H* fields exist when current is running through a conductor. The strength of the *H* field is directly related to current flow and is expressed in amperes per metre (A m^{-1}).

4.10 In practice, 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 practice fields usually encountered are in millionths of this (microTesla abbreviated as μT).

4.11 *E* fields can be shielded to some extent by most building materials, while *H* fields are not attenuated by most materials. However, both electric and magnetic field strengths fall off very rapidly with distance from a conductor. The manner in which these field strengths fall off with distance from a conductor carrying an electric current is complex, however, in all cases the fall-off in magnetic flux density and electric field away from the conductor is rapid.

4.12 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 transmission lines

4.13 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.

4.14 However, as stated above, both magnetic flux density and electric field strength fall off rapidly with distance from a conductor. That means that any electric or magnetic fields which do arise from overhead transmission lines fall off in strength very rapidly so that at a distance of a few metres they fall well within safety guidelines.

4.15 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.

4.16 The noise from this needs to be considered and should not exceed the ruling limits for the area and installation.

Electric and magnetic fields and electricity substations

4.17 Electric fields at the proposed Te Kowhai and Te Uku Wind Park substations will be effectively screened by the shielding of the underground cables, the design of the transformers and by the substation construction.

4.18 Magnetic fields will be relatively contained in the substation facility and due to the rapid fall off, only very low levels, if any, are expected at the boundaries of the substation site.

4.19 The major items of equipment in a substation are the transformers in which magnetic fields are enclosed and directed to induce current at a higher voltage in the secondary windings of the machines. The transformers themselves consist of tightly wound coils of electrical conductors and the magnetic fields found outside of these are much less than those associated with a conductor in free space.

4.20 There generally are some electric and magnetic fields measurable around the switchgear used for controlling the input and output of the substation but these are no more than would be expected from the conductors themselves. There is therefore, no reason to regard the potential for electromagnetic fields from a substation any differently to the rest of the line.

International Commission for Non-ionising Radiation Protection (ICNIRP) Guideline for protection against electric and magnetic fields

4.21 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 [1] which has subsequently formed the basis for most international standards.

4.22 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... The next revision of the ICNIRP Guideline for extra low frequency ("ELF"), will be based on the recently published EHC 238 2007 [2]. This publication is available now and so the approach expected in the next ICNIRP Guideline is already clear.

4.23 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.

4.24 This publication is entirely relevant to this matter and it is my view, that 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*" .

4.25 I share that view. In my opinion, the approach taken by ICNIRP to protection thresholds for general public exposure in its Guideline document should be regarded as definitive in this matter.

4.26 The ICNIRP Guideline uses the terms “Basic Restrictions” and “Reference Levels” which are the parameters most closely equating with actual biological or health effects. Reference levels are chosen to eliminate all known biological or health effects by a wide safety margin. Reference levels are given for a range of frequencies, for both the general public and at an occupational level. In the case of overhead transmission lines such as in this proposal, both the *E*-field and the *B*-field need to be considered. In the case of electricity substations, only *E* fields need to be considered. *E* and *B* fields are calculated using the formulae from table 7 on page 18 of the 1998 ICNIRP Guideline.

(a) Reference levels for the general public at 50 Hz (ICNIRP 1988) are as follows:

Public Levels at 50 Hz (ICNIRP)		
E-field strength (V m^{-1})	*H*-field strength (A m^{-1})	*B*-field (μT)
250/0.05 = 5000 V m^{-1}	4/0.05 = 80 A m^{-1}	5/0.05 = 100 μT

(b) Reference levels for occupational exposure at 50 Hz (ICNIRP 1988) are as follows:

Occupational Levels at 50 Hz (ICNIRP)		
E-field strength (V m^{-1})	*H*-field strength (A m^{-1})	*B*-field (μT)
500/0.05 = 10,000 Vm^{-1}	20/0.05 = 400 Am^{-1}	25/0.05 = 500 μT

4.27 That is, the conservative ICNIRP safety threshold for levels of magnetic flux density at 50 Hz (being the frequency associated with electricity reticulation), are 100 μT for members of the general public and 500 μT for occupational exposure.

Biological effects of electric and magnetic fields

4.28 Electric fields at 50 Hz generally have a surface effect on the human body. 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 such as the ICNIRP Guideline are thoroughly established to prevent these effects which are well understood,

characterised, and comprehensively documented in WHO Environmental Health Criteria.

