

BEFORE THE BOARD OF INQUIRY

IN THE MATTER of the Resource
Management Act 1991
AND
IN THE MATTER of applications for resource
consent and notices of
requirement by
Transpower New Zealand
Limited for the North Island
Grid Upgrade Project
(NIGUP)

STATEMENT OF EVIDENCE OF DAVID RUSSELL BLACK ON BEHALF OF
TRANSPOWER NEW ZEALAND LIMITED
(EMF and health standard issues)

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INTRODUCTION

Qualifications

1. **MY** name is David Russell Black. I am currently Senior Lecturer in the Department of Medicine of the Faculty of Medical and Health Sciences at the University of Auckland. I am also a founding director and currently principal consultant of Enviromedix, the New Zealand Institute of Occupational and Environmental Medicine.
2. **MY** qualifications are BHB and MBChB from the University of Auckland, which qualifies me as a medical practitioner. I am a Fellow of the Australasian Faculty of Occupational and Environmental Medicine of the Royal Australasian College of Physicians which qualifies me as a Specialist Physician, currently vocationally registered in Occupational Medicine in New Zealand (FAFOEM). I am also a Member of the Australasian Radiation Protection Society (MARPS) and am a Member of the Royal Society of New Zealand (MRSNZ).
3. I have been working as an academic at the University of Auckland since 1990. Prior to this, I was an academic 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 both my colleagues and the Environment Courts of New Zealand and Australia as an expert in Occupational and Environmental Medicine. I am currently a member of the NZ Interagency Ministerial Advisory Group advising the Ministers of Health and Environment on health issues relating to EMF. I am a named author of the current IEEE (ICES) Standard on ELF[1].
4. I confirm that I have read and am familiar with the Code of Conduct for Expert Witnesses in the Environment Court Consolidated Practice Note (2006). I have approached the preparation of this evidence in the same way that I would for the Environment Court.
5. I have been working on the North Island Grid Upgrade Project (**Upgrade Project**) for several years. Initially, when Transpower New Zealand Limited (**Transpower**)

proposed a 400kV line (**Original Proposal**), I was involved from the beginning assisting in assessing environmental and potential health effects to human populations, and also considering potential effects to animal health with respect to human health standards along the route of this line.

6. I have used the experience and understanding gained in relation to the Original Proposal to assess the current, Amended Proposal, in relation to the 400kV capable line, which will initially operate at 220kV. I have reviewed the proposals and I am familiar with the terrain along the proposed routes for the 400kV capable line, underground cables and substation sites. I am also generally familiar with the Waikato area having undertaken a variety of work in the district over the years.

Scope of evidence

7. **IN** this statement of evidence, I outline the Electric and Magnetic Field (**EMF**) levels associated with the underground cable and 400kV capable line (**Proposed Line**) components of the Upgrade Project, and also with the substations. I discuss the health effects of these levels of exposure on humans. As part of my evidence, I discuss the international bodies and guidelines that address exposure levels to EMF.
8. I have personally been associated with the development of a number of electromagnetic standards in both radio frequency and extra low frequency. I am a named participant in both the development and approval process of the current Institute of Electrical and Electronic Engineers (**IEEE**) Standard for extra low frequency magnetic fields (**ELF**).
9. **IN** this evidence, I will provide an overview of electric and magnetic fields and the principles of health protection from the proven and suspected effects. I will rely on the substantial body of scientific literature which is published on this topic virtually all of which (up to 2002) was reviewed for the IEEE project. In order to provide the Board with first hand expert evidence with respect to the disciplines which contribute to this public health approach, I will also refer to the evidence of Professor Elwood, Mr van Rongen, Professor Wood, Mr Rooney, Mr Khot, Mr Mitton and Mr Wildash.

10. **PROFESSOR** Elwood is a cancer epidemiologist who provides an overall context for the extent to which the current information regarding ELF and cancer has relevance for the overall problem of cancer causation in public health. My evidence will show that the approach taken to the use of the International Commission for Non-Ionising Radiation Protection (**ICNIRP**) guidelines and minimisation of exposure to electro and magnetic fields in New Zealand meets or exceeds any recommendations which could properly be derived from the extent to which there is any cause for concern about electromagnetic fields, magnetic fields in particular, and cancer.
11. **MR** van Rongen is a biophysicist working for the Health Council of the Netherlands which is responsible in the equivalent way to the Ministry of Health in New Zealand for public health management with respect to electromagnetic exposure in Holland. Mr van Rongen has also participated substantially in work for the IEEE and the World Health Organisation (**WHO**) and gives evidence as to the approach taken internationally and particularly with regard to Europe, and of course his own country.
12. **MY** evidence will show that the approach taken in New Zealand by the Ministry of Health in adopting the ICNIRP guidelines and by Transpower in undertaking strict compliance with these guidelines, does represent international best practice and is comparable with health protection measures in Europe.
13. **PROFESSOR** Wood is a biophysicist currently working in this field at Swinburne University in Melbourne. In addition to his research activities, Professor Wood has chaired and led the group currently developing an ELF standard for Australia. Professor Wood, in my view, provides the Board with a substantial resource for the understanding of the relevant biophysics at a level which does not exist in any New Zealand University. My evidence will show however that the approach adopted in New Zealand takes account of all available contemporary, scientific knowledge.
14. **MR** Rooney is a practising veterinarian from the Waikato who is familiar with the problems of leakage currents causing adverse effects, particularly with dairy cows in the region, and has also undertaken a substantial literature review with regard to any potential for adverse effects from the proposed line on non-human species, particularly domestic animals in the Waikato. I accept Mr Rooney's experience that stray leakage currents are a considerable problem in the Waikato.[2]

CONCLUSIONS

15. **MY** key conclusions are stated at the end of my evidence.

DESCRIPTION OF ELECTRIC AND MAGNETIC FIELDS

16. **ELECTRICITY** mains systems in New Zealand use alternating electric current at 50 Hz. This current is carried for long distances around New Zealand from the generating source to regional substations by high voltage lines running at 220kV or 110kV, and this is stepped down at local substations. These local substations are found frequently within communities and need to be placed relatively close to the ultimate destination of the energy 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.
17. **THERE** are, therefore, important reasons why substations must be situated in or close to the community in which the energy is being used. The next level of transformers is generally situated in suburban streets, usually mounted on the ground on grass berms or in overhead reticulation systems on power poles. Electricity is distributed to the consumer at low voltage 230 V power. The amount of electric current flow is measured in Amps.
18. **WHEN** an electric current flows in a conductor, there are effects which occur in the space surrounding that conductor which will be only apparent if another conductor enters that space. These are known as electromagnetic fields which have components which are thought of as electrical (electric field or **E**) or magnetic field (**H**). The magnetic field can also be measured in terms of its intensity which is called magnetic flux density (**B**). The unit used in the système international de unités (**SI**) system for magnetic flux density is the Tesla, and in practice, fields encountered are in millionths of this (μT microtesla). The unit for electric field strength is Volts per metre (**V/m**).
19. **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.

