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EXPERT DISAGREEMENT: A REGULATOR'S NIGHTMARE?

by

Christina Chociolko
B.G.S., Simon Fraser University, 1989

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
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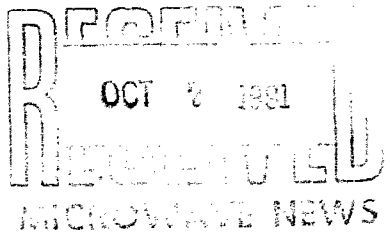

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ABSTRACT

This paper investigates expert disagreement in the controversy concerning power frequency electric and magnetic fields (PF E/MF) and human health. A recent public inquiry held by the BC Utilities Commission (BCUC) concerning the siting of a BC Hydro transmission line through a residential area on Vancouver Island serves as the case study. BC Hydro's experts testified that the transmission line E/MF were not a health risk. The public's expert testified that they were a health risk. The BCUC ruled that the transmission line would not be rerouted because of the uncertain state of the scientific knowledge concerning PF E/MF health effects.

Following a review of the history of the PF E/MF health effects controversy, the question of how technical expertise was used by the various parties involved in the public inquiry is discussed. Documentary evidence was supplemented by interviews.

Technical expertise was used by all parties to form, support and alter their own and others' views on the PF E/MF health effects issue throughout the inquiry. The decision-makers and their experts presented a picture of the scientific process, and of the relationship between science and policy decisions, that was exclusively "rationalist" in form. On the other hand, the public's expert presented a picture of science that emphasized what were in his view its "irrational" dimensions. Yet, after discounting all industry-associated research, he too relied on an ideal picture of the scientific enterprise to support his analysis.

The role of science and scientists in the making of public policy alters the relationships between science, values and public policy in significant ways. All parties need to understand how the pressures and constraints to reach conclusions that lead to public policy are felt by decision-makers and experts alike. In my opinion, this understanding requires that the inherent limitations of the risk assessment process (beginning with the limitations of science itself) be acknowledged explicitly. Furthermore, all parties should be involved in the decision-making process, not only for reasons of fairness, but because it is difficult (if not impossible) to separate the scientific and non-scientific components of risk assessment. The public perception of risk and the technical assessment of risk should be given equal status. With all parties participating in, and therefore being responsible for, the decisions made, there is a higher probability for acceptance of the decisions by a broad segment of the public.

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1.0 INTRODUCTION

This paper investigates expert disagreement in the controversy concerning power frequency electric and magnetic fields (PF E/MF) and human health. In particular, the use of technical expertise by parties involved in a dispute over the proposed routing of a power line is examined.

PF E/MF are not only produced by electric power generation, transmission and distribution systems (see Figure 1-1) but also wherever electric energy is used, whether in domestic activities, transportation, or in industry. These fields are prevalent throughout industrialized society. In much of the Americas and western Japan, PF alternating-current (ac) fields reverse polarity with a frequency of 60 cycles per second (60 Hz), and in most of the rest of the world with a frequency of 50 Hz. (Although both ac and direct-current or DC technologies are used to transport the world's electric energy, the bulk of it is transported by ac. DC PF E/MF are not the subject of current interest.)

Industrialized society is virtually dependent on the benefits provided by electric power. Electric energy provides lighting, refrigeration, heat, motor drive and countless other services which increase human health and welfare.

With increasing industrialization and constant advances in technology, the demand for electric energy continues to rise; in recent years it has doubled about once every ten years in highly industrialized countries.[1] These demands have resulted in an increase in total transmission line mileage and in voltages. In 1892, the highest voltage utilized in North America was 10 kilovolts (kV).[2] Today, the most efficient and economical lines are rated at 765 kV and above. Consequently, exposure to PF E/MF has increased considerably in the last few decades and will likely continue to so in the future. The demand for electric energy is expected to increase by about 40% in the U.S. by the year 2000.[3]

Acute effects of exposures to very intense PF electric fields have been recognized for many years. These include perception of the field (for example, from hair vibration), annoyance due to spark discharges, annoyance and muscular tetanus due to contact currents from touching ungrounded conducting objects such as vehicles, and interference with some cardiac pacemakers. (Interference with cardiac pacemakers can be eliminated through modifications in product design.) Exposure to very intense magnetic fields can produce visual phenomena called magnetophosphenes. Short-term shocks and perception are not the subject of current interest. They occur above fairly high and well-known intensity thresholds, are fairly well understood, and regulations are in place to ensure public safety. Concern has been raised over long-term

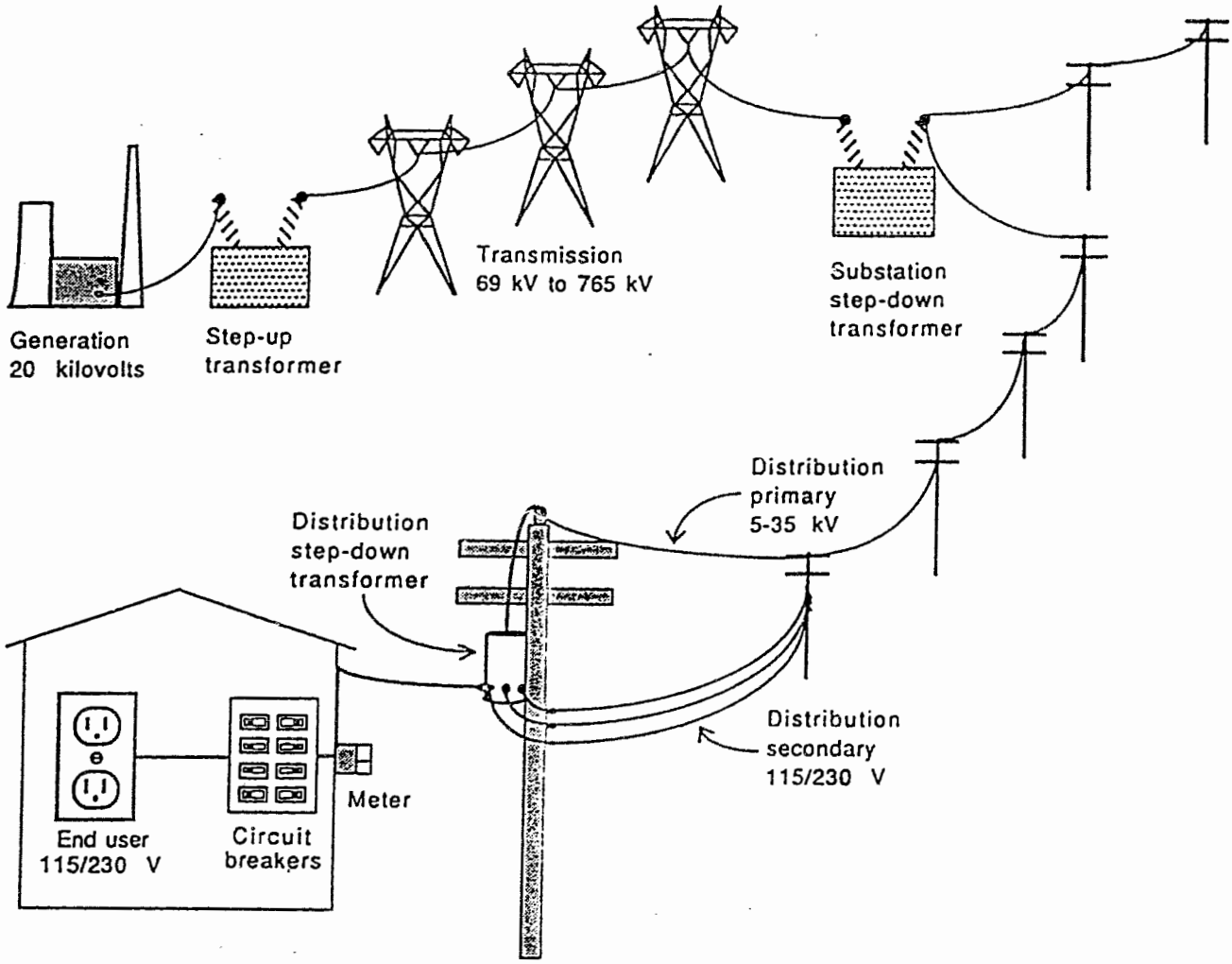

Figure 1-1. Simplified electric power system.

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health effects.

PF E/MF do not involve a significant propagation of energy through space and thus are not properly referred to as radiation. Because the energy they contain is far too low to break chemical or molecular bonds or heat tissue significantly, most scientists have assumed that the fields are biologically innocuous. However, in recent years, a growing body of research has demonstrated that PF E/MF can produce effects in a number of biological systems, including epidemiological evidence of an association between certain cancers and elevated residential and workplace electric environments. Because of incomplete scientific research and contradictory results of existing studies, it is not yet clear if exposure can give rise to significant human health problems. The PF E/MF and human health issue has now become the subject of serious scientific study and heated debate in Canada, the US, USSR, UK and Sweden, and has been addressed by the World Health Organization (WHO) and the International Radiation Protection Association (IRPA).

The debate has not been restricted to the scientific forum. As people and power lines have been moved closer together and general public awareness has increased, government has been called upon to take regulatory action. Litigation has been initiated against the utility industry involving potential, perceived and actual health effects. The controversy has occasionally made good copy for the mass media. Each of these interest groups have added their own impetus to the scientific investigation into the human health effects of PF E/MF exposure.

The PF E/MF and human health issue first received official recognition in BC during the summer of 1989. The BC Hydro and Power Authority was constructing a transmission line to supply power to an expanded Canadian Pacific Forest Products (CPFP) pulp mill at Gold River on Vancouver Island. Unsatisfied with the response of BC Hydro to their concerns about health effects from the PF E/MF associated with the transmission line, residents along the ROW filed complaints with the Provincial Ombudsman who turned the matter over to the BC Utilities Commission (BCUC). After being inundated with requests to reroute the new transmission line, the BCUC ordered that a public inquiry be held July 11-12 in Courtenay, BC.

BC Hydro's experts testified that the transmission line E/MF were not a health risk. The public's expert testified that they were a health risk. Although the main purpose of the inquiry was to gather information on PF E/MF health effects, several scientific issues commonly raised by experts in the area were not addressed by either "side." Instead, the inquiry more resembled a court of law. The lawyers for BC Hydro, the public, and the BCUC spent much of their time contesting the credibility of the other side's expert witnesses, questioning their strength of opinion and expertise in the PF E/MF health effects area. The expert witnesses from

both sides spoke with a legally-inspired caution. The nature of the Courtenay inquiry prompted this investigation into how technical expertise is used in disputes between parties.

The literature on the assessment, management, and communication of environmental and health risks formed the basis of my analysis. Documentary evidence, including inquiry transcripts, was supplemented by interviews.

The first 2 chapters of "Expert Disagreement: A Regulator's Nightmare" set the context for the case study of the Courtenay controversy. In particular, Chapter 2 introduces some of the basic technical concepts necessary to understanding the science, provides an overview of the state of science on PF E/MF health effects to December 1988, and reviews the general history of the PF E/MF and human health controversy, in terms of both science and policy issues, in North America to December 1988. Chapter 3 presents a detailed history of the Courtenay controversy according to events occuring before, during, and after the BCUC public inquiry. Chapter 4 analyzes how technical expertise was used by parties in the dispute and makes recommendations for improvements.

2.0 PF E/MF AND HUMAN HEALTH

2.1 General Concepts

2.1.1. PF E/MF

Electric, magnetic and electromagnetic fields arise from many natural sources and are found throughout nature and in all living things. They hold matter together (in both living and non-living things) and are necessary for the operation of the nervous system. Atmospheric processes produce large static fields at the earth's surface, thunder clouds produce lightning, and the earth's core produces a magnetic field that makes navigation possible.[1]

Electric and magnetic fields are also produced artificially, for e.g., by power lines, radio and television broadcast, and microwave ovens.[2]

In North America, electric current alternates at a frequency of 60 cycles per second (Hz), i.e., the current changes strength and direction 60 times per second.[3] The alternating current (ac) produces electric and magnetic fields (E/MF) that oscillate at the same frequency as the current. These power frequency (PF) E/MF are invisible fields of force that surround any conductor carrying electricity. They are present wherever electricity is in use.[4]

The "electric field" relates to the electric force a charged object is capable of exerting on other charges in its vicinity. The electric field intensity is directly proportional to the strength of its force. Electric fields are produced by electric charges that are "pumped" onto wires by electric generators. The "magnetic field" relates to the magnetic force. The magnetic field intensity around a current-carrying conductor is directly proportional to the amount of current flowing.[5]

The electromagnetic spectrum (represented in Figure 2-1) measures energy using a scale based on frequency and wavelength. All forms of electromagnetic energy are fields of force. The various spectral regions differ in terms of the physical and biological effects which are produced.[6]

PF E/MF are a type of nonionizing radiation (NIR). NIR, unlike ionizing radiation, is not powerful enough to break molecular or chemical bonds (or to create charged particles called ions). The high energy associated with ionizing radiation (IR) strips electrons from molecules. PF E/MF and other "extremely low frequency" (ELF) fields (ranging from 30 to 300 Hz)[7] do not heat tissue significantly compared to radiation from intense microwaves. Energy from higher frequency fields (of shorter wavelength) is absorbed more readily by biological material, and can produce heating, for e.g., microwave ovens. The extra long wavelength at 60 Hz allows the

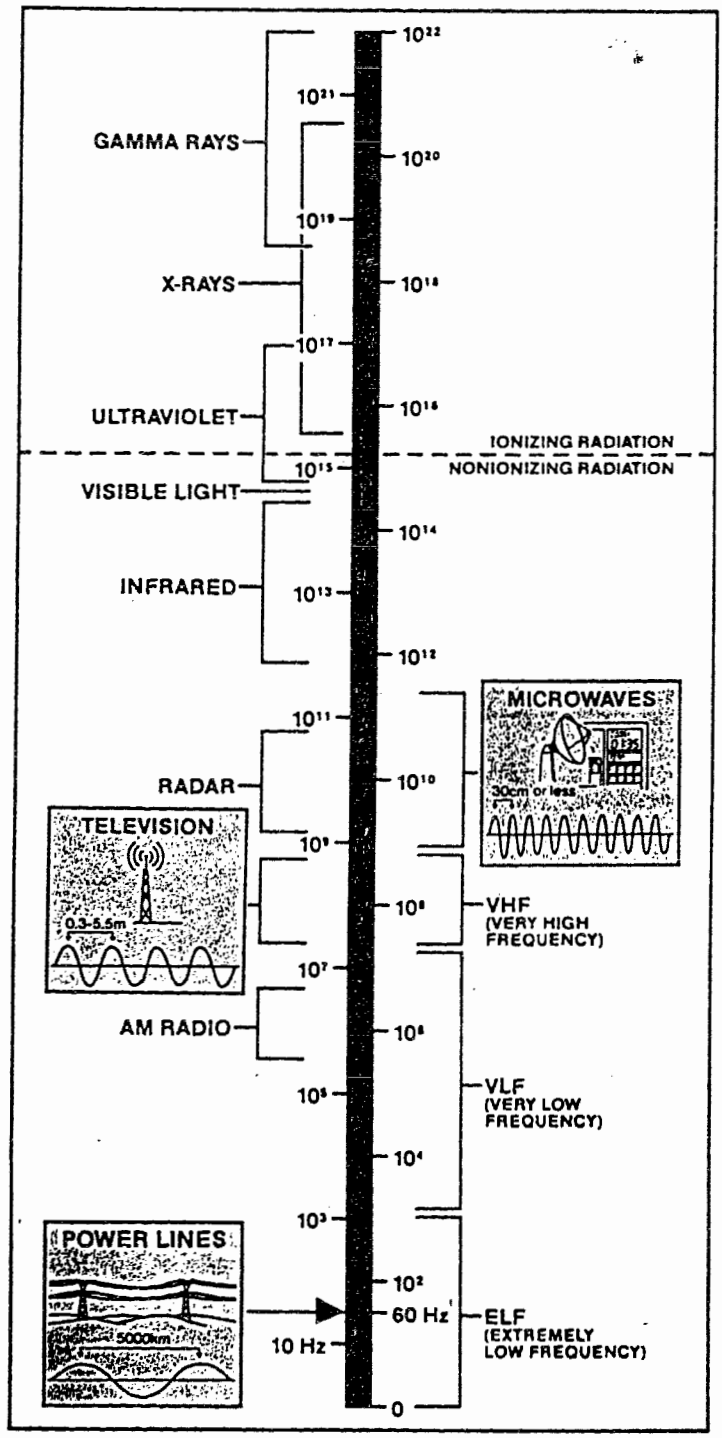

Figure 2-1. The electromagnetic spectrum.

Note: The limits of human hearing are from 20 Hz - 20 KHz.

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transfer of only a minute amount of energy to objects the size of a person.[8]

The term "electric and magnetic fields" is used when referring to power frequencies, rather than "electromagnetic radiation." Unlike ionizing and microwave radiation, PF E/MF do not involve a significant propagation of energy through space and are not properly referred to as radiation. In addition, PF electric and magnetic fields are not dependent on one another. The term "electromagnetic" connotes dependence, such as occurs at radio frequencies (RF) and above. PF E/MF are quasi-static and, from an engineering point of view, can be treated as independent entities.[9] (However, they may produce synergistic effects.)

Although PF E/MF are considered to be 50/60 Hz sinusoidal waveforms of a given strength and direction, the currents and fields associated with power lines, wiring and appliances at the same location can interact and resultant field strengths and directions will depend upon, for e.g., the location of the object, the location of nearby objects, and the electrical conditions of use.[10] Furthermore, other strengths and frequencies may be introduced by switching transients, power surges, harmonic distortions, and unique energy patterns are induced in transmission lines by solar flare activity.[11]

RF modulated by ELF are used in radio transmission, television transmission and radar.

Electric currents and fields of varying field strengths and frequencies from DC to microwave are also used for medical diagnostic and treatment. Several such applications are now in routine use. Electricity has been used for many years by some physicians in efforts to repair fractures by stimulating bone formation. DC currents are injected directly in or near the bone or E/MF, often combined with pulsed RF, is applied externally.[12]

Electric Fields

Electric field strength is measured in volt/meter (V/m). Table 2-1 shows the typical and maximum electric field strengths from power lines. The field strength is greatest in the area immediately surrounding the line and decreases rapidly with distance. Field patterns tend to be stable and can be calculated with great accuracy.

The electric fields created by wiring and appliances are generally much weaker than those close to power lines. (See Table 2-2 and Figure 2-2.) The fields are present whenever the electric appliances are plugged in unless the appliance has a 3-prong plug in which case the electric field will not be present when the appliance is off, due to grounding.[13] The field strength is greatest in the immediately surrounding area and decreases rapidly with distance.

TABLE 2-1

Typical and Maximum (in parentheses)
Power Line Electric and Magnetic Field Strengths

(kV, kilovolt; μT, microtesla)

		Beneath power line	Edge of ROW	100 ft from power line	200 ft from power line	300 ft from power line
12 kV	kV	.01-0.1				
	μT	.0001-0.001				
115 kV	kV	1.0 (2)	0.5	0.07	0.01	0.003
	μT	2.0 (4.0)	0.5 (1.0)	0.1 (0.2)	0.03 (0.06)	0.01 (0.03)
230 kV	kV	2.0 (3)	1.5 (1)	0.3	0.05	0.01
	μT	3.5 (7.0)	1.5 (3.0)	0.5 (1.0)	0.1 (0.2)	0.05 (0.1)
500 kV	kV	7.0 (9)	3.0	1.0	0.3	0.1
	μT	7.0 (14.0)	2.5 (5.0)	1.2 (2.5)	0.3 (0.7)	0.1 (0.3)
750 kV	kV	(12)	(2)			
	μT	(30)	(7)			

Notes: Measured 1 metre (3.3 ft) above ground.
Actual field strength and right-of-way (ROW) width depend on line design and voltage and current levels.
The right-of-way or ROW is a strip of land for which a utility acquires a permanent easement from the owner. This easement allows the utility to build, operate, and maintain its transmission lines and to keep the ROW clear. In some cases the land is purchased outright. The ROW is usually a specified amount of feet wider than the towers and lines, typically 50 or more feet either side of the center.

Sources: US, BPA, DOE, Electrical and Biological Effects, p. 14, 19;
Dan Bracken, "Properties and Effects of A.C. and D.C. Line Fields," Paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields.

TABLE 2-2

Typical Values of Power Frequency Electric Fields
Near Various Appliances

(V/m, volts/meter)

Source	Electric field (30 cm from source unless otherwise noted)
Bedroom (in centre of room, any source)	2-8
Broiler	130
Clock	15
Coffee pot	30
Color TV	30
Electric blanket (surface)	250 (from 100 to 2000)
Electric range	4
Fluorescent light (office)	10
Hair dryer	40
Hallway (in centre of room, any source)	13
Hand mixer	50
Incandescent light bulb	2
Iron	60
Refrigerator	60
Stereo sound equipment	90
Toaster	40
Vacuum cleaner	16
Vaporizer	40

Sources: A.R. Sheppard and M. Eisenbud, Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency, New York: New York Univ. Press, 1977, quoted in B.C. Hydro, "Symposium on the Biological Effects of Electric and Magnetic Fields;" US, BPA, DOE, Electrical and Biological Effects, p. 13.

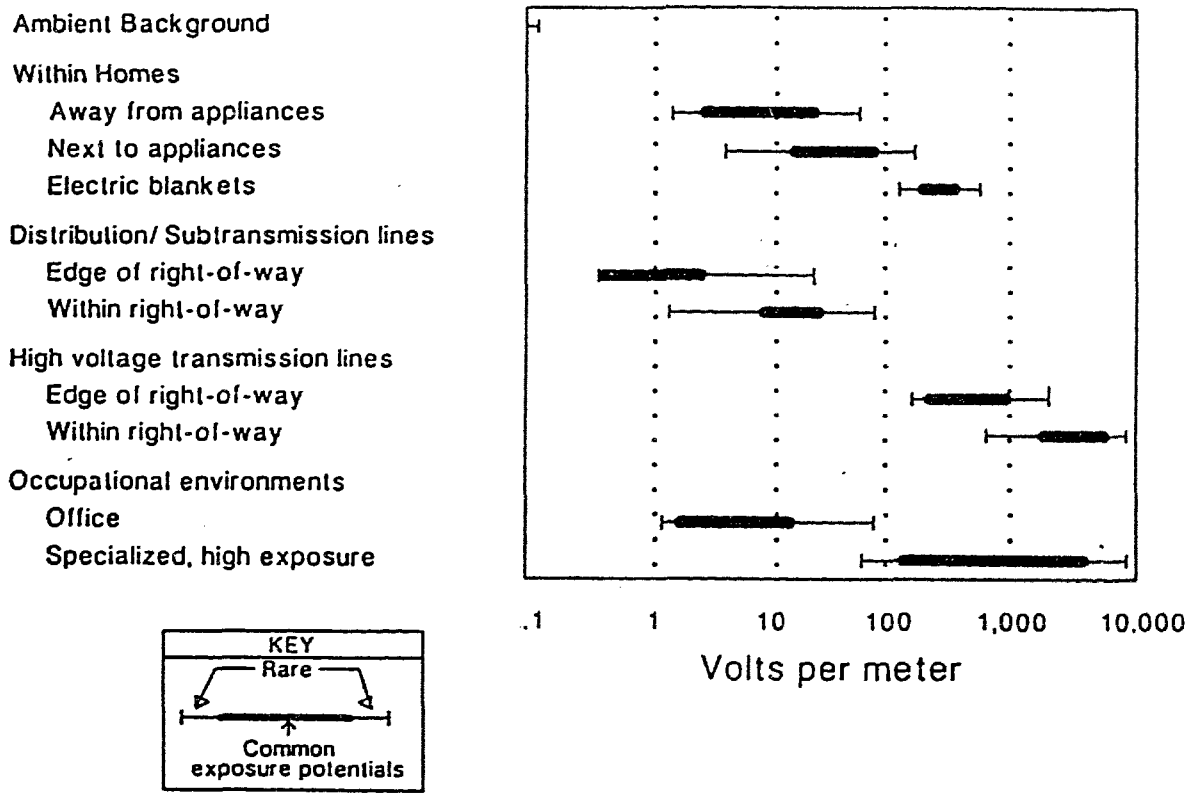


Figure 2-2. Electric field strengths (60 Hz).

Compiled from WEST Associates, A critical review of the scientific literature on low-frequency electric and magnetic fields: Assessment of possible effects on human health and recommendations for research. Reproduced with permission.

The electric field levels inside most homes and workplaces are not greatly affected by power lines. This is because buildings, fences, vegetation and other conducting objects can greatly reduce the strength of the external electric field. The amount of shielding depends on the conductivity of the material.

Magnetic Fields

Magnetic field strength is measured in ampere/meter (A/m). In air, magnetic field strength is proportional to magnetic flux density. The magnetic flux density, measured in tesla (T) or gauss (G), is sometimes called the magnetic field.[14] The simpler nomenclature is adopted in this paper. (1 microTesla = 10 milliGauss.)

The amount of current flowing in a power line varies as the demand for electric power changes throughout the day. Therefore the magnetic field strength varies over a wide range; it can easily change by a factor of two under normal conditions. Table 2-1 shows typical and maximum power line magnetic field strengths. The field strength is greatest in the area immediately surrounding the line and decreases rapidly with distance. Field patterns can be calculated given the geometry of the line and the line current.

Wiring and appliances also create magnetic fields. (See Table 2-3 and Figure 2-3.) Magnetic fields in wall wiring can can be quite small because parallel wires (hot and neutral) can cancel if they are close and the fields are equal and opposite. Otherwise, they can be significant sources.[15] A major source of the fields is the electric motor in appliances, with the number of coils essentially determining the magnetic field strength.[16] The fields exist only when current is flowing, i.e., the appliance is plugged in and turned on. The magnetic field is greatest in the immediately surrounding area and decreases rapidly with distance.

Outside sources of magnetic fields can contribute significantly to fields found inside the home and workplace. Buildings, vegetation, and most other objects do not provide appreciable shielding. Magnetic fields are shielded only by structures containing large amount of ferrous or other special metals.[17]

The contribution from outside sources such as power lines is complex because of the different field directions/orientations and phases from various other sources and is not well understood.[18] Except for houses close to transmission lines, the major sources of magnetic fields in homes are ground return currents from distribution systems (distribution lines and building wiring) and fields in the immediate proximity of appliances.[19]

TABLE 2-3

Power Frequency Magnetic Field Strengths

at Various Distances from Appliances

(μT, microtesla)

Source	Distance from Source								
	contact	near	2 cm	3 cm	5 cm	30 cm	50 cm	200 cm	1 m
Alarm clock(1)	300		10						
Arc furnace								300	
Blender				25-130		.6-2			.03-.12
Can opener				1000-2000		3.5-30			.07-1
Clothes dryer				.3-8		.08-.3			.02-.06
Clothes washer				.8-40		.2-3			.01-.2
Coffee maker				1.8-25		.08-.15			.01
Crock pot				1.5-8		.08-.15			.01
Dishwasher				3.5-20		.6-3			.07-.3
Drill				400-800		2-3.5			.08-.2
Electric blanket(2)		.3-5							
Electric oven				1-50		.15-.5			.01-.04
Electric range				6-200		.4-4			.01-.1
Electric shaver				15-1500		.1-9			.04-.3
Electric typewriter(2)									
back	2								
keyboard	.2								
Fan or blower				2-30		.03-4			.01-.35
Fluorescent lamp				40-400		.5-2			.01-.3
Fluorescent fixture				15-200		.2-4			.01-.3
Garbage disposal				80-250		1-2			.03-1
Hair dryer				6-2000		.1-7			.01-.3
Heating pad(1)	17								
Iron				8-30		.12-.3			.01-.25
Massager(1)									

TABLE 2-3, continued

Source	Distance from Source								
	contact	near	2 cm	3 cm	5 cm	30 cm	50 cm	200 cm	1 m
Microwave oven				75-200	200	4-8			.3-.8
Mixer				60-700		.6-10.15-5			.02-.25
Portable heater				10-180		.01-.25			.01-.25
Refrigerator				.5-1.7		1-25			.01
Sabre or circular saw				250-1000					.01-1
Soldering gun(1)	1000								
Teakettle(1)	30					.04-2			
Television				2.5-50		.06-.7			.01-.2
Toaster				7-18		2-20			.01
Vacuum cleaner				200-800					.13-2
VDT(2)						.1-.3			
screen									
back	5								
Wall clock(1)					300				
Waterbed heater		.3-1							
Welder							1000		

Notes: All data were obtained for the main voltage of 110 V, except for Arc furnaces and Welders.

In a country where the main voltage is 220 V, lower magnetic fields may be produced by the applicances, as they draw only half the current for the same power output.

1. Frequencies very nearly pure 60 Hz.

2. Frequencies from 10-500 Hz.

Sources: J.R. Gauger, Household Appliance Magnetic Field Survey, IIT Research Institute, Tech. Report E06549-3, 1984; Maria M. Stuchly, "Human Exposure to Static and Time Varying Magnetic Fields, Health Physics, 51, 2 (Aug 1986):221-2; Carstensen, p. 16.

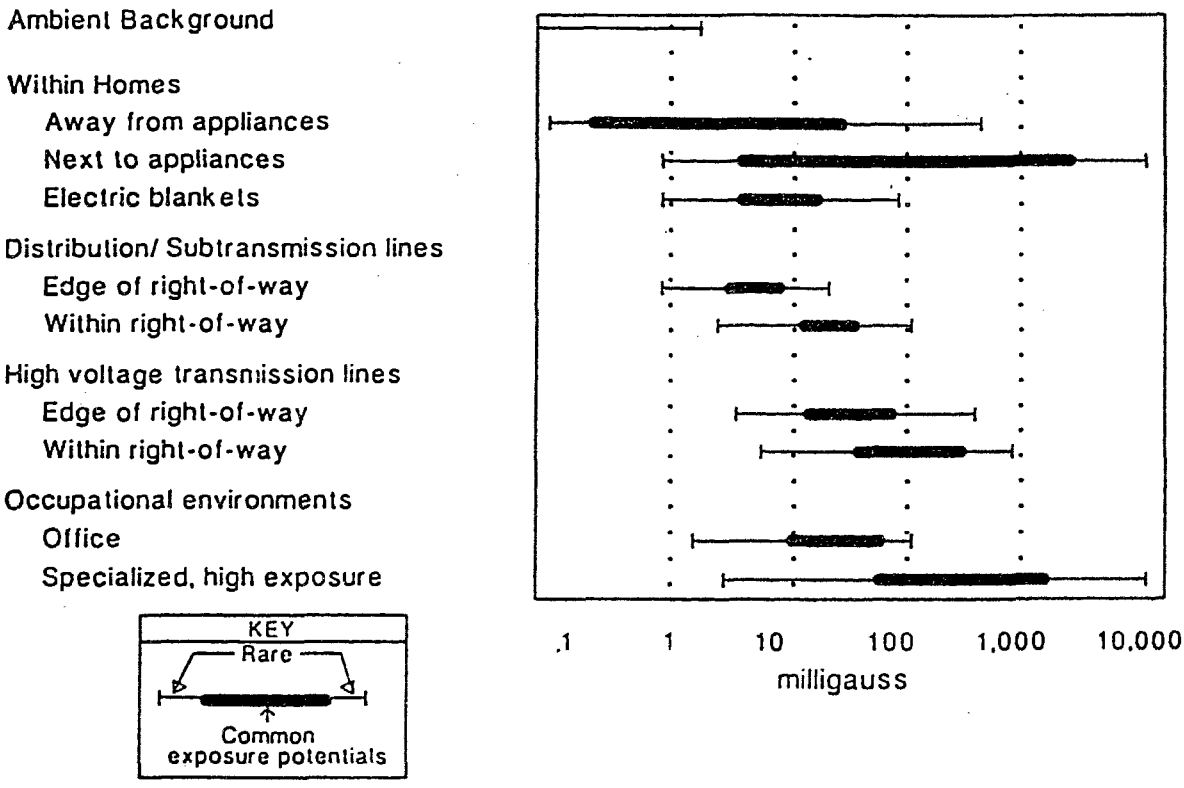


Figure 2-3. Magnetic field strengths (60 Hz).

Compiled from WEST Associates, A critical review of the scientific literature on low-frequency electric and magnetic fields: Assessment of possible effects on human health and recommendations for research. Reproduced with permission.