4.29 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 may be regarded as no more than perception, and is prevented by exposure standards for magnetic and electric fields (such as the ICNIRP Guideline).

4.30 Electrically conductive objects within electric and magnetic fields can also become charged with the potential to cause electric shocks if touched.

4.31 As discussed below, 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.

Possible low level effects of extra low frequency magnetic fields

4.32 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 [4]. 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 .

4.33 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 ELF (50-60 Hz) electromagnetic fields would be placed into category 2B, indicating that they are *possibly* carcinogenic (see Appendix A). 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 μT.

4.34 Category 2B 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.

4.35 In 2001 an NRPB report [6] had identified an apparent difference in epidemiological data in the incidence of leukaemia in children with lifetime average exposure at levels above about 0.3-0.4 μT. Whilst this effect is far from confirmed, it did move the renowned cancer epidemiologist Sir Richard Doll to regard levels of magnetic fields lower than this as well as all electric fields as no longer featuring in the debate.

4.36 It remains widely believed that these reported associations are caused by confounding 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 such a small magnitude that, even if it were to be confirmed, given the benefits of electricity, it probably would not alter the way in which electricity is used [7].

4.37 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 μT. This can happen in industrial and residential settings, although it is unusual in New Zealand.

4.38 Magnetic flux density is proportional to current and falls of very rapidly with distance. The more likely circumstances of such exposure are in domestic, industrial or commercial 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.

4.39 As an example, the WHO information website for electromagnetic fields includes a table of typical magnetic flux densities (which they term “magnetic field strength”) of common household appliances at various distances. This table (see Appendix B) shows that many ordinary household appliances may expose the public to greater levels of magnetic flux density than high voltage conductors.

4.40 In any event, I have not identified any circumstances or conditions even approaching them where such levels could encroach on the living spaces anywhere around the proposed WNUP transmission lines. For that reason, in my opinion, the unsettled science with regard to ELF and leukaemia is not an issue at all for consideration of the health effects of this proposal.

Cautionary approach or prudent avoidance

4.41 A number of authorities throughout the world have revisited the idea of applying a cautionary approach to electric wiring, particularly where larger currents are concerned, in order to minimise public exposure. Such a practice has been the subject of substantial analysis by the WHO and has also been summarised in the 2007 EHC238 . Such an approach requires demonstration of engineering which minimises exposure providing that this can be done at a reasonable cost and without undue disruption to the service goal of the installation. This is similar to the idea of ‘prudent avoidance’ advanced by Professor Granger Morgan of Carnegie Mellon University [8] more than a decade ago.

5. ISSUES RELEVANT TO PUBLIC HEALTH CONSIDERATIONS

Electric and magnetic fields and the WNUP transmission lines

5.1 EMF compliance for the WNUP transmission line has now been established in the report from Mr Mitton (Doc: MEL-R363 Rev-02) dated 11th November 2008. In this report, the electric and magnetic fields expected from seven different arrangements of the 110 kV line, either with or without a 33 kV or 11 kV line built underneath are calculated. These calculations were made under maximum load conditions. Loads above this level will not be permitted in the line and would trigger automatic shutdown. Therefore Mr Mitton's figures reflect worst case conditions.

5.2 In particular, this report shows that:

(a) The maximum electric field strength at any position accessible to the public or an occupier of an adjacent property is well under 2 kV per metre. The ruling level specified in the ICNIRP Guideline is 5 kV per metre.

(b) The maximum magnetic flux density at any position accessible to the public or an occupier of an adjacent property is well under 20 µT. The ruling levels specified in the ICNIRP Guideline is 100 µT.

(c) Electric field strengths at 30 metres are always of the order of, or less than 50 V/m.

(d) Magnetic field strengths at 30 metres are less than 1 µT.

(e) These levels are of the order which would normally be expected and frequently found in both rural and suburban roadside environments wired for domestic electric power supply. These levels are of no biological or public health concern.

5.3 These calculations are reiterated in the evidence of Mr Mitton.

5.4 The design and field strength calculations from Mr Mitton show that compliance with the Guideline is achieved with a wide margin of certainty.

