Report on Submissions of Hans Karow and Status of EMF Research

Prepared for

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PURPOSE OF REPORT

Q1. What is the purpose of this report?

A1. Exponent was asked by FortisBC to provide scientific comments on the documents and testimony filed by Mr. Hans Karow, and to summarize for the British Columbia Utility Commission (BCUC) the status of research regarding potential health effects of electric and magnetic fields (EMF).

INTERVENOR CONCERNS AND FortisBC RESPONSE

Q2. What is the nature of Mr. Karow's concerns?

A2. He is concerned that the operation of the proposed transmission and distribution lines will increase the public's exposure to EMF, which he believes to be associated with health risks. He also recommends that BCUC apply a precautionary principle with respect to EMF.

Q3. Will the proposed transmission/distribution lines increase exposure of the public to magnetic fields?

A3. No, on the contrary, the potential for exposure of the public to magnetic fields will be decreased. Based upon modeling performed by engineers at FortisBC (Response to BCUC Information Request No. 1, Q. 10.4), the levels of magnetic fields underneath the conductors of the new 63-kV transmission line and underbuilt 13-kV distribution line and outside the right-of-way are expected to decrease below the levels associated with the existing distribution line. For example, at normal operating loads, the magnetic field is calculated to decrease from 8.3 mG to 1.6 mG at 10 meters (m) from the centerline.

Q4. What is the effect of the proposed transmission/distribution line combination on electric field levels?

A4. The addition of the 63-kV transmission line above the distribution line will increase the electric field beneath the conductors by approximately 3 times. The elevated fields will be encountered along the pole line, and to a distance of about 50 meters from the conductor centerline. Because of the way that fields from the transmission and distribution lines "cancel," the elevation in electric field (3 times) is less than the elevation in line voltage (5 times).

Q5. Has FortisBC taken measures to reduce the magnetic fields from the proposed line?

A5. Yes, operating the new line at 63 kV, instead of at a lower voltage, reduces the current flow (which is the source of the magnetic field) required to deliver the same amount of power. FortisBC also has configured the phasing of the 63-kV transmission and 13-kV distribution circuit, and configured phase conductors of the transmission line in a delta configuration, instead of the more common horizontal configuration, to reduce magnetic field levels (Response to BCUC Information Request No. 1, Q. 10.5).

Q6. Even though the magnetic field levels achieved by these design measures are quite low, will they be as low as Mr. Karow has proposed?

A6. No, they will be above his proposed levels at some locations. In his opinion, the magnetic field should not exceed 0.3 mG at the edge of a right-of-way and 0.1 mG at a residence or workplace (C1-9, p. 2). The magnetic field from the proposed lines will diminish to levels of 0.3 mG at 32 m. At 50 m, the magnetic field level diminishes further to 0.13 mG.

COMMENTARY ON DOCUMENTS FILED BY MR. KAROW

Q7. Do the documents submitted by Mr. Karow constitute the best evidence on the topic of EMF and health that the BCUC should consider in this case?

A7. No.

Q8. Why not?

A8. The documents submitted by Mr. Karow are wholly inadequate and unreliable for the purpose of assisting the BCUC to evaluate the application of Fortis BC. To understand why, they are categorized as follows:

Table 1. Documents Submitted by Mr. Karow

Document Category	Document Reference No.
1. Testimony	C1-4, C1-17 (resubmitted with C1-21), C1-35
2. Govt. literature summary	C1-20, C1-21, C1-27, C1-28
3. Internet documents/media	C1-3, C1-9, C1-11, C1-13, C1-22, C1-25, C1-33, C1-34
4. Selected, peer-reviewed scientific studies	C1-10, C1-12, C1-14, C1-18, C1-26
5. No relevance to EMF	C1-19
6. Other topics	C1-1, C1-5, C1-6, C1-24, C1-29, C1-30, C1-31, C1-32
7. Information requests	C1-2, C1-7, C1-8, C1-15, C1-16, C1-23

Refer to Exhibit 1 for a complete summary of each document submitted by Mr. Karow and considered in this report (C1-1 – C1-35). This report considers the documents submitted by Mr. Karow in the first four categories and ignores the documents submitted in the last three shaded categories as these: a) have no direct relevance to the issue of health effects of EMF, b) address other topics relating to this case (with the possible exception being C1-29 that discuss methods to reduce fields from power lines), or c) consist of information requests.

Testimony

Q9. What testimony has Mr. Karow submitted?

A9. Mr. Karow has submitted testimony prepared by Kyong H. Nam, Ph.D., P.E. (C1-4) that had been previously submitted to the BCUC in another case before it (Exhibit C51-2, Vancouver Island Transmission Reinforcement ~ Project No. 3698395 Sea Breeze Pacific Regional Transmission System, Inc.). He also has submitted his own testimony in the form of a summary (C1-17) he has prepared of studies referenced in a report by wildlife biologists and engineers at the Bonneville Power Administration, and anecdotal comments in cover letters (i.e., C1-9, C1-18, C1-26, C1-32, C1-33).

Q10. What are the main issues addressed by Dr. Nam in his testimony?

A10**.** Dr. Nam objects to the exposure guidelines published by the International Commission on Non-ionizing Radiation Protection (ICNIRP). Dr. Nam also cites isolated studies as evidence for a causal relationship between EMF and cancer/miscarriage, and argues that because of concerns expressed by some national and local politicians, school boards, and a variety of concerned citizen groups, that the ICNIRP guidelines are no longer credible.

Q11. Are Dr. Nam's criticisms of ICNIRP well founded?

A11. No. First, based on an Internet resource describing its interpretation of how the ICNIRP establishes exposure standards, he concludes:

> The ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines were not formulated by scientists, but by technicians calculating how long it would take to heat a bag of sugar through one degree Celsius. **The absurdity is all that stands between us and the risk of life threatening or chronic disease** [Nam emphasis]. The ICNIRP guidelines only measure the immediate and very short term thermal (heating) effects of radiation, not the long term biological effect, which is the main threat to health. (C1-4, p. 4).

The ICNIRP exposure guidelines clearly explain the basis for their decisions, and the quotation he cites does not accurately describe the formulation of ICNIRP's

guidelines. Moreover, at extremely low frequencies (ELF) <1000 Hertz, the ICNIRP guidelines are based upon avoidance of shock perception and stimulation of neural tissues, not heating.[1] The scientists who reviewed the literature to establish these guidelines report that:

> only established effects were used as the basis for the proposed exposure restrictions. Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF. In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects and exposure at levels of 50/60 Hz magnetic flux densities substantially lower than those recommended in these guidelines (ICNIRP, 1998, p. 496). [This document is also cited in this proceeding as FortisBC Appendix A9.8.1]

Thus, ICNIRP did consider all of the available scientific evidence but concluded that the only scientifically proven evidence upon which to base a guideline were short-term adverse effects. ICNIRP did not establish exposure guidelines to address long-term biological effects (such as cancer) because it found the evidence insufficient and/or the research unconvincing for such effects.

Q12. Does Dr. Nam provide evidence to support his conclusion that there are "undeniable study results that show transmission lines and residential EMFs more than 3-4 mG (milligauss) can <u>cause</u> health risks, including childhood leukemia, adult brain cancer, and miscarriages."? (C1-4, p. 5)

A12. No. In support of his claim for a causal relationship between ELF EMF and health effects, he cites reviews of research of which none concluded that a causal relationship exists. Each of the cited reviews recognized only that an association is reported in some studies, but not that this association is causal.

Q13. Is there much of a scientific or health basis for recommendations by politicians at the national or local level, school boards, and intervenor groups to adopt policies that would address EMF at levels less than those recommended by ICNIRP for the general public, e.g., 833 mG?

A13. Based upon multidisciplinary reviews of the scientific literature by every national and international health agency that has considered the question

[1] At higher frequencies (e.g., as are produced by microwave ovens, cell phones, radar, etc.), effects related to heating are recognized in the setting of the ICNIRP guidelines.

of potential health effects, there is not. However, given public concern, some governmental organizations have proposed strategies that would reduce exposure to EMF, if there are low cost or no cost means of doing so.

Dr. Nam's descriptions of these actions are frequently misleading, incomplete, or just wrong, perhaps in part because of the unreliability of the sources he has cited. To give a few examples, there is no legislation in the U.S. that prevents new homes from being built near power lines other than electrical safety codes, as Dr. Nam concluded based on an Internet reference from his report. The Swedish government has no "safety limit" on exposures from power lines—the reference is to one agency that has guidelines on the emission levels of ELF EMF from computer monitors it purchases.