2.1.2 PF E/MF Interactions with Biological Systems

When a conducting object is introduced into PF E/MF, the electric field is perturbed but the effect on the magnetic field is negligible. All biological systems are good conductors in comparison with air.[20]

Perception

Strong electric fields can stimulate the skin of animals, by vibrating hairs or by triggering various skin sensors. (Human perception occurs at about 12-15 kV/m, related to the unperturbed electric field.)[21] A person standing in an electric field of 20 kV/m or greater will likely feel a slight tingling sensation. A variety of studies have shown that animals can also feel strong electric fields.[22]

Generally, people cannot detect the presence of magnetic fields. However, extraordinarily strong magnetic fields (found only in special situations such as the laboratory) cause flashes of light in the eye. Some animals have developed special sense organs that can sense the presence of very weak electric or magnetic fields. The organs are used in navigation and in searching for prey.[23]

Electric and Magnetic Induction[24]

The human body contains free or nearly-free electron charges that move in response to forces exerted by charges and currents on appliances and nearby power lines. These movements, or body currents, are produced by electric and magnetic induction.

Electric Induction

In electric induction, charges on, for e.g., a power line attract or repel the body's charges. The electric force causes the charges to move to the body surface because body fluids are good conductors of electricity. As the charges on the power line alternate from positive to negative (60 times per second), the charges induced on the body surface also alternate. Thus PF electric fields induce currents in the body as well as charges on the surface. (See Figure 2-4.)

Magnetic Induction

Magnetic fields and electric fields are interrelated. As previously discussed, alternating current produces magnetic fields that oscillate with the current. In turn, the alternating magnetic fields produce electric fields that exert forces on the electric charges contained in the body. This process is called magnetic induction. The induced currents, or "eddy currents," flow in loops are greatest near the periphery of the body and smallest at the centre. (See Figure 2-4.) Detailed

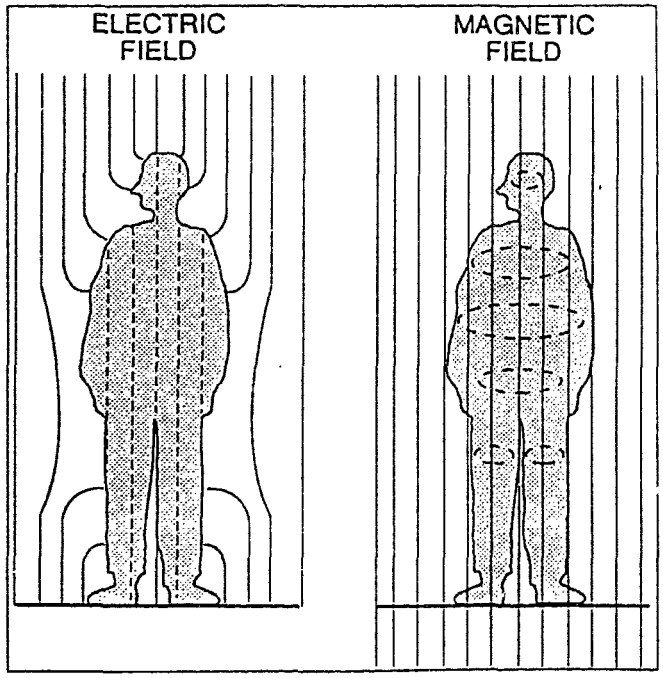


Figure 2-4. Currents induced by electric and magnetic fields in a human standing directly under a power line.

Notes: Solid lines represent invisible field lines.
Dotted lines indicate direction of induced current flow.

Reproduced with permission from US, BPA, DOE, Electrical and Biological Effects, p. 16.

data on the distribution of magnetically induced currents in humans and animals is sparse.

The magnitude of surface charges and internal body currents induced by PF E/MF depends on many factors, including the magnitude of the charges and currents in the source, the distance of the body from the source and ground, the presence of other objects that might shield or concentrate the field, body posture, shape and orientation relative to the field; and whether and how the body is grounded. (Therefore, induced surface charges and currents are very different for different animals.)

Compared to contact currents when touching, for example, a refrigerator, induced currents are typically small except in very strong fields.[25] For example, an electric field of 1 kV/m or a magnetic field of about 40 μT induces about 0.016 mA. A 10 kV/m electric field induces about 0.16 mA.[26]

Contact Currents

When physical contact is made between a body and a conducting object carrying an induced voltage, for e.g., a vehicle parked under a transmission line or a refrigerator door handle, contact currents flow into the body. If a person touches, for e.g., a vehicle parked under a power line, the body provides a path to ground through which the charge induced on the vehicle by the power line's electric field can flow. High current densities are often produced in the tissue near the point of contact resulting in some of the most intense exposures. However, they usually only last for a brief period of time, for e.g., as long as it takes to open the door car or refrigerator.

The magnitude of a contact current depends on several factors, including the local field intensity, the size and shape of the contacted object, and how well-grounded the contacted object and person are. The largest contact current is drawn by a well-grounded person touching a large metal object well-insulated from the ground. Most common contact currents are imperceptible (less than 0.2 mA). However, if large enough, they can result in an annoying spark discharge or painful shock.

For comparison, adult humans can typically detect a PF current of about 0.4 to 1 mA, "let-go" current is of the order of 5-15 mA, and ventricular fibrillation occurs at currents of 60-120 mA.[27]

Power line and appliance contact currents (and therefore exposure) are limited to a certain extent by existing safety standards. For example, the US National Electric Safety Code (NESC)

recommends that power lines be designed to limit contact currents from vehicles to 5 mA.[28] NESC also limits the "short circuit" current (the contact current that flows into a well-grounded person with wet hands) of new appliances to 0.5 mA (for portable units) and 0.75 mA (for stationary units). Typical appliance short circuit currents are 1-100 μA.[29]

In BC, similar standards are established by the Canadian Standards Association and Provincial Workers' Compensation Board, as well as by BC Hydro itself.

2.1.3 Exposure

Exposure Assessment

Exposure assessment involves the determination of the amount of exposure that may be encountered in homes, offices and factories. Direct measurement or, if direct measurement is unavailable or impractical, exposure modeling (i.e., theoretical estimates) are used to assess exposure.

Direct Measurement

Instruments to measure exposure from both electric fields, and, more recently, magnetic fields have been developed. Electric field instruments measure either the unperturbed electric field or the time integral of the electric-charge density on some area of body surface. Magnetic field instruments measure either the magnetic field or the time integral of the magnetic field produced on some area of the body surface. (See Figure 2-5.)

Several electric utilities will measure PF E/MF in homes and elsewhere. A number of engineering consulting firms make measurements as a commercial service. (The instruments are expensive and, because there are multiple sources, the procedure is complicated.)[30] Relatively inexpensive personal dosimeters are also available. Recently, dosimeters that are small enough to be carried in a pocket or worn like a watch have been developed.

Exposure Modeling

In simple situations, for e.g., a transmission line crossing an open field, PF E/MF can be calculated very accurately using formulas from physics and electrical engineering. Such calculations are often used in designing or approving transmission lines. In complex settings, direct measurement may be more practical due to the complex shapes or complex current and voltage patterns involved. (The fields may add or subtract, depending on phase.)

Exposure models consist of two elements: estimates of instantaneous exposure intensity as a function of time, and estimates of the length of time that people spend in such positions. The unperturbed field is often used as a measure of instantaneous exposure because it is easy to

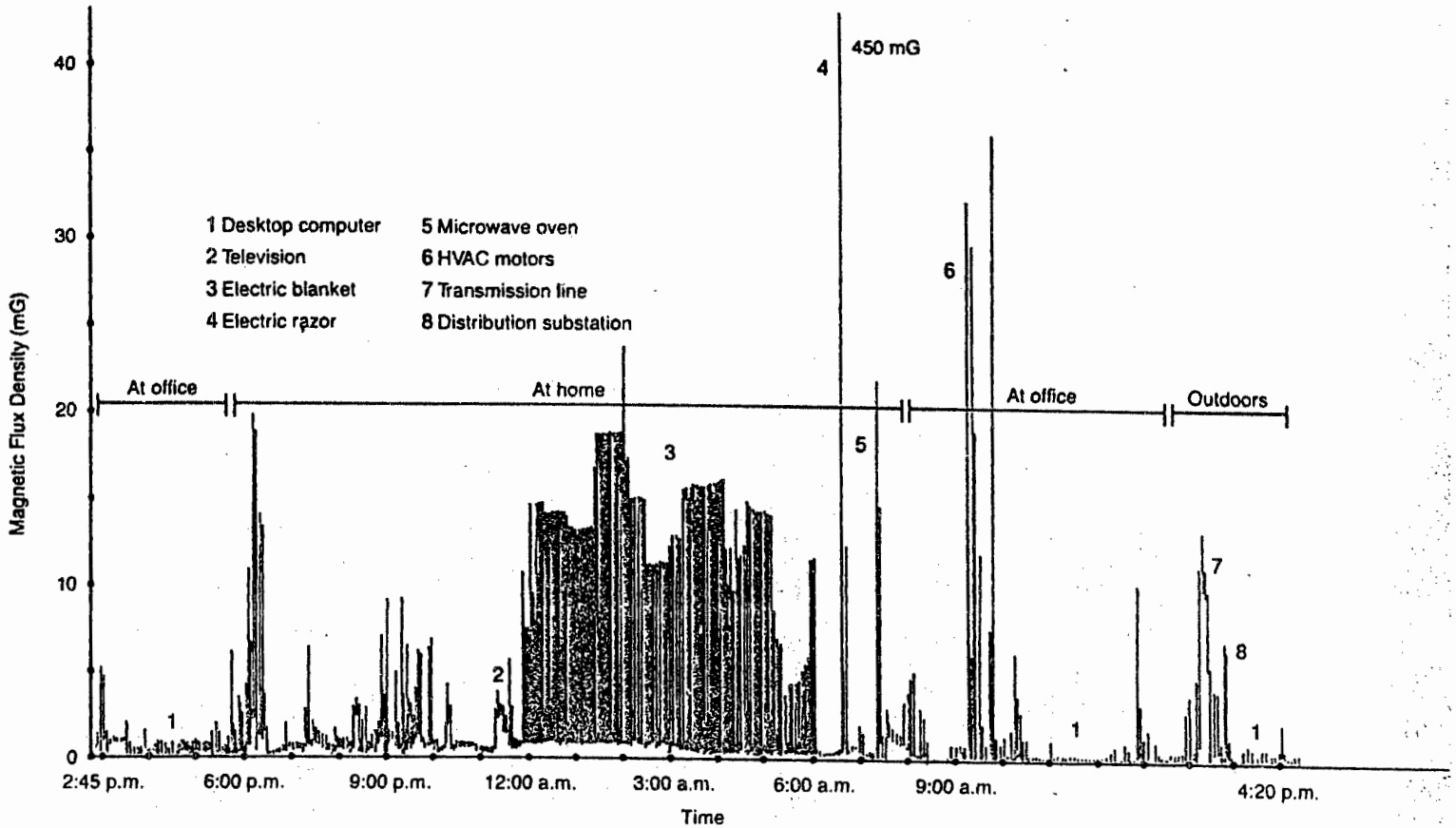


Figure 2-5. A personal 60 Hz magnetic field exposure record.

Reproduced with permission from Taylor Moore, "Pursuing the Science of EMF," p. 9.

compute and measure profiles of the field and, for some common exposures, the field is well correlated with other measures of instantaneous exposure, such as internal current or surface-charge densities. (Of course, precise relationships between external unperturbed fields and other quantities depend on factors such as the impedance between the body and other conductors, body shape and position, and field duration.)

The interpretation of results from direct measurement or exposure modeling is difficult not only because there are multiple sources but, more importantly, the exposure measure may not be appropriate because dose has not been defined. Even so, most studies have characterized exposure in terms of the unperturbed electric field or the magnetic field strength.[31]

Exposure Parameters[32]

The PF E/MF and induced currents that people are exposed to can be measured or computed. However, scientists do not know which, if any, quantity (or combination) is related to human health. The mechanism for field/biological effects has not yet been established and consequently the relevant exposure parameter has not been identified. Possible variables include (average or peak) field strength, change in field strength over time, (average or peak) currents induced in the body, and exposure duration (time spent in field or number of times subject passes in or out of field).[33]

For most known environmental hazards, such as chemical agents (PCB) or physical agents (IR), it can safely be assumed that if some of an agent is bad, more of it is worse. However, in the case of PF E/MF, much of the biological experimental evidence suggests that this assumption cannot always be justified. The problem involves defining "dose," i.e., identifying which, if any, aspect (or combination of aspects) of the field can affect human health.[34] Some studies have suggested a dose measure proportional to the long-term average of magnetic field exposure. Other studies have suggested (very) different measures of dose such as:

- frequency and intensity "windows" - biological effects are seen in specific narrow ranges of field intensity and frequency.[35]
- time thresholds - biological effects are observed only after several weeks of exposure.
- time "windows" - biological effects are seen after long- and short-duration exposure periods.
- field strength threshold - biological effects are observed only when field strength exceeds some threshold value.

Although each study involved different protocols and biological systems, together they suggest that dose is not necessarily proportional to field strength or to time spent in the field.

Comparing Exposures from Different Sources

A great variety of sources can contribute to total exposure.[36] However, because scientists do not know what measure is relevant in determining biological effect, comparisons cannot be made on the basis of relative contributions to effective dose. Only physical quantities that are (amenable) to measurement or theoretical estimates, including electric quantities such as induced surface charge and internal currents, exposure duration, frequency of exposure and number of people exposed, can provide the basis for comparisons among sources. Although such electric quantities may not be related to possible health effects, they can be used to indicate how similar or different people's exposures to various sources are.

As indicated in Figures 2-6 and 2-7, the rank of different exposure situations along one dimension can look quite different from the rank along another dimension. (The range of values indicated represents both uncertainty in the various factors needed to estimate dose and variability across exposed populations.) If field strength is the relevant variable, although appliances can generate fields that are higher than transmission lines, in most cases they decrease rapidly with distance and produce only intermittent exposure. However, electric blankets expose users for long periods of time and, like hair dryers and electric shavers, are operated close to the body. If induced current is the relevant variable, contact currents from appliances and VDTs are greater than power lines even when integrated over time.[37]

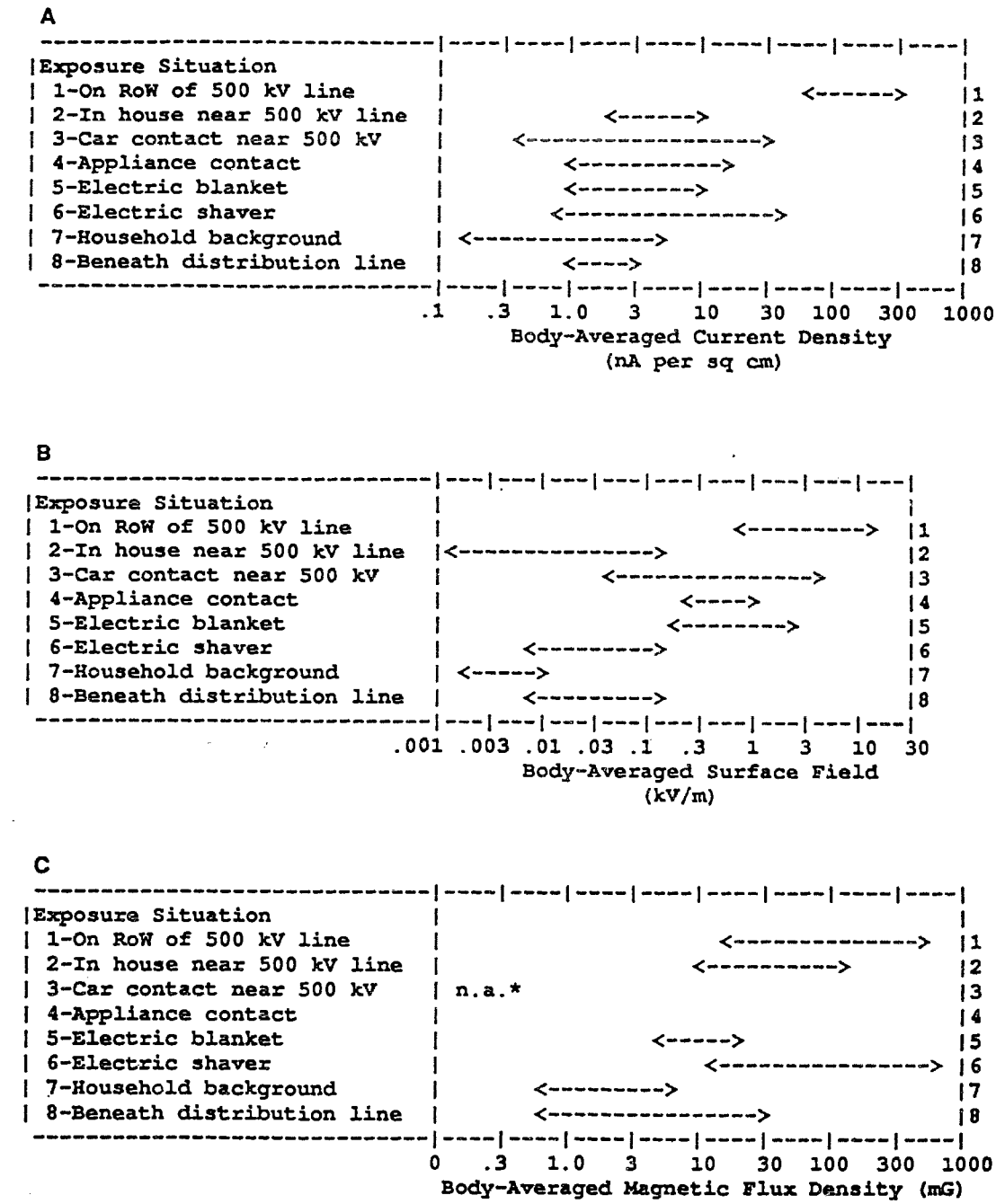
2.1.4 Research Methods

Studies concerning the effects of PF E/MF exposure on human health fall into two general categories: laboratory studies and epidemiological studies. They differ qualitatively in approach, sensitivity, analytical power, and potential relevance to the question at hand.

Laboratory Studies

Laboratory studies allow scientists to generate and examine specific hypotheses[38] and are capable of developing hard cause and effect relationships from experimental evidence.[39] Properly designed, performed and controlled laboratory studies can define mechanisms of action, provide indicators for studies in humans, and permit extrapolation to the human response.[40]

Under controlled conditions, biological subjects are exposed to carefully defined fields for known periods of time and compared to subjects treated the same (to the best of the investigator's ability) except for field exposure. Exposures can be graded and confounding effects such as diet, genetics and environment are minimized.[41] If large numbers of subjects are used and appropriate statistical analyses applied, it is possible in principle to detect differences



*Contact currents themselves produce negligible magnetic field. Of course the magnetic fields from the nearby 500 kV line would be comparable to those of exposure situations C1 and C2.

Figure 2-6. Three different exposure measures applied to 8 exposure situations.

Notes: Exposure measures are: A) the density of electrically- and magnetically-induced currents averaged over the body; B) the induced electric field averaged over the body surface; and C) the average magnetic field within the body. Ranges represents the span of typical values.

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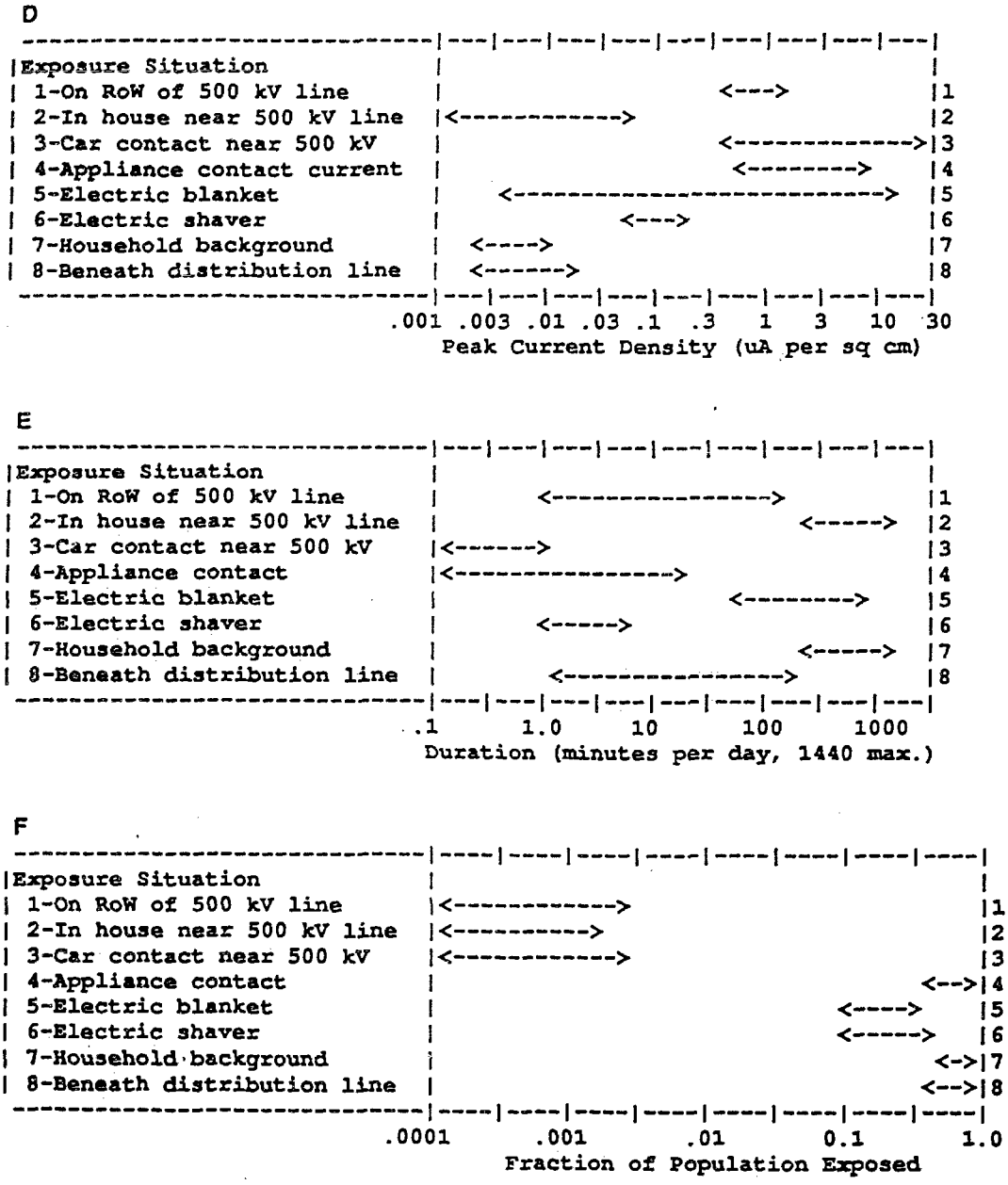

Figure 2-7. Three more exposure measures applied to 8 exposure situations.

Notes: Exposure measures are D) peak electrically- or magnetically-induced current density anywhere in the body; E) the duration of the field encounter; and F) the fraction of the population that regularly encounters the exposure situation. Ranges represent the span of typical values.

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between exposed and "control" or "sham exposed" populations which are even smaller than the normal variations that occur spontaneously in all biological systems. Thus, (with skillful experimental design), laboratory studies are able to reveal subtle effects that would be missed in epidemiological studies or casual observation.

Yet, the most sophisticated statistical techniques can tell only what the odds are that the two groups are different. Whether the difference resulted from field exposure or other factors depends on the skill and ingenuity given to the experimental design. There are few general principles to guide scientists; each experiment is its own challenge. Success depends not only on the concepts of the experimental design but also on meticulous attention to detail during execution.[42]

Both *in vitro* and *in vivo* techniques are used in laboratory studies. *In vitro* studies use isolated and artificially maintained preparations of cells or tissues; *in vivo* studies use living organisms.

Cell and Tissue Studies

In vitro studies are used to determine the biological effects of PF E/MF exposure on the functions of cells and tissues, with an emphasis on establishing mechanisms of interaction. However, the studies are limited by the scientific inability to predict physiological responses of biological systems on the basis of fundamental mechanisms. Cells are simple and their relationship with higher organisms is too tenuous. With some exceptions, notably relating to bone growth, *in vitro* functional changes are not closely linked *in vivo*.

Even when effects are demonstrated consistently at the cellular level in laboratory experiments, it is difficult to predict whether and how they will affect the whole organism. Cell processes are integrated through complex mechanisms in the animal. Other processes may compensate for cellular process perturbation by an external agent so that there is no overall disturbance to organism.[43]

It is also difficult to extrapolate *in vitro* to *in vivo* exposure conditions, nor may it be appropriate to do so. Ultimately, *in vivo* testing is required.[44]

Whole Animal Studies

Laboratory animal studies can be used to assess the existence and general nature of a health risk, and to give general guidance for safety levels. In studying the biological effects of PF E/MF, the emphasis is on providing information for eventual use in assessing the potential for biological effects on humans.[45]

It is normally not practical to conduct an animal study to determine if an agent causes

chronic disease such as cancer or heart disease. However, the existence of physiological effects such as neuroendocrine response, altered brain waves and depressed serum enzyme levels can be revealed.[46]

Animal studies are valuable in testing for possible deleterious effects. If chromosone damage cannot be demonstrated in the laboratory, it is unlikely to occur in exposed humans. However, if an effect is demonstrated in the laboratory, it does not necessarily follow that exposed humans will also show effects.[47] For example, experimental effects on chick embryos have not been found to be predictive of any human fetal effects from the same agents.[48] Developmental control is very different in the two species.

Determining the relationship of animal data to human disease is usually a matter of judgement, not demonstrable fact. Extrapolation to humans is very tenuous for a number of reasons: the relationship of the controlled laboratory to the real world; the relevance of effects on laboratory animals to humans; dosimetric considerations, including scaling of the species; and evaluation of the biological consequences of observed effects.[49] To accurately extrapolate the results of laboratory animal studies to humans requires detailed knowledge of the physical and biological mechanisms involved.[50]

It is difficult to compare exposures in laboratory studies with human exposures because of uncertainties about dose. For example, if the magnetic field is the measure of interest, the exposure of a rat at a given magnetic field intensity would be equivalent to human exposures at the same intensity. If magnetically induced currents are of interest, exposure of a rat at given magnetic field strength is much less intense than human exposures at the same field strength, because magnetically induced currents are proportional to body size.[51]

Indeed, it is not even possible to duplicate human electric field exposure using laboratory animals. To some extent, animal exposure can be scaled to approximate that of humans, taking into account how body size, shape and orientation influence field interactions. For example, exposing swine to unperturbed electric fields of 30 kV/m or rodents to 100 kV/m reflects, to some degree, the same situation as a human standing beneath a 765 kV transmission line.[52] However, strong electric fields can result in relatively high current density through the animal's legs, thus increasing the possibility of skin or hair stimulation. In addition, field perception for mice, swine, and birds occurs from 25 to 35 kV/m while for rats it occurs from 4 to 10 kV/m.[53]

Human Studies

Ideally, the best data for determining the biological effects of PF E/MF would come from laboratory studies of humans. General physiological and psychological responses of human

volunteers can be observed. However, the scope of these studies is severely limited due to ethical considerations, the difficulty of controlling genetic and environmental variables and exposures, and the length of the human lifespan.[54] (For example, the quasi-invasive measurement techniques routinely employed with animals are unthinkable in humans.)

Epidemiological Studies

Research with human populations in real-world situations is termed epidemiology. It is the study of the frequency and distribution of disease, or a physiological condition in human populations, and of the factors that influence its frequency and distribution. Epidemiological research is generally limited to establishing statistical associations or correlations rather than cause and effect relationships.[55] (An "association" means statistically that the things occur together but not necessarily that one causes the other.)[56]

Epidemiology takes advantage of the fact that certain subjects are exposed to some agent over the normal course of their daily activities at work (occupational) or at home (residential). Their health is compared with the health of unexposed subjects. Because the subjects voluntarily chose the exposure conditions, it is possible to study what would otherwise be ruled out in laboratory or controlled testing situations due to ethical considerations.

However, because there is no direct control by the investigator over the length of time or magnitude of exposure, or over other environmental influences that the subjects experience, epidemiological studies are expected to reveal only large scale or unusual effects.[57] Exposed and unexposed groups of subjects can differ in terms of many factors, including age, residence, occupation, and sex ratio. Some of these factors (for e.g., age and sex) are known to influence the incidence rate of many diseases and can be accounted for in study design or analysis.[58] Other factors associated with disease (and with exposure potential) may be unknown (even impossible to control for); such "confounders" may lead to an incorrect interpretation of a study.

Bias can also be introduced due to uncertainties in determining the actual exposure status of an individual, variations in disease definition and diagnosis in different geographic areas or in different hospitals, loss of study subjects who leave the area, unwillingness of subjects to participate, and inaccuracies in data sources such as death certificates and clinical records.[59] Furthermore, data on exposure is often drawn from incomplete medical records, personal recall, or personal descriptions of symptoms.[60] Practical solutions to many of these problems have been developed, but they are frequently not adequately addressed.[61]

Although bias can give rise to a spurious effect, that is, make the study show an apparent effect that does not exist in reality, bias can also mask a true effect.[62]

The quality of the study depends to a very large degree upon the skill and originality of

the investigator in selecting groups of subjects for comparison and, after determining that there are statistically significant differences between groups, in devising methods to ascertain which of the many possible environmental influences may be responsible.[63] Epidemiology has provided valuable clues in the search for causes of disease,[64] often providing the only available direct evidence linking human exposure to a disease.

A commonly used epidemiological study design is the (correlational or) cross-sectional study in which factors of interest in a defined population are examined at a particular point in time. It is a broad screening type of study correlating the occurrence of disease or death in some group (selected by occupation or geographic area) with the assumed presence or absence of exposure to some agent. The proportional mortality rate (PMR) or ratio of exposed subjects who died of a specific cause to the unexposed subjects who died of the same cause is often used to measure risk.[65]

Another common design is the retrospective case-control study, often simply referred to as a "case-control" study. Individuals who have already developed the disease are identified. An attempt is then made to compare the previous exposure experience of these "cases" with that of "controls" who have not developed the disease. Both groups are selected to be as similar as possible in all other characteristics.[66] The exposures have already occurred so they must somehow be estimated. The odds ratio (OR) or exposure odds among cases to exposure odds among controls is often used to measure risk.[67]

A third common design is the cohort study. The exposure status of non-diseased individuals is first identified. Then the subsequent rate of disease development in the cohort is determined. The two types of cohort studies, concurrent (or prospective) and nonconcurrent (or retrospective), differ in terms of when the study variables (exposure and disease) occur in relation to the onset of the study. Prospective cohort studies are most similar to the classic laboratory experiment and result in a "true" measure of relative risk (RR), the ratio of incidence among exposed to the ratio among unexposed (or less exposed).[68]

Epidemiological studies are very persuasive because they deal with people.[69] But it is a difficult science and is subject to many pitfalls, particularly when the differences in incidence of disease between groups is small[70] or the agent is weak with non-specific effects.[71] Very large populations are then required to attain statistical significance. In addition, because of the inherent biases in epidemiology, a great number of studies are usually required to establish pervasive scientific evidence about causal links.[72]

However, a series of carefully designed epidemiological studies all indicating a positive association supported by cellular and animal data can provide persuasive evidence for cause.[73]

Cause and Effect

Criteria commonly invoked to distinguish between causal and non-causal associations include:

1) strength of association - ratio of incidence rate in exposed to non-exposed populations, for e.g., RR;

2) consistency - same association observed in different populations under different circumstances;

3) specificity - single rather than multiple effects;

4) temporality - cause precedes effect in time;

5) biological gradient - dose-response relationship;

6) biological plausibility and coherence - association consistent or supported by known facts or observations;

7) experimental evidence; and

8) analogy - analogous agent.