5.5 The level of electric field strength expected in any area occupied or traversed by the general public is lower than levels which would be expected to cause any adverse effects or even perception of the presence of the electric field.

5.6 The level of magnetic field expected in any area occupied or traversed by the general public is lower than levels which should cause any concern about adverse health effects even having regard to the ongoing unsettled research about low-level chronic exposure and long-term stochastic effects.

5.7 From the above it is clear that the WNUP transmission line meets both the strict compliance requirements of the ICNIRP Guideline as well adverse best contemporary practice in terms of a precautionary approach to general public exposure to electromagnetic fields. The results show that even under worst case conditions, electromagnetic fields from the 110 kV line will be well under safe levels for both electric and magnetic fields.

5.8 As a result, the WNUP transmission line will easily comply with the Waikato Operative District Plan (**"**ODP**"**) regulation rule 9.5.10(j) regarding

electromagnetic effects, which states "*Activities shall be conducted to avoid electromagnetic nuisance…*"

Electric and magnetic fields and the Te Kowhai and Wind Park substations

5.9 As discussed in sections 3 and 4, the Wind Park substation will be located on the Vanhoutte property and will be fully fenced with controlled site access. The site does not need to be screened in any other way. Electric and magnetic fields in and around the substation are no greater than would be found from the conductors feeding to and from the substation.

5.10 Similarly, the proposed Te Kowhai substation will be fully fenced, with restricted access. Electric and magnetic fields from the Te Kowhai substation will also be no more than those found adjacent to the line feeding it.

5.11 Mr Mitton has provided a more detailed analysis of the electromagnetic fields around the substations in his evidence. In particular, Mr Mitton's evidence shows that;

(a) Electric fields at the Te Kowhai and Wind Park substations will not exceed 1.45 kV per metre.

(b) Magnetic flux density at the Te Kowhai substation will not exceed 14.7 µT at 1 metre above the ground.

(c) Magnetic flux density above the buried 33 kV cables feeding the Wind Park substation were calculated based on the worst case scenario, using a flat cable configuration (instead of trefoil). Using this configuration, magnetic field strengths are predicted to be 70 µT directly above the cables at ground level, and just over 20 µT at 1 metre above ground.

5.12 This is consistent with my experience of other substations similar to the two in this proposal and shows that magnetic and electric field strengths at both substations will be well within the limits prescribed by the ICNIRP Guideline.

5.13 Therefore there are no health related concerns regarding EMF and the Te Kowhai or Wind Park substations.

Electrical Safety

5.14 The WNUP transmission lines will comply with the New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001) which provides high level of safety equivalent to that found in other electrical transmission facilities in New Zealand.

5.15 Compliance with NZECP 34 provides general guidelines relating to electrical safety, including specifications of safe distances between transmission lines and water or land, and safe distances between transmission lines and buildings or structures.

5.16 Provided these specifications are followed, there will be no risk to the general public in regards to electrical safety.

Navigable waterways

5.17 Where the WNUP transmission line traverses any navigable waterway, the issue of electrical safety and safe clearance must be considered. This is covered by NZECP 34, which states "*The height of conductors over a navigable waterway shall be determined in consultation with the Maritime Safety Authority of New Zealand (MSA). The booklet titled "New Zealand System of Buoys and Beacons", produced by MSA, shall be used as a guide.*"

5.18 However, there is now a more recent publication from the Electricity Engineers' Association (EEA) and Maritime New Zealand entitled "Safety Management of Power Line Waterway Crossings; A Guide" [10]. The preface of this guide states "*This Guide supersedes previous publications including the information on power line crossing signage and safe clearances calculations contained in all versions of the New Zealand's System of Buoys & Beacons booklet, published prior to 2006.*"

5.19 This guide covers issues such as the identification of waterway crossings (including what the responsibilities are for the line owner and the waterway administrator), determination of whether formal hazard management is needed, the design and placement of warning signs (if needed) and methods for reviewing managed crossings to identify any changes impacting on health and safety. .

5.20 According to section 5.2 of this guide, it is the responsibility of WEL to identify any water crossings assessable to the WNUP transmission line and advise

the appropriate waterway administrator of the location of such crossings. WEL must also assist with hazard assessments and install and maintain appropriate signage.