Biological effects of electric and magnetic fields

20. **THE** possibility for electricity to cause biological effects, such as electric shock, is well known. This can occur when a conductive part of the body, or a conductor connected to the body is close enough to a conductor for the field to influence that conductor and cause energy to be coupled to it. In addition, when a conductive organism is close enough to conductors carrying electric current, energy can be transferred, at high levels this can be perceptible and, at even higher levels have adverse effects. The possibility that there may 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.
21. **FROM** an international health protection viewpoint, the control of non-ionising electromagnetic energy (generically called non-ionising radiation) has been delegated to the ICNIRP. In 1998, ICNIRP published definitive guidelines [3] which have subsequently formed the basis for most international standards. In 2002, the IEEE published an updated standard for ELF which is widely used in North America.
22. **NEW ZEALAND** and Australia do not yet have their own standards for exposure to low frequency fields, although both countries have published standards for radio frequency fields, above 3 kHz. Work on a standard is underway in Australia and is described by Professor Wood. However, in New Zealand, the ICNIRP guidelines have been adopted by the Ministry of Health and are generally and widely accepted as providing useful and evidence-based thresholds for public health protection. A copy of these guidelines is at **tab 10** of the **Common Bundle of Exhibits**.
23. **THIS** publication is entirely relevant to this matter and it is my view, which is consistent with that of the Ministry of Health and the Ministry for the Environment, that the approach to protection for thresholds for general public exposure in this document should be regarded as definitive in this matter. This position is clarified on the Ministry of Health's national radiation laboratory website which is www.nrl.moh.govt.nz/.
24. **ANY** electrical conductor which is charged (**voltage**) and carrying current (**amps**) will be surrounded by electric and magnetic fields. These fields are not an

emission from the conductor. If the conductors are surrounded by free space, not containing any conductive material, the fields result in no effects. Indeed, it can be argued that they are not even there. Electric and magnetic fields are best thought of as an area of influence rather than an entity, because they can only be detected by an object with suitable electrical properties which enters these fields of influence.

25. **THE** result of an electric field is to charge the surface of a non conductor (such as the surface of dry skin), which may cause a voltage to exist between conductive points (such as wet tissue). Thus, the strength of an electric field is expressed as volts per metre (**V/m or Vm^{-1}**). However, an electric field does not penetrate through the surface on which it acts. In contrast, a magnetic field is not blocked by either conductors or non-conductors, but tends to induce electric currents in conductors, including wet tissue. The magnetic field strength is measured in amps per metre (**A/m or Am^{-1}**), although the magnetic flux density is of more biological interest, measured in fractions of a Tesla.
26. **THE** behaviour and magnitude of these biological effects of such fields are well understood and entirely predictable, although often very complex. In the case of interactions with the human body, this has been the subject of sophisticated techniques of numerical analysis on which there is an extensive body of scientific literature.
27. **WHERE** electricity is transmitted by overhead lines both electric and magnetic fields are found around the conductors. Some reduction of potential exposure below the lines can be achieved by placing conductors so that field effects cancel (reverse phasing). This is discussed by Mr Khot in his evidence.
28. **WHEN** transmission is by underground cable, electric fields are effectively screened by the cable armouring sheath. Magnetic fields are usually measurable immediately above the cable, although the magnitude of these can be reduced by phase cancellation related to cable placement.
29. **AT** intervals during the transmission process the voltage is stepped up or down. This is mainly to minimise losses resulting from the electrical resistance of the conductors which are proportional to the current flowing (amps).

THE ICNIRP GUIDELINE & IEEE STANDARD

30. I have been a consulting expert to ICNIRP for the last five years and am very familiar with the approach taken by the International Commission. Page 2 of the ICNIRP guideline describes the basic approach which the Guideline takes to protection to general public exposure. The terms "*Basic Restrictions*" and "*Reference Levels*" are defined. In essence, the guideline sets a "*basic restriction*", compliance with which is assured if the more readily measured "*reference level*" is achieved. Reference levels are given for a range of frequencies.
31. **FOR** cables that are underground or screened, only the *B*-field needs to be considered. The *E*-field is effectively screened by the conductive ground and cable armouring sheaths and thus only the magnetic field is found above the ground. The *B*-field and the *H*-field are proportional, the latter being modified only by the medium which it passes through. By the time it is measured, nominally 1 metre above the ground, the field is travelling through the medium of the atmosphere and it is this density, usually measured in microtesla which is relevant to the potential for induction of an internal field in intercepting medium such as the tissue of human or animal. The *B*-field (magnetic) is calculated from ICNIRP's table 7 on page 18 [3], the relevant part of which is reproduced below.
32. **FOR** overhead lines the *E*-field needs to be considered as well, because there is no screening and thus the only attenuating factor is the distance from the conductor.

Reference levels for 50 Hz (ICNIRP 1988)[3]

<i>E</i> -field strength (V m ⁻¹)	<i>H</i> -field strength (A m ⁻¹)	<i>B</i> -field (μT)
250/0.05 = 5000 V m ⁻¹	4/0.05 = 80 A m ⁻¹	5/0.05 = 100 μT *
* Note that in old, non SI units 1 mG = 0.1 μT therefore 100 μT = 1000 mG		

33. **THESE** limiting thresholds defined by ICNIRP are widely accepted throughout the world. For example, they are regarded as definitive by the WHO and have been adopted as the basis for most international standards which do not rely on IEEE.

IEEE and WHO maintain a substantial relationship and formal communication, and are both aware of the reason for differences, where they do exist, between the IEEE standard and ICNIRP guideline. Both are recognised as providing complete protection against all known adverse health effects of electric, magnetic and electromagnetic fields.

34. **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 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[4]. The next revision of the ICNIRP guideline for ELF, will be based on the very recently published EHC 238 2007 [5]
35. **AT** the May 1992 International Congress of IRPA in Montreal, a new Independent Scientific Organisation – ICNIRP, was established as a successor to IRPA/INIRC and has continued in this role ever since. The publication of the environmental health criteria documents continues as a responsibility of WHO and these provide a resource for ICNIRP's work. The reason that ICNIRP's work is so widely supported, is that the Commission is strongly linked to (although independent from) other United Nations' projects. such as the WHO and IRPA, and is therefore intended to be a truly international resource.
36. **THAT** is not to criticise the IEEE. The IEEE and ICNIRP have different methodologies for standards production. ICNIRP has a relatively closed process for selection of members based on strict UN originated criteria with regard to matters such as conflicting interests. In contrast, the IEEE has a completely open forum approach to contributions, but then applies a rule based procedure for resolving or setting aside matters which cannot be agreed. Following that, there is submission of the candidate draft to an approval committee which has a membership elected by the Institute. In the case of ELF and RF standards, I am a member of that committee (IEEE SCC28). It is of mutual value to IEEE and

ICNIRP that the two bodies operate in such different ways and communicate, facilitating a large participation in standards and guideline development.

37. **FOR** its part, the WHO has been active for over a decade in holding regional scientific meetings on specific EMF topics which produce positions and go forward to the WHO EMF programme, influencing both the direction of research and matters taken into account in the production of the definitive EHC documents. I have been an invited guest of WHO at a number of these.
38. **IN** the United States, the American National Standards Institute (**ANSI**) as well as the Federal Communications Commission (**FCC**) and the Food & Drug Authority (**FDA**), all adopt the IEEE standard although are sometimes slow to take up the latest version because of the cumbersome bureaucracy involved. The IEEE standard is also copyrighted to the IEEE and is therefore not placed in the public domain. In my opinion, that is a significant limitation of the standard, although it is inevitable in the environment in which it is produced.
39. **NEW ZEALAND** and Australia have strong links with WHO and in general are more influenced by European than American initiatives. These are among the reasons why it is clearly appropriate for New Zealand to have followed the ICNIRP approach, particularly as the Ministry of Health is an active participant in the WHO EMF programme. However, those (relatively few) of us working in the EMF scientific area from New Zealand do participate, and are made welcome in the American standards process as well, as are many of the European participants in ICNIRP. Both the ICNIRP Guideline and ICES/IEEE Standards provide a good and equivalent level of health protection.