These criteria, developed by Hill, are not "hard-and-fast" rules of evidence. For example, specificity, biological plausibility, experimental evidence, and analogy are not necessarily required to demonstrate cause and effect. The criteria can help experts decide if there is another way of explaining the set of facts that is equally, or more, likely than cause and effect. As Hill points out, formal tests of significance cannot answer this question. They only indicate the effects of chance and the likely magnitude of those effects.[74]

Experts agree that a considerable degree of scientific judgement is involved in evaluating any epidemiological association. However, different experts stress different criteria; not all agree that certain factors are useful.[75] For example, one epidemiologist has suggested that cause and effect associations are only clearly established when relative risks are large (i.e., 5 or more) and results of epidemiological studies are consistent.[76] (In the past, epidemiology has been successful in identifying hazards when relative risks were greater than 10, for e.g., cigarettes and asbestos.) Temporality may be the only factor universally accepted as an essential criterion. However, it can be difficult to demonstrate with many chronic diseases (for e.g., cancer) which generally have long latency periods.[77]

2.2 State-of-the-Science (to December 1988)[1]

Research results on PF E/MF health effects are complex and inconclusive. Many experiments have looked for effects and found no difference between biological systems that were and were not exposed. However, the number of positive findings demonstrate that, under certain circumstances, even relatively weak fields can produce changes at the cellular level. It is not possible to demonstrate that health hazards from PF E/MF exposure do exist, and they may not. However, the emerging evidence no longer allows one to categorically assert that there are no risks. (That is, some scientists have examined all the scientific evidence but are unconvinced of any significant health risks; others conclude that there may be risks.)[2]

Cell and Tissue Laboratory Studies

The cell membrane appears to be the primary site of interaction between ELF fields and the cell.[3] The cell membrane is responsible for transmitting information arriving at its surface to the cell interior so that life processes can occur. ELF experiments have focused on how exposure changed processes governed by the membrane. Changes included: modulation of calcium ion flows;[4] interference with DNA synthesis and RNA transcription;[5] interaction with the response of normal cells to hormones and neurotransmitters; and interaction with the biochemical kinetics of cancer cells.

Research has demonstrated that under certain circumstances cell membranes are sensitive to externally imposed LF EMF, even when the fields' intensity is much weaker that the cell membrane's natural fields.[6] Therefore, processes (such as a cell's capacity to recognize other cells) governed by the cell membrane may be disrupted by exposure.

ELF fields do not have enough energy to disrupt the structure of DNA. However, research has shown that exposure may interfere with RNA transcription patterns, resulting in the production of structurally changed proteins. (Protein synthesis is a very complicated; experiments yield no simple interpretation about potential ELF effects on organisms.)

Experiments have demonstrated that ELF exerts an effect on endocrine tissue and endocrine processes *in vitro*, and that the effects show windows. It is not possible to draw further inferences.

ELF experiments on interaction with the immune response of cells showed that exposure had no significant effects on normal or immunized cell immunological functions. However, cells already stimulated by mutagens may be affected.[7]

Experiments have examined the effect of ELF fields on cancer cells. One hypothesis is that fields promote cancer formation or growth rather than initiate cancer. (Any potential

relationship between field intensity and degree of promotion may be highly complex.)

It is difficult to predict whether and how effects demonstrated at the cellular level will affect the whole organism. When an external agent such as an ELF field perturbs a cellular process, other processes may compensate for the perturbation.

The lack of a theoretical model to explain and understand potential cellular-level effects presents another problem in deductions about possible health concerns. Until recently, cell membrane biology (still in its infancy) was not understood enough to advance hypotheses (still at a speculative stage) about potential mechanisms of action. (Several decades of carefully designed experiments may be required before all current evidence can be placed in a coherent framework.)

Furthermore, there appears to be no analog among known environmental hazards. ELF cellular effects are complex and dependent on a number of factors, including frequency and field strength, time pattern of exposure to the field, and direction of the applied field. They may also depend on whether the field is a simple alternating or pulsed field.

Whole Animal (and Human) Laboratory Studies

Whole animal experiments have involved many different subjects, including rats, mice, miniature swine, cows, guinea pigs, and chicken eggs. They have been examined under a range of E/MF intensities and for various exposures and durations.

Experiments on detection, behavior, learning, and avoidance responses in animals have shown that there are central nervous system (CNS) effects which may be windowed. No general conclusions can be made.

Studies of effects on reproduction, growth, and development have measured a wide range of factors (such as reproductive behavior, prenatal viability, alterations in physical parameters, gross malformations, and CNS development). Most studies examining developmental effects have concluded that no overt defects and malformations resulted from exposure. However, because some studies have seen subtle effects, the possibility of an effect remains. Overall, studies examining the effects of 60 Hz fields on bone growth and repair have shown that high-intensity electric fields do not have a strong effect in rodents.

Animal studies of CNS effects from ELF exposure have indicated that interactions are very complex. They may vary with the background static fields present, the time of day, and exposure duration. Studies have found that developing nervous systems may be particularly susceptible, and effects may be latent, manifested only in certain situations or later in time. Research also shows that ELF fields are specific with respect to affected regions of brain tissue.

(Public health implications, if any, remain unclear.)

Experiments conducted on blood and immune system chemistry indicate no general or overall immune system performance changes or short-term endocrine system changes from several months exposure to high intensity electric fields.

ELF experiments on E/MF effects on circadian systems of man, primates, and lower animals indicate a definite effect on the periodicity of physiological functioning.[8] (Whether such effects are deleterious or long-lasting is not clear.) Physiological and psychological disorders have been associated with circadian system dyssynchrony, including altered drug and toxins sensitivity, internal conflicts between the timing of sleep physiological processes, and psychiatric disorders such as chronic depression.

Epidemiological Studies

Epidemiological studies have investigated the association between residential (adults, children) and occupational (adults) ELF field exposure and cancer. (The focus has been on cancer because of historical observation not because cancer is the most likely effect.) Cancer promotion (versus initiation) is most often cited as the role ELF fields play in carcinogenesis. No experiment or theory proves that ELF fields promote cancer or growth enhancement.

All studies are based on proxy exposure measures: job title for the occupational studies, and spot measurements and/or electric supply system wiring configuration code for residential studies. The validity of these measures as indices of historic field exposure has not been determined.[9] Furthermore, because most people are normally exposed to PF E/MF, it is not practical to conduct an epidemiological study involving unexposed people. A basic assumption is that the use of electrical appliances, and exposure to household or office wiring represents the normal or background exposure level. The studies are done to determine whether people who are exposed to field levels above background show any measurable difference in disease rates. People living close to powerlines, workers in various "electrical occupations," and people who use electrically heated beds are assumed to have higher exposures.[10]

Childhood Cancer

Three of the five studies that investigated the association between ELF field exposure and childhood cancer found positive results. The most recent study (by the NYSPLP) found:

- A 30% increase in risk (OR=1.31) for all cancers was observed at high magnetic fields (2.50+ mG). Higher field ranges did not always give a higher cancer risk.
- Lymphoma, brain tumors, soft tumors, and "other cancers" showed OR of 1.3-1.6 at high field exposures (2.5 mG+). Leukemia showed an OR of 2.11 for the high field exposures and 1.23 for the 1.00-2.49 mG field range.

- Cancer risk was not associated with magnetic field values at residence of birth.
- Higher electric fields did not show higher cancer risk.
- Results on the relationship of childhood cancer to use of appliances, electric blankets, heated water beds, and electric heat were mixed but suggested a few trends. Electric blanket and isolette exposures were associated with increased risk of all cancers, especially brain and soft tissue for isolette exposure.

Residential Exposure and Adult Cancer

Two of the three studies that examined the association between adult cancer and residential exposure to ELF fields found positive results. One study (by Wertheimer and Leeper) found an association between nervous system, uterus, and breast cancers, with an increasing risk for higher current configurations. Another study (by the NYSPLP) found no association between acute nonlymphocytic leukemia and residential wiring configuration and field exposure. The studies do not provide enough evidence that residential field exposure increases cancer risk.

Occupational Exposures and Adult Cancer

About 20 studies have examined the association between cancer, in particular, leukemia and brain cancer, and occupational ELF field exposure. Electrical worker populations or ham radio operators in the US, England, Sweden, and New Zealand have been used. Together, the studies indicate a small positive association or no association.

Studies of the association of ELF exposure and leukemia show electrical equipment assemblers and aluminum workers have the highest RR of all "electrical" occupations. However, uncertainties exist because, for example, job classification does not clearly indicate actual occupational field exposure, and studies did not consider confounding variables and other exposures. Studies show that telegraph, radio, and radar operators - the third highest RR group - consistently exhibit increased risk. They do not provide sufficient evidence that occupational PF E/MF exposures increase leukemia or brain cancer risk.

The association between brain and CNS tumors and occupational ELF field exposure has been examined in several studies, including some general cancer studies. Because adult brain cancer is rare, it is difficult to establish a causal association.[10] Also, because the brain is a favored site for metastasis,[11] cases counted as primary brain cancer may actually be secondaries from a different organ where the cancer actually initiated. Furthermore, exposure is estimated from job titles or general occupation codes. A code such as "electrical occupations" may include workers such as electrical and telecommunications engineers who are no more exposed to ELF than the average individual.[12]

2.3 General History (to December 1988)

This section reviews the general history of the PF E/MF and human health controversy in terms of both science and policy issues in North America to December 1988.[1]

By the late 1960s/early 1970s, individuals, citizen groups, government, the scientific and public health communities, and the electric utility industry began to express increasing concern about the effects of PF E/MF exposure on human health. This concern was occasionally reflected and influenced by the media.[2] Most scientists assumed that PF E/MF levels commonly present in the environment were biologically innocuous. They did not cause shock or heat body tissue significantly. Furthermore, field strengths were very small, well below the threshold of physical perception.[3]

Public attention initially focused on the aesthetic impact of large towers, on the aesthetic and ecological impacts on their ROWs, and on nuisance effects, for e.g., audible noise, radio/television interference, and induced shocks, from their strong electric fields. Provincial and state regulatory agencies adopted standards insuring that the lines did not produce gross effects such as shock and burns.[4]

Many scientists associated with the discovery of electricity and the formulation of its laws, including Hertz, Faraday, Tesla and Volta, were deeply concerned with the effect of electricity on animals and the role of electricity which originated within animals. However, by 1900 the early links forged between electricity and biology were broken. The search for answers to biological processes such as disease, growth, and reproduction increasingly employed the concepts and framework of solution chemistry. Biologists generally did not incorporate electricity in either their theories or the conduct of their experiments during the first two-thirds of the twentieth century. During this same period, the study of electricity evolved into a highly specialized set of disciplines aimed at understanding the interaction of electricity with non- living matter. Virtually the only knowledge produced by their combination was the determination of the current required to stimulate nerves, or cause shock, kill or burn an organism.

In the mid-1960s, scientists began to conduct laboratory experiments dealing with the effects of very minute amounts of electricity on both humans and animals. Their individual research aims were diverse: to alter growth patterns, stimulate regeneration, treat tumors, alter the course of specific diseases, and so on. The focus of their research was either therapeutic or purely speculative. It grew out of the scientists' dissatisfaction with the failure of the chemical approach to furnish insights into the way that living things functioned, and their

desire to utilize the methods and concepts of newly emergent areas of thought, such as solid-state physics and information theory. In some instances, the electric environment to which the investigator exposed the biological systems under study was similar to that created by high voltage transmission lines.[5]

When electricity was first introduced in the 1800s, the public was apprehensive. It then became clear there was no threat of fire or electrocution, and that enormous benefits could be derived. By the 1930s, transmission lines had become symbols of industrial development and modernization. In the 1940s, with the introduction of the US Rural Electrification Administration, High voltage transmission lines became representative of democracy in action. In the early 1960s, the environmental movement began consisting of powerful social currents reacting to negative social concerns about central authority and control. By the 1970s, the utility industry had grown from many small companies into several large companies.[6] Transmission lines had become powerful negative social symbols.[7]

Not only has a shift occurred in the last 25 years in attitudes toward technology in general, there has also been a growing preoccupation with technologically-induced risk.[8] The general importance of efficiency and productivity has decreased, while the importance of aesthetics, pollution control, safety, and health has increased. The establishment of the US National Environmental Protection (NEP) Act in 1969 institutionalized the change by requiring that non-economic impacts be considered in decisions affecting the environment.[9]

Increasing demand for power and the economies that could be realized when electricity was transmitted at high voltage led to increasingly higher transmission voltages. Transmission at 345 kV began in the mid-1950s, followed by 500 kV and 765 kV in the late 1960s. Environmental groups, government agencies and some members of the scientific community began to question if past biological effects research and experience with lower voltage lines provided an adequate basis for determining the possible health and environmental effects of higher voltage lines. Only a small amount of research had been conducted to explore the possible effects, especially long-term, on biological systems from transmission line electric fields. Almost no research had been conducted investigating magnetic field effects.[10]

The utility industry was not well prepared to address claimed health effects from PF E/MF. Previous industry research had focused on corona, the primary environmental issue prior to the mid-1960s.[11] Audible noise and "let-go" current considerations had also been investigated, usually by engineers and physicists, with endpoints definable in familiar engineering terms. Scientifically defendable research was limited to the development of computation methods

and measurement techniques based on well founded analytical and experimental procedures. Even on this subject, there was considerable debate as to correct procedures, adequacy of instruments, and traceability of measurements of electric fields.[12]

Interest in the possible long-term health effects from PF E/MF was largely prompted by Soviet reports in the 1960s (first given wide distribution at an international conference in 1972) regarding health problems experienced by men working in 400 kV and 500 kV switchyards.[13] By the early 1970s, a number of projects involving both humans and animals were reported in the scientific literature by groups in the US, Federal Republic of Germany, France, Spain, Sweden and Japan. Except for Spain, researchers in Western Europe and the US did not identify any prompt or acute effects other than from spark and electric discharge, and no permanent effects.[14] However, of the seven studies that were directly related to effects on humans, only two were based on long-term exposure to PF E/MF.[15]

None of the early studies received wide acceptance by the collective scientific community. They were criticized for poor exposure assessment, lack of control groups, and multiple methodological weaknesses. The research results indicated the need for further research to resolve inconclusive or contradictory research findings.[16] The need for an interdisciplinary effort was only starting to be recognized. Those projects based on sound engineering principles had little merit as biological studies. The few studies by groups qualified to conduct biological experiments were flawed by improper or untraceable electrical characteristics. In particular, electric shock could not ruled out as a confounding factor.[17]

Two events in particular made it clear that existing data was insufficient to determine if there were human health effects from PF E/MF: the US National Academy of Science (NAS) literature review for Project ELF and the New York State Public Service Commission's (NYS PSC) attempt to assess the effects of 765 kV transmission lines.[18]

In the late 1950s, the US Navy first proposed construction of Project Sanguine, an ELF submarine communications system.[19] The electric and magnetic fields produced would be similar in several respects to those created by high voltage transmission lines. In response to public concern and to comply with the recently-enacted NEP Act, a laboratory research program investigating exposure effects on animals and plants was conducted. Some of the early studies reported effects and others were inconclusive.[20] The US Navy then commissioned the National Research Council (NRC) to conduct a literature review. Published in 1977, the review concluded that the E/MF produced by Project ELF would not cause any significant biological effects other than shocks.[21]

In 1973, the New York Power Authority announced plans to build two 765 kV transmission

lines from the Canadian border to Central NYS to carry hydroelectric power from Quebec.[22] The licensing proceeding held by the NYS PSC from 1975 until 1977 involved the first lengthy hearing on the subject of PF E/MF health effects. Although there was considerable opposition for several reasons, the potential for health risks became the dominant issue.[23] In addition to the Soviet reports, some scientists had come forward with reports of effects on small animals.[24]

During the mid 1970s, slight improvements were made in the conduct of research, incorporating control groups with improved exposure assignment. Research was primarily aimed at trying to prove that biological effects did not exist with experiments that showed that electric fields had no effects. Although the null hypothesis is a valid scientific tool, it cannot be proven in any general sense.[25] Consequently, the studies received limited public acceptance.

The US Department of Energy (DOE) and the Electric Power Research Institute (EPRI) also realized that spending millions of dollars trying to prove that there were no effects would yield little support from the scientific community.[26] Therefore, they developed laboratory research programs that would focus on broad-based screening studies. Large numbers of rats, mice, etc., and various individual cells were exposed to high levels of PF E/MF to see if there were any general effects because there was no indication what system or function, if any, was most likely affected.[27] (The use of screening studies rather than specific hypotheses-testing caused some concern. If scientists looked deep enough and hard enough, they were likely to find some level of interaction.)[28]

The research programs initiated by the US DOE and EPRI explored areas that were considered most likely to produce effects. From an engineering point of view, this required a focus on electric fields. There was a long history of public exposure to weak magnetic fields with few accepted claims of effects. Also, the Soviet studies claimed effects based on strong electric fields. Concurrently, rigorous dosimetry and scaling research was instituted to provide the link for engineering changes if significant health effects were found. Most of the studies found no differences between exposed and unexposed groups. The few studies that did find effects were followed up with more detailed experiments using a range of field intensities, and varied exposure conditions and durations to look for mechanisms to explain the effects that had developed and determine their significance.[29]

In addition to the substantial US DOE and EPRI research programs, the Bonneville Power Administration (BPA) and Southern California Edison began significant programs.[30] (BPA primarily funded environmental and livestock studies.)[31] Diverse endpoints were examined, often with good experimental protocols. However, although many studies showed no effects, there were rarely enough numbers of subjects to detect low level effects.[32]

By the mid- to late 1970s, the possibility of biological effects from NIR other than tissue heating was gaining some acceptance by scientists. A number of US federal agencies and international agencies called for more research.

In 1976, scientists Bawin and Adey made a controversial discovery. Low intensity RF carrier waves modulated by certain ELF elicited biological effects. Further research showed that the calcium efflux effect in nerve tissue cells at 60 Hz but not at 55 Hz or 65 Hz. (The unusual behavior of calcium flow from cell membranes in brain tissue *in vitro* was the first clear, reproducible effect of ELF fields observed in biological tissue.)[33] Due to these "frequency windows," it appeared that a threshold below which exposures were without effect might not exist.

The US Environmental Protection Agency (EPA) basic science research program initially focused on the biological effects of RF EMF.[34] By 1982, after confirming the existence of frequency windows, a modest program of work with ELF, including PF, was begun in an effort to isolate cause and effect relationships. "Intensity windows" were discovered, where no enhancement of effects occurred at either higher or lower intensities. There was also increasing evidence that the earth's geomagnetic field influenced effects.

Until the late 1970s, researchers had concentrated most of their efforts on the effects of electric fields around transmission lines. By the early 1980s, an increasing number of epidemiological studies were reporting associations between cancer and residential and occupational PF magnetic field exposure. As a result, the focus of investigations began to shift to magnetic fields effects, especially cancer, and to other sources of PF fields such as distribution lines and electric blankets.[35]

In 1979, the first (case-control) study to link magnetic fields with cancer (by Wertheimer and Leeper) reported a possible association between childhood cancer and proximity to "high current configuration" distribution lines in Denver, Colorado.[36] Wertheimer and Leeper were also the first to report, in 1982, an association between adult cancers and residential wiring configurations.[37] In 1982, a study by Milham reported that power station operators had 2.5 times the death rate from leukemia in Washington State, the first report of an association between cancer and PF E/MF exposure in the workplace.[38]

Two of the three subsequent epidemiological studies of PF magnetic fields and childhood cancer, conducted by researchers in the US and in Sweden, also suggested an association. The four studies of PF E/MF and cancer among electrical workers that followed in the US and UK were also positive.[39] In 1986, Wertheimer and Leeper reported a link between magnetic field

exposure from electric blankets and electrically heated waterbeds to miscarriages, and to reduced birth weights and lengthening of the gestation period for infants born to exposed mothers. However, all findings were considered highly uncertain because of the many theoretical concerns and methodological questions raised, particularly the problem of long-term exposure assessment.[40]

Although some investigators speculated that a causative association might exist, others were more tentative and considered causation as only one of several possible hypotheses. There was no convincing evidence of causation - promotion was a possibility but most known chemical promoters were characterized by a degree of tissue specificity. Furthermore, if the association was causal, an increase in exposure over time should be followed by an increase in disease. Many believed that a temporal relationship had not been shown because a concomitant overall increase in cancers had not followed the rapid growth of electrification and use of electrical devices in the US during the past century.[41]

By 1979, concern among the public, and in regulatory and technical circles, about possible health effects from PF E/MF had increased. The numerous studies in the early 1980s further increased public concern, as well as precipitated additional research efforts and regulatory activity. Although many of the weaknesses and limitations of the pioneering epidemiology were expected to be overcome by ongoing studies, the existing studies were still inconclusive and inconsistent.[42] Mounting fear and public activism were already causing delays in the licensing and construction of major transmission facilities and encouraging the formation of regulatory policy.[43]

For example, a series of events precipitated by the Florida Power Corporation's attempt to gain certification for a 500 kV transmission line culminated with the Florida Siting Board's order that the Department of Environmental Regulation (DER) promulgate a PF E/MF standard.[44] In 1985, a Texas County Civil Court ruled that Houston Lighting and Power (HL&P) in building a 345 kV transmission line within 60 metres of a school had acted "with callous disregard for the safety, health, and well-being" of the children. The jury ordered HL&P to pay $25 million in punitive damages and to either move the line or nearby school buildings. (Some scientists had testified that exposure was an inadvertent prospective experiment.)[45]

In an effort to address these problems, the US DOE sponsored a three-year study on risk assessment at Carnegie Mellon University (CMU) in 1982, broadening the already multidisciplinary nature of the PF E/MF and human health controversy. By 1985, researchers concluded that the limits in scientific knowledge precluded conducting a meaningful 60 Hz field risk assessment or bounding analyses for developmental abnormalities and cancer endpoints.[46]

By 1983, EPRI had expanded had reoriented their research focus to magnetic field effects. Similarly, by 1985, the US DOE had determined magnetic field effects to be of higher priority although in several DOE programs research on both electric and magnetic fields continued.[47] DOE laboratory screening studies mostly concentrated on physiological systems considered highly sensitive to external stimuli, or to follow-up on earlier clinical reports of health problems.[48]

Reflecting the increasing interest in PF E/MF health effects research, the Bioelectromagnetics Society (BEMS) grew into a substantial professional society. BEMS is the only scientific society that deals exclusively with bioelectromagnetic research and questions related to the biological effects and uses of electromagnetic energy. Its quarterly refereed scientific journal is the single most important scientific journal in the world.[49] Similarly, two commercial newsletters - Transmission/Distribution Health and Safety Report and Microwave News were publishing by 1983. They carry nontechnical reports on the latest scientific, regulatory and other developments in the field.

By the mid 1980s, results of several major research projects were available with an increasing number of studies indicating a small but possible risk.[50] Numerous literature reviews had been conducted by private contractors, universities, electric utilities, and government organizations throughout the US and other countries, and by international organizations such as WHO and the IRPA. With few exceptions, there was general agreement that electric fields such as those produced by transmission lines had not been shown to cause harmful effects (other than shocks) in people or animals. However, because of effects reported in some studies, most reviewers pointed out the need for further research.[51] Although significant methodological advances had been made and there had been an accumulation of effects data, there was still a lack of experimental and epidemiological data on human exposures, insufficient data from animal experiments, and a lack of understanding of basic mechanisms by which low intensity fields could interact with biological systems, especially magnetic fields.[52]

A few reviews included the specific recommendation of "prudent avoidance."[53] As a result of work done for the Florida DER on practical policy options for the siting of transmission lines that addressed the potential for PF E/MF health risks, researchers at CMU had proposed a policy of prudent field avoidance in which utilities would be given incentives to choose transmission line corridors that minimized the number of people who lived nearby.[54] Although the concept of "more is worse" did not necessarily apply to PF field exposure, one thing was known for certain - if the fields posed a hazard to human health, the impact would be

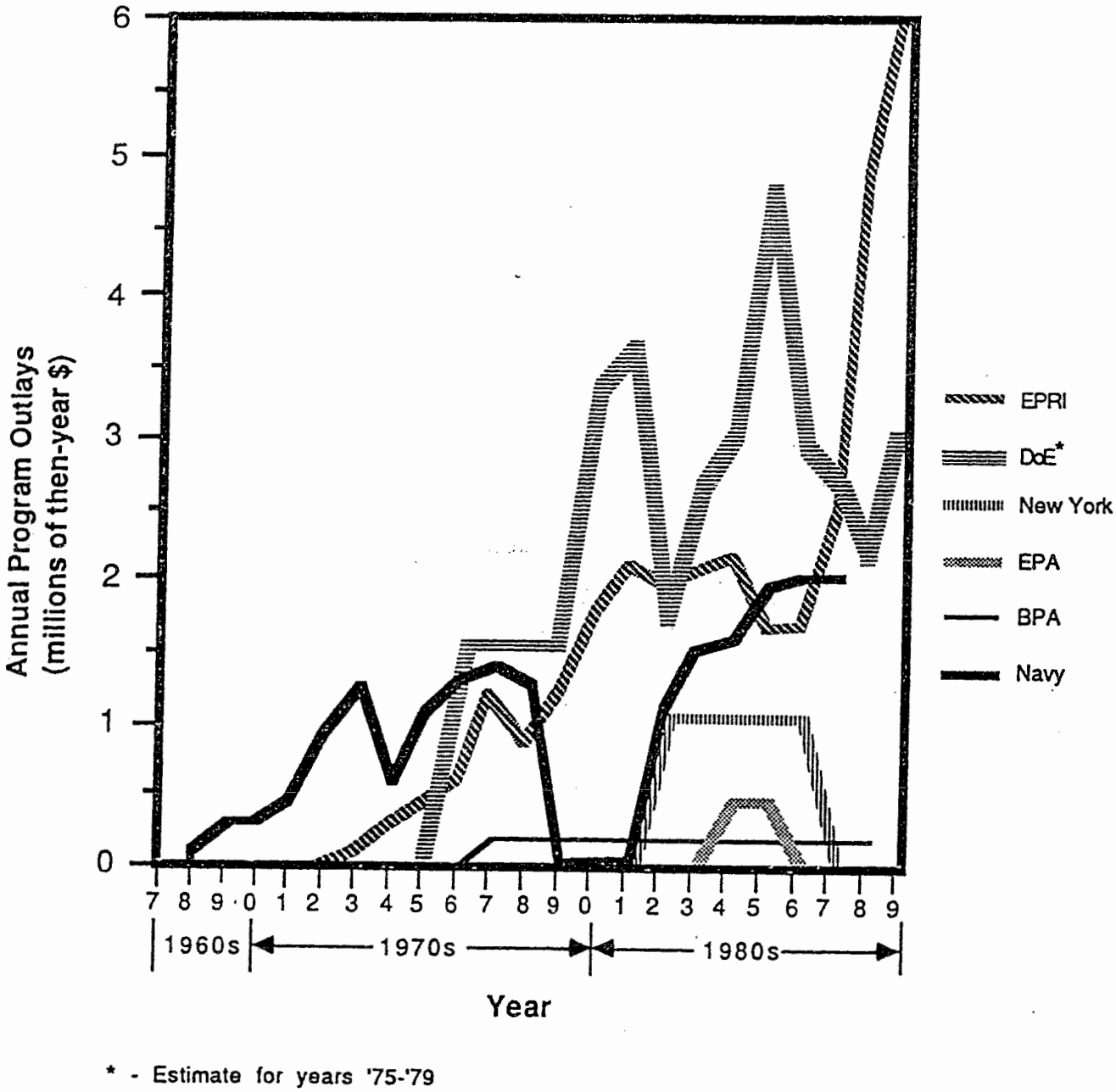
proportional to the number of persons exposed. In the case of distribution systems and appliances, they could be made "field free" at a modest cost based on earlier work done in 1984 at CMU.[55] However, the costs of entirely eliminating fields from most sources was larger than society seemed willing to pay.[56]

Although individually flawed, collectively the studies could not be ignored. Many scientists were not convinced of health effects and wanted more substantial evidence. However, by 1986 budgets within various US federal agencies for research on the health effects of NIR were being slashed reflecting the Reagan administration's civilian budget trimming. (See Figure 2-8.) Most of EPA's projects dealing with ELF fields were shut down in 1986.[57] The US DOE's budget dropped from a high in 1985 of $4.7 million to $2.7 million in 1986. (Even so, DOE continued to be the major source of PF field effects funding. EPRI was second, with $1.7 million budgeted in 1986.)[58] These cuts occurred after scientists had determined that the fields did have effects but before they could characterize and quantify the risks, if any, that were involved. If not for the NYSPLP program of research finally underway in 1982, there would have been little activity.

The NYSPLP Scientific Advisory Panel (SAP) Final Report, published in 1987, marked the first time that an impartial group of scientists had concluded that E/MF associated with transmission lines, especially magnetic fields, may be a hazard to human health and a factor in the cause of cancer and nervous system dysfunction.[59] In addition to evaluating previous scientific work, 16 biological and health-related studies on transmission line E/MF had been conducted.[60] The majority of the studies were negative with no effects on reproduction, growth, or development in isolated cells; a few did find effects including the possibility that magnetic fields might affect body rhythms.

One epidemiological study (by Savitz) was considered especially convincing, The case-control study reported a modest statistical association between exposure to E/MF from household wiring and distribution lines and childhood cancer in Denver.[61] The study replicated and improved on Wertheimer and Leeper's 1979 study and avoided most of the design flaws of earlier studies.[62] Although the RR = 1.5 was lower, the thoroughness of the study gave the findings greater weight. Still, exposure assessment, while improved, continued to be a major criticism and the number of cases was small.[63]

According to the SAP final report, magnetic fields from power lines, mainly distribution lines, could account for 10-15% of all cases of childhood cancers.[64] However a cause-effect link had not been established and information on population exposures was incomplete.[65] The link between adult cancer and power lines was left out because it was even more uncertain. (Another NYSPLP study found no association between adult non-lymphocytic leukemia and residential



* - Estimate for years '75-'79

Figure 2-8. History of funding for ELF bioeffects studies in the US from 1968 to 1989.

Reproduced with permission from US, Congress, OTA, Biological Effects, p. 70.

wiring configuration or residential field exposure.)[66] More research was recommended. As a result of the NYSPLP, transmission line levels of new high voltage lines in NYS were limited to those produced by 345 kV lines in operation for many years.

The NYSPLP findings generated headlines in newspapers all over the world. Public concern escalated. A flurry of regulatory and scientific activity began internationally. In the US, congressional hearings were held in 1987, the first federal forum to specifically address the issue of possible health effects from transmission line E/MF. Although the hearings were held too late in the Washington budget cycle to increase federal levels of spending in 1988, DOE and EPRI would continue to be the major sources of funding for research in North America, with EPRI substantially increasing its research budget from $1.7 million to $5 million. DOE spending would dip from a high in 1985 of $4.7 million to a low of $2.1 million in 1988.[67]

In the fall of 1986 when rumors began to circulate that Savitz' study would support Wertheimer and Leeper's earlier work,[68] the Canadian government set up a Working Group and made $50,000 available to Health and Welfare Canada (HWC) for research.[69] Ontario Hydro also expanded their research efforts.[70]

In addition, by 1987, several reports primarily based on census data had suggested that electrical occupations might have an elevated risk of leukemia and brain cancer. However, a large and comprehensive epidemiological study on occupational exposure had not yet been done.[71] These same cancers were specifically elevated in the childhood studies.[72]

The NYSPLP lent credibility to those few "dissenting" scientists who were outspoken about the possible health effects of PF E/MF. Throughout the history of the controversy, highly visible disagreements among experts, coupled with accusations of biased research agendas, had fueled concerns, particularly those of the public. Such expert disagreement was most often on display at public hearings and court cases concerning power line sitings. Less adversarial debate was also carried out, as usual, in scientific journals and at the two large scientific conferences where many scientists presented their latest research findings - the annual BEMS meeting and the annual US DOE/EPRI Contractors' Review.[73] These concerns were occasionally reflected and influenced by the media.

Some scientists continued to state that, on the basis of all the evidence, there were no health hazards or risk from PF E/MF exposure.[74] Conventional wisdom held that PF E/MF could pose no threat to human health because there was no substantial transfer of energy from PF fields to biological systems and because all cells in the body maintained large natural electric fields across their outer members. Furthermore, there was no large scale and obvious

public health effect associated with electrification.[75]

Another problem in deducing possible health effects from cellular effects was the lack of a theoretical model to explain and understand the detailed mechanism of interaction. This led some scientists to believe that a confounder was involved. Researchers began calling for whole animal experiments examining magnetic field exposure/cancer promotion to support or refute the epidemiology. An animal model was needed because of questions of dose-response relations, effects of frequency of field, and because possible questions of interaction between 60 Hz and earth's DC magnetic fields were not easily studied.[76]

By December 1988, several residential and occupational epidemiologic and laboratory studies sponsored by industry and government were planned or underway around the world to determine the mechanisms of interaction and effects, if any, of potential significance in terms of human health.[77] For example, Hydro Quebec, Electricite de France, and Ontario Hydro were co-sponsoring a $3 million epidemiological case-control study of electrical utility workers.[78] PF E/MF would be one of the risk factors examined in a $2.5 million US National Cancer Institute (NCI) study of the causes of childhood leukemia.[79] The NYS DOH was considering undertaking a major research program similar to the NYSPLP. (The question of who would provide funding was not resolved.)[80]

Work had begun on standardizing study designs and methodologies. The more recent studies had larger sample populations to account for low level effects and most were devoted to testing hypotheses. Exposure was measured more accurately, with recently available instrumentation for personal dosimetry of E/MF allowing examination of the assumptions made regarding exposure sources and improvement of the quality of surrogate measures.[81]

However, the ambiguity continued in studies completed since the NYSPLP. The pattern of lower or no risk reported by the better designed and executed studies continued, providing additional support for the possible role of PF E/MF in the etiology of cancer. For example, there was a consistent lack of evidence of adult acute leukemia risk from residential E/MF sources, including electric blankets, but a rather consistent suggestion of excess acute myelogenous leukemia and brain cancer from occupational exposures of electrical workers.[82] Yet, although the epidemiological studies covered a diversity of endpoints, they were of questionable quality.