Q14. Did Dr. Nam demonstrate any first hand knowledge of the relevant scientific literature as would be evident from citations to primary studies or reviews of EMF that have been published in the scientific literature?

A14. No. None of the 77 references he cites are to peer-reviewed studies published in scientific or engineering journals. All of his references are to secondary discussions of EMF science and related issues on Internet websites or to abstracts of papers available on the Internet, except for two citations to executive summaries of U.S. government reports (NIEHS, 1998; Neutra et al 2002).

Q15. What opinions does Mr. Karow express in his testimony and are they well founded?

A15. Mr. Karow's direct testimony is limited, but it can be presumed that the documents he submits are consistent with his beliefs and opinions. In his letter accompanying the submission of an unpublished report by Dr. Neil Cherry, he reiterates the belief of Dr. Nam and the unpublished paper by Dr. Cherry that "ICNIRP's guidelines are based on thermal effects and that so far the non-thermal effects have not been considered, some government agencies have set their own EMR regulation[s] at a far lower rate than the ICNIRP guidelines." (C1-9, p. 1). Mr. Karow also urges the BCUC to:

> consider the precautionary principle and prudent avoidance by keeping new electric facilities, including power lines, away from residential and pubic areas below certain EMF exposures, as an initial approach I would suggest 0.3 milliGauss at the border of the Fortis right-of-way, and 0.1 milliGauss at the out side wall of a residential and/or business building (C1-9, p. 2).

Mr. Karow incorrectly interprets research to conclude that EMFs cause an increased risk for childhood leukemia. In his letter with the submission of the Draper et al (2005) study (C1-18, p. 1), Mr. Karow erroneously states that the

study shows that "The incidence of childhood leukaemia more than doubles when the birth address is 70-99 meters from a high voltage line… " The authors did not measure incidence, which is the number of new cases of the disease that arise in some time period (usually a year); rather, in Table 3 they report that the percentage of children with leukaemia living 70-99 meters from transmission lines was 2.02 times greater than the percentage of children living >600 meters from transmission lines. As this is a case-control study, the results are comparisons of the distance from the line among children with and without leukemia. In the Draper study, distance of the birth address from a power line is used as a surrogate for exposures from power lines, thus limiting the inferences that can be made from this study. For example, some associations are reported at distances that are unlikely to be related to magnetic fields from power lines.

Mr. Karow cites no support for his opinion that the application of the precautionary principle would support restrictions of magnetic field levels to 0.3 mG at the edge of the right-of-way and 0.1 mG at a residence (C1-18; C1-26).

Q16. What about Mr. Karow's main testimony that his counting of human studies cited in tables by Lee et al (1996) [C1-21, C1-27, C1-28] indicate that 46.67% of the studies show positive results and that this finding "clearly indicates almost a one in two chance of being adversely affected by EMFs." (C1-17, p. 2)?

A16. The method by which Mr. Karow attempts to demonstrate a causal association between EMF and effects on human health and animals is flawed. The calculation of the percentage of studies with a positive association, without consideration of the individual studies, is too crude a method for summarizing a complex and diverse body of research. For this reason, it is not an appropriate method for assessing associations, much less causality, in the field of epidemiology. Rather, the only method that is robust enough to come to a conclusion about causality is a qualitative review of the weight-of-evidence, in which all studies are thoroughly reviewed and the strengths and weaknesses of each study addressed in order to arrive at a scientific consensus.

The flaws in this tabulation method include:

1) The EMF epidemiology studies, and sometimes laboratory studies, perform a multitude of analyses that attempt to relate a variety of exposure measures (e.g., distance to a power line, calculated field levels, etc.) and outcomes (e.g., leukemia subtypes, all cancer, etc.). Studies compute at least a dozen and often hundreds of associations but Mr. Karow's listing typically selects just one result from each study without any explanation for the rationale behind the selection. From a statistical perspective, one would expect about 1 in every 20 computations to result in a false positive association just by chance, i.e., to indicate a statistically significant association even when in reality no association exists. Furthermore, Mr. Karow includes studies in his tabulation where a

positive association or response may have been reported but which was not reported as statistically significant, i.e., reliably distinguished from no effect or association from a statistical perspective. So the number of associations or effects reported by Mr. Karow is inflated.

2) Mr. Karow inappropriately lumps biological studies of workers and general public discussed in Chapter 2 of the Lee et al report (C1-26) with epidemiologic studies of humans (Chapter 3, C1-21) and studies of laboratory animals related to behavior, stress, growth, reproduction and development, and melatonin (Chapter 4, C1-27). Moreover, within each chapter, diverse results are mingled together, ranging from changes in electrolytes to variations in mortality rates. This mingling of studies on unrelated topics cannot yield any recognizable or useful result and tests no specific hypothesis.

3) Mr. Karow's method gives no consideration to the relative strength and size of the individual studies. For example, the largest study with the best exposure techniques may have reported no association between EMF exposure and leukemia; however, in this analysis, this study is given equal weight to a small, poorly designed study.

4) Mr. Karow misinterprets reports of biological responses or statistical associations as being the same as *adverse* biological responses. In so doing, he makes it appear that 46.67% of the studies report adverse effects. Actually, the number of studies where a statistically significant adverse effect may be claimed is arguably less than 3%. A review of the tables he provides will easily show that few of the epidemiology, biological and laboratory studies actually report responses that are truly adverse.

Q17. Are more valid methods than Mr. Karow applied available to summarize associations reported in EMF epidemiology studies?

A17. Yes, more rigorous attempts to statistically summarize a large number of studies on a single effect—called meta-analyses or pooled analyses—are used by scientists to assess effects that might not have been apparent from a review of a collection of relatively small studies. Meta-analyses not only quantify the size of an effect and the associated uncertainty, but also permit study of the reasons for variations in the effects reported from individual studies. A number of such analyses have been performed over the years as part of the review of EMF epidemiology studies of childhood leukemia. Two of these (Albohm et al, 2000; Greenland et al, 2000) have figured prominently in evaluations of the research literature by the IARC, ICNIRP, HCN, and NRPB (IARC, 2002; ICNIRP, 2003; NRPB, 2004b). These pooled analyses included studies that estimated long-term average exposure to residential magnetic fields. The analyses found no association between leukemia and exposure to estimated long-term average magnetic field levels less than 3 mG. However, the analyses did report an

association between leukemia and estimates of long-term average magnetic field levels greater than 3-4 mG.

Q18. Are the results of the Ahlbom et al. and Greenland et al. meta-analyses free from problems in their interpretation?

A18. No. Meta-analyses of observational studies always present more problems in their interpretation than meta-analyses of randomized clinical trials (Egger et al, 1998). For the meta-analyses of EMF observational studies, there is particular concern that the potential effects of bias and confounding have not been fully eliminated, which limits the validity and interpretation of the combined estimate of effect derived from these pooled analyses. Greenland et al (2000) state:

> One can of course raise many criticisms of the individual studies, which would increase the already large uncertainty in our results. For example, confounding effects of socioeconomic status, residential mobility, residential type, viral contacts, and traffic density have been raised as possible explanations for the observed associations. (p. 632)

As further pointed out by Dr. Martha Linet[2] and colleagues in their guide to the interpretation of epidemiologic literature and claims regarding the causation of childhood leukemia (Linet et al, 2003), meta-analyses and pooled analyses of epidemiology studies are inherently less helpful than analyses of pooled observational data from *randomized clinical trials*, because, in the case of epidemiology studies, the various individual studies considered are likely to "differ in study design, types of control subjects selected, population size, methods used for exposure assessment, field work methods, and other factors." (p. 225). They further caution that "even a single study of poor quality can have a large effect on the results of a meta-analysis." (p. 225).

Linet et al. go on to state:

> Meta-analysis may be particularly problematic when attempting to ascertain whether an exposure of great public concern (eg,. . . non-ionizing power-frequency magnetic fields…) is linked with a specific type of childhood cancer, particularly when the association is modest and inconsistently observed in different epidemiologic studies. Thus, pediatricians need to be skeptical about attempts to decrease a complex array of differing investigations to a single risk estimate. (p. 225-226)

[2] Dr. Linet is the Chief and Senior Investigator of the Radiation Epidemiology Branch of the Division of Cancer Epidemiology and Genetics of the National Cancer Institute (NCI), one of the National Institutes of Health. She is a physician, board-certified in internal medicine and general preventive medicine; and she also holds a degree in public health from Johns Hopkins University. She has published extensively on the causes of leukemia, and is the author of the internationally recognized text "The Leukemias: Epidemiologic Aspects." She serves on the Advisory Group on Cancer and the Environment to the American Cancer Society and serves as the NCI liaison to the Committee on Environmental Health of the American Academy of Pediatrics.