5.21 Sections 5.4 and 5.5 of the guide provide criteria to assess whether or not a waterway crossing is classified as low risk, or as assessable (requiring an on site safety risk assessment). The proposed WNUP transmission line will cross the Waipa River near Te Kowhai. WEL will need to determine whether this waterway is classified as "assessable" and take the appropriate action.

5.22 If the waterway is classified as assessable and determined to need management, minimum safe electrical clearances will need to be calculated, as the standard NZ ECP34 clearance of 6.5 metres (between a conductor and water) is unlikely to be sufficient. Section 8 of the guide provides criteria for determining the minimum safe electrical clearances. This states;

"*The Maximum Safe Vessel Height above the waterline stated on Type 2 signs, shall be determined by calculating:*

a. The minimum available clearance from risk Case 1 or Case 2 below:

i Case 1 - The mean water level (inland waterways) or mean sea level, with the maximum design conductor temperature for that line (eg. 50, 75, 90, 120º C as appropriate); or

ii Case 2 - Maximum design flood level (inland waterways), or highest astronomical tide[5] *(for the sea) with a 35° C conductor temperature; and*

b. deducting the Electrical Flashover Distance from Table 2 below; and

c. *deducting the Safety Margin from Table 2 below.*"

5.23 Provided WEL follows this guide, adjusts the height of the transmission line where it crosses the Waipa River to ensure safe passage for vessels on the river and installs and maintains the appropriate signage, then I do not see any risk to public health and safety from the transmission lines and navigable waterways.

Noise and the transmission lines

5.24 As discussed in section 4, electric fields generated around high voltage conductors can cause ionisation of air such as corona. Under particular

environmental conditions, this can lead to a certain amount of noise (in the form of sizzling) around a transmission line.

5.25 The issue of audible noise from corona was addressed in section 4 of the Mitton report. Maximum levels of audible noise were calculated at 25 metres to the side of the outer conductor for the 6 different arrangements of the transmission line. The highest of these maximum noise levels calculated was 25 dBA.

5.26 Noise of this level is low enough to be of no concern from a public health perspective.

5.27 To put this in context, the WHO have published a document entitled "Guidelines for Community Noise" which aims 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".

5.28 The noise levels from the WNUP transmission line will be well below any of these levels specified by the WHO.

5.29 The noise levels calculated by Mr Mitton will also easily comply with the levels required by the Waikato ODP and by NZ Standard 6802:1999 . Noise in a Rural Zone is limited in the Waikato ODP under Rule 48.5.4(c). This rule states:

> "*All activities, excluding farming, shall be conducted and buildings located, designed and used to ensure that noise levels at or within the notional boundary do not exceed the following limits:*
>
> | | | |
> |---|---|---|
> | *Monday to Friday* | *7:00am – 7:00pm* | *50dBA (L_{10})* |
> | *Saturday* | *7:00am - 6.00pm* | *50dBA (L_{10})* |
> | *At all other times including Public Holidays* | | *40dBA (L_{10})"* |

5.30 A 45 dBA limit for noise is also given in NZ Standard 6802:1999.

Noise and the Te Kowhai and Wind Park substations

5.31 The noise effects of the proposed Te Kowhai and Wind Park substations are addressed in the evidence of Mr Nevil Hegley.

5.32 For the Te Kowhai substation, Mr Hegley has measured the existing operational noise levels and used this to help calculate the predicted total operational noise once the new transformer is built. His evidence shows that the predicted noise levels are acceptable in the environment at Te Kowhai.

5.33 For the Wind Park substation, Mr Hegley calculates that noise at the boundary will not exceed 20 dBA.

5.34 The noise levels calculated by Mr Hegley are low enough to be of no concern from a public health perspective. The levels also comply with the levels required by the Waikato ODP under Rule 48.5.4(c) as stated above.

6. OCCUPATIONAL HEALTH

Construction phase

6.1 In 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 evidence.

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 WNUP transmission lines and two associated substations are operational, workers will need to comply with the ICNIRP Guideline for occupational exposure to electric and magnetic fields given in section 4.

6.4 These levels remain entirely safe but with a lower safety margin than public exposure levels.

7. SUBMISSIONS

7.1 I have reviewed the submissions lodged with regard to this project, taking particular notice of concerns which could relate to health effects.

7.2 Several submitters just raised general concerns over possible health issues. I have already discussed any potential health issues in my evidence above.