Taken together, the results of the "hundreds" of studies conducted over the previous two decades throughout the world were inconclusive and few replications had been conducted. Several scientific reviews of the bioeffects literature concluded that no link had been established between E/MF such as those produced by transmission lines and adverse health

effects. However, they pointed out that some studies suggested the possibility of adverse effects and the need for long-term research to resolve the issue was universally acknowledged.[83]

Intensifying public opposition to new power line sitings in, for e.g., New York, Montana and Florida, and, to a much lesser degree, increasing concern about PF E/MF health effects in general from various other sources, including existing power lines, had placed pressure on government and industry. Public concerns had already stalled some transmission line projects and, in several states, health effects had become the central issue in transmission line site hearings.[84] Several court cases had been initiated in several states by the public against utilities based on potential and claimed health effects, and, by landowners in particular, based on perceived transmission line health effects.[85] Other less dramatic incidents were occurring all over the US.[86]

Although there had not been extensive media coverage, articles about PF E/MF health effects were increasingly appearing in reputable national publications and, in more recent years, on radio and television programs.

In response, regulatory agencies, standard-setting bodies, utilities, and school boards were struggling to make policies. (Neither the US nor Canadian federal governments had taken the lead.) There were two opposing views: enough evidence of potential health effects existed to precaution limited exposure or research must present proof of harmful effects before practical limits were determined.[87] Some governments, legislatures, and agencies were simply asking for literature reviews. Others were taking action by holding hearings, allocating or requiring funds from industry for further research, and issuing limits for power line ROWs.[88] A number of US states, including NYS, California, Washington, Virginia, and Florida, and at least one Canadian province were considering regulation of general public and occupational exposures to E/MF associated with power lines.

By December 1988, seven states already set limits on power line electric field intensity. (See Table 2-4.) NYS was the first state to consider restricting distribution line E/MF. No state has yet considered appliance fields.[89] US federal activity was directed towards possible power line standards through the EPA. The final report had been due in 1987 but they were still grappling with whether or not to recommend exposure limits.[90]. Canadian provincial and federal governments had not set any standards.

After the 1985 HL&P/Klein School court case, parents and school boards tended to be concerned about the siting of power lines near schools and visa versa. Concern continued to increase following the NYSPLP. By 1988, disputes had occurred in, for e.g., Arizona, Ontario,

TABLE 2-4

Summary of US Standards for
Transmission Line E/MF Strength

State/BPA	Electric Field		Magnetic Field	
	On Right-of-Way	Edge of Right-of-Way	On Right-of-Way	Edge of Right-of-Way
Florida	8 kV/m[1] 10 kV/m[2]	2 kV/m	—	150 mG (max. load) [1] 200 mG (max. load)[2] 250 mG (max. load)[3]
Minnesota	8 kV/m	—	—	—
Montana	7 kV/m [4]	1 kV/m	—	—
New Jersey	—	3 kV/m	—	—
New York	11.8 kV/m	1.6 kV/m	—	100 mG [5]
North Dakota	9 kV/m	—	—	—
Oregon	9 kV/m	—	—	—
BPA	9 kV/m 5 kV/m[4] 3.5 kV/m [6] 2.5 kV/m[7]	5 kV/m	—	—

1 For 230-kV or smaller lines.
2 For 500-kV lines.
3 For 500-kV double-circuit lines.
4 Maximum for highway crossings.
5 Proposed interim standard.
6 Maximum for shopping center parking lots.
7 Maximum for commercial/industrial parking lots.

Reproduced with permission from US, BPA, DOE, Electrical and Biological Effects, p. 58.

Alberta, NYS, and Florida.[91]

Concern continued to be raised by the public, government, and scientists over the credibility of health effects research conducted by electric utilities. As shown in Figure 2-8, most US research was supported by EPRI and DOE.[92] By 1989, EPRI would become the major source of funding at $6 million while DOE's proposed budget was $3 million.[93]

Furthermore, calls were being made for participation by US federal agencies whose missions concerned public health. Over the past decade, DOE had been the chief source of federal funding. The EPA Office of Radiation Programs had begun phasing out their entire NIR program.[94] According to some, without EPA, most of the work would be done by agencies with a stake in downplaying risks. There was disagreement over which federal agencies (EPA or the National Institutes of Health or NIH) should take over the major role.[95]

To date, little or no research had been done exploring the technical and economic feasibility of reducing or eliminating PF E/MF exposure, whether from power line or other sources. A small amount of work had been done on design strategies to reduce exposure at CMU in 1984 and EPRI in 1988.[96] One CMU researcher had explored the issue of product liability risk to manufacturers and how to motivate manufacturers to act.[97]

Most utilities and manufacturers had not acted to decrease power line fields on their own because no human health risk had been established.[98] However, a few utilities began to look for ways to mitigate fields in designing and siting power lines.[99] For example, BPA began to consider adopting a policy of "prudent avoidance" in 1987. At least one waterbed heater and one electric blanket manufacturer had also taken steps to reduce their products' E/MF.

By mid-1988, risk communication projects were underway to gain a better understanding of public perception of PF E/MF health effects and to develop communication tools to address those concerns. For example, the public's focus on high voltage transmission lines was felt misplaced because more recent studies had implicated an association with distribution lines and appliances. However, arguments that exposure from sources other than high voltage transmission lines was greater were not well accepted because of the conscious and voluntary nature of exposure.[100] By late 1988, CMU's Centre for Risk Perception and Communication was testing an experimental public information document.[101] (In 1987, CMU researchers concluded that risk managers had a moral obligation to communicate to the public the possible risks of PF E/MF but in the absence of clear evidence of health problems, such communication should occur only if people asked for information.)[102] Work sponsored by US DOE and by EPRI was also underway at CMU and private consulting firms to help utilities factor PF E/MF considerations

into the decision-making process.[103]

3.0 CASE STUDY[1]

A chronology of events before, during, and after the Courtenay inquiry is shown in Table 3-1. See Appendix B for a list of people involved in the case study.

3.1 Pre-Inquiry Events

Canadian Pacific Forest Products (CPFP) owns and operates pulp and paper mills throughout Canada, including a bleach kraft pulp mill near the village of Gold River. CPFP, along with its partners in the Gold River Newsprint Ltd. Partnership, wished to expand its Gold River operation at a projected capital cost of $323 million by adding a chemi-thermo mechanical pulp mill and a newsprint mill.[2]

A feasibility study by BC Hydro in 1987 determined that a 230 kV transmission line should be built along an existing ROW from Qualicum to Campbell River to provide power to the expanded operation.[3] (See Figure 3-1.) The three 138 kV transmission lines already on the ROW were capable of providing 40 megawatts (MW) of the 90 MW of power required by the mill.[4] (The proposed line was included in the Resource Plan submitted by BC Hydro to the BCUC in April 1988.)[5]

BC Hydro and CPFP concluded their discussions in the summer of 1987 and BC Hydro was committed to provide power by approximately July 31, 1989. The newsprint mill was scheduled to commence production September 1, 1989 for shipments in October 1989. The mill required the power by August 15 to meet break-in, production and shipment schedules. There was no time allowance for possible delays.[6]

In September 1987, Premier Bill Vander Zalm publicly announced the project, stating, "It's a great day for British Columbia and Gold River. Now the pulp and chips produced won't have to be shipped elsewhere to be processed. They will do it here and utilize B.C. labour and products." No government concessions or incentives were given to the company to encourage the development of the mill. CPFP proceeded with the mill expansion in the fall, using a "fast track" approach.[7]

BC Hydro used the approval granted for the existing 130 kV lines to begin the 230 kV project. They followed the normal review process, communicating with the appropriate federal and provincial government resource agencies, seeking the necessary government (including regional districts and municipalities) approval and advising them of the proposed construction.[8] None of the responses received raised health concerns.[9] Construction of the line proceeded as planned.

TABLE 3-1

CHRONOLOGY

1987 Summer	•BC Hydro begins construction of 230 kV transmission line along existing ROW from Dunsmuir to Gold River to provide power for CPFP pulp mill expansion.
1988 Mar	•BC Hydro receives formal notice of health concerns about the PF E/MF associated with the new line from Marton.
1989 Feb	•Unsatisfied with BC Hydro's response, Marton writes to Provincial Ombudsman. Ombudsman defers matter to BCUC and refers Marton to BC PIAC. •Kavkas file formal complaint with BCUC against BC Hydro regarding compensation for trees cut and PF E/MF health concerns.
1989 Apr	•After Darlene Kavka makes presentation about EMF health effects, C-S RD requests that BC Hydro reroute line. •CVRC formed. •Kavka makes presentations to Arden Elementary School Parents Group, and Comox Valley Teachers Association. Both request that BC Hydro reroute line because of possible health effects.
1989 May 8	•At meeting with Kavka, Marton and BC PIAC, BC Hydro offers to provide information on PF E/MF health effects. If concerns persist, BC Hydro will purchase the property of residents along the ROW.
May 16	•School District 71 delays expansion of Arden Elementary School until more information is received on health effects.
May 31	•Marino agrees to conduct a seminar for residents on EMF health effects. •140 people indicate interest in BC Hydro's buyout offer.
June 12	•BCUC orders that a public inquiry be held because of the amount of public concern about possible health effects. Line construction on hold.
July 11-14	•Public inquiry held.
July 27	•BCUC releases final report. Inconclusive evidence concerning PF E/MF health effects. Line not to be rerouted. Line construction to resume. BC Hydro to continue to honor buyout offer but acted "imprudently" in making it.

TABLE 3-1, continued

July 31	•CVRC blocks line construction on several properties.
Aug 9	•BC Hydro granted Supreme Court injunction.
Aug 12	•Darlene Kavka, only remaining protestor, camps out on ROW adjacent to her property.
Aug 15	•Wording of BC Hydro court injunction revised so RCMP can enforce.
Aug 16	•Kavka arrested.
Aug 19	•BC Supreme Court informs Kavka can do nothing unless new evidence on health effects.
Aug 20	•Kavka ends protest and construction proceeds on her property.
Aug 26	•Dunsmuir/Gold River 230 kV transmission line energized.
Nov 17	•71 property owners accepted buyout offer.

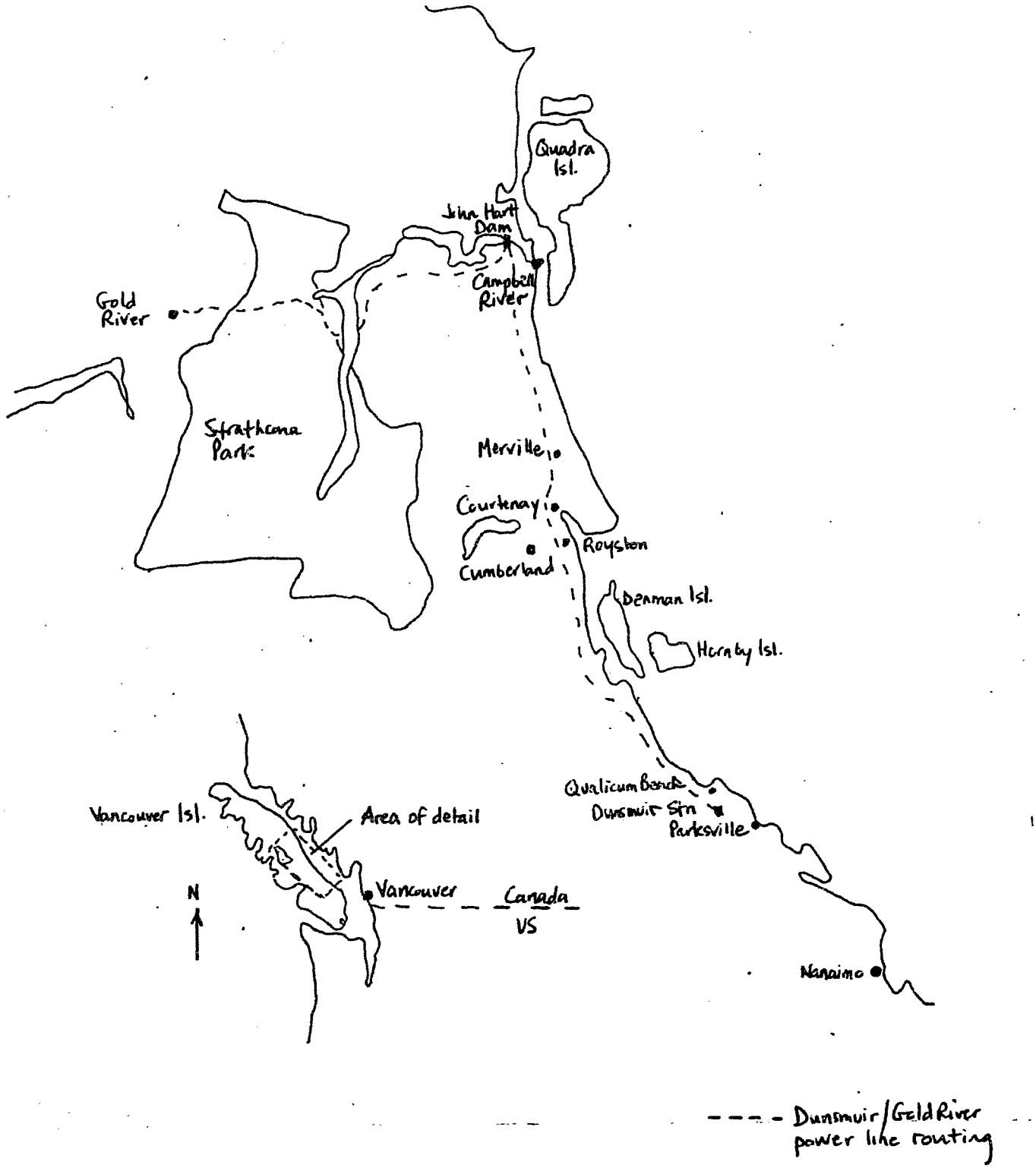


Figure 3-1. Area Map.

3.1.1 Emerging Concerns

All but 30 kilometres (km) of the 145 km Dunsmuir/Gold River transmission line passed through unpopulated areas. The most contentious portion of the seven km corridor through the Courtenay-Cumberland-Merville area would prove to be near Royston and Marsden Road.[10]

John Marton, Ph.D., a Courtenay psychologist, was advised by BC Hydro in September 1987 of the need to clear standing trees on his property. At this time, Marton raised concerns with BC Hydro about the possible health risks, in particular, of childhood cancer, from the increased PF E/MF levels resulting from the new transmission line.[11] On the suggestion of BC Hydro, he decided to pursue the health issue on its own, agreed to the clearing of trees, and accepted compensation for timber and damages.[12]

In February 1988, Lorne March, Ph.D., Director of Environmental Services, BC Hydro, told Marton that there was no proof of a causal relationship between PF E/MF and childhood cancers and therefore no action was required by BC Hydro.[13] He provided Marton with a 1987 literature review by the Ontario Ministry of Health (MOH), and the executive summary and table of contents from a 1985 literature review by the BPA. Both reviews concluded that there was no convincing evidence of a human health risk from PF E/MF.[14] March also provided Marton with calculations of the expected magnetic field levels on Marton's property, and any studies requested by Marton.[15]

Subsequently, Marton told March that proof of a causal relationship (the basis for the Ontario Hydro MOH conclusion) was not an appropriate criteria because proof in health effects was very difficult to find. Marton said that the research certainly indicated an association and felt that BC Hydro's position, as a crown corporation. was not a responsible one. March suggested that Marton write to Larry Bell, Chairman, BC Hydro.[16]

BC Hydro first received formal notice of health concerns in a letter from Marton to Bell dated March 16, 1988. Although Marton agreed (with March) that studies linking PF magnetic fields from distribution lines with childhood cancer had methodological problems, he thought it possible that the relationship was actually stronger (because of "type 2" statistical errors) rather than unlikely (because of "type 1" statistical errors). Marton was willing to accept a magnetic field level of 2.5-3.0 mG, but not the expected 10 mG level after the new line was complete. He requested compensation for the cost of moving.[17]

Bell referred Marton's letter to Tim Klassen, Vice-President Administration, BC Hydro, who replied on April 20. Klassen refused Marton's request for compensation, reiterated BC Hydro's earlier position, and stated that, in the absence of proof, they were "faced with perception of risk rather than known risk." A copy of an "open letter" to the public from David

Savitz, Ph.D., was included with Klassen's letter.[18] In the letter, Savitz stated that his study did not prove that PF magnetic fields caused childhood leukemia and that the question of a possible hazard had yet to be resolved. Interest or concern might be justified, but the study was "not sufficiently convincing to warrant drastic action by homeowners."[19]

Marton wrote Klassen on May 4 and cited a paragraph from the NYSPLP SAP Final Report stating that although there was no conclusive proof of a causal relationship between residential magnetic fields and certain childhood cancers, there was cause for concern. Marton asked on whom the burden of proof fell (the citizens or BC Hydro) and, if risk could not be assessed accurately, on whom the cost of minimizing risk fell (those close to the lines or shared among all users). On June 10, Klassen wrote Marton stating he saw "little merit" in continuing their correspondence and rejected Marton's assertion that BC Hydro was introducing fields of a potentially dangerous level.[20]

Marton wrote Klassen again on August 24 stating that electric blanket exposure was different from the constant total body exposure from power lines. He also wrote that assuming children exposed to 5-10 mG would have a 3-4 times greater than baseline rate for cancer and that there was a 1 in 60 chance that 1 in 3 children living under the lines for 14 years would develop cancer was as reasonable as assuming there would be no increase. He requested up to $20,000 in compensation but not necessarily on the basis of health risks if BC Hydro wished to avoid setting a precedent. Otherwise Marton would take BC Hydro to court. Alternatively, Marton suggested that BC Hydro reduce PF E/MF levels by burying or rerouting the line, or phasing the line currents. He gave BC Hydro until October 15 to reply.

On October 13, Klassen informed Marton that there had been no change in BC Hydro's position. On October 19, Marton wrote Bell and enclosed a sample of BC Hydro library's bibliography on PF E/MF health effects literature. Marton requested that Bell direct a review of BC Hydro's policy otherwise he would pursue the matter through legal channels. Bell replied on November 5 that BC Hydro had acted and would continue to act in a "responsible and pro-active manner." He suggested that Marton continue any further discussions with March.[21]

On February 5, 1989, Marton wrote to the Provincial Ombudsman seeking assistance in dealing with the matter. After discussion with the BC Utilities Commission (BCUC), the Ombudsman decided to defer the handling of the matter and similar complaints to the BCUC.[22] The Ombudsman also referred Marton to Richard Gathercole, Executive Director and General Counsel, BC Public Interest Advocacy Centre (PIAC).[23]

3.1.2 Increasing Concerns

By the end of January 1989, all but one property owner along the ROW had signed compensation agreements for timber and damages.[24]

On January 31, a BC Hydro crew began work at Frank Kavka's property despite his verbal objections. Kavka wanted a buffer zone of trees between his home on Marsden Road and the transmission line for health reasons. He first learned about the new transmission line in February 1988 when he received a phone call from Pat Beavan, Land Representative, BC Hydro, who informed him that his property would be surveyed. Beavan was unable to "guarantee" Kavka that the line would not pose a health risk to his family and, as a result, Kavka refused to give his consent for the line. Kavka "knew," having grown up in Eastern Europe, that high voltage transmission lines were a health risk.[25]

Frank Kavka also wanted more than the $2,000 compensation for timber and damages offered by BC Hydro.[26] Kavka wanted $10,000 to cover lost future yields of mushrooms and berry bushes.[27]

A Courtenay resident told the February 3 Comox Valley Free Press (Free Press) that the only way to fight BC Hydro was through media coverage. He had sold his property because of decreased market value and possible EMF health effects from the new line on his children. The Kavkas stated that BC Hydro refused to set up a trust fund in case of future health problems and that they could not afford a lawyer to fight BC Hydro. Peter McMullan, Corporate Communications Manager, BC Hydro, said that utilities could not stop operations until there was conclusive evidence of EMF health problems.[28]

On February 8, the Kavkas filed a formal complaint with the BCUC regarding their dispute with BC Hydro over compensation and raised concerns about PF E/MF health effects from the new line.[29]

By February, Darlene Kavka had begun to search for information on EMF health effects at local libraries and found very little. After locating a 10 year-old article by Becker and Marino reporting adverse effects on mice exposed to PF E/MF, she contacted Robert Becker, Ph.D., an orthopaedic surgeon and pioneer in the treatment of difficult bone fractures with electric currents to promote healing. According to Kavka, the first thing Becker said to her was "you've got a real problem on your hands." He also told her that "electromagnetic fields around high voltage transmission lines might be the most serious source of pollution in the world," gave her the names of scientists whose research supported his position, and suggested where she could locate relevant literature, including a transcript of the 1987 US House of Representatives subcommittee hearing on health effects of transmission lines.[30]

Kavka contacted the scientists and began to accumulate a number of scientific articles and reviews.[31] She thought it likely that many "other people were basing their decisions on incomplete facts" and was determined to bring the issue to the attention of others. About this

time, Kavka became aware of Marton and his dispute with BC Hydro.[32]

Darlene Kavka made her first public presentation to the Comox-Strathcona Regional District (C-S RD) board on March 28, stating that numerous health effects had been associated with high voltage power lines, including an "indisputable link" between "ELF electromagnetic radiation" and childhood cancer.[33] Kavka stated that, according to BC Hydro, homes within 90 to 120 metres from the existing and planned lines would have magnetic field readings of about 6 mG. The increased levels from the new line "could result in the Royston/Courtenay area seeing a childhood cancer incidence of between 2 and 5 children per thousand, as opposed to a 1-child-per-1000 incidence in the overall population. This means that within 2 years 2 to 5 children per 1000 could develop potentially fatal and avoidable cancers." According to Kavka, the researchers she had contacted by phone were "adamant that people take action to protect themselves." She also said that, in Europe, there were magnetic field exposure guidelines and people were not allowed to work under the lines.[34]

The C-S RD board voted 17 to 1 to write to BC Hydro requesting that new high voltage overhead transmission lines, including the new 230 kV line, not be routed through densely populated residential areas or near schools within the District, largely because of the suspected link between EMF and childhood cancer.[35] Written notice was sent to BC Hydro and the BCUC on April 5.[36]

On April 14, an article in the Record reported that, according to March, the bulk of the literature did not support a link between EMF and cancer and that there was no cause-effect relationship. Kavka told the Record, "No one can categorically say that overhead power lines will not cause childhood cancer." She also quoted Becker as having said that the most knowledgeable experts agreed on the link between ELF E/MF and cancer. The article cited Savitz' study and reported on remarks made by Dr. David Carpenter, NYS DOH, (the evidence for a correlation between residential magnetic fields and childhood cancer was too strong to pass off) and by Dr. Ross Adey, associate chief of staff for research, Veteran's Administration Medical Centre, (it was a "miracle" that so much had been accomplished in the face of inadequate research funding and disinterest, and even hostility from vested interests).[37]

3.1.3 Organized Concern

Darlene Kavka had begun to organize a committee (later known as the Comox Valley Rerouting Committee or CVRC) to "force" BC Hydro to reroute the new line.[38] She made presentations, on behalf of the CVRC, at the Arden Parents' Group and Comox Valley Teachers' Association. As a result, both groups and the board of School District 71 requested BC Hydro and the BCUC to

reroute the line. In particular, the board of School District 71 wanted the line routed away from Arden Elementary School which was 400 metres from the ROW.[39]

Kavka then set up public information booths in Washington Mall and made the information that she had collected available. Petitions were started and form letters were prepared to be sent to the BCUC and to Bell. By the first week of May, close to 100 form letters would be sent to Bell.[40]

According to the April 21 Record, most residents interviewed agreed that more research was needed, possibly conducted by BC Hydro. Most residents also agreed that the line should be rerouted before research results were available, especially if children were at risk. Others wanted results first. One resident thought that the "biddies" should "mind their own business and let progress take its course."[41]

An April 26 editorial in the Free Press commended the School District 71 for being prudent. The claims concerning transmission line "radiation" could prove to be legitimate or "hysterical." The lines could be another asbestos.[42]

McMullan told the Record on Apr 26 that BC Hydro was not considering rerouting the line. He also stated that the time for concerned residents to speak up was during initial meetings between BC Hydro and local government. [43] Darlene Kavka later told the Record that residents were unable to voice concerns during the planning stage because BC Hydro representatives came unannounced to the C-S RD board meeting last May. Furthermore, there was "absolutely no mention of the non-ionizing radiation."[44]

By early May, as construction of the line approached their property, many residents had become extremely concerned. Marton attempted to phone Bell and inform him that there was potential for civil disobedience (which Marton himself did not encourage) if BC Hydro did not address the residents' concerns. Chris Boatman, Vice-President of Corporate and Environmental Affairs, BC Hydro, returned his call and was "extremely helpful." Marton felt that Boatman was "committed to coming to a mutually acceptable solution to a very, very difficult problem." Boatman told Marton he would be in Courtenay within a week to meet with a group of residents and he would try to satisfy some of Marton's concerns.

By this time, Gathercole had contacted the Kavkas after Tom Thompson, Manager of Government and Public Affairs, BC Hydro, informed him that they were planning to place a second formal complaint with the BCUC requesting that the EMF health effects issue be examined in depth before BC Hydro was allowed to finish constructing the 230 kV line. Gathercole was in the process of preparing the Kavkas' complaint when BC Hydro suggested

the meeting.[45]

The Record reported on May 5 that, according to McMullan, BC Hydro was prepared to bring in experts to speak with the residents. The two experts would be March and William Bailey, Ph.D., of Environmental Research Information (ERI) Inc.[46] ERI is a New York-based consulting firm that specializes in reviewing, analyzing and conducting research on environmental health issues such as occupational health, microwave, radio frequency, video display terminals, and, infrequently, chemicals. ERI has conducted some research on the biological effects of PF E/MF and had been retained by utilities, public service commissions, public utility commissions and other state advisory bodies.[47]

The article also reported that although the debate about effects from power line "electromagnetic radiation" was "inconclusive," most researchers agreed that research should continue." Statements made by Carpenter in an article (the possibility of magnetic fields not being related to cancer seemed less likely with each additional study; the RRs reported by Savitz were similar to those reported for childhood leukemia in a home where one parent smoked) and by the NYS DOH in a brochure (an electric blanket's magnetic field was about four times greater than measured fields from distribution lines associated with higher cancer rates; scientists were unsure about the health risks of magnetic fields) were quoted. The Record concluded that any health risks were "certainly" related to long term exposure rather than one time or short term exposure.[48]

3.1.4 Buyout Offer

On May 8, an informal meeting was held at BC Hydro's office in Courtenay between Boatman, Thompson, Ken Curley, Area Manager, BC Hydro, and the Kavkas, Marton and their lawyer, Gathercole. BC Hydro maintained its position that there was no scientific evidence to indicate a conclusive relationship between PF E/MF and an increase in childhood leukemia, and offered to provide people living adjacent to the ROW with relevant scientific literature which could be used as a basis for their decisions regarding the possible risks. They would also, on request, provide further information and take field measurements, and have an expert available for discussions. If concern persisted about PF E/MF health risks, BC Hydro would negotiate the purchase of property at a "fair market value" determined by independent appraisers, one selected by the property owner and one selected by BC Hydro. Interested owners had until May 31 to register their requests.[49]

The buyout offer was made to Marton and the Kavkas on the condition that they not pursue their complaint to the BCUC. Marton immediately accepted the offer. However, the Kavkas had already (tentatively) accepted a private offer on their property. Frank Kavka

insisted that the offer be extended to other residents.[50]

The C-S RD was informed about the offer to purchase the following day at a meeting with Boatman, March, Thompson, and Jeff Barker, Project Manager, Transmission Projects, BC Hydro. March made a presentation on the PF E/MF health effects issue. Elizabeth Shannon, school board trustee, maintained School District 71's position that the line be rerouted away from Arden Elementary School.[51] BC Hydro stated that the line was being "pushed" through for economic reasons and that the line would not be moved because there was no substantial evidence that children had increased risk of cancer from elevated PF E/MF levels. BC Hydro's argument that people took risks when using a microwave oven was countered with the statement that people did so by choice. Kavka told the Free Press that BC Hydro made some "very inaccurate statements" at the meeting.[52]

On May 9 and 12, BC Hydro delivered or mailed letters to approximately 144 property owners adjacent to the ROW.[53] The letter stated that the NYS PSC report "summarized the findings of the wealth of scientific research conducted throughout the world over the past two decades. This research demonstrated that there [was] no reason to believe that exposures to electric and magnetic fields [posed] a risk to human health." The letter reiterated the agreement made at the meeting of May 8 and closed with, "To repeat, we believe that the enclosed material should allay concerns and alleviate the necessity for exercising this [buyout] option. However, we are sensitive to the feelings of owners when issues such as this are raised and wish to leave the decision up to each person."[54] A "background report" on the PF E/MF health effects issue prepared by ERI and the executive summary of BPA's literature review were included with the letter.[55]

ERI Background Report

The "Background Report on Health Issues Associated with Exposure to Power Frequency Electric and Magnetic Fields," was prepared on "very short notice" in response to one of BC Hydro's first requests for information. The report cited the findings of six "non-adversarial" panels: the 1987 NYSPLP panel; the 1985 Florida E/MF SAC (a "blue ribbon" panel) on PF E/MF health effects; the 1979 AIBS and 1985 NAS panels on project ELF; and the 1984 and 1987 WHO panels on the generic question of EMF. A number of studies on "community epidemiology" were reviewed. In particular, the results of Wertheimer and Leeper's 1979 and Savitz' 1988 studies were questioned because of surrogate exposure measurements. Several other studies were cited which failed to find PF E/MF health effects.

A number of laboratory studies were reviewed and the difficulty of extrapolating such findings to humans was discussed. The report stated that any significant effects were found at

PF E/MF levels much higher than those expected from the Dunsmuir/Gold River lines and that no dose-response relationship had been shown. The report also stated that there was no evidence of transformation to a cancerous state issue and discussed in detail the various stages of cancer. It was noted that the Soviets reported in 1980 that their initial concern about PF E/MF health effects had been overstated.

Several quotations from the NYS PSC were made, including their assertion that magnetic fields had not been shown to be hazardous and the rationale for their 765 kV transmission line PF E/MF standards.