APPLICATION OF STANDARDS AND GUIDELINES TO THE UPGRADE PROJECT

40. **IN** considering the relevance of standards for health protection from the effects of electromagnetic fields, in the context of the design of the proposed high voltage transmission line including underground sections, the relevant standards for exposure to members of the general public and to workers other than those working directly on the power line or cable or working directly with the power line or underground cables are those set by ICNIRP for general public exposure.
41. **THERE** are important characteristics of the "general public" which are taken into account in the standards setting. In particular, the general public may comprise a

wide range of people with differing health status, some of whom might be more susceptible to effects than others. A general public standard, must protect the most sensitive of the normal population.

42. **IF** there is a hypersensitive population, which is not established for electricity (as discussed by Mr van Rongen in his evidence), then that cannot necessarily be covered by normal population standards. By definition, a hypersensitive population is not contiguous with the general population with respect to a response to exposure at the most sensitive "tail" of the normal population. General public exposure also assumes continuous exposure 24 hours per day, 365 days per year for a lifetime. If the effects are only acute, that is to say happen at a moment in time related to exposure at that time, then only the peak exposure really matters. There is no convincing evidence of other than an acute effect of EMF at frequencies below ultra-violet.
43. **THIS** is the case with all known effects of electric and magnetic fields. The established science, on which the ICNIRP guideline depends, does not confirm any chronic or cumulative effect of exposure or any hypersensitive sub-population. However, if such effect did exist, then true exposure could only be assessed by considering accrued exposure over time. The approach then adopted for this could be to estimate annual average exposure. There is however, no justification for taking such an approach in terms of current established science even though it is sometimes suggested.
44. I will discuss below the epidemiology suggesting the possibility of **ELF** of levels of 0.4 μ T and above as a cause of childhood leukaemia. If this cause and effect relationship were to be accepted, it is likely that this would result from a cumulative effect. Furthermore, as Sir Richard Doll points out in the National Radiation Protection Board report,[6] this effect, to the extent that it is found in the epidemiology does not appear to occur at all at levels below 0.4 μ T, and so it is reasonable to confine future research to levels of lifetime average exposure above 0.4 μ T. Professor Wood in his evidence has expressed an opinion that there is a possibility that reducing exposure may result in a modest reduction in leukaemia incidence. I agree with that, but it could only be effective if applied to large dense populations. That is not the case with the Upgrade Project.
45. **MEMBERS** of the public working in the general area of the proposed transmission line, and underground cables and even transiting underneath the

lines or cables or working at times immediately underneath or above them, would still be unlikely to have average lifetime exposures of 0.4 microtesla or above. The most likely cause of such exposure is from low voltage wiring in close proximity to living conditions or perhaps living immediately adjacent to a heavy current carrying transmission line. For this reason, any possible implications of expression of this risk, if it does exist could only be made by identifying the number of children likely to live in such conditions with relationship to this line. This point is important and is discussed further by Professor Elwood and Mr van Rongen in their evidence.

46. **THE** ICNIRP guidelines allow for higher levels of exposure for electrical workers. The definition of an electrical worker in this context is an individual who is trained and skilled to work safely in an environment which is not necessarily safe and therefore permissible for the general public to enter. An electrical worker is therefore part of a defined population so that, if necessary, they can be identified in epidemiological studies. The levels of permitted exceedance for workers are generally a factor of 5 for energy, which translates to a lower factor for field strength. There is a different methodology adopted for electric fields because the onset of perception is lower.
47. **THE** approach to control, particularly with regard to legislation for worker exposure is importantly different to the approach for public safety. The aim for general public exposure is to completely eliminate side effects by a wide margin taking into account a relatively unknown population in terms of susceptibility and sensitivities, and one without any training about avoidance of hazards. In contrast, a worker population is one of known characteristics and with the skills to protect themselves.
48. **FURTHERMORE**, whereas the approach to the general public is often to take a minimisation of exposure approach to permissible levels, for workers, a hierarchy of control is more important. This can include enclosure of the hazard (for example, insulation) or the use of personal protective equipment (**PPE**). This approach is well developed in New Zealand and is embodied in the Health & Safety in Employment Act which is administered by the Department of Labour and applies to electrical workers. It is not at all relevant in consideration of environmental population exposure.

49. **THUS** the approach taken by Transpower in complying with the general public exposure levels in the ICNIRP guideline is not intended for provision of protection for electrical workers. That uses a different strategy of control (in accordance with workspace safety legislation) and is able to safely allow for higher levels of exposure during a working day. It is notable that the levels for worker exposure chosen by ICNIRP are still intended to eliminate all known health effects. The permitted level for general public magnetic field strength exposure (100 microtesla) is set at a conservative level to always prevent "retinal flashing" which can occur in some people in the presence of strong fields.
50. **MANY** authorities (such as the IEEE) and jurisdictions (such as the Netherlands), do not regard retinal flashing as an adverse effect, since it is simply an expected physiological response of a dedicated receptor in the eye to the presence of a field. In this case, the receptor is evolved to detect electromagnetic energy at visible light frequencies, but it is sometimes able to detect electromagnetic fields and other frequencies such as ELF. This is discussed in the context of the Dutch approach by Mr van Rongen in his evidence.
51. **THE** IEEE standard for ELF (2002) allows for a level of magnetic exposure some 10 times higher than ICNIRP, for the same reasons. This is shown in Appendix A of Professor Wood's evidence. Ultimately all the standard and guideline thresholds protect against effects, differing only in their approach to safety margins.
52. **IN** reality, the highest levels which will ever be found in the area immediately underneath the proposed line will be well within the ICNIRP thresholds for general public exposure. This is shown in Mr Khot's tables and graphs at paragraph 155 of his evidence. The table also shows how, at initial configuration of 220 kilovolts, the electric field strength is relatively low compared to the guideline and that as power load builds up the magnetic field strength increases.
53. **WHEN** the voltage is increased to 400 kilovolts the electric field strength jumps up, but the magnetic field strength would decrease proportionally for the same load because the total energy transmitted through the line is the product of voltage and current (**VA**). However, even in 2042 when the winter load is 80% of 2710 MVA (i.e. 2168 MVA or 3130 Amps) per circuit, the magnetic field strength is still only a third of the ICNIRP guideline, because the governing parameter for

the height of the line above ground all along has been the electric field strength at 400 kilovolts.

54. **THUS**, it can be readily established from Mr Khot's figures that at all stages in its life and development, the proposed line and underground cables easily comply with the ICNIRP levels which are themselves conservative compared to those in use in the United States (IEEE) and in some other jurisdictions.

POTENTIAL IMPACTS ON HUMAN HEALTH

Deterministic effects

55. **DETERMINISTIC** effects are those which are understood, are predictable and occur according to a dose response relationship, that is to say as the exposure to voltage, current or both, as the case may be, increases, the effect would be expected to increase. Such effects are relatively easy to understand, are thoroughly documented and covered by modern safety standards. The mechanism of these effects and the levels at which they occur are discussed by Professor Wood in his evidence.