Therefore, this section will only address specific concerns raised by submitters.

EMF and cancer

7.3 Mr R. Gibbs's submission raised the issue of cancer, stating "*there is considerable information backing up the theory that these lines contribute to CANCER*".

7.4 The issue of ELF radiation and health has been studied extensively and is the subject of many thousands of published articles. Despite this, no proven link has been established between cancer or childhood leukaemia and EMFs. As discussed, research is on-going and the ICNIRP remains up-to-date with that research. The current ICNIRP Guideline provides comprehensive protection against all known and established effects of electromagnetic fields.

7.5 It is true that the uncertainty about stochastic effects of long-term low-level exposure to magnetic fields has prompted some authorities, including the WHO to adopt a precautionary approach to exposure where this is substantial and continuous. This approach is described in detail in the latest WHO environmental health criteria publication (EHC 238). However, WHO emphasises that current guidelines including those adopted by ICNIRP continue to be appropriate for public health protection.

7.6 However, the ongoing research about health effects from magnetic fields is irrelevant in this case as there simply are no biologically significant electric or magnetic fields within a short distance of the transmission line.

EMF and "radiation"

7.7 Ms O. Fletcher's submission calls for the WNUP transmission line to be undergrounded, in order to "*minimise radiation*".

7.8 As already discussed, electromagnetic energy from a high voltage conductor such as in this proposal is not the same as radiation. Radiation is a phenomenon that occurs at much higher frequencies (it is generally not considered below 3 kHz). The term is used to describe when electric and magnetic fields combine to form an electromagnetic wave in which energy leaves the conductor and propagates away into space. Such a wave is part of the electromagnetic spectrum and this effect is utilised in radio technology and also as a means of transferring energy locally such as in microwave heating.

7.9 Electric and magnetic fields at extra low frequencies such as in this proposal do not combine, are not radiation and have importantly differently biological characteristics compared to an absorbed radiated wave.

7.10 In my opinion, the undergrounding of the WNUP transmission liner is not necessary from a public health perspective. With the current overhead proposal, the Mitton Report shows that levels of electric and magnetic fields are already well within safe limits (as set by the ICNIRP Guideline) in all areas accessible to the general public. Further mitigation is unwarranted.

Water quality

7.11 Mr R Wilson's submission raises the concern that run-off from construction could get into local streams and eventually lead to pollution of Raglan Harbour.

7.12 The Assessment of Environmental Effects for the WNUP transmission line includes proposed mitigation measures to minimize environmental impacts during construction. This includes the preparation of a Construction Management Plan ("CMP"), which will be submitted for approval to the Environmental Services Group Manager at the Waikato District Council. Part of the brief of the CMP will be to install sediment control measures.

7.13 Provided these measures are adequate, there should be minimal risk to waterways from sediment run-off during construction.

7.14 This is supported by the report on ecological effects of the WNUP transmission line and associated Te Uku wind farm and substations by Kessels and Associates Limited (Draft II, 6th October 2008). Included in this report, is an assessment of the risk of sediment run-off during construction effecting waterways. The report concludes "*Provided standard good practice silt control techniques are implemented during construction, effects on waterways would be short-term and no more than minor*". The report also states that there will be "*little effect on the downstream systems*".

7.15 Given this finding, I do not foresee any risk to public health and safety from effects on water quality.

8. OFFICERS REPORT AND PROPOSED CONDITIONS

8.1 I have read the officers report and consider that all of the issues raised relating to public health are fully dealt with in the design of the proposed line

and substations and by the conditions recommended in the officer's report and proposed by WEL.

Te Kowhai substation

8.2 Condition 2.3 stipulating the erection of a security fence and signage to prevent and warn of unauthorised entry to the substation will protect the public from potential electrical safety risks.

8.3 Condition 3.2 requiring the submission of a CMP provides adequate protection to health and safety from contamination of waterways.

8.4 Condition 4.2 limiting the operational noise levels at the substation boundary to 50 dBA (L_{10}) Monday to Friday 7 am – 7 pm and Saturday 7 am – 6 pm, and 40 dBA (L_{10}) at other times is sufficient to protect public health and safety regarding noise.

8.5 Conditions 5.1 and 5.2 that EMF levels comply with ICNIRP Guideline and that radio frequency fields comply with the limits in the New Zealand Standard NZS 2772.1 [13] are adequate to protect the public from potential effects from EMF and radio frequency radiation.