The ERI report then concluded, "The New York [PSC's] statement succinctly [summarized] the findings of the wealth of scientific research conducted throughout the world over the past two decades. This research demonstrated there [was] no reason to believe that exposure to electric and magnetic fields [posed] a risk to human health. These data should reassure the public that transmission lines [did] not jeopardize the health of those who reside in their vicinity."[56]

The Kavkas were elated over BC Hydro's buyout offer. An editorial in the Record commended BC Hydro for their action.[57] The utility industry had never made such an offer before. Darlene Kavka received calls from citizen groups with similar concerns in New York and Ontario.[58]

TDHSR contacted several utility representatives for reactions to the buyout offer. Most had heard of the offer; of those who agreed to comment, most expressed reservations about the wisdom of the move. Neither Ontario Hydro (the offer was impractical) nor TransAlta Utilities Corporation (the offer was unjustified) intended to follow a similar course of action.[59] Boatman told TDHSR that the offer was "a reaction to a situation that had gotten out of hand." It "defused... a very emotional issue." In the future, BC Hydro would be more aware of "public perceptions." They had not determined whether such an offer would be made in other cases. According to McMullan, it "certainly " did not apply to existing lines.[60]

Darlene Kavka told the Free Press that BC Hydro's information package would be biased. The article reported that Kavka had found studies during the past six months indicating a high incidence of childhood leukemia along high voltage power lines in the US. Some studies suggested that elevated EMF levels increased tumor growth rate and might weaken body immune systems. Kavka stated that she would not live by the line because her son was "five times more likely to get cancer." Kavka recommended that residents who could "see the line should check it out" and expressed concern about remaining and future property owners.[61]

Kavka also told the Free Press that PF E/MF level would increase 600% with the new line and even higher during peak consumption periods.[62]

3.1.5 Extreme Concern

Although the buyout proposal was designed to defuse the situation, it was interpreted by many people as clear evidence that BC Hydro recognized a PF E/MF health risk. The media highlighted the unusual proposal and it drew substantial publicity. The majority of property owners to whom the proposal was made were confused about the health effects issue and were forced to make important decisions on short notice using conflicting information and hearsay. They were also confused about the eligibility criteria[63] and conditions of the buyout offer, including its deadline. Not all owners whose property was adjacent to the ROW received the letter. Some owners who were not adjacent to the ROW (and did not receive a letter) were closer to the ROW than their neighbors who did receive letters. A few owners who did not receive letters contacted BC Hydro regarding the proposal and received no reply. Many owners thought they had to decide to accept the buyout offer by May 31, rather than simply register their interest. A number of residents approached the BCUC and expressed their concerns.[64]

BC Hydro placed a notice in local papers stating, "If you own property adjacent to or near the transmission line right-of-way, and you wish to know more about the effects of the line on your property, please call Ken Curley... toll free."[65] Residents, unable to reach Curley, contacted Darlene Kavka for more information. She was inundated with calls up until a few days past the deadline and again after a headline article appeared in the Free Press. Kavka assisted residents by composing and typing letters in reply to BC Hydro's offer.[66]

On May 16, the school board voted unanimously to delay a $1 million expansion at Arden Elementary School until more PF E/MF health effects information (concerning both children and employees) was received.[67] Darlene Kavka told the board that BC Hydro had taken a reading 40 times higher than the any of the figures subsequently released. However, she conceded that a number of readings must be taken over a period of time to obtain accurate results.[68] Shannon stated that she would not accept BC Hydro's self-monitoring of "its own pollution." The board also agreed that BC Hydro should fund an independent study to monitor PF E/MF levels within the school.[69]

A May 19 Free Press editorial commented that School Board trustees knew it was "politically smart... to be concerned with health and environmental issues." Also, even one case of leukemia would result in a "big lawsuit." Imagine how long people would live without pollutants and food additives given that lifespans in "western, industrialized, polluted" countries [had] never been higher." Did the "local committed environmentalists and 'health' addicts really practise what they preach."[70]

An editorial in the May 24 Free Press questioned "just how flexible must a society become

in order to accommodate all the divergent opinions to be found within a democracy?" Ecological considerations could never be adequately addressed. The correlation between childhood leukemia and transmission lines was only a theory. School District 71 could not be blamed for putting construction at Arden Elementary School on hold until it received safety assurances because of possible litigation but how could BC Hydro provide such an assurance?[71]

By May 26, BC Hydro had received 25 buyout requests. McMullan told the Free Press that the available scientific data on PF E/MF effects suggested there was no reason for that "amount of concern - what we're dealing with now is people's emotions." While agreeing that some data indicated otherwise, "Nobody has yet come down hard and fast with conclusive proof" about serious negative side-effects. People requesting the buyout would be advised to discuss it with a lawyer and real estate appraiser. There was no firm closing date for sales.[72]

Chris Hilliar, a Courtenay resident, in a letter to BC Hydro requested that the line be rerouted because the buyout was "a short term solution to a long term problem." Hilliar no longer felt that his home was a safe environment for his children. He was concerned that his children would receive a "second-class education" because, unless BC Hydro could disprove the possibility of health hazards, the Arden Elementary School expansion would not be built. Hilliar suggested that land sales and development of the existing ROW could help offset the cost of rerouting the line.[73]

At a May 29 C-S RD meeting, Hilliar, representing residents living near the line, said that BC Hydro was misleading residents in its buyout letter. The NYSPLP report had concluded there was a possible association between PF E/MF and childhood cancer and Washington and Oregon were considering moratoriums on the construction of high voltage power lines. Hilliar suggested the board write BC Hydro requesting that present and future lines be routed away from populated areas. He also requested that the board write the BCUC for information on its health standards and establish a "planned use policy" within the C-S RD. Board member Peggy Carswell noted that not all residents were satisfied with BC Hydro's offer; in the past month, she had received many phone calls on the issue, including requests from several delegations wishing to make presentations to the board.[74]

Darlene Kavka had contacted Marino who agreed to meet with residents for a one day seminar in mid-June provided his US $1,500 per day "travelling expenses" were covered.[75] By the end of May, Gathercole, now representing the CVRC, was negotiating with BC Hydro to bring in Marino, an "authority on EMR" (according to the Record), to speak at Arden Elementary School.

BC Hydro would decide after all the buyout requests had been examined.[76] According to Kavka, BC Hydro had offered at the May 8 and 9 meetings to pay for an expert chosen by the residents.

Marton, aware of the disagreement among scientists on the issue, was against bringing in Marino because, if the discussion "got into scientific expertise," the residents' "point of view" would be "muddled." Marton preferred to focus the discussion on "what form of risk was acceptable" and "whether BC Hydro had any responsibility, given that the risk was unknown." According to Kavka, Gathercole was also not in favor of bringing in an expert.[77]

Andrew Marino, a biophysicist, has his B.Sc. in physics, M.Sc. and Ph.D. in biophysics, and J.D. in law. He is a professor in the Department of Orthopedic Surgery and Department of Cellular Biology and Anatomy, Louisiana State University (LSU) Medical Centre. Marino is the chairman of the Louisiana State Medical School Institutional Review Board for Human Research and an associate professor in the Department of Bio-Engineering, Louisiana Technical University. He is also the president of the International Society for Bioelectricity, a member of three other bioelectricity-oriented scientific groups, and editor of the Journal of Bioelectricity.[78]

Marino was an associate of Becker's at the Veteran's Administration Medical Centre in Syracruse, NY, from 1964-1981. He has investigated the use of electrical energy to treat or cause disease in animals and conducted clinical studies in which electricity is applied to humans for therapeutic purposes. His studies have linked PF E/MF exposure to abnormal growth in laboratory rats and mice and linked living near power lines to suicide in humans. Marino has published two books, and about 60 papers and 20 abstracts, editorials and replies on the subject of EMF health effects.

Marino has testified as an expert witness on the EMF health effects issue numerous times, beginning in 1977 when he testified, along with Becker, on behalf of the NYS PSC, that PF E/MF was a health risk and industry-sponsored research was tainted. Since then, he has testified several times PSCs (including NYS and California) but generally on behalf of the people themselves. Marino has also published a third book which deals with the politics, particularly in New York State, of the EMF health effects issue.[79]

In late May, the Merville Environmental Committee (MEC) learned from a newspaper article that they were "eligible" for BC Hydro's buyout offer.[80] They too were concerned about possible health effects and decreased property values. Although BC Hydro was now mainly dealing with owners whose property was either adjacent to the ROW or came within 50 meters of the line (most of the Merville properties were further away), they agreed to take PF E/MF

measurements and might allow some leeway with the buyout deadline.[81]

A May 31 article in the Free Press reported that several residents were upset about moving but were doing so as a precautionary measure. Joiner did not want to take the "1 in 1000" chance that his child would get cancer.[82] He felt that BC Hydro was trying to "pass off" residents as "a bunch of environmentalists." When it came to "people and children," companies should consider more than profit. Another resident did not feel "comfortable" about the 230 kV line, "600 times greater that the existing 130 kV line."[83]

By May 31, BC Hydro had sent out 144 buyout letters and received 153 responses. Ninety per cent of the responses indicated an interest in the purchase offer.[84]

McMullan told the Free Press that there was "a level of hysteria surrounding the issue and some people have been stampeded into making a hasty decision." BC Hydro believed that after some careful thought, homeowners would change their minds and was asking those who had accepted the offer if they were certain they wanted to sell. BC Hydro also planned to give residents additional information on PF E/MF health effects. According to the Record, BC Hydro was still considering bringing in an outside expert selected by BC Hydro.

McMullan told MWN this was the first time BC Hydro had encountered the PF E/MF health effects issue. BC Hydro had determined which properties would have greater fields when the new line was energized. Darlene Kavka said that, according to BC Hydro, the magnetic field level in her home woul be between 2.5 and 6 mG.[85]

In a May 29 letter to Marton, Brian Phillips, Director, Radiation Protection Services, BC MOH, advocated continued research to better define EMF issues "so that the risks [could] be placed into proper perspective with other risks that the public deals with." (In general, the few people who had contacted the MOH with their concerns about PF E/MF health effects were referred to the BCUC.)[86]

BC Hydro had arranged for Radiation Protection Services, BC MOH, to measure PF E/MF levels at Arden Elementary School. Measurements were conducted by May 27.[87] In a June 6 letter to School District 71, Phillips wrote that the PF E/MF levels were similar to typical fields elsewhere in Courtenay and from typical household appliances. "The health effects of exposure to electromagnetic fields at the levels anticipated, as well as those presently occurring, have not been shown to exist." He predicted that the levels from the new line would be of little significance at the school site or other locations, but added that another survey should be done when the new line was operational.[88]

By this time, the Kavkas had spent $6,000 gathering information on EMF health effects[89] and were "financially strapped." Karen Walsh, who had recently become involved with the CVRC because all the relevant information held by the Courtenay library had been signed out, suggested that the CVRC solicit donations to bring in Marino, offered her home as a resource centre for residents, and became treasurer of the CVRC.[90]

On June 7, the Free Press paraphrased Savitz' open letter; a copy had been provided by BC Hydro. March told the Free Press that Savitz had told him, during a telephone conversation the previous week, he had "sufficient uncertainty of this work" and that people should not take action based upon it.[91]

Bud Jacobs, senior linesman and Port Hardy alderman, was appointed as local contact for BC Hydro in the Comox Valley to take calls about the new line, buyout, and health effects.[92]

3.1.6 Public Inquiry Ordered

On June 12, the BCUC ordered that a public inquiry be held in Courtenay July 11 and 12 because of public concern over EMF health effects. Particular concern had focussed on the possibility of long term health risks, including cancer, especially in children. This was the first time the BCUC had such a large number of complaints, having received "many" letters and more than 40 phone calls, including several inquiries made by the BC PIAC on behalf of the Kavkas.The BCUC felt that many of the people's concerns were fueled by misinformation and lack of information, and wanted to ensure that the issue was "out in the open" so people could judge for themselves.[93]

The BCUC also ordered that construction halt on the section of the line through the Courtenay-Cumberland area until the BCUC resolved the complaints. For the first time in BC, a major utilities project had been put on hold because of public pressure. BC Hydro's buyout offer was also put on hold.[94] The terms of reference of the inquiry were:

- Determine the need, routing and timing for the project;
- Review the process followed with respect to the environmental assessment of the project and identify any appropriate mitigation measures;
- Determine the levels of electric and magnetic fields associated with the new line, and assess the impact of these on the current fields created by the existing 138 kV line; and
- Address the health related concerns as expressed by property owners impacted by the new line, respecting biological effects of the electrical and magnetic fields generated by the line.

John McIntyre, Chairman of the BCUC, was appointed to chair the inquiry with the assistance of Commissioner Milt Swanson, QC, and staff members Bill Grant, Director of Engineering and Accounting, and Neptune Smith, Manager, Engineering and Project Review - Electrical.[95] Karl Gustafson, of Lane, Mitchener, Lawrence and Shaw, was appointed as BCUC counsel. McIntyre would work with BCUC staff and develop decisions and/or recommendations, and present the inquiry findings and recommendations to the BCUC "as a whole" for approval. Swanson and the other two full-time Commissioners would have "some" input while McIntyre defended his report.[96]

Gustafson, as BCUC counsel, was reasonable for ensuring that the "hearing" moved along smoothly and stayed on track, and for handling the "timing concerns." He would talk with all parties frequently, including the lawyers (sometimes in conference), so that each party who wished to make a case would have "fair opportunity" to get on "the record." In addition, he would try to make certain that the evidence received was as unbiased and objective as possible through his cross-examination of witnesses.[97]

Notice of the inquiry appeared in several newspapers; BC Hydro had been ordered to arrange for publication. Announcements were made on the local radio station and posted on community bulletin boards. Relevant documents were filed in the local library and at the C-S RD office. The public could call the BCUC collect or toll-free.[98]

BC Hydro and concerned citizens cheered the announcement of the inquiry. However, the project director at the Gold River pulp mill thought that the issue had been dealt with. The consequences of the delay in line construction were "quite severe."[99]

McMullan told the Free Press that BC Hydro would not discuss the new line with Courtenay residents until the BCUC issued its report. Any queries would be directed to the BCUC. (The decision was not a requirement of the BCUC.) One previously scheduled presentation would still be held.[100]

An article in the Vancouver Sun cited a 1982 study by Milham which "showed power station operators had 2-1/2 times the death rate from all types of cancer" and noted that Boatman had said, on a radio talk show last month, that two decades of research had shown inconclusive results.[101]

On June 16, an informal meeting (called the previous day) was held between a number of concerned citizens and BCUC personnel to discuss public participation at the inquiry and to hear the issues that would be raised. Those attending included Marton, the Kavkas, Kevin Keys, a

regional planner, Carswell, Grant, Smith, Swanson and Gustafson.[102] Carswell questioned the procedures used by BC Hydro to inform the C-S RD board about the line. Furthermore, BC Hydro had presented (at the May 1988 meeting) disputes over tree-cutting as the major issue which "clearly wasn't the whole story." Concerns were also raised about the ROW being located on an earthquake fault and about the limits that BC Hydro's easement placed on the residents' use of their own land.[103]

Darlene Kavka asked the BCUC how the costs of expert witnesses would be covered, and pointed out that BC Hydro could better afford to do so. The BCUC responded that they were aware BC Hydro could "overwhelm them with technical studies" but the experts could submit written evidence rather than testify in person.

Darlene Kavka later told the Free Press that one of the major questions the CVRC wanted answered was who would be held liable when health problems occurred. The CVRC planned to discuss the matter with the BC PIAC and the West Coast Environmental Law Association.[104]

School District 17 trustees decided to keep the Arden Elementary School expansion on hold, at least until the inquiry was held. Concerns had been raised about the "looming deadline" for the expansion and about reduced school enrollment because of residents with children selling their property.[105]

Marino would lecture on the biological effects of EMF exposure on the afternoon of July 11, followed by a question and answer period. He might also testify at the inquiry. Frustrated with BC Hydro's "stalling tactics," CVRC members had pooled their money and begun raising funds to bring in Marino for 4 days. Some members believed that BCH reneged on their offer to bring in an expert selected by the residents specifically because Marino had been chosen.

Over $ 5,000 of the $10,000 that the CVRC needed to pay for legal and travel expenses was raised through methods such as bottle drives, neighborhood canvassing (about 120 families had made donations) and a telephone blitz of local businesses (which raised $1,000). A flea market would be held the following weekend. Donors would be assured of a seat at the free lecture. [106]

On June 26, the C-S RD board wrote the BCUC informing them of the Merville residents' wish to have the new line rerouted away from schools and residences. In addition to their submission to the C-S RD board, the MEC had requested support from Hagen, contacted Jack Davis, BC Minister of Energy, Mines and Petroleum Resources, contacted BC Hydro, and requested (on June 13) that the BCUC include them in the inquiry. Their request that the BCUC include the

Merville area in BC Hydro's stop-work order was rejected (by June 26) because the "hearings" were then less than two weeks away. The Merville area was not included in the original order issued by the BCUC because letters of concern from Merville residents had not been received earlier. However, residents accepted the BCUC's invitation to participate in the inquiry.[107]

BC Hydro was requested by the BCUC to provide the following information:

- Was the EMF concern discussed with the BC MOH?;
- Demonstrate that the best possible route was selected. Describe the "next best route" if the disputed segment was bypassed and include a capital cost breakdown;
- State BC Hydro's policy with respect to EMF considerations adjacent to a ROW;
- Was BC Hydro contributing to any ongoing EMF research?;
- Provide a synopsis of meetings and discussions BC Hydro or its agents had conducted with residents along the proposed route on EMF health-related concerns;
- File all technical or other information on which BC Hydro based its assessment of the EMF issue, with special focus on biological effects;[108]
- What selection criteria were used by BC Hydro to determine residents' eligibility for the buy out offer? If any residents less than 20 metres from the ROW were not sent a letter, explain why;
- Provide an example of a typical ROW agreement for property owners along the ROW and identify any existing anomalies;
- Describe how BC Hydro would provide arbitration and resolution of land disputes (clearing and compensation) outside of the Utility Commission Act;
- Provide a list of all residents in the area who had contacted BC Hydro on EMF-related health concerns association with this line; and
- Identify personnel to be used in the inquiry, including external consultants.

BC Hydro's response was required no later than July 4 because of the "in service" requirements of the line.[109] The inquiry would be continued to July 13 and 14, if additional time were required. Also, because of the time constraints imposed on residents, the BCUC had extended its July 7 deadline for written submissions.[110]

The CVRC decided to approach the press after Paul Brodeur's series of articles titled "Annals of Radiation: The Hazards of Electromagnetic Fields" appeared in The New Yorker.[111] According to Walsh, "None of us wanted to, but it helped and, during the inquiry, we felt the public's support." Gathercole disagreed with bringing in the press.[112]

At a July 4 local press conference in the home of a CVRC member, Darlene Kavka

presented the results of a health survey the CVRC had conducted of 120 adults and 103 children (or 62 of 257 families) whose illnesses had started or worsened since moving to the Marsden Road area. Residents had a "significant number" of physical ailments including migraines, Crohn's disease, allergies, miscarriages and abnormal births, menstrual cycle irregularities, and cancer. Kavka admitted that the survey was not "scientific."[113]

The CVRC also told the press that BC Hydro had been less than forthright in explaining the potential health hazards of the transmission line's magnetic field. BC Hydro's own literature hinted at the possibility of an increased incidence of leukemia in people living within 300 meters of such lines. The CVRC said that although studies had not necessarily confirmed Wertheimer and Leeper's' 1979 study, neither had they shown conclusively that exposure would not harm one's health. Darlene Kavka stated, "We are not radical people, and we're not trying to hurt anyone. But we feel as if we're part of a massive experiment, and we choose not to be experimented on." Walsh said, "From May 12 to June 15, I repeatedly tried to get BC Hydro to answer questions about the effects of the electromagnetic field. I wanted to know if it was safe. I wanted reassurance. They couldn't give it."[114]

On July 5, Gathercole and Vance instructed 38 members of the CVRC on how a public inquiry functioned and on how best to present arguments to the BCUC during the inquiry.[115]

By July 8, the BCUC had engaged "expert advisor" Richard Gallagher, Ph.D., BC Cancer Control Agency (BC CCA), to "assist the public" in the review of the technical information and studies relating to PF E/MF. He was a "well-known" scientist and epidemiologist active in the PF E/MF field.[116] Gallagher would advise on the strengths and weaknesses of the various epidemiological studies, in comparison with the "pronouncements from both sides.[117]

An "independent expert" was hired because although the BCUC was fairly sure that the inquiry would be "balanced" they were "not sure enough."[118] (Marino's position had been anticipated on the basis of transcripts of his testimony in other situations. The position of BC Hydro's experts was anticipated on the basis of their prefiled evidence and conversations with BC Hydro's counsel, Ken MacKenzie, Guild, Yule and Co.) Gallagher would only "take the stand" if the testimonies were "terribly out of balance." In addition, because much of the evidence was technical, he would help analyze the information, and help the BCUC ask the right questions so that the "record would be complete."[119]

Linda Erdreich and Antonio Sastre, both of ERI, would act as expert witnesses for BC Hydro at the inquiry. Neither had testified as an expert witness before. Erdreich, an epidemiologist with a B.A. in biological sciences, M.Ed. in science education, M.Sc. in biostatistics and

epidemiology, and Ph.D. in epidemiology, has been a senior research scientist with ERI since April 1989. Her work is in the review and evaluation of studies; she has conducted no research on PF E/MF health effects. Erdreich is a member of several societies including the American College of Epidemiology, the Society for Risk Analysis, and the Sigma XI Scientific Research Society. Previously, Erdreich was senior epidemiologist at Clement Associates and performed public health evaluations for hazardous waste sites and for incinerators. She was a group leader, US EPA, Office of Research and Development, of the Methods Evaluations and Development staff, managing a group that developed [risk] assessment methods and guidelines. Erdreich has served as a reviewer and scientific advisor concerning health risk assessment issues for industry and government agencies, and lectured to professional groups or organizations numerous times. She has published a number of articles in a variety of scientific journals, written chapters in books, and served as an editor for proceedings published from scientific conferences.[120]

Antonio Sastre, a laboratory scientist, has a B.A., M.S., and Ph.D. in applied mathematics and neurobiology. He was a post-doctoral fellow in neurobiology and pharmacology at Cornell University. Sastre has been a senior research scientist at ERI since 1988 and is an adjunct associate professor, Department of Pharmacology, Cornell University Medical College. He was an associate professor, Department of Neuroscience, John's Hopkins University School of Medicine. Sastre's general area of expertise is in the electrical properties of cells from the nervous system, heart, and blood vessels (at the whole animal, cell, and molecular level). He has analyzed and evaluated responses of biological organisms to AC E/MF. Sastre has studied the interaction of one of the key stress hormones, cortisol, on the nervous system. Sastre has published about 20 research articles (in peer review journals) on the physiology and pharmacology of electrical excitability. He has written two chapters in research monographs and co-authored a chapter in a widely-used textbook on medical physiology. He is on the editorial boards of two journals, the American Journal of Physiology: Cell Physiology, and Blood Vessels. Sastre has served as a reviewer of research grant proposals submitted to the US NIH, the NSF, and the American Heart Association.[121]

A public information session was held by the BCUC during the morning and afternoon of July 11.BC Hydro and the BC PIAC were not invited to attend.[122] Smith and Gallagher "did a very fine job" explaining "why they were there" and what questions would be asked. Gustafson outlined the inquiry procedures and informed the public of their rights. There was "very high emotional pitch" and a "tremendous outpouring of emotion" from the people. They spoke out very strongly, fearing that the "hearing" would not be fair or impartial, and would "whitewash" the issue. Some were angry, even physically upset to the point where they were

shaking and almost in tears. BCUC staff listened to the people's concerns, told them they understood, and suggested how they could explain their concerns at the inquiry. During the meeting and after, Gustafson spent "long hours" helping people write their presentations and formulate questions. He listened to their concerns and helped them "talk out their frustrations." "Historical beefs" against BC Hydro were "weeded out" and, in some cases, rectified outside of the inquiry. It was "not easy to deal with the questions and answers."[123]

Ross also attended the meeting. According to Ross, he tried to broaden the issues to include sources of PF E/MF other than power lines. However, the BCUC's only mandate was to "get the line in," rerouted or not.[124]

More than 150 people attended Marino's 2-1/2 hour lecture. According to the Free Press and the Record, Marino stated that transmission line EMF played a significant role in causing illness and could cause genetic damage. EMF acted as a stressor on the body and disease occurred when the system was "overloaded." Numerous studies, including Marino's, had shown that constant exposure to high EMF, such as those from transmission lines, produced birth abnormalities in laboratory animals, changes in blood protein, and changes in brain activity. He cited studies reporting greater incidence of leukemia among workers exposed to EMF and linking spontaneous abortions to electric blanket use. Marino said that BC Hydro's proposed line would generate an EMF 100 metres wide on each side of the ROW. "An EMF will go through everything. There is a health risk." In addition, Marino said that experts had already proven that EMF increased the likelihood of illness, but utilities and the military didn't want people to know. Utility companies compounded the problem because they wanted to put their lines in as cheaply as possible.

Representative(s) of BC Hydro who attended the lecture (described by one as a "love-in") did not participate in the discussion that followed Marino's lecture.[125]

On July 11 (prior to the start of the inquiry), BC Minister of Health Peter Dueck commented in the BC legislature on PF E/MF health effects."There [was] no conclusive evidence [of a health hazard] either way."[126]

In the BC legislature on July 12, Anne Edwards, MLA, Kootenay, asked Davis about the PF E/MF health effects issue. Davis stated, "The jury [was] out... with the scientific community, and regulatory bodies and electric utility companies around the world [were] carefully monitoring studies... in progress." He did not envy the BCUC chairman his job. "He's going to have to have the wisdom of Solomon to deal with the issue, because if... there's a problem, it's not confined to that area. It's many places in the province, many highly developed urban areas worldwide." Edwards stated that the "implications to BC Hydro and to the public

purse... or certainly to the public utilities' and Crown corporations' purses - are going to be horrendous."The legal ramifications could be great.

Edwards asked Davis to consider involving BC Hydro in a study (at arms length preferably) because the situation in BC might be different from elsewhere. Davis replied that the issue was a matter of human health and he was in no position to express an opinion. However, both the BCUC and BC Hydro were following the issue. BC Hydro was also "doing some work." Fortunately, to date at least, the health effects of power line magnetic fields [were] nothing... as consequential as the effects of gasoline or a number of other commodities that [were] commonly sold around the province." If at some point there was reason to carry out an unique BC health study, he was sure that either "Health or perhaps Hydro" would address it.[127]

On July 12, Courtenay council refused the CVRC's request that they support efforts to have BC Hydro reroute the local section of the new line. The one council member who supported the request said it would make far more sense to reroute the line now, even though the jury was still out on the health question, than to have to relocate it later if further research bore out the concerns. An alderman argued that all taxpayers would have to bear the costs of relocating the line and, for council to request rerouting would be just as unreasonable as the Lower Mainland mayors who wanted a natural gas pipeline rerouted away from the Coquitlam watershed.

Council also rejected supporting a bid to request that BC Hydro pay the cost of Marino's visit. Hilliar, representing the CVRC, suggested that BC Hydro build the line on the opposite side of Cumberland through largely undeveloped land. He also said that several countries had already established "health standards" for the siting of high voltage lines.[128]

An editorial in the Record, commenting on Council's decision, stated that caution was warranted even though further research was required. "Have we learned nothing from the horrors of thalidomide, DDT, dioxins, nuclear energy and the like?"[129]

3.1.7 Written Testimony

The following summarizes the written testimonies of BC Hydro's and the CVRC's expert witnesses.

3.1.7.1 Erdreich and Sastre

Erdreich was responsible for the section on epidemiology. Sastre was responsible for the section on PF E/MF, and on laboratory studies. Both were responsible for the section on methods of evaluation and analysis of the literature.[1]

Methods of Evaluation and Analysis of Literature

First, "all" scientific research relevant "to the question of whether 60 Hz E/MF exposure produced changes in biological systems" was considered. It was not possible to cite and discuss every relevant study in the report, nor in one "many times its size."

Second, the reports were analyzed, using "widely accepted scientific criteria." The questions addressed included: how appropriate were the experimental methods used to the line of inquiry; how reliable were the data; and how sound were the conclusions drawn from the data. Some reports emerged as "particularly noteworthy" and others as being of lower quality or reliability. The criteria used to "judge scientific quality and merit" were routinely used by scientists and regulators, and were endorsed by the US NAS in 1977 and the AIBS in 1985 for the evaluation of EMF. Third, the reports were considered collectively to assess the consistency, reliability and coherence of the findings.

The process of evaluation was similar whether providing a new experimental design for research projects or serving as a resource to citizens and regulatory bodies. Many studies had been carried out concerning responses of organisms to PF E/MF, generally with inconclusive and often contradictory results. Some of the reasons for the failure of scientists to reach consensus were the technical and conceptual difficulties intrinsic to the nature of interactions between EMF and tissues. The difficulties were "not ordinarily encountered in other fields of biological research." A very large number of factors other than PF E/MF could affect the outcome of an experiment and must be recognized and controlled.

Fourth, the results of the analyses were placed in the appropriate conceptual framework, necessary because virtually all studies have inherent limitations due to design methodology.[2]

The data available to regulatory bodies in an inquiry was, of necessity, incomplete "due to the nature of the scientific process." Some data could be "truly, or only apparently, of a conflicting

nature." Scientists agreed that the best evidence was data from humans but for ethical and practical reasons it was often absent or incomplete for environmental agents. Hence scientists and regulators (including the International Agency for Research on Cancer) routinely made decisions about the safety of air, water and food based on studies of intact animals "judiciously combined," using the "weight of the evidence" approach, with in vitro tests and epidemiologic studies of humans. The weight of evidence approach had gained wide acceptance in the evaluation of data which was of necessity incomplete and in resolving contradictory data.

The NYSPLP was administered by the New York State DOH and overseen by an "impartial, independent" SAP of scientists and engineers selected for their expertise and relevant experience. The intention was to improve upon past research with carefully designed studies (performed under contract by "independent investigators" in the US and Canada) that were controlled, accurate, and reproducible. In particular, exposures were limited to 60 Hz E/MF associated with transmission line environments and actual exposure conditions were carefully monitored and documented with the assistance of the US National Bureau of Standards.[3]

Electric and Magnetic Fields

PF E/MF were found wherever electricity was used, including distribution lines, indoor wiring and appliances. The levels associated with transmission corridors, distribution lines, and electric appliances shown in Figure 1 (of the report) were measured at fixed distances but could vary, both with distance and over time. Tables 1 and 2 (of the report) showed PF E/MF levels of appliances.[4]

The Health Issue

Epidemiologic Studies

The objective of the literature review was to assess the quality of individual epidemiologic studies and to evaluate collectively if they supported the conclusion that magnetic field exposure was causally associated with increased cancer risk, with adverse reproductive effects, or adverse effects on general health. The criteria used were: consistency of studies, strength of association, temporal relationship, coherence (biological plausibility), dose-response relationship, and specificity (if absent, causation could not be ruled out). The criteria were used by the US Surgeon General in preparing the first report on the health risks of smoking.[5]

Cancer. The results of various residential studies reporting a relationship between PF E/MF and cancer were reviewed. The main criticisms were internal inconsistency, no dose-response relationship, and limited information on actual PF E/MF exposures.

After reviewing the literature, the NYSPLP SAP reported that a causal relationship between magnetic fields and cancer had not been demonstrated and that causality was only a hypothesis. The only well-designed study (by Savitz) had unresolved questions. Furthermore, no basic mechanism of action was known to explain a causal relationship.

Conclusions about the relationship between PF E/MF and cancer could not be made from occupational studies because of the lack of exposure assessment and, in most cases, the absence of control of potential confounders.

In 1987, the WHO Environmental Health Criteria on magnetic fields arrived at essentially the same conclusion.

"Thus, the studies conducted in human populations on magnetic fields and cancer... [did] not sufficiently satisfy the criteria used traditionally to assess causation." The studies were inconsistent, did not have a "particularly strong" association with estimated exposures, lacked specificity of cancer type, showed atypical temporal relationships, and failed to demonstrate a positive dose-response relationship. The weight of evidence from the epidemiologic data did not support the suggestion that power transmission lines magnetic fields were "causally associated" with cancer.

Reproductive Effects. There were no studies of adequate quality to address questions about exposure to PF E/MF and pregnancy outcome among the general population.[6]

Laboratory Studies

PF E/MF did not appear to affect animal or human health, or mental perception and performance. Most effects reflected normal variations and any unusual responses returned to normal when the fields were removed.

General Studies in Cells and Tissues. A number of responses had been reported but the findings were extremely difficult to apply to the resolution of uncertainty because most studies used field strengths well above the ambient, and frequencies and waveforms uncharacteristic of 60 Hz transmission lines. In many, no dose-response relationship was shown, "contrary to the known mode of action of toxic agents." There could be a decrease in response with an increase in field strength.

Reproduction. The weight of evidence on reproductive effects supported the conclusion that exposure is not harmful. The NYSPLP SAP stated that there was "currently" no conclusive

evidence that fertility or growth were affected and that further animal studies did not seem warranted.

Cancer. Studies failed to substantiate that PF E/MF exposure produced cellular effects indicative of transformation to a cancerous state. Laboratory studies were valuable because practically all human carcinogens had also been shown to be animal carcinogens. Tumor initiation (likely damage to DNA, irreversible) did not result from E/MF exposure. Tumor promotion (growth of initiated cells, reversible) and tumor progression (further DNA changes, irreversible) were not as well understood as initiation. There was no general agreement on the validity of specific assays for the identification of tumor promoters or progressors. This reflected the limited knowledge about the biology of cancer stages.

In vivo studies had shown no effects. The majority of in vitro studies had failed to show changes in cell growth or DNA synthesis. Alterations of enzyme properties in vitro were not always reflected in vivo. Increases in ODC had been shown, yet being licked by a puppy also increased levels. A link between laboratory studies and carcinogenesis in exposed persons or animals did not exist and had not been demonstrated.[7]

Review Panels

Several independent panels of scientists had been convened to review PF E/MF health effects since the mid-1970s and to offer their evaluations. Specific issues prompting their formation included: AC transmission lines - Florida E/MF Scientific Advisory Commission, a "blue-ribbon" panel (published in 1985), NYSPLP (1987); Project ELF - NAS (1977), AIBS (1985); and the generic question of exposure to EMF - WHO (1984), WHO (1987).