Direct effects

56. **WHEN** a conductive organism, such as a human or a mammal made up of wet salty tissue, is close enough to conductors carrying electric current, energy can be transferred, and at high levels this can be perceptible and, at even higher levels can have adverse effects.
57. **INTERNAL** electric fields result in electrical potentials and currents in the body which can be disturbing at low levels and potentially dangerous at high levels. These internal electric fields result largely from magnetic fields and are restricted in the ICNIRP approach by limits on the resultant current density.
58. **EXTERNAL** electric fields induce electric charges at the body's surface. The first noticeable effect occurs when electric field strength is sufficiently strong to cause movement of hair on the skin's surface, or small electric shocks which may be sensed by some people. The lowest level at which this occurs is with an electric field strength of about 10kV/m and these effects are not a significant problem

below 25kV/m. The ICNIRP guideline level for general public human exposure is 5kV/m.

59. **THE** electrical activity of the body, particularly of nerves, can be observed on the surface of the skin. This is used in medicine with techniques such as ECG, EEG, and electromyography. Some cells in the body, particularly in nervous and muscle tissue, are electro-sensitive.
60. **IF** currents or voltages from sources outside the body reach electro-sensitive tissue, and the levels exceed the natural levels arising from the body's own electrochemical activity, then neuro-stimulation might result, which is regarded as an adverse effect. Also, significant currents flowing in the body can cause heating by dissipation of energy as the current flows through resistive structures, and that can cause unpleasant sensations and, at high levels, tissue damage.
61. **WITH** regard to magnetic fields, these can induce currents in the body and at low levels that are generally unnoticed. The lowest level effect reported is the stimulation of light sensitive cells on the retina of the eye, which are seen as visual flashes. This occurs when the effect of induced currents is of a similar magnitude to the effect of these highly sensitive cells being switched on by reception of light. This effect does not usually occur at levels below a few mT (millitesla, that is thousands of microtesla), and well above the field strengths which will ever be encountered on the ground below the Upgrade Project transmission lines, above underground cables, or in areas adjacent to substations accessible to the general public.
62. **IN** general, the human body is not particularly sensitive to small induced electric currents, including those generated by magnetic fields. This is expected because there are many natural sources of such induced currents encountered in moving through the geo-magnetic environment of the earth.

Indirect effects

63. **THE** direct effects I have described above, relate to those which occur when electric and magnetic fields have a direct effect on the body of a person or animal within the field and are caused by the direct interaction between the field and tissue. Indirect effects can also occur when there is a conductor in the field which gathers charge and this conductor then makes contact with a person or animal

standing in the field. Such objects by definition are electrical conductors and the extent to which such conductors are able to collect electrical charge and energy is influenced by their length and orientation in the field. In practice, most often, these are metallic objects. A good example would be a fence wire running underneath a power line and isolated from the ground which becomes charged and can therefore under certain circumstances be the source of an electric shock if touched.

64. **THIS** behaviour of conductors in a field is well understood by electrical engineers, can be predicted and can be effectively mitigated, by grounding such objects or by other measures. The extent to which such direct effects are permissible are also covered by Standards and guidelines. A further explanation of the mechanisms causing these effects and appropriate precautions and mitigations are covered in the evidence of Mr Mitton.
65. I have already described biological effects associated with electric and magnetic fields at strengths which would actually be "*felt*" by the human body. These effects only become a problem at high levels of exposure, much higher than the field strength levels ever found under a transmission line such as the 400kV capable line. I have also considered analogous effects on animals, which I will discuss later in my evidence.

Low level stochastic effects

66. **THE** possibility that there may be effects at levels below perception has been investigated and debated in detail over many decades. Ideas of such effects, most of which have never been proven to exist, are the subject of literally thousands of papers published in the scientific peer reviewed literature. Low level effects means effects at levels below the thresholds for acute effects. Stochastic means that the effects do not occur in every person exposed and may appear to be random. (Stochastic is the opposite of deterministic.)
67. **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 [7]. 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.

68. **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 substantial volume of literature regarding ELF and childhood cancer. This work was overseen in the United Kingdom by the NRPB and was ultimately published in a very thorough publication ELF Electromagnetic Fields and the Risk of Cancer, Report of an Advisory Group on Non-ionising Radiation, [6] often called the "Doll report".
69. **FOLLOWING** that publication and after years of deliberation, 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 (also linked to WHO), delivered a finding about the category into which ELF fields would be placed .[8] That was preceded by further work and advice from ICNIRP, including a separate review of the epidemiological evidence (i.e. that examining the statistical relationship between cancers and the presence of ELF fields).
70. **THE** IARC's classification was that higher magnetic fields at ELF belong in the category of possible carcinogens known as Class 2B. This was primarily due to the existence of literature suggesting an association which has not been disproved or overturned. That will remain the position for the foreseeable future and applies to magnetic fields arising from electric currents, irrespective of whether they are from transmission systems or household wiring, which is a much more common source of exposure.
71. **THE** Doll report had 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 μ T (4 mG).
72. **IT** remains widely believed that the reported associations relating to magnetic fields are most likely to be caused by confounding factors (in other words the presence of something else which goes along with the presence of electricity transmission). I tend towards this view, but keep an open mind on the matter. However, the association cannot be confirmed (as causal) either way and so research will be ongoing and continue to 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, it probably would not alter the way in which electricity is used on a cost benefit basis.

73. **THE** New Zealand Ministry of Health publication from the National Radiation Laboratory[9] puts it this way (at page 10):

For most people the greatest exposure to power frequency magnetic fields arises from distribution (street) wiring, household wiring and domestic appliances. Living close to an AC transmission line may not substantially increase this exposure.

If in the future a positive association between exposure to power frequency fields and cancer were to be demonstrated beyond doubt, the indications are that ELF fields would have to be a very weak carcinogen (cancer causing or promoting agent). There is no strong evidence that magnetic fields are associated with other health effects.

To give another perspective, the incidence of leukaemia in children is about one in twenty thousand (50 per million). Although research may never give an absolute yes or no answer about the safety of ELF fields, we can say with some assurance that if they are associated with an extra risk, it is unlikely to account for more than a very small fraction of this incidence. A New Zealand study found that none of 86 cases of childhood leukaemia reported over a four year period were associated with exposure to strong magnetic fields.

74. **THE** study to which this NRL publication refers, is Dockerty, J.D., et al. [10].
75. **IN** my opinion, whether or not the reported relationship between magnetic fields and leukaemia is causal, is not an issue which affects the public health impact of the Upgrade Project, Professor Elwood discusses this issue in more detail in his evidence.

UK Advisory Stakeholder Advisory Group on ELF/EMF (SAGE Report)

76. **THE** SAGE Report (**Common Bundle of Exhibits, tab 12**) was published in April 2007, as a first interim assessment of electric and magnetic fields arising from power lines, wiring and electrical equipment in homes. The process was initiated by the UK national grid and pursued under the auspices of the Department of Health, and completed by private facilitators who were not stakeholders.
77. **THE** purpose of SAGE is to provide advice to the UK Government and is a reconciliation of the discussions that have taken place within the process. It is not a definitive set of universally agreed conclusions, but is intended to capture the point of evolving discussions at the point they had reached at the time of

publication. It is acknowledged that there is not total agreement between the stakeholders, but all views are represented.