Q19. Do Dr. Nam or Mr. Karow have any scientific training that would be relevant to their understanding of EMF health issues?

A19. None that they have reported. As Mr. Nam himself states, "I am not an EMF expert, nor have I been involved in EMF research." (C1-4, p. 3). He does have a degree in electrical engineering, with a specialty in lasers, but he does not address any technical issue involving electrical engineering in reference to the need, design, or operation of transmission lines. He has indicated no scientific training in any area of the health sciences, nor has Mr. Karow.

Q20. What is the scientific weight that should be accorded to some of the conclusions reached by Dr. Magda Havas in testimony that has been submitted to the BCUC in the VITR case?

A20. A report prepared by Exponent and sponsored by Dr. Linda Erdreich that addresses issues in Dr. Havas' testimony has already been submitted to the BCUC (Exhibit B1-37, Rebuttal Evidence, Vancouver Island Transmission Reinforcement ~ Project No. 3698395 Sea Breeze Pacific Regional Transmission System, Inc.). Therefore, Dr. Havas' testimony will not be discussed again here. However, some additional comments on a publication by Dr. Havas on EMF and health issues are provided later in this report.

GOVERNMENT LITERATURE SUMMARY

Q21. Does the summary of the literature "Electrical and Biological Effects of Transmission Lines: A Review" (Lee et al, 1996) provide an up-to-date and authoritative evaluation of the scientific literature regarding EMF and health?

A21. No. The report published by the Bonneville Power Administration (C1-20, C1-21, C1-27, C1-28)_was prepared over 10 years ago by a wildlife biologist, Dr. Jack Lee, and colleagues at this U.S. federal power agency. He summarized his reading of epidemiology and laboratory research studies but did not conduct a critical evaluation of these studies. While no issue is taken with Dr. Lee's report for what it is, there are other more recent, critical, in-depth reviews of the literature by scientists with specialized knowledge of the relevant scientific disciplines are available to provide guidance to the BCUC. For example, the BCUC might consider more recent reports prepared by large, multidisciplinary panels of scientists that have prepared comprehensive reviews of the EMF health literature including the National Institute for Environmental Health Sciences (NIEHS, 1998; 1999), the International Agency for Research on Cancer (IARC, 2002), the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2003), the National Radiological Protection Board of Great Britain (NRPB, 2004b), the Health Council of the Netherlands (HCN, 2000), and the

Canadian Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC, 2005).

INTERNET DOCUMENTS/MEDIA

Q22. What are the problems with accepting documents downloaded from the Internet or media articles as scientific evidence? What types of documents are acceptable?

A22. Internet or media sources are not considered by scientists to be reliable sources of information, in part because many Internet sources are opinions of individuals or journalists without scientific training. An exception is the web site of a national or international scientific organization or regulatory agency, which reflects information written by scientists and has undergone internal review. Scientific research is generally described in reports of experiments that are published in peer-reviewed, scientific journals. Many reviews of the research prepared by scientific organizations or regulatory agencies (e.g., the National Radiological Protection Board [NRPB], the WHO, the USEPA, and the ICNIRP) include only such publications.

Research that has been published in peer-reviewed journals is the basis for valid health risk assessments for two reasons. First, publication in a scientific journal indicates that the study has been reviewed by other scientists to determine if the research meets some minimum standards of quality. Second, other published information in the form of abstracts, conference proceedings, book chapters, or personal opinion rarely includes sufficient information for a judgment of the quality of the research to be made. However, even a published study may be screened out of consideration, or assigned little weight, if it is found to lack a clear explanation of its methods, to be of inadequate study design, or because it is not responsive to the relevant questions.

Q23. Does the booklet printed by Citizens United for Responsible Electricity in 2001 (C1-3), provide better or more accurate information about EMF than the reviews published by NIEHS, IARC, NRPB, and HCN?

A23. No. It contains tables, figures, and text, largely copied and pasted from other sources, which present a layman's view of EMF. However, it does provide the caveat that "this subject consists of highly technical and specialized fields. Often doctorates and professors of electrical engineering do not understand electricity's biological effects on people or animals…It would take the years of learning invested into a doctorate degree to truly understand each scientific field discussed here…" (C1-3, p. 3).

Q24. What about the unpublished 165-page report by Dr. Neil Cherry (C1-9) that criticizes the ICNIRP guidelines for radiofrequency and microwave radiation (100 kHz – 300 G Hz)?

A24. This document is concerned with the potential health effects of mobile phones and microwave communication towers, which operate at frequencies millions of times higher than ELF. The interaction of ELF EMF with matter is very different from higher frequency fields because they have different frequencies and wavelengths, and, therefore, a different energy level. Only studies of ELF EMF fields are relevant to assessing the potential biological and health effects of such fields. Since the focus of Mr. Karow and the BCUC in this siting evaluation is on frequencies about 60-Hz EMF, not radiofrequency or microwave radiation exposures, Dr. Cherry's paper is not on target. That Mr. Karow included this report to support his beliefs about EMF from power lines speaks to his confusion of these two very different physical agents.

Q25. Does the unpublished report by Dr. Neil Cherry on EMF from high-voltage power lines and buildings (C1-11) provide any new insights into the research literature on potential health effects of EMF?

A25. No, this report represents a selective compilation of studies to support his conclusions. He provides no basis in public health practice to support his recommendations regarding desirable levels of magnetic fields in homes, schools, and workplaces.

Q26. Mr. Karow has referenced a news release downloaded from the Internet about an article by Dr. Wan Ho that addresses childhood leukaemia and DNA damage to brain cells (C1-13). From this news release, does this article address these topics in a different way than have reviews of these topics by national and international panels of scientists?

A26. Yes, the article described in the press release would not have been considered by scientific review panels because the article appears not to have been published in a scientific journal. It also reaches different conclusions from the reviews by these panels because of the incomplete and selective nature of Dr. Wan Ho's citations to the research literature.

Q27. What is melatonin and does the 2001 unpublished paper by the student G. Kustavs (C1-22) provide a balanced and critical evaluation of what scientist's know about the effect EMF on the body's production or regulation of the hormone?

A27. Melatonin is a hormone that is released by a small gland at the base of the brain, largely during the nighttime hours. In humans and other mammals information about light in the environment is transmitted from the eye by multiple nerve pathways to the pineal gland. The release of melatonin is regulated by light, which suppresses melatonin release, and also by neural pacemaker cells in the brain and eye that can maintain the daily variation in release of melatonin in the absence of light. The function of melatonin in the body is not yet known but scientists have conducted considerable research as to its potential role in circadian rhythms involving sleep disorders, jet lag, and alertness. Based on much more limited research, other hypotheses have been proposed to suggest that melatonin might have beneficial effects in reducing sex hormone levels that affect the risk of breast cancer, or cancer in general by some anti-oxidant effect.

The paper by Kustavs does not offer a balanced critique of the current understanding of melatonin. The paper is a superficial listing of only studies that have looked for (and found) effects of variations in the earth's magnetic field, DC magnetic fields, AC electric and magnetic fields, and radiofrequency fields on melatonin levels in mice, rats, hamsters, and humans. The author only lists in her tables studies with "positive findings." (p. 8), which, of course, completely biases her view of the literature because studies that report no effect, or perhaps an increase in melatonin with exposure, have been systematically excluded. However, she does paraphrase from the opening sentence of the abstract of one study by Graham et al (2000) - "So far mostly occupational and residential studies have observed significant changes in melatonin activity." (p. 14) – yet fails to complete Graham et al's evaluation that "but not in laboratory-based exposure studies." In fact, in this study, Graham et al report that power-frequency magnetic fields at "28.3 microtesla, μT, [283 milligauss, mG] had no differential effect on concentrations of melatonin or its major enzymatic metabolite (6-hydroxymelatonin sulfate, 6-OHMS) in daily morning urine samples [of human subjects], compared to [human subjects given] equivalent no-exposure sham control conditions."

Furthermore, a key concept for Kustav's paper is the simplistic notion that a lowering of melatonin levels is a cause of breast cancer. However, the research underlying this hypothesis is not seriously reviewed, nor does she consider the studies that have looked for associations between EMF and breast cancer in humans and in laboratory animals. If exposure to EMF really does lower melatonin levels, and lower melatonin levels increase the risk of breast cancer, then the literature altogether should report a consistent association between EMF and breast cancer, which it does not (IARC, 2002; ICNIRP, 2003; NRPB, 2004b; HCN, 2005).