"None of the panels had an adversarial interest in the outcome of the deliberations." Each panel was multidisciplinary, composed of biological, physical and health scientists. In each case, they provided technical support and input to public organizations or a body faced with determining if field exposure created unacceptable risks to human health, safety and welfare. In several cases, the panels considered issues related to cancer. Each concluded that the available evidence did not provide a basis to presume that public health risks were associated with exposure to electric or magnetic fields.[8]

Conclusion

The NYSPLP PSC stated that although they were considering setting an interim magnetic field standard, PF magnetic field exposure had not been shown to be hazardous. The purpose of the standard was to ensure exposure to magnetic fields from future transmission lines was no greater than the fields from 345 kV lines which had operated for many years throughout New York

State.

The New York State PSC statement "succinctly summarize[d] the findings of the wealth of scientific research conducted throughout the world over the past two decades. The research conducted to date fail[ed] to substantiate the suggestion that exposure to electric and magnetic fields from power transmission lines pose[d] a risk to human health."[9]

3.1.7.2 Marino[10]

Clinical disease developed when the total physiological load from internal, environmental, and external factors exceeded an individual's adaptive capacity. Chronic exposure to man-made EMF produced by high voltage power lines was such a factor and had public health consequences.

PF E/MF levels could be measured but calculations were more useful and practical. The average levels in the US and Canada (for individuals not living near power lines or using electric blankets) were 1 V/m and .4-.8 mG.[11]

Effects of EMF on Animals

Exposure to EMF could alter the metabolism of all body systems. The effects manifested were largely independent of the type of EMF. An organism's response to EMF was determined by a combination of factors, including physiological history, genetic predisposition, and the totality of prevailing environmental conditions. EMF-induced biological effects in animals were best characterized as adaptive or compensatory because the fields presented the organism with an environmental factor to which it must accommodate. Simple dose-response relationships were generally not observed.

Animal studies showed EMF could be a biological stressor, that is, it could elicit an adaptive response. The ability to adapt to chronic stressors was finite and the addition of any chronic stressor made it more likely that a subject's ability to cope would be exhausted - a condition manifested clinically as a disease. Power line fields taxed adaptive capacity therefore linking them with human disease. It was Marino's "opinion" that an electric field of 50 V/m and a magnetic field of 1-2 mG were absolute upper limits for chronic, involuntary human exposure.[12]

Human Epidemiology

There was no signature disease for cold stress. For example, either infection (if a viral agent were present in the environment) or pneumonia (if the respiratory system were already

weakened) could result. The effects produced by environmental electromagnetic energy depended on diverse factors and, therefore, would be manifested as an increase in all disease in the chronically-exposed population.

An elevated disease pattern, in both occupational and non-occupational groups, had been seen for leukemia, nervous-system cancer and overall cancer. The frequency of cancer increased when EMF was added to the environment therefore the fields were a risk factor for the disease. The emergence of epidemiology showing a correlation between EMF and cancer was largely because society maintained adequate statistical records regarding cancer incidence. This did not mean cancer was a more likely manifestation than other diseases in chronically-exposed populations. EMF had also been linked with suicide, fetal development, "etc." EMF was "a potentiating factor for all disease because it was one of a milieu of neurogenic and somatic stressors."[13]

Counter Arguments

Since 1974, when Marino first expressed "judgments" (in testimony before the NYS PSC on behalf of PSC staff) that evolved into these views, data requiring a contrary conclusion had not appeared. Marino was "convinced" that none would.

Several arguments had arisen in the last 15 years that tended to oppose, weaken or trivialize Marino's conclusion. (For a more detailed discussion, he referred to his book on the NYSPLP and to three books on microwaves by other authors.) To support Marino's conclusion:

- Several bodies of data must be integrated and connected;
- It must be recognized that present exposures were built on the assumption of safety, not actual evidence of safety of EMF;
- All pertinent laboratory work involving exposure of numerous animal species to simulated environmental EMF must be considered;
- Literature regarding the disease promoting nature of chronic stressors must be admitted;
- It must be recognized that human epidemiology of EMF has inherent limitations, forever dealing in shades of grey and never providing unassailable conclusions; and
- A realistic notion of how science is done and who pays for it was required.

"If the individual links in the chain [were] not connected, then the conclusion [could] not be sustained for simple ignorance." Marino then considered statements in the literature that ran counter to his "judgements of risk."

- There were no biological effects from EMF therefore there could be no hazard. This was one of the chief arguments advanced by the "polluter" in the bulk of present

litigation in US courts regarding health risks of environmental EMFs. It was first made in New York in 1973 and had subsequently been repudiated by essentially every investigator in the field.

- Several blue ribbon government and industry panels had concluded there was no significant health risk due to environmental EMF exposure. These arguments were not "bona fide opinion evidence because they [were] invariably collective judgments of individuals chosen by the polluter. Such a procedure [was] simply a matter of the fox being on the jury at the goose's trial." Blue ribbon panels made it impossible to attribute a given view to a given person and to ascertain a specific basis for the view.
- EMF did not stimulate nerves or deposit heat systems therefore they could not be a health risk. The unofficial US exposure standard was founded directly on this argument. Proponents of this view assumed that nothing could happen to a biological system other than via processes that they first accepted as proven. This argument was "invalid" because it was "unscientific."
- Power and communications companies had not received any reports of illness among people who live or work near EMF sources and "nothing untoward" was observed on visual inspection of their premises. These arguments, appearing in essentially all US judicial and administrative proceedings regarding the EMF issue, were "self-serving and irrelevant."
- Because there was so much negative literature, the reports were in conflict or contradictory and definitive statements regarding risk could not be made. This argument, increasingly prominent since the 1986 Ontario Hydro Symposium (when industry spokesmen decided that their previous position of "no effects therefore no risk" was no longer tenable) and now the main power industry position, was "shibboleth because the negative EMF literature establishe[d] essentially nothing. There [was] not a single such study that [had] taught us anything worthwhile about nature. Anyone [could] drill a hole and fail to strike oil, and the existence of an empty hole [was] the meanest evidence available that oil [did] not exist. To weight such studies against actual observations [was] illogical."
- Whatever the magnitude of risk from environmental EMF, it must be accepted because alternatives were too costly, disrupted society, and endangered national security. Continued discussion was therefore pointless. This argument could prevail. [14]

Involuntary Human Experimentation

Power companies were generally silent about the EMF they liberated into the environment so most subjects were unaware of their presence. The Dunsmuir/Gold River lines would result in

exposures significantly above the ambient and involve human experimentation under both New York Public Health Law and US federal regulations. "All modern authority oppose[d] involuntary intervention upon a subject." It was Marino's "opinion" that living near the Dunsmuir/Gold River lines was "exactly the kind of physical intervention upon subjects proscribed by law and applicable ethical principles."[15]

Summary

Chronic exposure to biological stress was a risk factor for disease. Laboratory studies showed EMF can be a biological stressor. Such fields, when present in the environment, acted as biological stressors and were therefore risk factors for disease. The Dunsmuir/Gold River power lines were a health risk because they produced significant E/MF in human living space.[16]

Appendix

Marino wrote in "Negative studies and common sense," an editorial published in the Journal of Bioelectricity, that if negative studies balanced out positive studies, then the power industry could escape liability and responsibility.

Negative studies could be and were being brought about by designing studies or analyzing data in particular ways, or through contracting inept scientists. If such a strategy was doubted, then try to explain all the industry-sponsored negative studies.

In an experiment, the null hypothesis (a statistical measure) was formally tested (in contrast to the experimental hypothesis). The null hypothesis asserted that the mean values of the dependent variable in experimental and control groups were identical. When it occurred, it was concluded that there was no evidence to indicate that the independent variable affected the dependent variable.

However, the null hypothesis had been elevated by those who spoke for industry to the level of an affirmative finding. A negative study could mean the investigator looked for the wrong thing, in the wrong place, at the wrong time. It was only relevant if, under identical conditions, opposite results were found. Then true behavior under those conditions was uncertain. But replications of studies on EMF health effects were rare.

The "good news" was that the structure of science could not be corroded. The "bad news [was] that judges and other generalist laymen, unfamiliar with the concept of the null hypothesis, [could] be susceptible to the Siren call of the negative study."[17]

3.2 INQUIRY EVENTS

The inquiry began on the evening of July 11, included the evening of July 12, and lasted until July 14. Attendance by the public was unusually high for a BCUC hearing and varied from about 125 to 180 people.[1]

The BCUC's panel included McIntyre, Swanson, Grant, Smith, Gustafson and Gallagher. BC Hydro's first panel included Erdreich, Sastre and MacKenzie. Their second panel included Boatman, Barker, Beaven, Paul Wong, an electrical engineer with Powertech Labs (a BC Hydro subsidiary) and MacKenzie. The CVRC's panel included Marino, Kavka, Gathercole and Vance. CPFP's panel included R.J. Bauman, Counsel. Witnesses included 22 individuals, including Edwards, Bob Skelly, MP (Comox/Alberni), Marton, and representatives of School District 71, C-S RD, MEC and Friends of Strathcona Park.[2] Ross attended the inquiry as an observer on behalf of the BC MOH.[3]

BCUC staff, McIntyre, Swanson, and Gallagher had reviewed a "tremendous" amount of material in preparation for the inquiry. A public resource room adjacent to the hearing room contained copies of this material, which included "generally as much relevant information as the Commission could assemble with the cooperation of BC Hydro." A glossary of terms was included and efforts were made during the inquiry, especially by the experts, to explain some of the terminology used. The public had use of a photocopier. Transcripts would be available after the inquiry. Gustafson and, occasionally, BCUC staff and advisors were available to assist participants throughout the inquiry.[4]

During the inquiry, every effort was made to hear pertinent testimony, whether or not intent to present had been filed previously. The Chairman stated that he wished the inquiry to be informal and non- confrontational. Witnesses presenting "technical evidence" would be sworn in. No final arguments would be presented because the purpose of the inquiry was "fact-finding."[5]

The Chairman appeared diplomatic and fair. He attempted to put members of the public at ease and kept the proceedings relatively informal, primarily through his sense of humor.[6]

3.2.1 Summary of Oral Testimony - Health-Related Issues

Edwards/Skelly

Edwards stated that the studies by Wertheimer and Leeper and Savitz showed "a clear correlation but not necessarily cause and effect relationship between childhood cancer in Denver area children living near power distribution lines." Notice of the "warning flags" had been taken. For example, Ontario Hydro, Hydro-Quebec, and the UK Central Electricity Generating

Board had begun research into EMF health effects. In 1987, Richard Phillips, Director of the Developmental and Cell-Toxicology Division, Health Effects Research Lab, US EPA, said that troubling health effects were seen that could not easily explained away. In 1985, Houston Light and Power was ordered to reroute a transmission line passing through a school yard and to pay the local school district US $25 million in punitive damages for a "callous disregard of the children's health."[7] Edwards also said that the hazard was "real" and that rerouting the line might be necessary because of the "possible hazards of electromagnetic radiation at low levels."[8]

Skelly supported Edwards' testimony, adding that the ROW was acquired prior to 1957 (by threat of expropriation) when the PF E/MF health effects issue was relatively undeveloped and "when the hazards of electromagnetic radiation were not as well understood as they are today." He urged the BCUC to relocate the power line "for health reasons, for planning reasons, and for many other reasons."[9]

Under cross-examination by BC Hydro, Edwards stated that she was not concerned that some people felt research conducted by industry was suspect. She was "a practical person... BC Hydro may have the resources to do that kind of study."[10]

BC Hydro - 1

MacKenzie stated that BC Hydro did not wish to be adversarial. The problem was "one arising out of the basic nature of scientific enquiry. Scientific inquiry is empirical and the facts should speak for themselves. And the conclusions in any empirical study should be capable of confirmation by repetition or replication."

The biological effects of electromagnetic fields was "a relatively new area of scientific enquiry... The results to date are not so consistent that conclusions can be stated in an unqualified manner. Most... support the conclusion that EMF, particularly at the levels involved here, do not present a risk to health." Some studies did suggest an association and should not be dismissed. Some results were inconsistent and had not been adequately explained. Some inconsistencies "may be due to the normal statistical variations between different samples, and then again, they may not."

BC Hydro could not give "unqualified assurance or a definite statement that there [was] no health risk involved in EMF. More scientific research needs to be done. All that BC Hydro [could] do [was] retain qualified and independent experts to provide their best judgment on the evidence to date and be guided by their advice."[11]

Erdreich and Sastre

After being sworn in, Erdreich and Sastre discussed the section of their written testimony on

methods of evaluation and analysis of the scientific literature. Erdreich noted, "The more the [evaluation] criteria are fulfilled, the stronger the evidence that an association is actually a cause-effect relationship." The use of several criteria ensured that "people in all different places and different times are looking at things in the same way." They were "just guidelines, not rules." Therefore, the process was called the "weight of the evidence." There was "no rule for how much good evidence should weigh, it's a judgment call." In response to a question from the Chairman, Erdreich replied that the guidelines had widespread use by epidemiologists and other scientists in the UK and USA who "sometimes call their colleagues on not applying these guidelines."[12]

Sastre said that there were analogous guiding principles that scientists used for evaluating laboratory studies. Each relevant study must exhibit consistency and rigor and be reproducible, "the hallmark of experimental science." If a study could not be replicated in another location, scientists tried to resolve the issue by "correspondence, scientific meetings, exchanging information, until a consensus [was] reached." Replication was used "everywhere that scientists work."[13]

Only studies with exposures relevant to a power transmission environment were evaluated. Erdreich stated that microwave was "a different type of electromagnetic field, just like water is not the same chemical as chlorox" and confirmed that she had considered both positive and negative studies."[14]

Erdreich concluded that, based on her reading of the literature, the electric and magnetic fields associated with distribution and transmission lines were not one of the factors that caused human disease. Sastre, stressing that a distinction between an effect and an adverse effect should be made, concluded that, "at this point," there were no adverse effects on an intact organism's health.[15]

Under cross-examination by Gathercole, Erdreich agreed that her expertise in the PF E/MF health effects area was "fairly recent." However, her previous experience was relevant because the methods used in health risk assessment asked "the same questions. And I've gone into different chemicals and different agents ... many times, so that I know all the pits and... traps."[16]

Sastre, under cross-examination by Gathercole, stated that he and Erdreich relied on evaluative summaries of individual studies generated by themselves and by their colleagues. For this testimony, they wrote a "considerable amount of original material." Sastre discussed the studies that he had reviewed with his colleagues, with experts in those particular areas, and with the "authors" of the studies.[17]

Erdreich told Gathercole it was "misleading" to say she relied on someone else's opinion

of non-epidemiologic studies. While employed at EPA, she had worked with a toxicologist and learned the "right questions to ask." She agreed with the approach taken by the International Agency for Research on Cancer, the United States Environmental Protection Agency, and Health and Welfare Canada, i.e., that the epidemiological and animal data could be examined separately. The final decision rested on "putting it all together." If the information was provided separately, the BCUC could also "weight it." Later, Erdreich stated that she infrequently had discussions with the "people" who actually carried out the studies.[18]

Gathercole asked Sastre a number of questions about ERI, its clients, and its relationship with BC Hydro and with EPRI. Sastre told Gathercole that his particular research experience was in 60 Hz non-sinusoidal fields and that stress was not the prime focus of his work.[19]

In response to a question from Gathercole about tenure, Sastre explained that at a number of universities and colleges, in particular, state universities such as the one at which "Dr. Marino" was a faculty member, tenure meant employment for life, with a guaranteed salary and office. However, at Johns Hopkins, Stanford, and many private institutions, the status of tenure was reviewed every five years.[20]

The differences between laboratory studies and epidemiologic studies were discussed. Erdreich detailed the different types of epidemiologic studies. She stated that epidemiology provided "little better than an association." "You can infer a causal relationship from epidemiological data only if you can weigh the evidence that way and [rule out] some of the intervening factors."[21]

Erdreich, under cross-examination by Gustafson, stated that "absolute proof in some circumstances is very difficult," particularly in biological systems because of natural variability.[22]

Erdreich commented that one reason for having many different types of epidemiologic studies was because of the "inherent... state-of-the-art limitations on any single study. That's why replication is so important in... any scientific field." She stated that one of the factors involved in determining what type of epidemiologic study to conduct was the availability of resources, including funding. Because the resources in any field were so limited, decisions were based on available data. She had "never had ideal data for any risk assessment." Gathercole suggested that funding agencies would probably not be as responsive to a replication of a study as to a new study. Erdreich thought that science supported replication but there were "too many issues."[23]

Erdreich and Sastre provided a review and evaluation of the studies related to PF E/MF health effects. Sastre said that the conclusion of a laboratory study by Marino (designed to improve on the methodology of his 1977 study) was justified when published in 1980, but a

number of subsequent attempts at replication had failed. He had "heard" that Marino was attempting a third study. "If clarification on... the mouse studies, or any of the other places in which the bulk of the scientific community has failed to replicate Dr. Marino's studies, if any light is shed on that by this inquiry, not only would this commission have done a tremendous service to the people of BC, but to scientists throughout the world."[24]

Gathercole asked Sastre if an exact replication of Marino's studies had been attempted. Sastre replied that some attempts were made. That was "generally the case in science" and that had "never impeded consensus on reproducible findings." In the case of an inexact replication, "one determines whether, on the basis of all available scientific knowledge and judgement," the changed variable was likely to have been a "critical" one. It was important not to dismiss a study because of "failure of reproduction when, in fact, things were wildly non-comparable." It was also "irresponsible as a scientist" to say that unless a study was an exact replication, its relevance to anything else was "questionable." Sastre stated that he had not conducted a study similar to Marino's 1977 study but he did have related experience hence his "judgment that the method was inappropriate."[25]

Sastre stated that investigators should be consulted to supplement reviews of published studies. ERI consulted Graham regarding his studies on human performance, physiology and subjective state and found he had replicated his own studies (testing the stressor hypothesis) with slight variations "several times" essentially finding nothing. Sastre commented that that was a "scientist's nightmare." "Negative data seldom see the light of day" and the peer review system was interested only in positive effects unless there was "controversy." This was "part of the reason" why Graham had only published three articles on his work.[26]

Erdreich and Sastre criticized the methodology and conclusions of a 1981 study by Perry, Marino, et al. that reported people living near power lines had a higher rate of suicide. Sastre told Gathercole that by the time he discussed the study with Erdreich (he had discussed it earlier with others), they had been notified that they might be involved in an adversarial proceeding and thought it "grossly improper to contact Dr. Marino."[27]

Gustafson, after reading an excerpt from an article in Public Utilities Fortnightly,[28] asked Sastre to comment on the amplification of weak electromagnetic signals at the cell surface. Sastre was familiar with the theory but it had received "very little if any experimental support that would be considered convincing." Another theory suggesting the earth's static geomagnetic field (or an artificially adjusted field) determined whether 60 Hz E/MF produced biological effects was "absolutely fantastic." However, none of the studies actually measured the field across the cell membrane. In addition, the effects could be reproduced in the lab but it was "very difficult to extrapolate to anyone being under a transmission line."[29]

Sastre gave a lengthy explanation delineating the difference between a stressor and a stress reaction. Major variables determining the impact of a stressor on the body were its' intensity and duration. An acute stressor became a chronic stressor through prolonged exposure. A chronic stressor must first be acute. Sastre had seen no evidence that PF E/MF was a stressor.[30]

Erdreich told Gathercole that the Savitz study was internally inconsistent because there was greater risk at low power than high, "which is the reverse of what you would logically expect." In response to the Chairman's question about why it was logical to expect that, Erdreich said, "Most agents act that way... and we have insufficient data to think [otherwise]." Toxicologists had a statement that "toxicity is dose." It was a "rule of thumb" used by scientists.[31]

Gustafson again read from the Public Utilities Fortnightly article stating that several parameters, including field strength, frequency, and time of exposure, "may be necessary to define dose" and that the simple assumption that "more is worse" may not apply to some of these parameters. Sastre replied that based on his background in pharmacology and toxicology, it was a "general useful rule of thumb." The exceptions he knew of fell into "one category," where there was an increase in effect with dose to a plateau and then a decrease.[32]

Gustafson noted that Erdreich and Sastre, in their written evidence, had assumed that magnetic field measurements more directly reflected exposure than wiring codes. Erdreich responded that Savitz made the same assumption and it seemed "fair" to her. She agreed that if measurements were taken long after diagnosis, they may not reflect dosage or exposure, but "then again, they may." Sastre stated that a study was only as good or as bad as the surrogate reflecting the variable of interest. In an ongoing study, Cowney and Savitz were attempting to validate wiring codes as a surrogate measure of exposure. An earlier study by Cowney found a low correlation (16%) between measured magnetic fields and wiring codes; most scientists and epidemiologists would prefer a 70-80% correlation. Sastre said that it would be some time before good dosimetric measures were available that were accurate. Portable monitors had only been available for the past year or two.[33]

Gustafson said that of 10 studies randomly selected by Gallagher from the 30-odd occupational studies concerning PF E/MF health effects, 6 or 7 showed RRs that were of reasonable significance (1.4, 1.3, 1.9). Although the other three or four were much lower, "we found it rather startling." When Erdreich suggested that their selection was "not quite random," Gustafson assured her it was. She then said that the limitations of the type of study conducted should be kept in mind. However, she thought that the "occupational issue merits further study."[34]

Sastre stated that laboratory study of PF E/MF effects involved difficulties not

ordinarily encountered in other fields, in terms of exposure facility design and PF E/MF measurement. In addition, all aspects of human epidemiology were complex, especially when associations were very weak. The odds ratios were very low and, at least some of the time, failed to reach statistical significance "which is the scientist's cornerstone of saying is this due to chance or is this a real reflection of the world."[35]

Gustafson read from a journal article in which Savitz stated that an elevated odds ratio could be expected if magnetic field measurements were more complete. Erdreich replied that his hypothesis was possible "but it's only speculation because this is the appropriate approach for the analysis of this kind of data." Sastre reminded Gustafson of the ongoing work by Savitz et.al. on surrogate exposure measures. "It's certainly not something that he ignores and certainly not something that we ignore."[36]

Erdreich, in response to a question from Gathercole, stated that agents usually caused a specific disease, not a number of different cancers. This was one of the reasons she had "difficulty" with Wertheimer and Leeper's 1979 study.[37]

In response to Gathercole's comment that Wertheimer and Leeper (and Erdreich) had published in the American Journal of Epidemiology, a "well-respected" and "prestigious" journal, Erdreich said that publication was "evidence of merit, [but] not of perfection." "It was "important for the people to understand that publishing articles allows other scientists to see them and evaluate them.... If an article is considered to have some merit, or to address an important issue, it gets published... All of us who consider ourselves scientists have critiqued other people's studies and have listened to critiques of our own studies and have taken those critiques to go design better studies. It's fair game and it's [the] nature of the science. I think it's very hard for people who aren't in science to understand this business. But it's very difficult to do a perfect study and studies are published to allow other people -- you were all here for the cold fusion discussion." The peer review process involved in publishing "says a lot about the individual studies. But my experience on health risk assessment tells me that decisions of major [import] are made after evaluations of all of the data and weighing the evidence. And it's not only the United States, it's international. All scientists do it that way and all major decisions are made with an evaluation of all of the evidence."[38]

Sastre elaborated on Erdreich's comments, stating that they were correct but incomplete, based on his experience on the editorial board of two journals. He found papers in which neither he nor his reviewers could find any flaws. "Our collective scientific experience says this can't possibly be right but we know that we can be wrong." "And we collectively decide with the senior editor and reviewers... [that] science will be best served by publishing the paper." This could mean that the paper was "wonderful and flawless," "competent," or that science would be

"best served by publication and the attempts at replication and discussion that [would] ensue."[39]

A discussion ensued about the NYSPLP. Erdreich did not agree with the NYSPLP SAP conclusion that Savitz' study added credibility to the hypothesis that ELF magnetic fields might cause cancer. She did agree with the status of "hypothesis."[40]

In reply to Gathercole's question as to why six review panels were listed in her report, Erdreich said, "Some very serious and independent bodies have paid sufficient attention to this field, have identified this issue as being important.... They did the best they could to find people that they identified as experts or relevant to evaluate this." The panels were usually set up independent of any authority and were selected on the basis "that it's difficult for individuals to evaluate all this. It was hard for me when I first came to ERI faced with... literally stacks and stacks of information... (And it is certainly difficult to evaluate it in view of the way the media and the press have picked it up. Journalists have little time to file stories, they don't have time to get into background, and they come out in ways that make it difficult for people to understand, or even scare people...) These panels were designed to address an important question in the best way that the decision- making bodies thought was possible at the time.... And that is why we feel that it's important, even though we make our own assessment of the literature. We not only look at their bottom line, but we would like the opportunity to evaluate how they arrived at their bottom line." "I have to confess that I make my own opinion and that we use these reports to indicate that other scientists have this opinion and that... other scientists that have credentials have thought about it." When asked by Gathercole if these opinions were valid opinions, Erdreich replied that they were "useful information."[41]

Erdreich explained to Gathercole that the term "blue ribbon panel" meant that the members of the panel had "important and significant and relevant credentials." When she could not recall the names of the members of the Florida panel, Gathercole suggested that the members were not of "significantly high blue ribbon quality." Erdreich replied that they were in fields other that epidemiology.[42]

In response to Gathercole's query of whether any of the panel members were employed by or did research on behalf of the utility industry, Erdreich stated that she did not think any were. She said, "Research funding is not considered to be a bias in science because people have to publish their papers with their source of funding annotated at the bottom so that it behooves people to be objective." Recalling her experience with EPA, Erdreich stated, "We had the confidence that academic people could be independent especially under the peer review process.... There's a general feeling that it is useful to have these studies funded by industries. Unfortunately, it's just the nature of our funding in the Western world." Later, Sastre, under

cross-examination by Bauman, stated that there may have been one participant on the Florida panel from a utility, but otherwise the members were from outside industry.[43]

Erdreich told Gathercole that most of the scientists she knew obtained publication rights beforehand. "It's one way that they do things because that's how they live. It's important to scientists to publish."[44]

Both Erdreich and Sastre agreed with Bauman when he suggested it "unfair" to characterize a 1977 NAS panel (assembled to review Project ELF) as industry funded. Erdreich noted that the NAS was a scientific advisory council to the US president.[45]

Bauman asked if Erdreich and Sastre, "as scientists, and belonging to various organizations," were subject to discipline if their colleagues perceived or proved their research was biased. Erdreich replied, "No,.. but you suffer the opprobrium of your colleagues. In fact, many... scientific groups... have guidelines because sometimes in the area of ethics... it becomes... sometimes very subtle and sometimes not clear whether you're conflicted or not, because scientists just like to get their hands into any opportunity to handle data, so that scientists... do watch each other. There's no formal disciplinary action in the societies that I belong to that I'm aware of except the good old fashioned ones of peer pressure, and lots of comments to that effect in letters to the editor and in more informal newsletters."

Bauman then asked, "Is it fair to say all you've got to trade in as a scientist is your credibility amongst your peers?" Sastre replied, "That is absolutely perhaps the single most important criterion and that is why to date... no disciplinary measures... have been deemed as necessary. And more over, scientists are human first... I don't think that there would be a scientist alive who has not... come up with a result [that] subsequently he himself could not reproduce, let alone others. It is your willingness to participate in the give and take of criticism... going back and forth, that constitutes a life blood."[46]

Gathercole noted that there was "some disagreement among reputable scientists" regarding the health risks associated with power lines. Erdreich responded, "There is disagreement [and] there is some consensus among reputable scientists." "I get the impression that there are more people who feel... there is no health risk than there are scientists who feel there is a health risk... I'm not sure whether I should make that statement, but that's the impression I get from reading the literature." She agreed with Gathercole that an assessment should not be based on counting up "the number on one side and the numbers on the other."

Bauman asked if the final paragraph of Erdreich and Sastre's written testimony represented their and their (ERI) colleagues' views. Sastre stated that the wording was his and Erdreich's. "I hasten to add that as scientists we always have discussions and differences." Bauman pointed out the differences between the conclusion of the background report (which Sastre co-authored) accompanying the buyout letter and that of Erdreich and Sastre's written

testimony. Sastre agreed that there was some difference "and it reflects the degree to which there is difference of opinion, however slight, which as scientists we always will have." He later told Gustafson that the phrasing he would give and had sworn to was in his testimony. Gustafson asked if the interpretation of the New York State PSC statement incorporated in the "Background Report" conclusion was as accurate as Sastre could have made it. Sastre replied that he "would probably have gone on at much greater length as to what their [the New York State PSC] spectrum of conclusion was... When forced to try and make a... one paragraph summary of an enormous wealth of data, and to do it fairly with the appropriate caveats, it's very difficult to do so." "I think that a statement like 'there is no reason to believe' is perhaps stronger than I, as a scientist, would ever want to make about anything." "I do not conversely say that 'there is a reason.' I don't think that the data to date substantiates a suggestion of risk."[47]

In reply to Gathercole's question if the proposed BC Hydro 230 kV line was safe, Erdreich responded, "'Safe' is a very broad term. I'm providing information that says from my reading of the data, there is no indication of potential health risks of concern. 'Safe' becomes a value judgment." Erdreich agreed with Gathercole that her opinion was based on the work and readings she had done. She added, "And I expressed my credentials and I don't have credentials in 75 different fields."[48]

Gathercole asked Erdreich if, in her opinion there were health risks associated with the new 230 kV and the three existing 138 kV lines running through the Comox Valley. Erdreich replied that there were no health risks and that no hazard had been shown from those kinds of exposures.[49]

When asked if the addition of a fifth line would change her opinion, Erdreich stated, "That would be unlikely to change my opinion... One of the kind of guiding lights of health risk assessment is that you have to understand some very basic points. Most people recognize that almost anything could be dangerous if you give enough dose... Water is dangerous, salt water is dangerous.... But usually there's some relationship with dose. But, if something is not generally a hazard and is not associated with a hazard under normal circumstances... small changes in a dose don't make a difference." If a sixth or seventh line were added, it became speculative nor had she seen "any measurements." Gathercole said that he understood Erdreich to be saying that at some point there might well be a health hazard. Erdreich replied, "As a scientist I just don't like to make sweeping generalizations.... Health risk is usually related to the amount of exposure only if something is proven to be a potential hazard to begin with."[50]

Erdreich agreed with Gathercole's suggestion that it was "fair to say" the causes of various health effects were unknown. "We have different amounts of information on different

diseases, but there are very few where we know all of the factors." When Gathercole asked how Erdreich could say the line was safe if the causes or potential causes of various health effects were unknown, she replied, "How can you jump from a – you can introduce anything for that argument. If we don't know what causes leukemia, we don't know what causes it. It doesn't mean this line causes it... unless we have evidence. I'm here to provide information on evidence."[51]

Gathercole asked Erdreich if there was any evidence that the line was safe. Erdreich replied, "One usually doesn't have that kind of evidence in that they've studied everybody ever exposed and looked at the incidence of cancer and compared it to people who weren't exposed. There's rarely an opportunity to do such a study." Gathercole asked if she could "point us to any study that meets the standards which you've set out that conclusively determines that... this line or a line similar to this poses no health risk?" She replied, "One wouldn't really in a scientific world expect to find any one study that conclusively gives such a global statement. I can't find that for anything." "What we really feel is that the weight of evidence strongly suggests that the line is safe" based on the "weight of the evidence that is available and that we have reviewed."[52]

Erdreich agreed with Gathercole that there may be some increase in PF E/MF levels. "I feel it's important to indicate that because of my assessment of the hazard here, which is that there isn't any, that the dose-response relationship... which is the most difficult part of health risk assessment, which is what I've been doing most of my professional career, is not the paramount issue here."