78. **THE** Report identified what it describes as a "WHO/HPA" view and a "California" view. A contentious issue between these two view points was whether or not dedicated corridors for new power lines are justified. The Report suggested that this is a matter for Government to decide. The Report also provided a range of options regarded as precautionary with identified costs and possible benefits. SAGE recommended the use of "optimal phasing" (reverse phasing) to reduce exposure.
79. **THE** rationale and source documents for SAGE are scientific papers, most of which are already published in the peer reviewed scientific literature. There are inputs from a number of academics which are listed in the Appendix to the Report. However, neither these, nor the Report contain any new scientific information. In my opinion, the SAGE Report is of limited value outside of the context in which it was prepared, i.e. to provide the Government of the United Kingdom with an ongoing commentary on discussions formed by a group designed to identify issues and points of view, to be forwarded to be considered in policy formation.

APPROACH TO MANAGING EFFECTS

80. **THERE** are well established guidelines and Standards in place throughout the World for limitation of adverse biological and health effects from electric and magnetic fields. These guidelines and Standards are generally based on a large body of published evidence, including thousands of peer reviewed scientific papers, which have been published over the last fifty years. By the 1980s, such Standards were relatively complete and stable, and were universally applied. The Transpower approach of compliance with the ICNIRP guideline is such an approach.

Precautionary principle and precautionary approach

81. **MY** understanding of the *precautionary principle* as applied to environmental issues is that it is most applicable in situations where there is an established risk of rare probability of occurrence, but with a high impact if it does occur. An example is the sinking of oil tankers. It has been found that double skinning of

such vessels reduces the impact of pollution when a sinking does occur and therefore this is a sound and worthwhile precautionary approach to take in this industry, because if it is universally applied, there will ultimately be a benefit.

82. **THE** application of the precautionary principle can also be justified where there is incomplete or uncertain knowledge of safety with regard to a possible catastrophic outcome. Examples of this are the introduction of new medicines or vaccines, where specific uncertainty is unavoidable.
83. **EVEN** where either of these thresholds exist, the response in terms of appropriate mitigation measures needs to be proportional.
84. **IN** my opinion, neither of these thresholds are applicable to the health risks of transmission lines (or cables) leaving any legal issues associated with application of the precautionary principle under the Resource Management Act 1991 (**RMA**). There is unsettled research which does at least give a consistent magnitude for the worst outcome, if it were established. However, that outcome, although of high significance to the individual, is of very rare probability and the strength of the possible relationship is far from proven. The levels of EMF exposure in respect of the Upgrade Project do not exceed ICNIRP guidelines and in my view there is no risk to the health of people.
85. A number of authorities throughout the world have, however, revisited the idea of applying a *precautionary approach*. An example is in relation 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.[5]
86. **THIS** precautionary approach simply requires demonstration of engineering which minimises exposure provided that it 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 [11] more than a decade ago.
87. **ONE** example of this precautionary approach is the reverse phasing of the transmission lines currently practised by Transpower in the construction of new lines, which effectively reduces field strengths around the lines under normal operation.

88. **IN** my view, by far the most useful strategy is to encourage, particularly with new transmission lines, best industry practice to minimise exposure to the maximum number of people. This reduces overall population exposure without limiting legitimate development of the technology. This is sometimes referred to as the exposure minimisation approach. Examples of this approach in practice would include locating transmission systems in sparsely populated areas for most of their length, or implementing changes in wiring techniques within particularly domestic buildings.
89. **THE** latter has been recommended in many countries and has recently been the subject of suggested additions to wiring codes in Australia and New Zealand. However, unless specifically required by a customer, economic and competitive factors generally mean that changes in wiring techniques are not routinely achieved. In reality, the benefits of such techniques to an individual or their family are so remote as to reasonably only justify a low funding priority.
90. **THE** idea of prudent avoidance is however quite consistent with the exposure minimisation approach although it is, by definition, limited by being achievable at little or no additional cost.
91. **WITH** regard to the Upgrade Project, these precautionary principles hardly apply (if at all in my view), as it involves lines and underground cables to which human exposure is very limited and thus, even if the worst case possibility of cancer risk was established, expression of it would not be seen in decades, probably centuries, if ever. However to the extent that a precautionary approach is relevant, I consider for reasons that I later discuss, that Transpower has appropriately applied that approach.

Application of the ICNIRP Guidelines and the WHO Cautionary Approach to the Upgrade Project

92. **THE** ICNIRP limit (reference level) for general public exposure with mains frequencies is 100 microtesla. Below these levels there are no established health effects. There are suggested effects, such as the possibility of an increase in some rare cancers, but even taking the worst case interpretation of the literature, the effect of this even over a very large population would be small. In this context, exposure from high tension transmission lines is virtually irrelevant because the

number of people exposed in this way is so small that the likelihood of a case occurring is *extremely* low.

93. I have applied my understanding of the level of protection provided by compliance with the ICNIRP Guidelines and the possibility of any risks which are not yet fully understood, in the context of the actual field strength levels which would be found in the vicinity of Upgrade Project. In this regard, I am relying on the evidence of Mr Khot and Mr Mitton.
94. **INSOFAR** as the overhead lines are concerned, the design techniques adopted by Transpower include reverse phasing to minimise fields and significant elevation so that electric fields even at the last stage of 400kV, do not exceed the thresholds in the ICNIRP guideline (5kV/m). This is consistent with best international practice and, with respect to human and animal exposure to electric and magnetic fields, is consistent with the adoption of a precautionary approach as discussed above.
95. **THE** section of the line which is underground in South Auckland is laid at a depth of 1.5 metres, generally in road or reserve areas with no habitation above the cables. The cables are laid in a trefoil configuration, which although increases the cost of construction, it provides phase cancellation and reduces the magnetic flux density inevitably found above the trench. These measures are consistent with international best practice in minimising magnetic field exposure from such an underground cable and amount to a precautionary approach. No further mitigation is in my view necessary.
96. **SUBSTATIONS** are inevitable components of electricity transmission, either where lines join or particularly where there are voltage changes or switching requirements for distribution. Therefore, the constituents of a substation are switches and transformers. Neither of these have any particular characteristics which provide electric fields greater than those found around conductors in any case. Although they are at a lower height and therefore inside the switchyards in particular, the proximity of electrical workers to live conductors is relatively close.
97. **FOR** this reason, switchyards are kept highly secure and no persons other than those with significant skills in electrical safety are permitted to enter them. The transformers used for voltage changing are, by their nature devices which contain their fields within their magnetic core. Generally, screening of electric fields is

complete, and although magnetic fields are measured adjacent to transformers, the levels fall off very rapidly, more so than from a conductor. In my experience, in areas accessible by the public which includes the area immediately around the periphery of substations, magnetic and electric field strengths are usually no more than those found adjacent to the transmission corridor.

ISSUES RAISED IN SUBMISSIONS

98. I have reviewed all of the submissions provided to me by Transpower carefully and considered the issues raised in terms of the research I have undertaken into public health issues surrounding the Upgrade Project.

P W & J O Alderdice (Submission No. 1138)

99. I have read this submission from P W & J O Alderdice. I accept that there are benefits to undergrounding, but note that the greater separation distance of overhead lines results in little difference in exposure to magnetic fields.

Issues raised by Barry and Freda Aldridge (Submission No. 0950)

100. **BARRY** and Frieda Aldridge are concerned about farming operations in the context of overhead lines with a corridor width of 65 metres. In particular, they raise site specific concerns about health effects due to the combined effect of lines in the area.
101. **MR** Khot has calculated the maximum magnetic and electric field strengths at any point at the edge of the easement (see his response to submissions, and Appendix E in his evidence). These calculations show that the field strength levels at the edges of the boundaries of such an easement will be less than 10% of the acceptable reference level for general public exposure set out in the ICNIRP guideline. I consider that the levels at the Aldridge property are entirely acceptable. In particular, during the life of the project the magnetic flux density levels at the edge of the easement will never exceed 20-30 μ T. Even this value is only a worst case theoretical value, based on the most onerous combination of ambient conditions that may not in practice be seen in a life time.