Q28. What about Mr. Karow's reference to an article published in *The Sunday Times* newspaper in 2005, titled "Electrical fields can make you sick" (C1-25)?

A28. The news article that Mr. Karow submitted that describes a forthcoming report by the Health Protection Agency of the United Kingdom (HPA) grossly misrepresented the purpose and conclusions of the November 2005 report by the HPA on electrical sensitivity (HPA, 2005). The HPA report is simply a review of the published literature on electrical sensitivity, its natural history, prognosis and treatments.

The HPA report did not at all conclude that electrical fields make people sick, nor did it recognize electrical sensitivity as an established medical condition. In fact, after a thorough review of the published literature, the HPA was unable to find consistent, objective clinical signs or pathophysiological markers for this condition. The authors of the report conclude, "[w]hile sufferers and their support groups are firmly convinced of a causal relationship with EMFs, the majority of mainstream scientific opinion does not consider there to be robust evidence of such a relationship." (p. 9). Other agencies have reviewed this topic and reached a similar conclusion, including the World Health Organization (WHO, 2005b) and the Health Council of the Netherlands (2005).

Furthermore, the authors of the news article claim "a report by the Health Protection Agency (HPA), to be published next month, will state that increasing numbers of British people are suffering from the syndrome." The HPA report, however, contains no information to suggest that electrical sensitivity is a significant problem in the United Kingdom.

Q29. Do the editorial opinions published in the Internet newsletter *Microwave News* that Mr. Karow has submitted (C1-33) provide the BCUC with any substantive scientific evidence?

A29. No, these are just editorial opinions of a journalist who distributes his newsletter over the Internet and largely consist of *ad hominem* attacks on scientists at the World Health Organization and other agencies with whom the editor disagrees.

Q30. Does the unpublished compilation of legislation and policy regarding EMF by the law student Ms. Wu (C1-34) represent a scholarly review of this topic?

A30. No, it is troubling that much of the information that she has referenced was not obtained from law journals or published laws—for this reason, the paper is quite superficial in its coverage.

It appears that Ms. Wu cites results obtained from an Internet search and that is why the majority of her legal references are to newspaper articles, presentations, and compendiums of information on advocate websites. She draws no distinction between proposals for legislation and laws and statutes that have been enacted. This is important because there are many proposals by politicians for legislation in response to constituent concerns that are never actually passed. By citing proposals for legislation without following up on subsequent developments, she presents incomplete and misleading information.

A case in point is her discussion of proposals made in Sweden in 1992 for legislation, which I have quoted below:

> In 1992 the Department of Electrical Safety of the National Board for Industrial and Technical Development stated that Sweden would soon set exposure standards for new homes near power lines, and for all new electrical facilities, and that these standards might require average annual exposures to be in the neighborhood of 2 mG. This came after an announcement by the National Board for Industrial and Technical Development that they intended to henceforth "act on the assumption that there is a connection between exposure to power frequency magnetic fields and cancer, in particular childhood cancer." In addition, Swedish regulators have declared that they will propose a ban on the construction of houses within 330 feet of high-voltage lines. (This ban is now in effect.) (p. 6-7)

The reference for this information is not to any official Swedish government website. If Ms. Wu had done a more thorough search, she would have found that none of the proposals she mentioned were enacted. The Swedish government has not set exposure standards or banned home construction near high voltage power lines; rather, the only action they have taken is to adopt the precautionary approach summarized below:

> If measures generally reducing exposure can be taken at reasonable expense and with reasonable consequences in all other respects, an effort should be made to reduce fields radically deviating from what could be deemed normal in the environment concerned. Where new electrical installations and buildings are concerned, efforts should be made already at the planning stage to design and position them in such a way that exposure is limited (SNBOSH, 1996).

Ms. Wu also draws a conclusion that is historically impossible. She writes, "many jurisdictions have taken the initiative to legislate in this regard. This appears to be in response to the recommendations of the World Health Organization, and in light of a Council Recommendation by the European Commission." Many of the legislative proposals and activities she cites were initiated before any recommendations regarding EMF were made either by the WHO (whose International EMF Project started in 1996) or the European Commission, which published its first standard in 2000. These examples suggest that readers take a *caveat emptor* approach to her citations and independently confirm any data covered by her discussion.

PEER-REVIEWED SCIENTIFIC STUDIES

Q31. Dr. Bailey, do you object to the BCUC receiving into evidence the five peer-reviewed studies that have been published in scientific journals, which have submitted by Mr. Karow as submissions C1-10, C1-12, C1-14, C1-18, C1-26?

A31. Not at all, these are the type of information sources that should be given greater attention than those discussed above.

Q32. Does the paper by Maxey (1991) (C1-10) contribute anything to our overall understanding of EMF and health?

A32. No, in spite of the paper having been published in a peer-reviewed journal, he simply summarizes a medley of information collected from a variety of sources. The noteworthy statement in the paper is his suggestion that entrainment of human brainwaves to EMF at an intensity of 0.3 mG from an old Russian study "suggest that an EMF level of 0.3 mG is less desirable." (p. 61), which may be one of the unnamed sources for Mr. Karow's recommendation for limit levels at the edge of a transmission right-of-way to 0.3 mG.

Q33. What are the conclusions of the study by Milham et al. (C1-12) and are they properly supported by the analysis presented in his paper?

A33. Milham et al. (2001) compared statewide mortality rates of childhood leukemia to the percentage of homes that were served by electricity in the United States for the periods 1928-1932 and 1949-1951. The authors concluded that the emergence of a peak in childhood leukemia mortality rates over the time period 1920-1960 is directly attributable to concurrent increases in the electrification of residences. This descriptive analysis is of academic interest; however, it is not robust enough to support the authors' strong conclusion that the occurrence of a peak in childhood leukemia is due to increases in EMF levels.

An association between two characteristics of a population does not, in and of itself, have the capability to determine whether the association is causal among the individuals that make up the population. For example, we cannot conclude that just because breast cancer rates have increased over a particular time period, that it must be the consequence of simultaneous increases in the consumption of high-fat diets in the same population. This conclusion would require us to be sure that the increases in breast cancer rates are not due to other changes in the population over the same time period. Milham et al. does not give adequate consideration to the many alternate explanations for the results observed in this analysis. Electrification is associated with economic development, urbanization, and industrialization; and there are innumerable factors besides EMF levels that have changed as the United States has progressed over the period 1920-1960.

For example, there have been increases in traffic density and the consumption of processed foods, changes in the migration patterns of populations, and changes in behaviors such as smoking. The observed association could theoretically represent any number of the many factors that have changed along with the development of the United States in the 20th century. Furthermore, the authors do not explain why they believe EMF exposure would cause an increased risk of leukemia for children between the ages 2-4, but not for other ages.

Furthermore, if this hypothesis were true, one might expect to see a strong rise in leukemia rates with the more recent, massive increases in the use of electricity and electrical appliances in the home. To the contrary - childhood leukemia rates have been stable during the period 1973-1995 (Lieberson et al, 2000; Linet et al, 1999). But without detailed data about exposures of the population to EMF and many other factors over time, any hypotheses about a causal relationship between magnetic fields and leukemia rates are speculative and incapable of being adequately tested.

Q34. What were the findings of the Draper et al study (C1-18)?

A34. The Childhood Cancer Research Group in the UK completed a large case-control study of childhood leukemia in 2005 (Draper et al, 2005). This study compared the distance of the birth address to high-voltage (275-kV and 400-kV) transmission lines among children who developed childhood cancer and those children who did not have cancer. The study included 9,700 childhood leukemia cases and an equal number of matched controls in the analysis. The study reported an association between birth address within 200 m of transmission lines (versus greater than 600 m) and childhood leukemia; likewise, a smaller association was reported between birth address within 200-600 m of transmission lines (versus greater than 600 m) and childhood leukemia. No statistically significant associations were found with other childhood cancers, including cancers of the brain and central nervous system. The reported association is not consistent with several smaller studies that evaluated distance to power lines and leukemia risk in children, e.g., Kleinerman et al (2000) and UKCCS (2000).

Q35. Do the findings of the Draper et al (2005) study strongly support an association between EMF and childhood cancer?

A35. No. There is little evidence from the study to link childhood cancer to EMF. The major limitation of the study was that no measurements or calculations of magnetic fields were published; distance from a power line was used as a proxy for exposure. Furthermore, if EMF were the causal factor, it is not plausible based on existing data that there would be an elevation in the magnetic field level resulting from the transmission line at some of the distances where the authors observed an association. This means that the association cannot be explained by an increase in the magnetic field level as a result of the transmission line. Draper

et al conclude that they have no good explanation as to how magnetic fields could be the cause of the reported increased risk associated with distance to a power line.