Erdreich did not agree with Gathercole's suggestion that, given the state of the scientific evidence, exposing people to the increased levels was human experimentation. "I recognize that whenever you have a positive study it becomes very difficult to... address the health risks because, in people's minds, positive studies weigh more than negative studies. And negative studies and replication are very important, and really very scientifically challenging to evaluate... When something poses a potential hazard... then it is important to look at it and see at what level it's safe, what level it poses infinitesimally little risk, and what level it poses a risk... In my experience, when some chemical does not pose a hazard [it] is not associated with adverse health effect[s]. For example, I studied copper, which is an essential element, and the body has a high cushion for handling it, a homeostatic mechanism, and only at very, very high levels people get nauseous and they get rid of it. When something does not pose a hazard, then it really isn't important in these narrow ranges to talk about... the amount of exposure."[53]

Erdreich said that although future studies might change her opinion, she based it on the "level of possibility, because we're talking about drastic changes here, and if the possibility is

very low, and my uncertainty is very low, I feel it doesn't support a conclusion that there is a hazard." Questioned further by Gathercole, Erdreich stated that she was "uncomfortable" with the whole concept of human experimentation. "Of course, I'm against it. It just doesn't seem to be an applicable term here. I mean, we allow people to smoke. Is that human experimentation? People do it willingly." Gathercole said that choice was the issue. Erdreich replied, "But when there's no risk, what's the issue?"[54]

When Sastre was questioned by Gathercole about whether or not the line was safe, he replied, "Safety is primarily determined by risk but not exclusively. And safety consideration is both personal, societal and regulatory." His opinion was that the evidence "does not support that there is a risk from the electric and magnetic fields generated by this line," based on the research he reviewed, his training and experience, and "numerous lengthy discussions with active, long-term participants in the field," "[55]

Erdreich and Sastre were also cross-examined by Marton. He asked Erdreich whether a study comparing health inventories of children living near power lines to those of children living away from power lines had ever been conducted. After Erdreich replied there was no such study, Marton suggested that she might feel more confident with her position if such a study existed. Erdreich replied, "I don't like to ask for something that's not do-able." For a rare disease such as leukemia, a case-control study was required otherwise the population would be too small. In addition, individual exposures would be difficult to ascertain.[56]

Marton continued, "You've come here to say studies... that link ELF fields and adverse health effects are not very good. Yet you have now said there are no studies indicating health in association with power lines." "You don't agree because you think there should be more research." Sastre interrupted to clarify, "We have come here to provide information... We would be grossly irresponsible if we did not point out to you where the data is very strong, but also where the data may be weak." For example, "Using all the best dosimetry, ...scientists such as Dr. Erdreich and myself and a number of others, have failed to identify a hazard. That does not mean we have closed our minds. That does not mean that we want research to stop." Marton responded, "You said you came here to provide information yet you did not provide information that you have no studies indicating health [of children] until I pointed that out."

Erdreich said that Marton's question was "very important" because it addressed what the people there were concerned about. "That would be the ideal study. I think it hasn't been done for two reasons. One reason, and I know you understand this, Dr. Marton, and I think it may be a little difficult for the rest of the people, but if they're patient, they will understand" was that the scientific community did not believe there would be a large difference in the amount of PF E/MF exposure between children who lived in homes with higher exposures due to power lines

and children who did not. Because of this, it would be very difficult to detect subtle effects and a "very, very large sample size" would be required.

The second reason was that "there have been no suggestions of health effects in children that haven't been studied." No hypothesis had been generated that indicated there would be general health effects other than leukemia and cancers. Studies had shown that there were no short-term effects. There was evidence that "people have worked in this for a long time without deficits... People don't want to fund or participate in studies where they don't feel there is a strong hypothesis, and that is why most of the studies address the cancer issue - because there is stronger reason to look into it because it's more confusing."[57]

Marton suggested that "type 2" errors in the studies resulted in a failure to detect differences between the two populations studied, and that the links found were not due to chance alone. Erdreich stated that although Savitz had improved exposure assessment, he did not find a higher relative risk than Wertheimer and Leeper found which indicated that the association was not as strong as originally thought. Marton suggested that because all of the studies were "imprecise," a higher correlation or a correlation with other kinds of disease processes might exist but was missed because the wrong "thing" was measured, or the "right thing" was not measured in the "right way," at the "right time." Erdreich replied, "A study can only address the effects it sets out in the onset to study." Sastre interjected that because Erdreich had only been with ERI for a short time, she was unaware that such a possibility was being considered. Kabot and Savitz had just received funding from the State of California to obtain a better exposure measure from Savitz' own cases on the premise that such a "bias to the null" was possible. After explaining "type 1" and "type 2" errors, Sastre said that it was "very hard" to get such studies funded."[58]

Marton suggested to Erdreich that if a study showing a relationship between EMF and health effects could not be believed because there was confounding, every study that had ever been done in epidemiology would have to be thrown out. "It's impossible to control for every possible thing in the whole world." Erdreich replied, "I'm sure you're overstating the case." Not every study was confounded, just some were more confounded than others. "I recognize that the uncertainties in science are not comfortable... They are very difficult to explain and people don't want to hear them. We have tried to explain them honestly and, to indicate, I have not rejected all of the studies. I have simply tried to interpret their conclusions in light of all the others."[59]

Marton asked whether the results of studies that were poorly conducted were then incorrect. Sastre stated that that was an "improper inference. It was possible for a study with "less than ideal methods" to point "in the direction where others may see that effect." Questioned further, Erdreich stated that there was some "confusion." She and Sastre had said

that the studies were not conclusive, or not indicative of an association. "This does not necessarily mean that it wasn't a good study. We have avoided excessive review of some of the negative studies because in fact some of the negative studies have serious methodological limitations that do not inspire confidence." She also stated that the criteria for evaluation were "not criteria of good or bad. [They] were criteria of whether an association is there.... They're just guidance for coming to some conclusion."[60]

In response to the Chairman's comments about whether there would "ever be total consensus" regarding the issue of health effects, Erdreich said, "That's why we're stuck with that term 'weight of the evidence.'" "It's a regulator's nightmare."[61] Later, the Chairman commented on "the division that exists in the scientific community... the 'competition'" and asked Sastre if there was a "more universal approach... that could possibly address this issue in a way which could... eliminate the negative and have a scientific community that's more united on the issue as it addressed the public concern, and their perception of reality." Sastre replied, "I'm afraid there are no quick fixes." More "reliable scientific data" was needed, "which takes time." "Believe me, if there were quick fixes we would have been using them... I'm not aware of any... and, believe me, people have tried."[62]

Gustafson asked Sastre if, in an area "as difficult as this, where the consequences are potentially so far reaching, must we not pay closer attention?" Sastre replied that a scientist must "demand" statistical significance because "we can all, every day in the lab, or in epidemiology, come up with things that are apparent associations that are not significant." The follow-up study by Cowney and Savitz to determine how much confidence could be placed on the wiring code as a surrogate, was "proof positive" of the importance of this issue. "That is not the kind of thing that a scientist who would rather go on to his next study would do.... It is... our role as scientists to point out where the science is with all its limitations and words. It's for you, the Commission and the citizens here to make your evaluation on the much more difficult step of saying does this translate into safety as opposed to risk." A precedent has been set for both decisions. "We would not attempt to tell you which way to go on that."[63]

Erdreich told Gustafson it was useful to pursue the PF E/MF health effects issue. "I know that this audience finds the ambiguities frustrating... It's very hard to impart my experience with epidemiological studies that have really low associations, less that two, because so many of them have later proved to be unfounded. You all were around for coffee and pancreatic cancer." A major investigator, author of the first and one of the "foremost" epidemiology texts, had conducted a study with "some design flaws." Some members of the scientific community thought his subsequent publicizing of the results (a "statistically significant risk of 1.5") on television was "irresponsible" because the public became "inflamed." Media reports were

"biased" because "journalists have a short amount of time. Experiences like that make me very wary of over- interpreting data."[64]

In response to Gustafson, Sastre stated that two things must be considered - the "science as it stands" and "society's concern as to what would... or could happen if that assessment of risk, [however] small its uncertainty, nonetheless is not accurate... I know of very few issues where either the laboratory studies or epidemiology, ...where data which is so contradictory, so hard to replicate, and where one simply cannot get a very clear handle on anything, would have been pursued for very long. However, scientists are not just in ivory towers. Scientists are people. Some of the concerns raised by the studies affect them every bit as much as... everybody else. And I believe that most of us [scientists] have our personal... and... social consciences and say, well, if this happened to be the association between a full moon and a dog howling, ...maybe it's just not worth spending an awful lot of time and effort on... But precisely because there may be a possibility (there is always a little bit of uncertainty) a great deal of time, effort, money and attention has been devoted to this and there is no question... that more time, effort and money needs to be devoted to try and get better data." It is "absolutely worth pursuing." However, it would not be encouraging if the quality of studies was improved and their number doubled but the associations were not stronger. "So far the continued attention... has not improved the situation... significantly." Sastre clarified for the Chairman that he was referring only to the "scientific side" of the issue. Inquiries could help settle the issue quickly by focusing attention.[65]

Erdreich told the Chairman that several studies were already planned that would help generate the information required to resolve the PF E/MF health effects issue. "We have to keep an open mind and see what the results are." However, the two studies by the US National Cancer Institute and the BC CCA (involving large populations of children) were case-control studies; the ideal prospective study was unlikely. Also very important was the determination of individual PF E/MF exposures. Earlier studies were not necessarily "flawed by incompetence" but "by not having the experience to work on." Sastre told the Chairman that "seldom if ever is there one study... that clears the air." His "utopia... would be an accumulation of good laboratory and epidemiology studies which together... make it very clear" if there is a hazard. The tools of risk analysis would then be applied to indicate what should be done. Erdreich, using the increasing concern about hazardous waste sites in the US as an analogy, added that perhaps a study comparing the health status of the community to another could be "useful and reassuring" (as Marton had suggested) but such studies sometimes lacked strength.[66]

Marino

After being sworn in, Marino said that the literature on PF E/MF health effects could not be

reviewed in a short period of time, "certainly not over six weeks," and that it had taken him 27 years.[67]

Marino described how he calculated the level of PF E/MF expected after the addition of the 230 kV line to the existing 138 kV lines. The technique was based on an article published in an engineering journal about ten years ago which he co-authored. Measurements were "impractical." The average electric and magnetic field levels for people not using electric blankets and not living next to high voltage power lines were 1-3 V/m and .3-.5 mG, respectively. During cross-examination, MacKenzie suggested that due to the approximations made, Marino overstated the magnetic field level close to the line and understated the level further away. Marino replied that the assumptions were practical and routine for the method used. Later (after Marino had returned home), Wong testified that the results of his magnetic field calculations were higher than Marino's. The Chairman suggested that the assumptions made by Marino were suitable for Marino's purposes. Wong replied that he would not make such assumptions as an engineer and could not accept the 300 percent error that resulted.[68]

Marino stated that, based on the literature, the existing and proposed Dunsmuir/Gold River power lines were a health risk. Exposures from PF E/MF levels off the ROW were many times above average and produced changes in the bodies of animals and humans. "If you look at the many hundreds of studies and you discount the ones that lead nowhere, like the industry-funded ones, you are led to the conclusion that the fields are biological stressors." It was "well-established" that chronic exposure to stressors promoted disease because the body's adaptive capacity was reduced. EMF did not "'cause' disease. That's a red herring of a word in a hearing like this. No factor causes any chronic human disease." Rather, magnetic fields were risk factors for cancer in the same way that smoking was a risk factor for lung cancer.[69]

In response to Gathercole's comment, "We have a situation where there are conflicting opinions, and that's not surprising in scientific situations," Marino interjected, "It's not the scientific situation that is the cause of the conflict, it's money... Every study that they [Erdreich and Sastre] point to as supporting their side is paid for and run by the utility companies, and it's been my experience since 1973 that if the utility industry has anything to do with the study, ...if it designs it, pays for it, analyzes it, pays to have it analyzed, touches it in any way, it's tainted and not worthwhile." In response to the Chairman's question of what then was worthwhile, Marino replied, "Studies that are done... by honest scientists who don't have to sign a contract in advance to produce data that the industry wants. All the studies that they point to are done in secret. The protocol isn't available... and the data that's obtained is held in secret... and the industry releases only data that it chooses. That's a form of extreme bias, and it makes any result that they produce worthless. The only [studies] in science that are

worthwhile... are done in an open way, as is traditional in American science. For example, funding from NIH... is the traditional way of getting competitive funds in the United States. You send the government a proposal to do a study and that proposal is public knowledge. You can't hide anything. You've got to report to the government what your data is every year.... It's been clear over the years that many of the studies that showed adverse effects, that were bad for the corporations, never saw the light of day."[70]

Marino stated that exposing humans involuntarily to power line E/MF constituted human experimentation, based on US "rules." If a proposal was made to expose humans to increased levels without consent, it would not be approved by any US medical school. "It wouldn't pass muster in any place. Maybe in Nazi Germany, but not in America."[71]

According to Marino, Donald Gan, then of Johns Hopkins and under contract with EPRI, was found by an EPRI review panel to be "an incompetent scientist" after reporting adverse effects on dogs and baboons from PF E/MF exposure. His grants were cancelled and his laboratory was "destroyed" within sixty days. "Don Gan gave up work in this area, figuring it was too political." "And that was just the first of a litany of those kinds of stories." Sastre, who knew Gan "fairly well," testified earlier that Gan discontinued his work with PF E/MF because he had "great reservations about the reproducibility of the findings."[72]

Marino said that, despite being "well-funded for 17 years," after he and Becker testified in New York during the late 1970s "all of a sudden our funding, ...my job, ...the laboratory... [and] the equipment evaporated... Dr. Becker was essentially forced to retire."[73]

Disagreeing with Erdreich and Sastre's views about "blue-ribbon" panels, Marino said, "She's [Erdreich] new to this field. When she's here a little longer, she'll realize that virtually nobody would say that. It's simply untrue." Marino clarified for the Chairman that he was not talking about the panel members as individuals but in their roles as contractees, consultants or advisors to the utility industry. "They have a well known attitude about health risks, and it was because of the attitude that they were put on the panel." The Chairman questioned whether even one panel member, as a research scientist, might have produced work of value. Marino replied, "There's a contradiction in terms... The way the game works is that you go to them, and you say I would like some money to do research. That's what, for example, H.B. Graves did. He's the Chairman of the Florida Advisory Committee that she called a blue ribbon panel. He's now a full-time consultant for [one of] the biggest law firms in the country that represents utility companies." At that time, Graves was an EPRI research scientist and wanted to conduct research. EPRI agreed and told Graves "'Here's what you do.' Now, if HB had his choice, he would have done other things. I've talked to him and I know it."[74]

By this time, the atmosphere in the inquiry room was very tense. The Chairman stated, "I may demonstrate some sensitivity... because it's difficult to disassociate the BC Utility

Commission from this... My paycheque and that of the other Commissioners comes from the Provincial Government, ...BC Hydro is a crown corporation; there is some potential incestuous arrangement here because of the way we're both funded. I'm sorry, I don't wish to be argumentative, but... I fail to see the syllogistic value.... In relation to the people's concern this is an important point... There would seem to be two sides in terms of the expert witnesses and therefore it's important to me to be able to recognize" if there is any bias on either or both panels. Marino responded, "There really aren't [two sides] with the exception of people like these folks who have no background in this field... They're hired to come in and to pass off the same testimony that their bosses gave in other places... That doesn't elevate what they've said to any logical syllogistic... meaning. What they're hoping to do is to count on the relative informality of this forum and not let you see the underlying substratum."[75]

Marino offered an example of how he first realized his views. In the early 1980s, "Dick" [Richard] Phillips, then at BPNWL, received US $5 million from EPRI to repeat Marino's experiments showing adverse effects in mice and rats.[76] On a visit to Marino's lab, Phillips said that EPRI wanted him to use "fat rats in small cages." Marino replied that it would be impossible to observe any effects because the animals, including the controls, would already be "so stressed out." "It's [just] a job for him. If it's not syllogistically clear to you then, Mr. Chairman, I probably can't do any more, other than give you similar examples." The Chairman replied, "I can't resist this. Maybe it's time for a short break, but I presume it's the fat cats that insisted on the fat rats." "I've been almost two years with the Commission, and I don't think I've been as aroused as I have in the last 10 minutes here. Gustafson commented, "It's not a chronic stressor, Mr. Chairman." The Chairman then called for a break.[77]

When the inquiry reconvened, Shannon made a presentation and asked, "Are we willing to risk the health of our parents, our children and ourselves no matter how small that risk may seem to be? ...What is our message to the youth if we allow economics to be a guiding principle in this decision... To not decide is to decide." The ensuing applause prompted the Chairman to state, "I... appreciate that these sessions are long and occasionally I'm prone to make the odd comment which I hope is not too distracting. But these are very serious proceedings, and I do take it seriously, and... the expressions of support which are generated by applause or by comments that are called out... probably have the potential of... perhaps distraction which is really not a normal part of this process. And even though I said that we would have an informal arrangement here, I think that while we won't rule it out, I would ask that it be contained or at least restrained if possible."[78] The Chairman then responded to Shannon's presentation, stating that the role of the BCUC under the Utilities Commission Act was "to protect the public interest... We're asked to (act in a just manner) on the basis of the facts as best we can adduce

them through a quasijudicial process, not a court process.... The important ingredient is... information.... When the information is hard to detect, is cloudy, or diffused... our job really becomes quite difficult, because... all said and done, we are lay people charged with the legal responsibility."[79]

Marino resumed his testimony, stating that he had a "clearer opinion" about what was an unsafe level of PF E/MF exposure than about what was a safe level. Levels of 50 V/m and 1-2 mG or higher "thoroughly contaminates the land that is burdened with those fields. It... makes the land unfit for human habitation... That land ought to be reserved... for a highway of energy and we shouldn't have a fiction that people can live there safely." "One couldn't logically say that the lines created no risk" until the fields were less than .4-.8 mG or less than 1 V/m. At those levels the line would be safe because "you would... be outside the zone of influence" of the line. Later, under cross-examination by Gustafson, Marino stated that his choice of absolute upper levels for chronic involuntary exposure were different than those previously given under oath in a different jurisdiction because of "the amounts and kinds of exposure" expected to take place. Gustafson asked Marino several times in a variety of ways to explain the basis for his opinion regarding safe levels. Marino stated that he based it on increases over existing levels. An increase of a few percent was no basis for concern while doubling one's exposure was. Gustafson said that he didn't understand why Marino chose .4 mG over any other number. Marino answered, "The question of whether .4 is bad for you or not, is just not dealt with in this kind of a forum." It was a judgment on his part, based on his reading of the literature.[80]

Marino was asked, under cross-examination by MacKenzie, if an "honest and objective scientist" could conclude, based on the evidence to date, that power line E/MF exposure did not pose a health risk. Marino replied, "That would clearly be against the weight of the evidence... If you want to reach that conclusion, what you do is ignore parts of the data." MacKenzie then asked Marino whether it was his view "that a fair-minded scientist reviewing all the data could not reach that conclusion." Marino replied, "It's not a question of being fair-minded, it's a question of including all the data." MacKenzie continued, "But the hypothetical I put to you is that it's a scientist who has looked at all the data... is it possible for an honest and fair-minded scientist... to come to that conclusion?" Marino responded, "It's the same question, counsellor, and I'll give you the same answer... It would be independent of the nefarious subjective state of the individual, whether he was right-minded or not is irrelevant. It would simply be against the weight of the evidence."[81]

Marino told MacKenzie that although Savitz was a competent scientist, his opinion was "not unbiased... If David says that there are no health effects at all... then the EPRI would...

pull his grant because... why should they give him $500 000 if there is no problem... If he says there is a problem then the EPRI would [also] pull his grant because they never fund anybody who takes such a controversial view... So David walks a fence in which he never appears at a formal hearing, and his name is always thrown about but [he] never speaks himself." After MacKenzie commented that Savitz had testified at an US Congressional hearing, Marino replied that Savitz also "spoke" at a Florida hearing but what Marino was referring to was cross-examination, "the hot seat type of testimony."[82]

Marino, responding to MacKenzie's question of whether Savitz' research was tainted by its industry association, stated that "on the contrary, David did nothing more than was done by Nancy Wertheimer" and, "to his everlasting credit," reached the same conclusion. Wertheimer originated the hypothesis, and funded the study herself. "David's $330 000 was for essentially a re- examination of the same data.... He's now doing a $500 000 study but the protocol... is secret." Savitz, because of his "contractual relationship" with EPRI, and EPRI both refused to give Marino the protocol.[83]

MacKenzie, reading from Savitz' open letter, asked Marino if the paragraph including the statement "we have not proven that magnetic fields cause cancer" was "fair comment." Marino replied, "It's a good example, Mr. Chairman, of the way words can be used to create great confusion." The "classic laboratory science definition of cause" was that there was an effect when the cause was present and no effect when the cause was not present. With regard to any chronic human disease, such as cancer, "we only speak of factors that predispose because there's no factor which when it is present always produces a certain disease in people. So this statement is a slippery eel way of stating the obvious. We don't have a proof that magnetic fields cause cancer, and we never shall because such a thing is impossible. All we'll ever do is make plausible the link between field exposure and cancer. And the more such studies that we have, the more plausible is that link."[84]

MacKenzie asked if Marino was suggesting that the misleading statement by Savitz was biased by his source of funding. Marino answered that the statement was misleading for the reasons he had just given. "Why David acts is inside his brain. Get him here and talk to him about these studies instead of bandying his name around and we'll find out." MacKenzie then asked Marino if he was inferring that Savitz' motive was improper in publishing the open letter and whether he could have made the statement as an "honest and unbiased" scientist. Marino said he had "no comment about David's motives." When MacKenzie questioned him further, Marino stated that he was not interested in Savitz' opinion of whether power lines were a health risk because Savitz had an interest in the answer. "I think it's a bad way to make decisions."[85]

MacKenzie referred to the WHO Environmental Health Criteria 69 which stated that induced current densities less than 10 ma/m had not been shown to produce any significant biological effects. Marino said that the statement had no relationship to the issue at hand. "No one here has been presumptive enough to testify about currents induced in people." Induced currents could not be measured. Marino also said that the report was the collective views of an international group of experts and did not necessarily represent the position of the United Nations Environment Program, the International Labour Organization or the WHO, and contained a disclaimer indicating this. The delegates included power company representatives from "many" countries, including the Philippines, Australia and the UK. Marino added, "There was a dispute on this panel between the Western... and the Russian scientists, and the Russian scientists walked off." Their names were not listed on all drafts of the report. MacKenzie replied that his copy of the published report included their names. Under further questioning, Marino stated that the three Soviets on the panel were with the Maraziev Research Institute in Kiev but added that their concerns were with electric field health effects. He did not know the basis of their opinions.[86]

Marino explained how the NYSPLP came about, noting that New York (investor- owned) power companies only complied with the New York State PSC's order to provide funds for independent study of the PF E/MF health effects issue after litigation resulted in a court order. Marino accepted some of the conclusions of the NYSPLP SAP, however, "part of the arrangement that led to the study gave the New York Power Association significant control over who was on the panel." Most of the studies funded were animal or in vitro studies, and not useful in determining health risk to humans.[87]

MacKenzie pointed out that Marino did not cite Savitz in his written testimony. Later, Marino told Gustafson that there was "no significant reason" why he did not. Wertheimer had already reported the basic observation and Savitz' report "merely reanalyzed the same data. So I just didn't cite it. Nothing of great moment. In fact, I thought I did cite it."[88]

Marino told MacKenzie that distinguishing between microwave and PF E/MF exposure was "very foolish and unwise." Furthermore, many of the studies ERI cited involved both exposures. "Every" occupational study involved individuals exposed to both high and low frequencies. "The general rule in Bioelectricity with respect to the issue of health effects is that you consider all the energy." It would be like arguing that only one brand of cigarettes was relevant to the relationship between cigarette smoking and lung cancer.[89]

Marino explained to Gustafson why he included studies involving pulsed radio frequency, microwave, and 60 Hz exposure, as was "standard procedure" in Bioelectricity. In his 1982 book, Marino explained that he brought together a number of studies for comparison and showed that

although there may be some specific effects from exposure, for example, cataracts from microwaves, the general effects were the same. Both fields functioned as biological stressors and placed a demand on the immune system, therefore the "literature from both areas is pertinent and routinely used. It's a standard industry argument that you should exclude high frequencies. It's a very unwise thing to do, and in my estimation rarely done in forums such as this. I can't think of any forum that ever has done it."[90]

Marino continued, stating that all EMF, "perhaps up to infrared and maybe even above," appeared to tax the body's adaptive capacity. He clarified that he was referring to subthermal microwave, that is, energy levels that did not heat tissue. Marino commented, "Not even utility company witnesses" make the argument anymore that because there was no heating, there were no effects. He added that the physics of ionizing radiation were "fairly well understood," but not those of non-ionizing radiation.[91]

Dack, a BC Hydro employee who worked on distribution lines and lived 100 metres from the Dunsmuir/Gold River lines, wanted to know "in percentages" what his chances of contracting cancer were. (Earlier, both Erdreich and Sastre had told him that because there was no hazard there was no risk. Dack had responded, "And you [Sastre] are, I would gather, a leader in your field... or one of the leaders." Sastre said that he would not describe himself as such, only as a "student in the field. And moreover, what's important is what the studies show... It's the data that speaks, not I." Sastre added that his backyard terminated at the ROW of a 167 kV line and health was not one of the factors he and his wife had considered when they purchased their home.)[92] Marino told Dack that he did not know what Dack's chances were. "The conclusions that we're making are much more general than that. The only way you get answers to those kinds of questions is if you pay the money to do the studies." Marino knew of no study in progress that would do this. "They may be going on in some secret way someplace... There's nothing in the literature about them."[93]

Marino told Gustafson that an additional transmission line could not practically reduce PF E/MF levels due to phase cancellation effects, because of the complexity of the phase relationships. However, bringing the lines close together in an underground pipe would reduce the fields significantly.[94]

The Chairman asked Marino if, in some circumstances, people living near a power line might be getting exposures from appliances and wiring configurations within their homes that were higher than those from the power line. Marino concurred that this might be true. Because living standards and patterns varied, individual circumstances must be placed in context. He was using .4 mG as an example.[95]

Marino told Gustafson he did not know if there had been a seven-fold increase in residential energy consumption since 1950 through to 1985. Gustafson then asked if a large increase in residential energy consumption in North America were to be shown, would Marino expect to find a corresponding increase in disease generally. Marino replied that there was "no direct correlation. Disease is multifactorial."[96]

Gustafson then asked why the BCUC should accept Marino's "hypothesis over the weight of the evidence reported by others in the scientific community." Marino stated that he knew of no one in the scientific community who had "sustained the position" of the ERI panel. "The only people who take [that] position... are people who directly work for power companies." He knew of no scientist working in Bioelectricity in North America, Europe, Japan, the Soviet Union, or China who "would take the position that there is no risk from power lines.... So your characterization of the literature is just way off base.... Now, in a sane, reasonable world where money isn't determinative, and where legal arguments don't rule, [studies] indicate that there's some risk associated with being exposed to those fields, particularly when you bear in mind that the studies span the gaps." The only common factor that the subjects were exposed to was EMF.[97]

The following exchange brought the BCUC's cross-examination of Marino to an abrupt halt.

> Gustafson: Your evidence as presented here had been extremely interesting, entertaining, and... provocative and I have absolutely no doubt that you hold your views seriously and sincerely. During the course of your evidence, you've made a number of what can only be characterized, ...even in the most conservative terms, as highly controversial statements, and... some would characterize them as inflammatory and potentially slanderous or libelous. You've made allusions to Nazi Germany, ...branded a host of scientists as little more than dishonest prostitutes, ...made allegations regarding international --
>
> Marino: Now wait a minute, wait a minute --
>
> Gustafson: Allow me to finish my question and I'll let you --
>
> Marino: This is ridiculous, this is ridiculous. Now, I didn't make any slanderous statements, and the evidence I gave was evidence that I'm prepared to back up if you want to go into it. Now if you want to take these one by one and ask me questions, then ask me questions. Don't give me a speech. I didn't come here to listen to that business.
>
> Gustafson: I want to ask you a serious question.
>
> Marino: I appreciate you do. Let's leave off the comments about my behaviour. Let the

Chairman decide about that.

Gustafson: You've made allegations concerning a conspiracy to suppress information. You said that certain studies had been kept secret and couldn't be accessed.

Marino: What, for example? Are you referring to Dr. Donald Gan's study... [or] Dick Phillip's?

Gustafson: Well, you tell me. You're the one that said that certain studies --

Marino: Well, they're the two I remember speaking about, and I wouldn't characterize them as a conspiracy. What Dick Phillips did made a lot of sense if he wanted to do his research...

Gustafson: Did you not say that power companies and scientists had worked together to suppress certain scientific data?

Marino: No. No, you're fabricating my testimony

Gustafson: Did you not say that --

Marino: I didn't say that at all.

Gustafson: -- certain studies had been kept secret?

Marino: Certainly they're kept secret, and EPRI will tell you they keep them secret... Ask the Chairman of the Public Service Commission in New York...He wrote and asked them for studies and copies of their protocols and they told him no. And I've written and they've told me no. You just don't know the territory or you wouldn't make such outrageous statements.

Gustafson: Well, what I'm concerned about... is... that many of the statements that you've made have been cast in extremely strong terms... Have you given any consideration to the effect of that kind of statement on your position [as] a research scientist and to the weight that people will attach to the results of your research, given the strength of your convictions and the way... you... phrase them in this kind of forum?

Marino: Yes, I think it would be inappropriate for me not to tell the truth, and that's what I've done. You simply find it hard to believe that some of the things I've said are true... The issue is not whether I said them.The issue is whether they're true... I have spent many years investigating, so far as the information is available under American process, the nature of the studies performed by industry. And although there are some exceptions, the general rule... is that the data is rigged to support the industry conclusion.... If you're relying on that data, you're not thinking right. Now, that's simply an analysis of the data.That's not something I sucked out of my thumb.[98]

Gustafson: I find the suggestion... that data has been rigged to be a strong statement...

Marino: No... I said the studies were rigged...

Gustafson: All right...

Marino: There's a big difference. Do you understand what the difference is?

Gustafson: Yes, I do...

Marino: Are you sure?

Gustafson: Yes. And, Dr. Marino, if the studies –

Marino: Well, why don't you explain it to me and we'll make sure it's right.

Chairman: Just a minute, Dr. Marino.

Gustafson: -- are rigged it implies... that people are deliberately seeking to disguise... or to hide the truth, or to falsify results?

Marino: You just don't know the territory and you're just taking too simple a view. I don't think Dick Phillips... was thinking anything more that the $5 million contract and the 30 employees that the money would give. That's what the sponsor wanted. His job was to do that study. In and of itself there's nothing wrong with that. It becomes wrong when out of the mouth of... utility company witnesses, that's held as evidence that lines are safe, because that field didn't cause an effect. That's where the undesirability, the impropriety of it comes from, and if it offends your ears I apologize, but it's the truth.[99]

Using the analogy of drilling for oil from Marino's written testimony, the Chairman suggested that perhaps some of the studies with utility involvement were simply "dry holes." Marino commented that no one would tell the Chairman they only considered part of the data, whether they had or not. "I considered all the data, Your Honour, Mr. Chairman. The negative data and the positive data." Marino said that the difficulty with the negative data was not whether it was considered or not but how it was used for argument. The industry used the negative studies to negate the positive studies. "It's only lawyer's argument that would allow you to juxtapose them. There's no scientific juxtaposition. [The] negative study scientifically only has value when it reasonably duplicates the positive study and finds an opposite result."[100]

The Chairman was troubled by Marino's position that industry-funded research was invalid even if replicated. "We're talking about millions of dollars." He asked Marino if it wasn't the case that industry paid for "everything." Marino agreed, stating that he did not know "how honourable people" were going to be in the future. He could only relate what had happened in the past. "There's a documented litany of dishonourable things that have been done with regard to the interpretation and the production of data. That leads me not to have faith in industry. If the industry produces a study which says my children are not at risk for cancer, it has a low credibility in my judgment, based on their past production." Marino

estimated that since funding began with Gan's study in 1972, about US $100 million had been spent by industry. He told the Chairman that, of that sum, no study had been produced "that is going to be useful for you to make a decision. They have put their money in other places."[101]

The Chairman asked Marino how people who accepted his position should respond. "Should they take you absolutely literally or... literally in context?" Marino replied, "I'd like to be perceived as giving advice that attempts to stake out the middle ground.... It's extreme to say it doesn't make any difference how many power lines you put on that right of way [because] there's no risk... It's also extreme to... attribute every disease, every clinical syndrome, ...to the line. There is a middle position which amounts to a recognition that there is some health-impacting aspect of being chronically exposed to electromagnetic fields. But... these fields don't cause disease, ...they are factors associated with disease like many other factors.... One strategy for coping, if it's undesirable to exclude the fields from your living area, if it's impractical, or impossible, [is to] ...assess the other factors in your life that similarly produce or orient to a disease, and reduce those factors. There doesn't need to be an excessive reaction. There needs to be a total integrated view of the factors reasonably suspected to pre-dispose to a disease, and a judgment made then."[102]

The Chairman stated that he had "enjoyed this very much. This is an experience." The next time he attended a meeting of the US National Association of Regulatory Commissioners (he was Chairman of the Canadian counterpart), he would suggest that "perhaps they consider a test for Commissioners, ...and that is that they really are on probation until they've had an interface with Dr. Marino." The Chairman also thanked Marino for indulging his reminiscences into Thomistic philosophy.[103]

Marton

John Marton had a Ph.D. in experimental and child psychology. During his training as a research psychologist, he investigated the prevalence of mental illness and evaluated the results of various treatments. This training included a "very heavy" statistical and epidemiological component.[104]

Marton was sworn in and recounted his involvement in the Courtenay controversy. MacKenzie interrupted to provide corrected calculations of the PF E/MF levels on Marton's property. They indicated a level of 5 mG at peak load. The information originally sent to Marton, indicating 10 mG, had been based on "thermal limit numbers." Marton continued, stating that, from his reading of the evidence, adults were at "minimal risk." However, children were at "substantial" risk as "developing organisms." The fact that there was no "causal proof" did not reassure Marton. Proof was not an appropriate criteria because proof in health effects was very

difficult to ascertain. Research "clearly" indicated an association. There was a one in 60 chance that one in three children living under the lines for 14 years would develop cancer. His assumption of a three- to four-fold increase in cancer was as reasonable as the assumption of no increase.[105]

Marton commented that Erdreich, Sastre and March relied entirely on "knocking down" studies which showed adverse health effects. In his experience "as a scientist, any study can be disputed." He was "very concerned" that Erdreich and Sastre had no knowledge of a comprehensive health survey of children living under power lines and could not understand how they could speak with any confidence that there were no health effects. Marton disagreed with Erdreich's earlier statements that such a study was "very complicated and difficult and we don't do studies like that." Health surveys of children were conducted everywhere. He was involved with one recently completed on northern Vancouver Island. Marton found the lack of such a survey to be "very telling."