102. **MR** and Mrs Aldridge live about 15 metres from the current ARA-PAK 110 kV lines. Their cow shed and other work buildings are closer. Mr and Mrs Aldridge consider that they are "deeply affected",
103. I note that Mr and Mrs Aldridge appear to have a misunderstanding about electrical engineering, referring to the "*total capacity of 1060kV*", and comparing a "*concentration of power*" in the narrow corridor with "*another dioxin fiasco in 30 years time*". They are of the view that a member of their household who has suffered from constant chest and stomach complaints and frequent pneumonia in recent years, may be affected by the current lines. They also consider that "*the corridor may become an unproductive wasteland*".
104. **IN** my view, Mr and Mrs Aldridge should be reassured by the certainty and stability of the reference of the public exposure levels in the ICNIRP Guidelines. These guidelines confidently exclude any acute effects and none of the health issues raised have been associated with exposure to electric and magnetic fields. Far from being a wasteland, the corridor underneath the finished lines can be good productive farmland, which would require minimal (if any) mitigation measures for electrical safety.

Issues raised by Dr Laura Bennet / Adrian Kinsler (Submission No. 1085 and 1091)

105. **DR** Laura Bennet / Adrian Kinsler raise a number of concerns about adverse health effects from electrical and magnetic fields. These two submissions appear to be identical.
106. **DR BENNET** who lives on High Ridge Road, Clevedon in the vicinity of the proposed line is an Associate Professor of Neo-natal Physiology in the Faculty Medical and Health Sciences at the University of Auckland. Her submission, however, is as a member of the community. In paragraph 1-5, she provides a clear statement of her views on the Upgrade Project, as well as her analysis of matters, such as alternatives (e.g. underground cable route), need for the project, energy utilisation, electricity planning and economics.
107. **AT** paragraph 9, Dr Bennet begins discussion about "*adverse health effects from electro-magnetic radiation*". As I have previously stated in my evidence, there is no radiation from lines such as those proposed, or at least to the extent that any

radiation, if it existed, is insignificant. This is covered by Professor Wood in his evidence.

108. **HOWEVER**, there are electric and magnetic fields. At paragraph 9a, Dr Bennet discusses "*a direct effect via EMF*". The use of this term in the context of the ICNIRP guidelines, (referenced at paragraph 9b) is potentially confusing, because the Guidelines specifically define direct and indirect effects. Direct effects are those resulting from direct interception of fields, whereas indirect effects are a result of interception by another conductor and then touching that conductor. The most common example in this type of situation is the charging of a metal fence.
109. **AT** paragraph 9c, Dr Bennet goes on to say "*as a health professional, I cannot support continued use of the ICNIRP Guidelines on the EMF, until these guidelines are updated to reflect the considerable body of new information on the potential effect of EMF on health*" (emphasis original).
110. **WHILE** acknowledging all due respect for Dr Bennet's considerable achievements in her field, I can not avoid observing that, she is not, and does not purport to be a health practitioner working in public health. Accordingly, in my view, her opinion that the ICNIRP Guidelines are regarded as having a "*deficit*" is not relevant since it is not well founded.
111. **IT** is true that ICNIRP are beginning to work on the next revision of the guidelines. However, it is important that the approach in the ICNIRP Guidelines for this area (extra low frequency electro-magnetic fields), have been extensively reviewed by the WHO in a very recent publication (the new ELF Environmental Health Criteria 258). [5] This publication continues to support the ICNIRP Guidelines and will be used as the basis for the next revision.
112. **THE** current guideline was based on an earlier document, EHC137, which was published in 1993[4]. This new WHO document (EHC238)[5] is available on their website and I respectfully draw attention to its conclusions about the safety of the current ICNIRP approach. (Section 1.1.12 Protective measures):

"It is essential that exposure limits be implemented in order to protect against the established adverse effects of exposure to ELF electric and magnetic fields. These exposure limits should be based on a thorough examination of all the relevant scientific evidence. Only the acute effects

have been established and there are two international exposure limit guidelines (ICNIRP, 1998a; IEEE, 2002) designed to protect against these effects. As well as these established acute effects, there are uncertainties about the existence of chronic effects, because of the limited evidence for a link between exposure to ELF magnetic fields and childhood leukaemia. Therefore the use of precautionary approaches is warranted. However, it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."

113. A point raised by Dr Bennet is that Transpower has advised the Ministry of Economic Development Reference Group on electricity transmission that it considers the ICNIRP Guidelines as dated and unsatisfactory in a number of respects. I am aware of the matters that have been raised with the Ministry.
114. I understand that Transpower's concern does not arise from any suggestion that the thresholds in the guideline provide inadequate protection. Rather, Transpower's concern is due to the fact that the guideline does not take into account modelling undertaken in the last 10 years which would, if anything, support a raising of permissible reference levels as was incorporated in the more recent ICES Standard (as shown in Professor Wood's Appendix A to his evidence), and is likely to be incorporated in the Australian Standards with work currently in progress.
115. **DR BENNET** states that the width of the transmission corridor is based on achieving noise levels of 45dB at 32 metres from the centreline of the corridor. (In fact the level is 40dB). While this parameter does become more critical than magnetic or electric fields, it is my understanding that ultimately the key factor in determining the width of the corridor was conductor swing. However, the electric fields are very low by that distance and the magnetic fields are also in order of magnitude, below the ICNIRP reference level. I consider that both levels and the easement width are entirely acceptable.
116. **AT** paragraph 9e, Dr Bennet goes on to say that "*it is generally accepted that there is a risk to human health from excessive exposure to electromagnetic fields*". That is true. However, such excessive exposure is entirely and effectively

protected against by compliance with the relevant Standards, including those of ICNIRP and ICES. Dr Bennet's statement is not true of levels within the ICNIRP guideline.

117. **DR Bennet** then goes on to say there are "*now numerous human population studies strongly and statistically demonstrate an association between ill-health and levels as low as 0.4 microtesla*". (paragraph 9e) That is partly correct, but with important qualification. There is a large body of research which has looked at the possibility of various diseases being associated with electro magnetic fields most of which have dismissed the relationship. It is true there is a persistent issue with childhood leukaemia and magnetic fields, and this is dealt with authoritatively in the NRPB/Doll report of 2001 and brought thoroughly up-to-date in the 2007 WHO Environmental Health Criteria 238 [5] The NRPB/Doll report and subsequent documents recommended further research and compliance with the ICNIRP guideline.
118. **DR BENNET** at paragraph 9e goes on to say "*there are currently insufficient numbers of scientific studies to say exactly how EMF causes illness*". I would not agree with that statement. There are a large number of studies by any standard. The problem is, that all that has been shown, and only by some of them, is an apparent association, which is very weak and without any biological plausibility or explicable mechanisms, either theoretical or established by experimental studies. Any epidemiological relationship between EMF and illnesses has to be looked at both in terms of the association, including the strength of association and other criteria of applied logic, which were described in the 1960s by Sir Austin-Bradford Hill and are therefore often known as the "*Bradford Hill Criteria*" or "*Viewpoints*".
119. **THE** Bradford Hill Criteria, find that a weak statistical association alone is not sufficient to confirm a cause and effect although, it can indicate the need for further exploration. That is the reason why the IARC have placed extra low frequency electro magnetic fields on their register of 2B carcinogens indicating a need for further research. These techniques of epidemiology are discussed in detail by Professor Elwood in his evidence.
120. **DR BENNET** goes on to say "*thus there is debate about how to address this issue of uncertainty in terms of what public health policy should be followed*." (paragraph 9e) In my view this statement is incorrect. As Mr Gledhill has stated in his submission on behalf of the Ministry of Health, when the possibility of a rare

risk like this is identified, assessment of the possible magnitude of the risk and the worst case number of possible cases becomes of paramount importance.