Q36. Does the paper by Burch et al (2000) (C1-14) provide unambiguous support for the hypothesis that magnetic field exposure reduces melatonin levels?

A36**.** No. Burch et al. compared the concentration of a break-down product of melatonin (6-OHMS) in the urine of utility workers after work in two different environments: 1) in the office, while traveling, or near single-phase distribution lines; and 2) in electric substations or near 3-phase distribution/transmission lines. Exposure to magnetic fields was measured using a personal monitor.

They report that the level of 6-OHMS in the urine of workers in the first environment was not related to the mean, daily magnetic field level.

For the workers in the second environment, 6-OHMS levels measured after work and in the evening tended to be higher for workers that worked < 2 hours in that environment as the average level of the magnetic field increased. For workers who spent > 2 hours in the day in that environment, as magnetic field levels increased in intensity the levels of 6-OHMS were significantly *lower* in the evening but not after work or overnight.

Thus, higher magnetic field levels were associated in this study with both increases and decreases in the levels of the melatonin metabolite. Whether the magnetic field is the cause of these changes is not clear because the workers and their work environments differ in many ways, including some that may affect melatonin. Only age, average workplace exposure, and month of participation were considered as possible confounders but not others such as body weight and height, medications, alcohol intake, and exercise level that are reported to affect melatonin and metabolite levels. Perhaps more important is that the two work environments would have clearly differed in the opportunity for exposure to sunlight, which is widely regarded as suppressing melatonin levels. For most utility systems, substations are almost always located outdoors so the workers in the second environment might be expected to have more exposures to sunlight. Burch et al. attempted to adjust for light levels by means of light sensor readings from each subject, but did not provide any data on the this confounder. However, if the sensors were not sensitive to light of blue wavelengths, which is more prevalent in sunlight than artificial light indoors, the sensors would not have registered the most potent melatonin-suppressing wavelengths. Thus, further research would be needed to determine whether longer time spent in magnetic fields or in light, or still some other environmental/biological factor, is the critical stimulus for the observed response.

Q37. Do the multidisciplinary panels of scientists that have reviewed scientific research on EMF and melatonin (including studies by Burch et al) conclude that a reduction in melatonin in humans from exposure to magnetic fields is a 'real' effect or that, if confirmed, such a reduction would be adverse?

A37. No. These organizations have judged that potential reductions in melatonin associated with magnetic field exposure under field or controlled laboratory conditions are not significant (NRPB, 2004b), not adversely affected by magnetic fields (ICNIRP, 2003), difficult to distinguish from other factors (IARC, 2002), are not found when measured in the blood of human subjects [5 studies] (HCN, 2000), or are based on inadequate data (NIEHS, 1998).

Q38. What is the purpose of the paper by Dr. Magda Havas (C1-26)?

A38. Dr. Havas' report summarizes and critiques reviews prepared by multidisciplinary, scientific panels organized by the National Academy of Sciences (NAS, 1999) and the U.S. National Institute of Environmental Health Sciences (NIEHS, 1998). Both reviews were weight-of-evidence reviews that provided a scientific consensus on the literature published on EMF through approximately 1996 and 1998, respectively. Dr. Havas reviewed the process involved in preparing these reports, the consensus of the scientific panels, and what she believes are the flaws of these reviews and the scientific method in general. The report provides a brief summary of the research related to EMF and possible effects on cancer, reproduction, depression, Alzheimer's disease, and electromagnetic sensitivity. Dr. Havas also writes about higher frequency EMF, biomagnetism, and magnetobiology, which are not relevant to an assessment of the effect of ELF EMF on health, as described above.

Q39. What are the major conclusions of Dr. Havas' report?

A39. Dr. Havas disagrees with the conclusions of the reviews conducted by large panels of scientists assembled by the NAS and the NIEHS. She contends that the conclusions are inaccurate because they do not consider the full range of relevant topics: "The evidence is considerably stronger than appears in this evaluation if a much broader literature is examined." (p. 94).

The "broader literature" that Dr. Havas refers to includes the beneficial effects of EMF on bone repair, the ability of different species to perceive EMFs, and the evaluation of health effects of higher frequency EMFs. None of these topics are relevant to a focused evaluation of the possible effects of power frequency fields on health. Dr. Havas also expresses the opinion that mechanistic and animal research was given too much weight in the overall evaluations. Her conclusions are at odds with the evaluations conducted by panels organized by the NIEHS and the NAS, which were balanced, objective and considered the full range of relevant research.

Dr. Havas' opinion that there is strong support for a causal relationship between EMF and health effects is largely based on her belief that plausible mechanisms for a toxic effect of EMF have been demonstrated (in particular, the melatonin hypothesis). However, Dr. Havas' discussion of melatonin research is restricted to positive studies and does not include those that did not report effects or failed to replicate earlier studies. As reviewed by the NAS and NIEHS panels [as well as subsequent reviews by NRPB (2004), ICNIRP (2003), IARC (2002), and HCN (2000)], the current body of research is inadequate to suggest that EMF suppresses melatonin. Furthermore, Dr. Havas' evaluation of the possible effect of EMFs on cancer, depression, reproductive issues, and Alzheimer's disease is not balanced. Overall, most of the conclusions and recommendations that Dr. Havas makes are not adequately supported with citations or supporting evidence, which suggests that they are not founded on scientific inference but, instead, reflect her opinions.

WEIGHT TO ACCORD MR. KAROW'S SUBMISSIONS AND TESTIMONY

Q40. Do the documents submitted by Mr. Karow to the Commission constitute a body of evidence upon which valid scientific conclusions can be drawn?

A40. No. Mr. Karow presents a hodge-podge of scientifically weak information that he believes supports his position but which does not stand up to scrutiny. Some information provided in the form of peer-reviewed papers and reports may be useful and relevant. Other information, cobbled together from a variety of sources, may be neither relevant nor correct. The material submitted by Mr. Karow does not represent an objective weight-of-evidence review, which is the accepted method by which scientists and public health authorities assess whether exposures (including EMF) cause adverse effects on health.

Q41. How does Mr. Karow's submission deviate from a weight-of-evidence review?

A41. Mr. Karow presents material that supports his position without recognizing: 1) the importance of remainder of the relevant literature, which may not support his position; and 2) the limitations of the documents he has submitted. Regarding the limitations of the documents, Mr. Karow does not provide any evaluation of the materials he has submitted other than his opinion that they support his conclusion that EMF causes adverse health effects. Mr. Karow presents published papers that are methodologically weak (e.g., C-12), information from scientifically unreliable sources (e.g., C1-13, C1-25), and reviews that are not scientific, objective, balanced (C1-4, C1-9, C1-11, C1-22 and C1-26) or relevant (C1-9).

Q42. Are Mr. Karow's opinions and conclusions regarding a causal relationship between EMF exposure and adverse health effects supported by the multidisciplinary reviews of the literature you have previously cited?

A42. No, they are not supported by any of the multidisciplinary reviews of the health research literature published by FPTRPC, NRPB, IARC, NIEHS, NAS, and HCN (FPTRPC, 2005; NRPB, 2004b; IARC, 2002; NIEHS, 1998; NAS, 1999; and HCN, 2000).

Q43. What did these scientific panels conclude?

A43. The assessments by the FPTRPC, the IARC, the NIEHS, the NAS, the NRPB, and the HCN agree that there is little evidence suggesting that EMF is associated with adverse health effects, including most forms of adult and childhood cancer, heart disease, neurodegenerative diseases, depression, and reproductive effects. However, these assessments concluded that epidemiology studies *in total* suggest an association between magnetic fields at higher estimated average exposure levels (greater than 4 mG) and childhood leukemia. All agree that the experimental laboratory data do not support a causal link between EMF and any adverse health effect, including leukemia, and have not concluded that EMF is, in fact, the cause of any disease. These organizations have not recommended exposure limits or required measures to reduce exposures encountered under ordinary circumstances, since they have not concluded that a causal relationship between EMF and adverse health effects exists.

The conclusions of these reviews in the form of quotations are provided in Exhibit 2.

Q44. Mr. Karow has made reference to the precautionary principle. What is it?

A44. The European Commission and the Government of Canada have identified the precautionary principle as a key tenet of environmental policy and it is embedded in regulatory considerations and actions. As defined by the Rio Declaration on the Environment, the precautionary principle is to be applied "[w]here there are threats of serious or irrevocable damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measure to prevent environmental degradation." (United Nations Conference on Environment and Development, 1992).