WNUP transmission line

8.6 Condition 2.2 requiring the submission of a CMP provides adequate protection to health and safety from contamination of waterways.

8.7 Condition 4.1 that EMF levels comply with ICNIRP Guideline is adequate to protect the public from potential effects from EMF.

8.8 With respect to the Waipa River crossing, having read the evidence of Mr Molliken and Mr Jackson I am entirely satisfied that the matters that I have raised will be met by the proposed design with a good margin of safety so that no specific condition regarding this crossing is necessary.

Wind Park substation

8.9 Condition 2.3 stipulating the erection of a security fence and signage to prevent and warn of unauthorised entry to the substation will protect the public from potential electrical safety risks.

8.10 Condition 3.1 requiring the submission of a CMP provides adequate protection to health and safety from contamination of waterways.

8.11 Condition 4.2 limiting the operational noise levels at the substation boundary to 50 dBA (L_{10}) Monday to Friday 7 am – 7 pm and Saturday 7 am – 6 pm, and 40 dBA (L_{10}) at other times is sufficient to protect public health and safety regarding noise.

8.12 Conditions 5.1 and 5.2 that EMF levels comply with ICNIRP Guideline and that radio frequency fields comply with the limits in the New Zealand Standard NZS 2772.1 [13] are adequate to protect the public from potential effects from EMF and radio frequency radiation.

9. CONCLUSION

9.1 In my opinion, the project proposed by WEL and the conditions proposed by the Council adequately address any potential issues regarding public health and safety. Provided these conditions are met, there are no biological or health concerns about this proposal and no reason not to proceed on the basis outlined by WEL in their Notices of Requirement.

David Russell Black
March 2009

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APPENDIX A

International Agency for Research on Cancer (IARC) Classification of Human Carcinogens

Group	Supporting data required for classification in group	Examples	Number so classified
Group 1: The agent *is carcinogenic* to humans.	*Sufficient* epidemiological evidence	Alcoholic beverages, Asbestos, Benzene, Radon, X-rays, Sunlight, Tobacco, Secondhand smoke	95
Group 2A: The agent is *probably carcinogenic* to humans.	*Limited* or inadequate epidemiological evidence PLUS sufficient animal evidence	Creosote, Diesel exhaust, PCBs, Sun lamps	66
Group 2B: The agent is *possibly carcinogenic* 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 *unclassifiable as to carcinogenicity* in humans.	*Inadequate* 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

Typical magnetic field strength of household appliances at various distances

From the WHO site: http://www.who.int/peh-emf/about/WhatisEMF/en/index3.html :

"…The following table shows typical values for a number of electrical devices commonly found in homes and workplaces. The measurements were taken in Germany and all of the appliances operate on electricity at a frequency of 50 Hz. It should be noted that the actual exposure levels vary considerably depending on the model of appliance and distance from it.

Electric appliance	3 cm distance (µT)	30 cm distance (µT)	1 m distance (µT)
Hair dryer	**6 – 2000**	0.01 – 7	0.01 – 0.03
Electric shaver	**15 – 1500**	0.08 – 9	0.01 – 0.03
Vacuum cleaner	200 – 800	**2 – 20**	0.13 – 2
Fluorescent light	40 – 400	**0.5 – 2**	0.02 – 0.25
Microwave oven	73 – 200	**4 – 8**	0.25 – 0.6
Portable radio	16 – 56	**1**	< 0.01
Electric oven	1 – 50	**0.15 – 0.5**	0.01 – 0.04
Washing machine	0.8 – 50	**0.15 – 3**	0.01 – 0.15
Iron	8 – 30	**0.12 – 0.3**	0.01 – 0.03
Dishwasher	3.5 – 20	**0.6 – 3**	0.07 – 0.3
Computer	0.5 – 30	**< 0.01**	
Refrigerator	0.5 – 1.7	**0.01 – 0.25**	<0.01
Colour TV	2.5 - 50	0.04 – 2	**0.01 – 0.15**
With most household appliances the magnetic field strength at a distance of 30 cm is well below the guideline limit for the general public of 100 µT.			

Source: Federal Office for Radiation Safety, Germany 1999) Normal operating distance is given in bold"