121. **IN** the case of this proposed line for the Upgrade Project, I doubt, even on a worst case acceptance of epidemiological data over hundreds of years that there would not be any cases of leukaemia or any other illness. However, such risk analysis is the province of the professional epidemiologist and in this regard, I defer to Professor Elwood's evidence.
122. **AT** paragraph 9f, Dr Bennet says, "*the World Health Organisation recommended opting a precautionary approach (proactive strategies taken to minimise exposure). This differs to the current prudent avoidance guidelines which state that minimising exposure is only necessary if it does not cost much or anything.*" Dr Bennet considers that prudent avoidance is an unacceptable guideline "*where there is clear human population data indicating risk, and at the very least there is considerable uncertainty about the risks*".
123. **AGAIN**, there is not considerable uncertainty about the worst case possibility of the risks, if any. Dr Bennet is correct that the WHO have recommended a precautionary approach. As is clearly stated in EHC 238 [5] (and as cited above) WHO still endorse the ICNIRP Guideline levels as appropriate for public health protection from Time Varying Extra Low Frequency Electro magnetic fields.
124. **THEREFORE**, turning to the position Dr Bennet has taken in paragraph 9g, I cannot agree that the current standard of ICNIRP "*are not rigorous enough to protect the public*". I agree that Transpower should adopt a precautionary approach in designing new installations with regard to public exposure to electro magnetic fields. However, reduction of exposure to less than 0.4 microtesla which, as Dr Bennet states would or could require minimum distances of 300-400 metres either side of a line, are not justified. The relevant level which should govern such distances is the ICNIRP reference level for general public exposure, and in this case, compliance is by at least in order of magnitude with respect to EMF. As I have stated previously, any idea of a benefit of further reduction could only apply to a very large (hundreds of thousands to millions of population).
125. **IN** paragraph 9g(iii), Dr Bennet raises the concept of "*sensitive populations*" and cites "*schools, nurseries and hospitals*". I would point out that by definition, the levels quoted for the general public by ICNIRP have included a higher safety

factor than the already safe occupational levels with the intention of protecting the most sensitive members of the population and this is explicitly stated in the guideline.

126. **ON** page 508 of the Guideline, ICNIRP states;

"The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. It is these considerations that underlie the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population."

127. **AT** paragraph 9h, Dr Bennet raises the discussions which have gone on in the United Kingdom and for that matter, the rest of Europe, citing the SAGE Report. It is my understanding that the approach taken by Transpower in compliance with the ICNIRP guidelines is virtually identical to that regarded as best practice in Europe. Mr van Rongen comments on this in his evidence.

128. **OVERALL**, with respect to Dr Bennet's submission, I consider that public health decisions have to be made with the best knowledge available of strategies to eliminate any known risks, minimise the impact of any possible risk in a way which best uses available resources for a balance of strategies in the community to maximise public health.

Issues raised by Mr Bruce Davidson (Submission No. 0874)

129. **MR** Davidson also advocates a wide easement (600m) considering that a "65m Easement area is totally inadequate to protect human populations, particularly children, and a much wider Easement area with restricted human activity is required to ensure the health, safety and welfare of adjacent populations".

130. I can understand why Mr Davidson would draw that conclusion, because the region between the proposed 65m and 600m is that where the levels for ongoing research has been recommended by the Doll report [6] and IARC[8]. However, given that the 400kV capable line largely passes through sparsely populated farm land, the risk on a population basis is miniscule.

Issues raised by Federated Farmers of New Zealand Incorporated (Federated Farmers) (Submission No. 1060)

131. **FEDERATED** Farmers has submitted that "*scientific and epidemiological evidence does not discount the possibility that prolonged exposure to elevated electromagnetic radiation represent a long term risk to health*". I presume that the reference to "*electro-magnetic radiation*" is referring to EMF. Federated Farmers considers that Transpower "*should be required to prove it is safe to proceed on a precautionary basis*". In my opinion, Transpower has shown that it is safe to proceed with the Upgrade Project by a wide margin. This position is supported by the other health evidence.

Issues raised by Franklin District Council (Submission No. 1048)

132. **LINDA** Alberton from Franklin District Council considers (at paragraph 6.1) that because the 65m easement width was originally proposed to manage noise effects, it is not based on considerations of safe operation. She also raises concerns about trees. That is a matter for other witnesses to comment on. Mr Campbell/Lake addresses the easement width originally being set based on noise considerations, but that the easement width in relation to the 400kV capable line now relates to conductor swing. However, I can confirm that if the distances have been chosen based on certainty of compliance with the ICNIRP guidelines, it would have been no more than 65m.

Issues raised by Mr Robin Smart (Submission No. 0473)

133. **MR** Smart (FRACS) is a well respected Auckland surgeon who lives at 76 Sutton Road, Brookby, at a position of approximately 360m from the proposed line. Mr Smart has taken a considerable interest in the Upgrade Project and undertaken substantial research which he has documented for the Board.

134. **IN** paragraph 2, Mr Smart outlines some of the basic science most of which I agree with and none of which I take serious issue with. At paragraph 3, Mr Smart discusses biological research on adverse effects of EMF on animal cells, experimental animals and humans. Most of his discussions appropriately report scientific papers which have proven to be of interest, although it does not reflect the very large body of such research, extending to literally thousand of papers as was available to the drafting committee writing the recent American ICES Standard [1].
135. **THE** overwhelming conclusion from the committee which developed the standard, was that only established acute effects can be used for standard setting and that effects below these had not been established as occurring at all. This is well documented in the rationale which is published in the Standard.
136. **AT** paragraph 4.3, Mr Smart discusses childhood leukaemia. However, he misrepresents the meaning of the research at paragraph 4.11 by saying "*the risk is definite at 0.3 microtesla and at least double at 0.4 microtesla*". The risk of childhood leukaemia has never been confirmed. There is no more than an association. I accept that that association is sufficient to justify ongoing research, and that it also may be sufficient to explore the worst case implication in the event that that association could be translated into a real risk. This matter is dealt with extensively in the 2007 WHO Environmental Health Criteria 238 [5] and is explained in more detail by Professor Elwood in his evidence.
137. **AT** paragraph 5.6, Mr Smart says "*there is very conclusive evidence that the risk of miscarriage is increased by AC 50 Hz magnetic fields up to 5.7 times in early pregnancy with a previous history of miscarriage*". And that "*the evidence relating to computer screens resulting in the Swedes regulating against more than 0.2 uT at 50 cm*". In my view, these two statements are not justifiable in 2007. The international consensus is that there is no such effect and this is reflected in the 2007 WHO Environmental Health Criteria 238 [5].
138. **MR SMART** goes on in paragraph 7 to discuss a number of other diseases, all of which I accept have been raised, but none of which have been pursued as likely causative associations. These issues are discussed by Professor Elwood in his evidence.