Q45. How has the European Commission proposed to implement this principle?

A45. The European Union Commission has recently provided guidance to decision makers on the application of the precautionary principle (Commission of the European Communities, 2000). The Commission recommends that:

- Proportionality. "Measures . . . must not be disproportionate to the desired level of protection and must not aim at zero risk."
- Nondiscrimination. "[C]omparable situations should not be treated differently and. . . different situations should not be treated in the same way, unless there are objective grounds for doing so."
- Consistency. "[M]easures . . . should be comparable in nature and scope with measures already taken in equivalent areas in which all the scientific data are available."
- Examination of the benefits and costs of action or lack of action. "This examination should include an economic cost/benefit analysis when this is appropriate and feasible. However, other analysis methods . . . may also be relevant."
- Examination of scientific developments. "The measures must be of a provisional nature pending the availability of more reliable scientific data". . . "scientific research shall be continued with a view to obtaining more complete data."

The Commission's recommendations make very clear that "The precautionary principle should be considered within a structured approach to the analysis of risk which comprises three elements: risk assessment, risk management, risk communication."

Q46. Has the European Commission applied the precautionary principle to EMF?

A46. No. The European Commission has concluded that the precautionary principle should not be invoked "because there are no clear scientific indications that the possible effects on human health may be potentially dangerous." Therefore, the Commission decided to base its proposal on established health effects only (EU, 2002).

Q47. And has the European Commission further determined that meeting EMF exposure limits based upon those recommended by the International Committee on Non-ionizing Radiation Protection (ICNIRP) is the appropriate way to protect against established adverse health effects of EMF?

A47. Yes (Swanson, 1999).

Q48. Is the Canadian approach to the precautionary principle generally similar to that outlined by the European Commission?

A48. Yes. Fourteen departments of the federal government collaborated in the publication of a document in 2001, "A Canadian Perspective on the Precautionary Approach/Principle", that summarizes guidance for the federal government.

Q49. Is there anything in the approach these departments have outlined that is particularly relevant to the consideration of the documents filed by Mr. Karow and his testimony in this proceeding?

A49. Yes, in particular, among the general principles described is the need for "[s]ound scientific information and its evaluation must be the basis for applying the precautionary approach…". The approach starts with "a valid and reasonable scientific information base" and risk assessments that include:

- "evaluation of all available scientific information…"
- "[p]eer review…[to] demonstrate the soundness of the scientific evidence and its inherent credibility within the scientific population."
- "[s]cientific advice ...drawn from a variety of sources and from experts in relevant disciplines in order to capture the full diversity of scientific schools of thought and opinion. Scientific advisors should give weight to peer-reviewed science and aim at sound and reasonable evidence on which to base their judgments."
- Relying upon scientific evidence to the "fullest possible extent" but also weighing "societal values, public willingness to accept risk, and economic considerations."

The testimony and the supporting documents submitted by Mr. Karow contradict each of the elements above, upon which the evaluation of the need for a precautionary approach should be based.

Q50. Even if the need for a formal precautionary approach has not been established in this case, has not FortisBC taken steps to address the concerns of some citizens by limiting exposure through actions that are of small cost?

A50. Yes, FortisBC has proposed designs for this project that reduce magnetic fields (in this case, below the levels associated with the operation of an existing distribution line) that can be implemented at little additional cost. This type of approach - termed prudent avoidance - was originally recommended by Dr. Granger Morgan to address public concern about EMF:

> …because our understanding of the science of the problem is still very incomplete, there is a real chance that some or all of the expense and associated trouble that would result from "aggressive action' taken now, would ultimately turn out to have been ineffective. There are two ways this could happen. First, it could turn out that there are no health risks from fields or that there are risks but they are very small. Second, it could turn out that while there are risks, we've done the wrong things to control them and gotten little or no improvement for our money…" (OTA, 1989)

Q51. Are such actions also consistent with recommendations of the WHO and the NIEHS?

A51. Yes.

Q52. What precautionary steps have been recommended by scientific organizations that have reviewed the EMF literature?

A52. In recognition of response to public concern, the NIEHS has identified simple steps that interested persons can take to limit their exposures. NRPB supports the concept of the WHO precautionary framework and concludes that it is important to consider the possible need for precautionary measures with respect to exposure of children to power frequency magnetic fields (NRPB, 2004b). HCN supports the precautionary principle and recommends moderate measures since no health effects have been found (HCN, 2004). According to the HCN report, conducting further research and monitoring scientific developments are adequate steps for precautionary measures. The FPTRPC (2005) is of the opinion that moderate measures and participation in the process of acquiring new knowledge are sufficient.

Q53. Would setting exposure limits at an arbitrarily low level, and requiring they be achieved regardless of cost be supported by these organizations, or a science-based public health approach?

A53. No. For example, the WHO cautions that "scientific assessments of risk and science-based exposure limits should not be undermined by the adoption of arbitrary cautionary approaches. That would occur, for example, if limit values were lowered to levels that bear no relationship to the established hazards or have inappropriate arbitrary adjustments to the limit values to account for the extent of scientific uncertainty." (WHO, 2000, p. 5). Moreover, the WHO recommends against adoption of an ALARA (as low as reasonably achievable) policy for powerline magnetic fields from power lines "in the absence of any expectation of risk at low exposure levels and given the ubiquity of exposure" (WHO, 2000, p. 5).[3]

Q54. What are the "science-based exposure limits" that WHO does recommend to national governments?

A54. The WHO recommends exposure limits developed by the ICNIRP, which are based on the known effects of electric and magnetic fields. The limits established by ICNIRP are much higher than any of the field values that have been calculated by FortisBC. The ICNIRP guidelines (ICNIRP, 1998) recommend limiting the magnetic field exposure of the general public to 100μT (833 mG at 60 Hz). The

[3] WHO is now in the process of completing a recommended *Framework, Guiding public health policy options in areas of scientific uncertainty, Dealing with EMF (WHO, 2005a).*

National Radiological Protection Board of the United Kingdom recently described these guidelines as a "cautious approach to the interpretation of the scientific data" (NRPB, 2004c).

Q55. Have any governmental authorities adopted the ICNIRP guidelines?

A55. Yes. The United Kingdom and 30 other countries have adopted these guidelines or are in the process of doing so (NRPB, 2004c; NRPB, 2004a). NRPB (2004c) summarizes the process it followed in addressing public concerns about EMF, the public comments it received, and its response to them.

Q56. Will the calculated levels of EMF associated with the operation of the proposed project conform with the ICNIRP guidelines?

A56. Yes.

Q57. Does this conclude Exponent's report?

A57. Yes, it does.

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Exhibit 1. Summary of the documents submitted by Hans Karow

Submission Number	Title of Document	Brief Description
C1-1	E-mail	Email requesting intervenor status
C1-2	Letter	Letter containing comments on the Application and a preliminary Information Request to FortisBC
C1-3	Evidence No. 1 - "FactSheet Electrical Pollution"	A booklet by the organization C.U.R.E (Citizens United for Responsible Electricity) with the goal of introducing the layperson to EMF (2001)
C1-4	Evidence No. 2 - "Nam report"	Evidence submitted by Mr. Kuong Nam, including a report (Exhibit I), a visual exhibit (Exhibit II), and a letter to Mr. Bruce Barrett at BCTC (Exhibit III)
C1-5	Letter	Letter containing requests to Commission
C1-6	Letter	Letter requesting reconsideration of Order No. G-114-05
C1-7	E-mail	Email reminding Applicant to respond to Information Request
C1-8	E-mail	Email requesting clarification of FortisBC's November 30, 2005 submission
C1-9	Evidence No. 3 - "Criticism of the health assessment in the ICNIRP guidelines for radiofrequency and microwave radiation (100kHz -300Hz)"	An unpublished report by Dr. Neil Cherry (2000)
C1-10	Evidence No. 4 - "A Lethal Subtle Energy"	A published commentary by Dr. Stanton Maxey (1991)
C1-11	Evidence No. 5 - "Evidence that electromagnetic fields from high voltage powerlines and in buildings, are hazardous to human health, especially to young children"	An unpublished report by Dr. Neil Cherry (2001)
C1-12	Evidence No. 6 - "Historical evidence that residential electrification caused the emergence of the childhood leukemia peak"	An published paper by Milham et al (2001)
C1-13	Evidence No. 7 - "Electromagnetic Fields, Leukaemia and DNA Damage"	An ISIS press release describing a commentary by Dr. Mae-Wan Ho (2004)
C1-14	Evidence No. 8 - "Melatonin Metabolite Levels in Workers Exposed to 60-Hz Magnetic Fields: Work in Substations and with 3-Phase Conductors"	A paper published by Burch et al (2000)
C1-15	E-mail	Request to Applicant to provide EMF measurements
C1-16	E-mail	Information Request No. 1 to Commission regarding Electric Power Research Institute

Submission Number	Title of Document	Brief Description
C1-17	Evidence No. 11a - Mr. Karow's summary of Bonneville Power Administration book	One-page summary/assessment by Mr. Karow of results presented in a book by Lee et al., “Electrical and Biological Effects of Transmission Lines: A Review” (1996)
C1-18	Evidence No. 12 - "Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study”	A published paper by Draper et al. (2005)
C1-19	Evidence No. 9 and No. 10 - “The Corporation, The Pathological Pursuit of Profit and Power” and “Unequal Protection, The Rise of Corporate Dominance and the Theft of Human Rights”	Two books unrelated to EMF
C1-20	Evidence 11b – Contents, Summary and Chapter 1, "Alternating-Current (AC) Fields" (pages 1-1 – 1-26)	Contents, Summary and Chapter 1 of book published by Lee et al, “Electrical and Biological Effects of Transmission Lines: A Review” (1996)
C1-21	Evidence 11b - Chapter 3, "Human Studies of EMF and Cancer" (pages 3-1 – 3-45)	Chapter 3 of book published by Lee et al, “Electrical and Biological Effects of Transmission Lines: A Review” (1996), and a one-page summary/assessment of results by Karow
C1-22	Evidence No. 13 – “Melatonin: Fundamental Non-Ionizing Electromagnetic Settings for Optimal Human Performance”	A paper by student Katharina Gustavs and Information Request No. 2 to FortisBC (2001)
C1-23	Letter	Letter requesting exhibits be made available at the Osoyoos public library and filing of an urgent Information Request
C1-24	Evidence No. 15 - Cornelia Clennan affidavit	Cornelia Clennan affidavit (Exhibit C3-30 from VITR project) and supporting email from Cornelia Clennan (2005)
C1-25	Evidence No. 16 - "Electrical fields can make you sick"	Article by Sara-Kate Templeton in *The Sunday Times* in the UK (2005)
C1-26	Evidence No. 17 - “Biological effects of non-ionizing electromagnetic energy: A critical review of the reports by the US National Research Council and the US National Institute of Environmental Health Sciences as they relate to the broad realm of EMF bioeffects”	A published paper by Dr. Magda Havas (2000)
C1-26	Evidence 11b - Chapter 2, "Exposure Assessment and Non-Cancer Human Health Studies" (pages 2-1 – 2-35)	Chapter 2 of book published by Lee et al, “Electrical and Biological Effects of Transmission Lines: A Review” (1996), a and one-page summary/assessment of results by Karow

Submission Number	Title of Document	Brief Description
C1-27	Evidence 11b - Chapter 4, "Effects of EMF on Animals and Plants" (pages 4-1 - 4-26)	Chapter 4 of book published by the Bonneville Power Administration, “Electrical and Biological Effects of Transmission Lines: A Review” (1996), and a one-page summary/assessment of results by Karow
C1-28	Letter	Response to Commission’s letter dated December 13, 2005
C1-29	Evidence No. 18 - "Electric and Magnetic Field Reduction: Research Needs" report	Report of the Washington State Electric Transmission Research Needs Task Force (1992)
	Evidence No. 18a – Contents and Executive Summary (pages 1-3) Glossary (pages 7-9) Chapter 1 – “Introduction” (pages 11-12) Chapter 2 – “Background” (pages 13-15)	
	Evidence No. 18b – Chapter 3 – “Electric Power Systems and Electric and Magnetic Fields” (pages 17 -24)	
	Evidence No. 18c – Chapter 4 – “Comparisons of Power Line Design and Resulting Electric and Magnetic Fields” (pages 25-34)	
	Evidence No. 18d – Chapter 5 – “Engineering Research on EMF Management Reduction” (pages 35 - 39) Chapter 6 – “Other Approaches to EMF Exposure Reduction” (pages 41 - 44) Chapter 7 – “Conclusions and Recommendations” (pages 45 - 48) References (pages 49 - 51)	
	Evidence No. 18f – Chapter 7 – “Conclusions and Recommendations” (pages 45 - 48) References (pages 49 - 51)	
	Evidence No. 18g - Appendices (pages 53 - 80)	
C1-30	E-mail	Letter in response to Commission’s letter dated December 13, 2005
C1-31	E-mail	Information Request No. 1 to FortisBC

C1-32	Evidence 19 – “Power Lines and Property Values: The Good, the Bad, and the Ugly”	A published paper by Bolton and Sick on property devaluation (1999)
C1-33	Evidence 20 - selected commentaries from Dr. Louis Slesin	Selected commentaries by Dr. Louis Slesin in the Internet newsletter, *Micro Wave News*
C1-34	Evidence 22 – “Regulating Power Line EMF Exposure: International Precedents”	Unpublished report prepared by student Nadine Wu for the Tsawwassen Residents Against Higher Voltage Overhead Lines (TRAHVOL) (2005)
C1-35	Evidence 21 – “Expert testimony of Magda Havas, B.Sc., Ph.D.”	Expert testimony of Dr. Magda Havas, previously submitted in the Vancouver Island Transmission Reinforcement ~ Project No. 3698395 Sea Breeze Pacific Regional Transmission System, Inc.

Exhibit 2. Conclusions of Large Multidisciplinary Review Groups Assembled by Health Agencies and Scientific Organizations

Agency or Scientific Organization	Conclusions
Federal-Provincial-Territorial Radiation Protection Committee	"Based on the available scientific evidence to date, the Federal Provincial Territorial Radiation Protection Committee (FPTRPC) concludes that adverse health effects from exposure to power-frequency EMFs, at levels normally encountered in homes, schools and offices, have not been established." (FPTRPC, 2005)
Health Council of the Netherlands	"The committee arrives at the conclusion that it has not been demonstrated that exposure to electric or magnetic fields originating from the electricity transmission and distribution system at field strengths below the limits of exposure that have been established for short-term effects, induces any kind of disease or abnormality. It feels that, on the basis of the current scientific understanding described in this report, there is no reason to recommend measures to limit living near overhead power lines or working under conditions involving ELF EM field exposure that is increased, but not exceeding the exposure limits." (executive summary, HCN, 2000) "The Committee therefore finds that it is not possible, based on these studies, to draw conclusions regarding the possible effect of exposure to ELF EMF " (HCN, 2004)
International Agency for Research on Cancer	"There is *limited evidence* in humans for the carcinogenicity of extremely low- frequency magnetic fields in relation to childhood leukemia." "There is *inadequate evidence* in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to all other cancers." "There is *inadequate evidence* in humans for the carcinogenicity of static electric or magnetic fields and extremely low-frequency electric fields." "There is *inadequate evidence* in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields." (IARC, 2002)
International Commission on Non-Ionizing Radiation Protection	"In the absence of evidence from cellular or animal studies, and given the methodological uncertainties and in many cases inconsistencies of the existing epidemiological literature, there is no chronic disease outcome for which an aetiological relation to EMF exposure can be regarded as established." (ICNIRP, 2003)

Agency or Scientific Organization	Conclusions
National Academy of Sciences	"An earlier Research Council assessment of the available body of information on biologic effects of power-frequency magnetic fields (NRC 1997) led to the conclusion 'that the current body of evidence does not show that exposure to these fields presents a human health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produces cancer, adverse neurobehavioral effects, or reproductive and developmental effects'. The new, largely unpublished contributions of the EMF-RAPID program are consistent with that conclusion. We conclude that no finding from the EMF-RAPID program alters the conclusions of the previous NRC review on the Possible Effects of Electromagnetic Fields on Biologic Systems (NRC 1997). In view of the negative outcomes of EMF-RAPID replication studies, it now appears even less likely that MFs [magnetic fields] in the normal domestic or occupational environment produce important health effects, including cancer." (NRC, 1999)
National Institute of Environmental Health Sciences	"A majority of the Working Group concluded that classification of ELF EMF as possibly carcinogenic (Group 2B) is a conservative, public-health decision based on limited evidence of an increased risk for childhood leukemias with residential exposure and an increased occurrence of CLL associated with occupational exposure." (NIEHS, 1998) "In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reductions in exposure should be encouraged." (NIEHS, 1999)
National Radiological Protection Board of Great Britain	"The Advisory Group recognises that the scientific evidence suggesting that exposure to power frequency electromagnetic fields poses an increased risk of cancer is very weak. Virtually all of the cellular, animal and human laboratory evidence provides no support for an increased risk of cancer incidence following exposure to power frequencies, although sporadic positive findings have been reported. In addition, the epidemiological evidence is, at best, weak." (NRPB, 2001) "Because of the uncertainty… and in absence of a 'dose-response' relationship, NRPB has concluded that the data concerning childhood leukemia cannot be used to derive quantitative guidance on restricting exposure." (NRPB, 2004b)