139. **IN** later paragraphs 8 and 9, Mr Smart discusses the challenges raised to orthodox science in California and the United Kingdom, neither of which have influenced international peer review scientific opinion including WHO, although these views are well known.
140. **AT** paragraph 10.1, Mr Smart discusses the ICNIRP guideline briefly. In particular, he states that the Commission has set aside evidence concerning health risks from ill health effects not substantiated by laboratory evidence. That is not a fair appraisal of the ICNIRP's approach. Rather, the Commission found that there was inadequate evidence at levels below demonstrable and repeatable acute effects on which to base exposure guidelines. That remains the case today although, there is further and more detailed discussion of that approach in the 2007 WHO Environmental Health Criteria 238 [5].
141. **AT** paragraph 10.2, Mr Smart discusses the IARC classification approach and criticises Mr Gledhill and myself for "*downplaying the significance of class 2B, quoting coffee, vehicle exhaust fumes and pickled vegetables*" as co-members of this category and not mentioning others. The important point about Category 2B is reflected in its name: "*possible human carcinogens*" compared with category 2A: "*probable human carcinogens*"[8].
142. **CATEGORY 2B** is the appropriate place for magnetic fields above 0.4 microtesla, because there does exist unsettled research showing a possible association with cancer, as there is for many other common substances. However, as I have stated in response to other issues raised in submissions, it is also important to look at the magnitude of the possible risk and also the likelihood of any movement or promotion of categories. The IARC categories are a system through which substances can flow up or down as research evolves. It is generally true that substances which have lasted in 2B for a long time should not be of particular concern.
143. **AT** paragraph 11, Mr Smart goes on to discuss the response of other countries. He speaks of Italy and the political responses of three regions for setting local ordinances to overtake the national guideline for EMF strengths. However, I consider that there can be no doubt that the most authoritative opinion in Italy prevailing at a Federal level, is acceptance of the ICNIRP approach.

144. **MR** Smart also raises issues regarding a cluster of leukaemia at the Vatican in 2005, and the Vatican's radio transmitters. In my view, this matter is completely irrelevant to this extra low frequency grid Upgrade Project. There is currently an acceptance that there is no association between radiofrequency exposure and cancer.
145. **IT** is true that there is a Swedish standard for fields dating back to the early 1990s for fields from CRT computer based monitors, although there is no longer any scientific support for any possible benefit from this and it does not matter as the technology is rapidly receding. Mr van Rongen will discuss the situation in the Netherlands, where Mr Smart says "*there is a government proposal to reduce exposure for homes, schools, sensitive areas to no more than 0.4 uT*".
146. **IN** general, it is accepted around the world that there are politically driven local ordinances which come and go and suggest local levels differing from national standards. In many, if not, most cases, compliance with these ordinances is poor and often not policed. In general, the vast majority of standards or guidelines around the world are based on ICNIRP or ICES.
147. I note that at paragraph 11.17, Mr Smart notes that the United Kingdom lowered its permitted levels in 1999 by adopting the ICNIRP guideline. That is correct. At the time, the ICNIRP guideline was regarded as a precautionary approach because the United Kingdom has previously used evidence based standards which were rigorously designed to avoid all effects, whereas ICNIRP is already much more precautionary.
148. **IN** summary, at paragraph 12.6, Mr Smart advocates that New Zealand should adopt a regulation requiring "*sensitive areas*" near high voltage lines to limit background field strength to 0.1 microtesla. That approach would radically change the way in which our towns and cities are planned and would in my opinion be unworkable. Having said that, the average background level experienced by most New Zealanders would be no more than 0.1 microtesla. This is the point raised by Sir Richard Doll in the 2001 NRPB report when, commenting on his opinion about studies of average lifetime exposure over 0.4 microtesla, Sir Richard commented that in practice there would be very few children in Great Britain exposed to these levels. This is discussed in more detail by Professor Elwood in his evidence.

149. **TURNING** to Mr Smart's summary, it is important that I comment on this. At paragraph 13.1.1, Mr Smart states *"That there is in 2007 clear and irrefutable evidence of harmful health effects on people exposed to more than 0.2 uT AC low frequency (50 Hz) magnetic fields as a background in their homes, schools and other places where they spend long periods of time. The evidence is strongest for childhood leukaemia, miscarriage, adult brain cancer, amyotrophic lateral sclerosis, suicide and depression, adulthood leukaemia"*. In my view, that statement is not correct. There is not clear and irrefutable evidence of any ill health effects at such low levels and the only substantial area of ongoing research, and academic interest, is about childhood leukaemia.
150. **AT** paragraph 13.1.2, Mr Smart states *"the trend over recent years has been for the evidence of harmful effects to increase as more studies are done, for example, the Tasmanian study by Lowenthal"*. That comment requires a careful qualifier. In particular, that there is a strong tendency for better quality studies to be negative, and with poorly designed or controlled studies, the converse is true: poorly designed and controlled studies are more likely to produce positive results. The Tasmanian study is, in my view, of limited validity and is inconsistent with other data.
151. **AT** paragraph 13.1.3, Mr Smart considers that (referring to the ICNIRP guideline) *"the level of 100 uT is so high and impractical in the real world that it represents no regulation at all"*. That is not correct, 100 microtesla represents a conservative level compared to other Standards, and that is likely to include the new Australian Standards. There is no indication in the 2007 environmental health criteria of the WHO that this level will be changed. Thus, there is no reason, based on ill health effects, to agree with Mr Smart that the Upgrade Project should be declined.

Submission by the Ministry of Health (Submission No. 0823)

152. I note the submission from Mr Gledhill, Senior Advisor (Science Radiation Laboratory at the Ministry of Health). In my view, the Ministry of Health has taken a position which is well supported and identical to that recommended by the WHO and reflecting well accepted international best practice in health protection.
153. I agree with and endorse all of the points made by Mr Gledhill. I have considerable experience of working with the National Radiation Laboratory and have always found their approach to be evidence based and up-to-date.

CONCLUSIONS

154. **THE** project proposed by Transpower is planned using widely accepted controls on electromagnetic field exposure reflecting best international practice. There is unsettled research about rare risks, but any intervention on this basis could only be justified in cases of very large population exposure. In contrast, the majority of this line passes through rural or semi rural country.
155. **RETURNING** to the purpose of my assessment, which is to identify any public health issues which may be associated with the Upgrade Project, I have found no cause for concern. Compliance with meeting the ICNIRP guidelines, which Transpower have proposed on a strict compliance basis, as if the guideline were a standard, will effectively eliminate all established significant adverse health effects which could plausibly arise from the transmission of electrical energy, including electric and magnetic fields. There may of course, be residual indirect effects, such as the potential for accumulated charge in unearthed metal objects in the transmission line corridor as discussed by Mitton in his evidence. However such effects are generally easily identified and invariably remedied if necessary by simple and well established techniques.
156. **THE** design of the line and its current earthing systems ensures that there is no potential for leakage currents to adjacent areas on the properties which are traversed.

157. **IN** summary, I consider that, after mitigation of the minor issues discussed above, there will be no residual health effects at all from this proposal. I say that because the established effects are all covered using the approach recommended by WHO and ICNIRP. The possibility of rare and unproven low level effects raised in some scientific literature has been discussed and considered in detail. However the low density of population and incorporation of a precautionary approach to design effectively eliminates the possibility of such a risk for the expected life time of the lines and this applies in all its proposed configurations.

A handwritten signature in cursive script, appearing to read "DR Black".

David Russell Black

1 February 2008

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