Exponent®

William H. Bailey, Ph.D.
Principal Scientist and Director, New York Office

Professional Profile

Dr. William H. Bailey is a Principal Scientist in Exponent's Health Sciences practice and Director of the New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electromagnetic fields and health. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental and occupational health issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. He is particularly well known for his research on potential health effects of electromagnetic fields and has served as an advisor to numerous state, federal, and international agencies. Dr. Bailey has investigated exposures to alternating current (ac), direct current (dc), and radiofrequency electromagnetic fields, 'stray voltage' and electrical shock, as well as to a variety of chemical agents and air pollutants. Currently, he is directing research projects on effects of electrical charge on the deposition of aerosols in the respiratory tract. He is a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is a visiting scientist at the Cornell University Medical College and has lectured at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Credentials and Professional Honors

Ph.D., Neuropsychology, City University of New York, 1975
M.B.A., University of Chicago, 1969
B.A., Dartmouth College, 1966

Sigma Xi; The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety (Subcommitee 3, Safety Levels with Respect to Human Exposure to Fields (0 to –3 kHz) and Subcommitte 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to3 GHz); Elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society (1998–present); Invited Speaker, First Institute of Neurological Sciences Symposium in Neurobiology, University of Pennsylvania (1980); Invited Speaker, National Heart and Lung Institute (1977).

Publications

Bailey, WH, Nyenhuis, JA. Thresholds for 60-Hz magnetic field stimulation of peripheral nerves in human subjects. Bioelectromagnetics (in press).

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Book Chapters

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Blondin J-P, Nguyen D-H, Sbeghen J, Maruvada PS, Plante M, Bailey WH, Goulet D. The perception of DC electric fields and ion currents in human observers. Annual Meeting of the Canadian Psychological Association, Penticton, British Columbia, Canada, June 1994.

Erdreich LS, Bailey WH, Weil DE. Science, standards and public policy challenges for ELF fields. American Public Health Association 122nd Annual Meeting, Washington, DC, October 1994.

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Charry JM, Bailey WH, Bracken TD. DC electric fields, air ions and respirable particulate levels in proximity to VDTs. International Conference on VDTs and Health, Stockholm, Sweden, June 12–15 1986.

Charry JM, Bailey WH. Air ion and DC field strengths at 10^4 ions/cm^3 in the Rockefeller University Small Animal Exposure Chambers. EPRI/DOE Contractors Review, November 1985.

Charry JM, Bailey WH. DC Electrical environment in proximity to VDTs. Seventh Annual Meeting of the Bioelectromagnetics Society, June 1985.

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Salman SL, Weiss JM, Bailey WH, Joh TH. Relationship between endogenous brain tyrosine hydroxylase and social behavior of rats. Society of Neuroscience, November 1980.

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Bailey WH, Maclusky S. Appearance of creatine kinase isoenzymes in rat plasma following myocardial injury by isoproterenol. Fed Proc 1978; 37:889.

Bailey WH, Weiss JM. Psychological factors in experimental heart pathology. Visiting Scholar Presentation, National Heart Lung and Blood Institute, March 1977.

Bailey WH, Weiss JM. Effect of ACTH 4-10 on passive avoidance of rats lacking vasopressin (Brattleboro strain). Eastern Psychological Association, April 1976.

Research Appointments

- Visiting Fellow, Department of Pharmacology, Cornell University Medical College, New York, NY (1986–present)
- Visiting Scientist, The Jackson Laboratory, Bar Harbor, ME (1984–1985)
- Head, Laboratory of Neuropharmacology and Environmental Toxicology, NYS Institute for Basic Research in Developmental Disabilities, Staten Island, NY (1983–1987)
- Assistant Professor, The Rockefeller University, New York, NY (1976–1983)
- Postdoctoral Fellow, Neurochemistry, The Rockefeller University, New York, NY (1974–1976)
- Dissertation Research, The Rockefeller University, New York, NY (1972–1974)
- CUNY Research Fellow, Dept. of Psychology, Queens College, City University of New York, Flushing, NY (1969–1971)
- Clinical Research Assistant, Department of Psychiatry, University of Chicago; Psychiatric Psychosomatic Inst., Michael Reese Hospital, and Illinois State Psychiatric Inst, Chicago, IL (1968–1969)

Teaching Appointments

- Lecturer, University of Texas Health Science Center, Center for Environmental Radiation Toxicology, San Antonio, TX (1998)
- Lecturer, Harvard School of Public Health, Office of Continuing Education, Boston, MA (1995, 1997)
- Lecturer, Rutgers University, Office of Continuing Education, New Brunswick, NJ (1991–1995)
- Adjunct Assistant Professor, Queens College, CUNY, Flushing, NY (1978)

- Lecturer, Queens College, CUNY, Flushing, NY (1969–1974)

Advisory Positions

- National Institute of Environmental Health Sciences/ National Institutes of Health, Review Committee, Neurotoxicology, Superfund Hazardous Substances Basic Research and Training Program (2004)

- National Institute of Environmental Health Sciences, Review Committee Role of Air Pollutants in Cardiovascular Disease (2004)

- Working Group on Non-Ionizing Radiation, Static and Extremely Low-Frequency Electromagnetic Fields, International Agency for Research on Cancer (2000–2002)

- Working Group, EMF Risk Perception and Communication, World Health Organization (1998–present)

- Associate Editor, Non-Ionizing Radiation, *Health Physics* (1996–present)

- Member, International Committee on Electromagnetic Safety, Subcommittee 3 - Safety Levels with Respect to Human Exposure to Fields (0 to 3 kHz) and Subcommitee 4 - Safety Levels with Respect to Human Exposure (3kHz to 3GHz) Institute of Electrical and Electronics Engineers (IEEE) (1996–present)

- Invited participant, National Institute of Environmental Health Sciences EMF Science Review Symposium: Clinical and *In Vivo* Laboratory Findings (1998)

- Working Group, EMF Risk Perception and Communication, International Commission on Non-Ionizing Radiation Protection (1997)

- U.S. Department of Energy, RAPID EMF Engineering Review (1997)

- Oak Ridge National Laboratory (1996)

- American Arbitration Association International Center for Dispute Resolution (1995–1996)

- U.S. Department of Energy (1995)

- National Institute for Occupational Safety and Health (1994–1995)

- Federal Rail Administration (1993–1996)

- U.S. Forest Service (1993)

- New York State Department of Environmental Conservation (1993)

- National Science Foundation
- National Institutes of Health, Special Study Section—Electromagnetics (1991–1993)
- Maryland Public Service Commission and Maryland Department of Natural Resources, Scientific Advisor on health issues pertaining to HVAC Transmission Lines (1988–1989)
- Scientific advisor on biological aspects of electromagnetic fields, Electric Power Research Institute, Palo Alto, CA (1985–1989)
- U.S. Public Health Service, NIMH: Psychopharmacology and Neuropsychology Review Committee (1984)
- Consultant on biochemical analysis, Colgan Institute of Nutritional Science, Carlsbad, CA (1982–1983)
- Behavioral Medicine Abstracts, Editor, animal behavior and physiology (1981–1983)
- Consultant on biological and behavioral effects of high-voltage DC transmission lines, Vermont Department of Public Service, Montpelier, VT (1981–1982)
- Scientific advisory committee on health and safety effects of a high-voltage DC transmission line, Minnesota Environmental Quality Board, St. Paul, MN (1981–1982)
- Consultant on biochemical diagnostics, Biokinetix Corp., Stamford, CT (1978–1980)

Professional Affiliations

- The Health Physics Society (Affiliate of the International Radiation Protection Society)
- Society for Risk Analysis
- New York Academy of Sciences
- American Association for the Advancement of Science
- Air and Waste Management Association
- Society for Neuroscience/International Brain Research Organization
- Bioelectromagnetics Society
- The Institute of Electrical and Electronics Engineers/Engineering in Medicine and Biology Society