Marton disagreed with Erdreich and Sastre's opinion that studies showing an association between PF E/MF and health effects erred on the side of showing an association "stronger than real life." He suggested that the studies, because they were "not very good," erred by showing an association that was "lesser than real life."[106]

Under cross-examination by Gustafson, Marton stated that the available data could not detect an increase in overall incidence of disease with an increase in electricity use.[107]

Marton confirmed for the Chairman that he was not putting himself forward as an "expert." The Chairman commented that Marton was "certainly better informed" than he was.[108]

CVRC

Darlene Kavka read aloud a number of letters and petitions on behalf of area residents. (Three of the petitions were concerned with rerouting the power line(s) because of possible PF E/MF health effects; the fourth concerned BC Hydro's use of ROWs.) Then, Kavka recounted her own and the CVRC's involvement in the Courtenay controversy. She noted contacts made with scientists, including four Ontario doctors who "very much wanted us to know their opinions with regard to the placement of the lines." One letter was from AH Martin, Ph.D., FRSM, a neuro-embryologist who had studied the chick embryo for the past 20 years and published 30 papers dealing with its normal and abnormal development. He understood that EMF levels in the range of 6-10 mG would occur near homes in the vicinity of the line and wrote, "Until we can conclusively demonstrate that no damage will occur to a developing embryo from such lines, we have a moral, ethical and public responsibility to seek alternate routes which bypass residential areas." Kavka had tried to contact Savitz, but he was a "busy man."[109]

Kavka also presented the results of the health survey conducted by the CVRC. "We are not pretending to be scientists. It is completely subjective, not objective." The CVRC welcomed more studies of that nature "because the increases in certain diseases may not in themselves be so terribly profound." The Chairman responded that the survey "doesn't necessarily establish very much.... It may possibly be used or taken by individuals for more or for less than what it really is... It's been well established that there is concern in this area... Some... have opinions on whether... that concern has been fanned or promoted... over time or this week." The Chairman, concerned that the information might give rise to an "escalation of concern," cautioned that those having the information be very careful when interpreting it or drawing conclusions. It was not "necessarily correct to draw specific conclusions... other that to recognize this as a tangible evidence of concerns."[110]

Kavka said that she was never once told of the possibility of harm from living by the lines. She asked BC Hydro if, in their opinion, it was safe for her children to play under the lines [in her backyard] all day. "They said 'certainly.'"[111]

Kavka read a submission on behalf of the CVRC, which, among other things, stated, "There are literally hundreds of scientific studies which converge to indicate that electric fields, magnetic fields and combined electromagnetic fields do produce biological, neurological and cellular alterations and harm. There seems to be a tendency in reviewing the literature to draw the line regarding potential harm at the inconclusive nature of the dozens of studies linking extremely low frequency electromagnetic fields to cancer... The link is not only real but currently grossly understated.... The magnetic radiation does not discriminate. Known and undisputed biological effects of electromagnetic radiation include component alterations of cerebral spinal fluid." The NYSPLP reported "lengthening of the inter-beat interval of the heartbeat" and "significant alterations in behaviour." A medical degree was not required to "clearly understand that brain function is being affected in some way to result in behavioural alterations."

The issue was not whether biological effects constituted a hazard to exposed human populations but rather "to what extent, if any, is it ethical, moral or even legal to knowingly physically alter exposed populations without informing them honestly and fully." Examples of misinformation from BC Hydro included the Ontario MOH's review of epidemiological studies, distributed to some residents, and ERI's background report, included with BC Hydro's buyout proposal. The author of a March 1988 article in Listener Magazine titled "The Killing Fields" had been referred to the Ontario MOH review by the UK Central Electricity Generating Board. He asked an epidemiologist with the WHO and Carpenter to comment on the report. They said that it was "terrible, incomplete, superficial, factually incorrect in places, biased, unconvincing, flawed, and wholly inappropriate as guidance." Kavka had sent the ERI

background report to Louis Slesin who has a Ph.D. in "occupational risk analysis."[112] He was "highly critical" of ERI's "interpretive conclusions," stating that the document was "unsuitable as informative guidance."

Safety concerns about earthquakes (the power lines could fall) and the proposed routing of the Vancouver Island Natural Gas Pipeline along the ROW (leaks and sparks could result in an explosion) were raised. Whether the Canadian Charter of Rights and Freedoms, which "guaranteed rights of life, liberty and security of person," would allow for involuntary exposure to the various risks of the lines was questioned. Although the buyout offer to some extent addressed the involuntary exposure issue, there were not enough alternate home sites for the "ninety percent of the exposed property owners who wished to remove themselves from the risk." The lines should be rerouted so that residents "regain the relative risk odds ratio that the rest of the population here lives in."

In conclusion, "two analogies" were made. The first was that before the "exact mechanism" of rabies was understood, people knew enough to stay away from the mad dog. The second was that this was a case of "Russian roulette, power line style." Potentially lethal lines pointed at the residents who asked BC Hydro to guarantee that they were not loaded. BC Hydro answered that they did not know if they were, they "just [had] to pull the trigger a few more times to find out."[113]

Kavka said that the CVRC did not want to jeopardize the buyout proposal for people who wanted to leave the area. They saw it as a "band-aid on a jugular hemorrhage," passing on the problem to a whole group of people who may not have heard about the issue. It became a "very serious conscience issue" because of the some 1000 children who lived close to the lines. That was why she and her husband had not moved. They had considered that their actions might be "unpopular" with many people, and devastate their property value and any possibility of "getting out intact financially."[114]

Kavka read a statement from her husband, Frank. He had boycotted the inquiry since July 12 because it was "utterly impossible... that a fair, informed and just decision could be arrived at on the basis of four days of evidence." BC Hydro's expert witnesses were "totally uncredible." If the new line was "raised," his property would be "donated as a symbolic cemetery, a memorial to those who will die and who have died as a result of these high voltage lines in our community and elsewhere, while we fail to correct our mistakes." If the line was raised, it would be without his consent "at any price."[115]

Under cross-examination by Gustafson, Kavka stated that BCUC staff had told her the BCUC would not pay for Marino's expenses but advised her to send a letter of request anyway. She had

not been informed that the BCUC was precluded by statute under the Utility Commission Act from paying the cost directly or from requiring that any other participant in the proceedings pay the cost. Kavka commented, "Since the taxpayers and rate-payers are paying for every other expert here, ...it seems a little bit more than unfair that it has been off the sweat of the brow of people who are trying to protect themselves that Dr. Marino has been brought in."[116]

Kavka told Gustafson that the calculated magnetic field levels BC Hydro was now presenting (.5 mG for the existing lines, 1.1 mG with the new line) were lower than those originally indicated to her by BC Hydro.

In reply to Gustafson's suggestion that the magnetic field levels in Kavka's home were primarily influenced by sources other than the transmission lines, Kavka said that that was a "trap" used in the literature and by ERI. "I do not live with my nose at my toaster oven, nor do I live with my nose at the fridge.... I do not even live in my kitchen. I do not have an electric blanket... [or] waterbed heater... They are not chronically something that I live in and they should not be compared in any way, shape or form. I have the one other option which really is what this all comes down to.... I can stop using electricity altogether... But I am still going to be impacted by these lines because I cannot protect myself."

Kavka agreed with Gustafson's point that, as Marino had said, each person had an unique set of exposure circumstances. However, "We have not always been aware of what was affecting us." People living in extremely high electromagnetic fields did not choose to live by them. If they had, they never would have bought their property. Society, not just individuals, were faced with "very, very major decisions." "You must not... start drawing the line of whether you accepted 8 mG last week and now it's not good enough for you... No one is actually accepting those levels."[117]

Gustafson pointed out that the PF E/MF levels in Kavka's home were within the average range of values as stated by Marino in his written evidence. Kavka replied that saying she was not affected because the levels fell into the average zone was inaccurate. Also, those averages were for a North American city. She lived in a semi-rural property with one small distribution line at a "considerable" distance from her home. Kavka added that the levels in her home were "quite irrelevant" even if "normal." Half of her property was in the 20 to 30 mG range. "It's a heck of a big deal."[118]

MEC

Cathy Burns, representing the MEC, noted that the series of articles by Paul Brodeur recently published in the New Yorker magazine, "of which all of us here are by now aware," chronicled the research conducted and suppressed over the past 30 years. A passage concluding that society

should "err on the side of caution" was quoted because it reflected their concern.

The MEC acknowledged that some of the scientific research had been "deemed" inconclusive but their contact with the local scientific community had "increased the suspicion that a biohazard exists." Terry Anderson, Ph.D., past head of the Department of Health Care and Epidemiology, UBC, John Syrett of Pacific Power, Oregon, and Mary McWright of the BC CCA had spoken with them about ongoing research. If time, effort and money were being spent on research "there was justification for believing that we really do have something to be concerned about." A recent rerun of W-5 aired the Bridlewood dispute and aired some key statements by scientists, including Jerry Phillips, who said that "living in close proximity to power lines removes all freedom of choice."[119]

School District 71

The Chairman of the school board told Gustafson that he was not aware that the magnetic field from the transmission lines would be .5 mG at the Arden Elementary School building according to the measurements presented that day by BC Hydro. He added that the Board was concerned with the total living environment of students.[120]

Others

Several residents gave anecdotal evidence on PF E/MF health effects. Thate, a rabbit breeder, attributed a decrease in conception rate and increased rate of abnormality in his rabbits to PF E/MF from the lines. He told MacKenzie that he had not consulted a veterinarian.

Robertson stated that electric blankets had been found to "affect the immune system." He also stated that "electromagnetic radiation" had been used to heal bone and cause bone growth. Robertson's wife developed thickening of the bone in her leg and migraines since they moved into their house. Both his wife's migraines and his three year old son's speaking problems and belligerent behavior disappeared when the family moved into town while their house was being renovated. Since moving back, his son had developed thickening of his collarbone. Robertson believed that he and his daughter were not affected because they were at work or school during the day.[121]

Zajac stated that she was on adrenal and thyroid medication, and suffered from frequent and severe headaches, muscle weakness, dizzy spells, allergies, constant fatigue and heart palpitations. Both she and her daughter experienced dramatic changes in their birthmarks. She lost her first child due to birth defects which could not be attributed to heredity. The health problems had surfaced since she resided in her home near the lines.[122]

Nordis attributed her headaches, loss of hair, vomiting and insomnia to stress from the lines. Painter stated that his family was using more Tylenol.[123]

Comments made by other local residents included:

- Learn from society's earlier mistakes such as asbestos and defoliant sprays;
- The studies may be flawed individually but they could not be ignored collectively;
- Err on the side of caution, especially because children might be involved;
- People's lives, families and communities must be considered before the financial cost of moving the line; and
- If PF E/MF were found to affect people's health in the future, moving the line would be more expensive.[124]
- Should citizens be required to show that the lines were dangerous or should BC Hydro be required to show they were safe?;
- If BC Hydro was so certain the lines were not a hazard, then they should accept financial liability and provide health and life insurance;
- People living close to the line should be compensated;
- The ROW agreements should include health, safety and environmental impact riders; and
- Let the lines go through the tree farms. The "forestry people" should live with them.[125]

Safety concerns were again raised regarding earthquakes and the Vancouver Island Natural Gas Pipeline. The Chairman commented that the pipeline issue had been dealt with at an earlier hearing at which there was little public participation.[126]

The public also raised environmental concerns including:

- Why choose short-term economic gain (jobs and a higher standard of living) when it was questionable whether the pulp mill expansion was even needed?;
- Recycling could save valuable resources and reduce pollution (resulting from effluent and landfill); and
- Animal populations might also be affected by EMF.

<u>BC Hydro - 2</u>

After being sworn in, BC Hydro's second panel recounted their involvement in the Courtenay controversy, focusing in particular on how the PF E/MF health effects issue had been handled. During cross-examination, the panel was asked if they would live near transmission lines. Beaven said that he was not concerned about possible health effects and lived within 100 metres of a double 230 kV circuit. Both Wong and Barker said they would not live nearby for esthetic reasons. Boatman said that health concerns would be one of the factors he would consider (along with esthetics, property value, and personal needs) but it would not be the

deciding factor.[127]

Boatman told the Chairman that the Chairman's decision would have a considerable effect on the whole of society. He told Vance that if a definitive link between power line E/MF and health effects was found in the future, that BC Hydro did not have a contingency plan. However, if that was the case, the whole of society would have a "major problem," not just BC Hydro.[128]

3.2.2 Summary of Oral Testimony - Other Issues

CPFP

CPFP confirmed that the 230 kV line would be of no direct benefit to Courtenay. The new mill could not operate without the additional power provided by the line.

For each day delivery of electricity to the Gold River pulp mill was delayed beyond August 15, 1989, unrecoverable out-of-pocket expenses of $115 000 would be incurred, not including lost profit. 128 direct jobs and 250 support jobs were associated with the new mill. Both national and international members of the Limited Partnership would be expecting newsprint supplies.[129]

The Chairman questioned whether the Gold River pulp mill should bear some of the cost of rerouting the line, or was the problem exclusively the utility industry's. (As usual, BC Hydro was covering the construction costs and expected to recover the costs in rates over time.) Earlier, CPFP had said they would not contribute to the costs of the buyout program or the costs of completing the new line and its subsequent rerouting.

BC Hydro

BC Hydro explained the rationale for the buyout proposal. They did not estimate buyout costs prior to making the offer nor did they consider the possibility that the costs could exceed rerouting costs.

The issues of burying the lines to reduce PF E/MF, alternative sources of power, both permanent and temporary, to allow for pulp mill operation during rerouting, and co-generation were discussed. Burying the lines would cost up to 20 times more than routing overhead lines through residential areas; the 7 km Courtenay- Cumberland section would cost about $14 000. A stand-by gas turbine plant in Port Hardy could supply the required power, but was not designed for continuous base loading.; fuel costs alone would amount to $100 000/day. Local generation was not economical compared to purchasing power from BC Hydro.[130]

BC Hydro's methods for selecting transmission line routes were also discussed, including the alternate routes selected by BC Hydro to bypass the Courtenay- Cumberland section. BC

Hydro was criticized because the alternate routes were only "lines on a map." No aerial survey had been conducted and the map used for plotting was 15 years old. Detailed costs and time estimates for various options were given: rerouting the 230 kV line ($200 000/km); finishing the line, building a bypass and removing the contentious section (20 or 26 km at $650 000/km over 18-24 months); and rerouting all the lines. (The transmission component of the original planned routing cost from $170 000 to $175 000/km.) Acquiring a new ROW could be difficult and would involving other environmental and social problems. (The plans for the Island Corridor, a common corridor for utilities and transportation systems, were not advanced enough to allow for its consideration as an alternate route.)[131]

BC Hydro testified that the selection criteria for the buyout offer would be based on distance, that is, any property within 50 metres from the edge of the ROW was eligible.[132] (A number of residents suggested that the criteria should be based on any increase or a doubling of existing PF E/MF levels.) BC Hydro had not considered the possibility that, under the Utility Commission Act, they might be expected to extend the offer in "fairness" to anyone in BC living near a line. (Vance told the Chairman that the CVRC wanted the buyout offer extended to include Royston-Marsden residents, or even residents along the entire ROW, but not, at the present time, all of BC.)

Appraisal value of the property would be based on the three existing 138 kV lines. "Fair market value" was defined. BC Hydro would honour the buyout offer whether the line was rerouted or not, and might extend the buyout deadline.[133]

When asked whether property owners would be compensated for lowered real estate market values due to fears of health effects triggered by BC Hydro's buyout letter, Boatman questioned whether values were lowered because of the letter or because of the reaction of residents to the letter. BC Hydro would consider taking into account what otherwise would have been market value but did not feel responsible because they had tried to help. (BC Hydro noted earlier that one property in the area had recently sold close to its asking price.)[134]

Public

Comments made by residents regarding the buyout offer included:

- The buyout offer did not apply to employer-owned houses and rental housing was scarce;
- Media attention had resulted in increased health concerns and stress and decreased interest in purchasing properties and property values. Some residents were angry with each other because of this; and
- The value of property near power lines elsewhere in BC had dropped.[135]

•BC Hydro should compensate property owners for moving and legal expenses, or for decreased equity if they chose to remain;

•They should also compensate owners for higher interest payments on their new properties;

•Replacement value should be offered, not market value;

•BC Hydro had already had the use of the ROW for next to nothing;

•The future value of the land (including what it would produce) should be offered;

•Both "panic selling" and "panic buying" had occurred. One property owner said that Block Brothers Realty had told him to "get out" while he could. Other owners had been told they were living in a "real estate dead zone;" and

•The Courtenay manager of Block Brothers was on BC Hydro's Board of Directors and had inside information.[136]

Comments concerning BC Hydro's handling of the controversy included:

•Power companies would only reconsider line construction when forced to because citizens unite and threaten them with law suits and other actions; and

•BC Hydro damaged the public trust when they attempted to rush the project by residents. If BC Hydro was fair and responsible, public meetings would have been held as soon as concerns were voiced, and not just with those considered bothersome.

•Local government involvement in the planning process would improve public participation in the planning process.[137]

Residents also criticized BC Hydro for its "past misdeeds" regarding ROW acquisition and property damage incurred during line construction.[138]

3.2.3 Media Coverage

During the inquiry, the Vancouver Sun reported the 1985 court decision involving Houston Lighting and Power, as cited by Edwards. The Sun stated that Erdreich's expertise in the area of PF E/MF health effects was "fairly recent." Sastre's testimony about his nonconcurrence with the conclusions of ERI's background report was quoted.[139]

The title of another Sun article was "BC Hydro data rigged, American claims." (In a September letter to the editor, Boatman took offence to an article in Sun. He felt that the title inferred that BC Hydro "deliberately falsified evidence given before the BCUC." Boatman stated that Marino was referring to the scientific research reviewed by ERI and that the BCUC, in their final report, rejected Marino's "blanket condemnation.")[140]

Of the Vancouver Sun, the Record, and the Free Press, only the Free Press noted Marino's recommendation that concerned citizens should reduce other risk factors in their lives if they were unable to reduce exposure to power line E/MF.

On July 14, the CBC Afternoon Show interviewed Marino and resident Herb Robertson. Robertson said that his wife's severe migraines and his child's behavioural and developmental problems disappeared when they moved away from the existing power line for three weeks. In addition, his wife had abnormal bone growth. (Robertson testified at the inquiry.)[141]

The Vancouver Sun also reported on Robertson.[142]

A later Sun article reported on the CVRC's health survey.[143]

3.3 POST-INQUIRY EVENTS

3.3.1 Pre-BCUC Ruling

North American electrical utilities were closely monitoring the situation. A decision to move a power line for health reasons had never been made before. It would be a precedent used in any subsequent challenge to a line.[1]

After the inquiry, some residents were "more confused than ever." Until new research results were available, they advocated taking "the cautious course" and bypassing residential areas[2] (It wasn't fair to make residents move. Only those who generated the power said living under the lines was safe.)[3]

Frank Kavka was skeptical that the line would be rerouted, and noted that both BC Hydro and the BCUC were under provincial government jurisdiction. Some residents, including the Kavka's, had declined BC Hydro's buyout offer, claiming the line would be a health hazard to anyone who moved into the area. The Kavka's still intended to donate their $60 000 property as a "symbolic cemetery" even though they had exhausted their financial resources.[4]

The Kavka's plan surprised Bob and Wendy Brown. In early May, they had agreed to the Kavka's asking price of $48 900 and on May 12 signed an agreement allowing them to take possession of the property July 4. The Kavkas had initially told them the power lines were "harmful to health" but the Browns were not concerned. In June, Kavka informed the Browns that they wanted to "back out of the deal" because they were waiting the outcome of further negotiations with BC Hydro who had made the Kavkas a buyout offer on May 8. The Kavkas refused to sign the title transfer and did not pick up a double registered letter sent from the Browns' solicitor.

However, Kavka said they didn't back out and could prove the sale was conditional on completion of negotiations with BC Hydro for compensation (for 393 trees that were "unlawfully" cut on their property.) A second condition was that any purchaser would have to convince him (and the Browns had not) that they understood the potential hazards of living next to a transmission line. The general manager of Realty World, the company handling the sale, said that Kavka's conditions were written into the listing contract but could not be written into the sales contract.[5]

In an article in the Free Press, a local real estate appraiser told residents who said property values were lowered because of the new line were "shooting themselves in the foot" and

"creating a false market through fear-mongering." According to another appraiser, the more residents near the ROW complained, the more property values would be influenced. A third appraiser was not conducting appraisals on property close to the line until the BCUC made its decision because an appraisal was based on what a "prudent purchaser, ...fully informed about all aspects of the property, would pay." He felt that property values had dropped but the area was "less favourable" than some, and property values would be affected by more than just the line.

The sales manager of Realty World said that although proximity to the line might eliminate up to 50% of the potential buyers, that might not necessarily affect the sale price. He also said that three properties in the area sold recently at "fair market value."[6]

Dr. Maria Stuchly, physicist and engineer, Health and Welfare Canada, told the Vancouver Sun in a July 22 article, "We can't say [PF E/MF] truly causes harm, but we can't say that it doesn't." The article stated that researchers at CMU concluded, in a report for the US OTA, that there were "legitimate reasons for concern" about power line E/MF but that levels from appliances and household wiring were higher than those from transmission lines.[7] Dr. Samual Milham, Jr, epidemiologist with Washington State DOH, was quoted as having said, "The only naysayers I know are on the take from the power companies." However, he also stressed that the health risk must be put in perspective with other risks such as smoking, poor diet, and excess drinking. Chris Van Netten, toxicologist, UBC Department of Health Care and Epidemiology, told the Sun, "It is frankly amazing" that the human body can be subjected to strong EMF with no outward effect."

The article stated that "recent studies suggested an inward effect." For e.g., some studies indicated that the cell membrane was where the effects occurred. Milham had conducted a number of epidemiological studies indicating a link between occupational exposure to PF E/MF and brain tumors and lymphomas. His results were supported by two other "small" studies. On the other hand, a study by BC epidemiologists did not find an association.[8]

Boatman told that Free Press that although aware of public concern, especially in other jurisdictions, BC Hydro "got caught." The decision to build the new line was made in 1987 before certain studies on E/MF effects had been conducted.[9] Even so, recent hearings into transmission line health effects had always concluded that there was no need to move the lines. Two months ago, the Alberta ERCB concluded that "a transmission line over a school was not a health risk."[10]

Boatman also told the Free Press that the ways in which information was spread in Courtenay "caused tension and panic." BC Hydro was discussing "how best to get this

information out and get the public involved before a line [was] routed near a community." A community could decide where a line should go. However, they would pay higher hydro rates because BC Hydro's practice was "to put the line in the cheapest place." People would have to examine the evidence and "weigh the risks." There were risks in everything that people did.[11]

3.3.2 BCUC Report and Recommendations

On July 26, McIntyre submitted his Report and Recommendations to the BCUC. The following day, the BCUC adopted the Report in full and ordered that:

- The stop-work order be lifted;
- The citizens' request for rerouting be denied;
- BC Hydro extend the buyout offer to residents immediately adjacent to the ROW to September 15, 1989;
- BC Hydro exclude the (net) cost of the buyout program from the cost of service;
- BC Hydro collaborate with the BC MOH in devising and funding EMF research programs; and
- BC Hydro apply to the BCUC for a "Certificate of Public Convenience and Necessity" for all future 138 kV and above transmission lines.[1]

The following section summarizes the BCUC's Report and Recommendations.

3.3.2.1 Electromagnetic Fields and Health

Over the past few years, there had been increasing concern about PF E/MF health effects.(1) The public might have been focusing on high-voltage transmission lines rather than other sources because of their high visibility. Other sources of PF E/MF included electric distribution wiring (fields similar to transmission line fields but lower intensity), electric home appliances (significant levels of magnetic fields while in use), and electric blankets and water beds (probably the strongest sources of magnetic fields). The health issues surrounding BC Hydro's proposed 230 kV transmission line were examined in the context of overall human exposure and health effects, in addition to the particular exposure resulting from the power line.[2]

A brief overview of the properties of ac E/MF followed.

<u>Health Effects - General</u>

The scientific literature on the long-term health effects of "electric and magnetic fields" (E/MF) was assessed together with the evidence of Drs. Marino, Erdreich and Sastre.

Because it was very difficult to actually prove or demonstrate cause-effect relationships in science, particularly in epidemiological studies, "scientists [dealt] in probabilities rather than certainties, and criteria such as replicability of studies and consistency of results [became] important in evaluating results."[3]

Inquiry Evidence[4]

The oral testimony was summarized.[5]

Assessment

Associations between variables had been found before a cause and effect relationship was documented, for e.g., lung cancer and cigarette smoking,. The biologic mechanism of action was still unknown and specificity of association was absent, for e.g., cigarette smoke was also related to heart disease. "We may never demonstrate true causality in science and thus must rely on inference of biological effect from the research data."

It was "clear" that some results from the studies gave "reason for concern." The study by Wertheimer and Leeper, although imperfect in many ways, suggested an association between childhood leukemia and exposure to potentially high current residential wiring configurations. Savitz partially confirmed their results although he failed to confirm a relationship between measured magnetic fields and leukemia. Other studies had not replicated those results, and some studies had shown no association. However, there was evidence suggesting the possibility of an "adverse effect" from 60 Hz EMF.

To suggest that there was "conclusive scientific evidence of an adverse effect of electromagnetic radiation" was "equally unwise " Associations found between EMF exposure and workers required further study with improved control of potential confounding factors.

The studies "directly relating residential exposure to high voltage transmission lines and cancer [had] been either ambiguous... or negative."

Many animal studies that demonstrated adverse effects had not been successfully replicated and usually involved "high frequency energy." Their relevance to the possible adverse effects of 60 Hz exposures had also been questioned." In addition, a number of negative studies in the epidemiologic and laboratory areas had shown no effects at all.[6]

Inquiry Findings. There was "cause for concern within the scientific literature about the biological effects on humans of electromagnetic radiation." However, there was "insufficient evidence to support a presumption of an actual health risk." The conclusion held for effects within residential areas due to distribution wire configuration and measured magnetic field, within occupational categories due to implied exposure to EMF, and within residences close to high voltage transmission lines.

"The question of whether the design or results of studies financed either by individual power

companies or by the Electric Power Research Institute [were] biased by such funding [had] been considered carefully." Each published study was "open to criticism in the scientific literature and inappropriate design features or unsubstantiated conclusions would be detected quickly. In addition, since published studies must state the source of their funding, systematic attempts to distort findings would not go unnoticed or uncriticized. The blanket condemnation of such studies by Dr. Marino [was] rejected entirely."

"More and better" laboratory and epidemiologic research was necessary. Research involving humans required "better measurement and characterization of actual E/MF exposure." Determining the sources of exposure (transmission lines,distribution lines, appliances) was also "very important."

Establishing "fixed standards for EMF exposure" along ROWs "would involve undesirable and unfounded speculation... The evidence of any health hazard [was] inconclusive and the establishment of standards would create either unwarranted alarm in some people or result in a potentially false sense of security in others."

"It should be emphasized" that calculations of expected magnetic field levels at houses along the ROW were "generally quite low. In some cases, fields from transmission lines [had] lower readings than those from distribution wires."

BC Hydro had not "attempted to engage itself in any way in human health research." Entering BC Hydro's workers into studies such as the joint Ontario Hydro and Hydro Quebec occupational study "could help answer the questions" which prompted the inquiry. Also, BC Hydro could be "pro-active in approach" by contracting with "recognized investigators to devise studies and utilize such resources." Ideally, though, funding should be at "arms-length."

Moreover, there was a lack of coordination between Canadian government agencies, utilities and scientific organizations in their approach to the "problem." A Health and Welfare committee set up in 1986 to review the problem had not yet published recommendations, "particularly with regard to the nature of the scientific study necessary to investigate the problem. In the meantime, it was estimated [by Dr. Marino] that some $100 million [had] been spent worldwide without conclusive results."[7]

"It would seem appropriate that funding for some well focused studies might come from utilities, perhaps through the... Canadian Electrical Association [CEA]. In order to ensure that funding [was] perceived to be at arms-length, perhaps the CEA could have studies financed and managed through Health and Welfare... [or] the Medical Research Council."[8]

A brief overview of research underway and proposed in Canada to evaluate the potential health effects of "electromagnetic radiation" followed.

"It would not be appropriate to complete an assessment of the complaints respecting the proposed transmission line without reflecting on the elevated concern of the residents. Much documentary and other information had been made available to them on the subject and it cannot be denied that people have the right to draw their own conclusions. Fear, however, can be preyed upon by activism which can fuel anxiety by the unscientific association of information purported to be fact. The evidence given by Mrs. Kavka and the inferences of many other individuals alleging an association between various illnesses and the powerlines [were] indicative of concern as opposed to proven cause-effect relationships. The issue of EMF and its potential biological effects must be addressed by scientific studies. Accordingly, while the concern of the people [was] genuine, that concern in itself should not be used to draw serious conclusions which [had] high socio-economic effects. People's motives vary and in this case there may well be motives for the actions of a few which transcend the EMF issue."

There was no reason to delay expansion of Arden Elementary School "as a result of EMF concerns." Magnetic field readings were very low and would remain very low at the school after completion of the 230 kV line. The "only meaningful EMF influence" at the school came from the local distribution lines and internal school wiring. "These influences would exist at any school."[9]

3.3.2.2 Supply Alternatives

The "feasibility and ramifications" of various supply alternatives were discussed. Continuation of construction on the present ROW was the "only feasible" short-term solution. If a longer term solution became necessary, "possibilities" included: line rerouting, especially if a common corridor with the proposed Island Highway showed merit; co-generation or supply from a private power producer; and undergrounding.[10]

"Given all the prevailing circumstances, it would be unjust to enforce a line rerouting at this time since BC Hydro and the mill had followed all the appropriate procedures... An order to reroute, at short notice, could only be justified if evidence were presented to demonstrate a potential health risk."

In response to the BCUC's information request, the feasible alternative routes selected by BC

Hydro were "essentially lines on a map... This should not be construed as a criticism of BC Hydro, because the time available from the date of the... request did not allow for a meaningful evaluation."[11]

3.3.2.3 Recommendations

The recommendations "flowed" from the literature review, the evidence of Drs. Marino, Sastre and Erdreich regarding risks related to power line E/MF, and "the evidence of the concerned citizens and BC Hydro regarding the events that transpired between them in the past year."[12] It was "unfortunate" that the EMF health risks evidence was "not conclusive." "The moderate statements of Dr. Savitz, at times reasonably paralleled by Dr. Marino, that there [was] no need for public alarm [were] of only limited comfort to those who [could not] be definitively assured that there [was] no meaningful risk."

"The question of magnetic fields from high voltage transmission lines [was] but one part of a larger issue related to the use of electricity in everyday life. Electric distribution lines, household wiring and electric appliances [created] the greatest preponderance of EMF radiation." Scientists from Carnegie Mellon University, in a June 1989 report to the US Congressional Office of Technological Assessment, advocated "prudent avoidance," for e.g., the avoidance of continuous close contact with electric blankets and alarm clocks. An extension of their views "could be that some [might] view it as 'prudent avoidance' that young children be discouraged from continuous play on the ROW itself... Simple actions could substantially reduce overall exposure" because magnetic fields fell off sharply with distance.[13]

The magnetic field from the proposed 230 kV line would also fall off rapidly with distance. Magnetic fields from the existing lines at residences near the ROW were not "substantially different" from the ambient magnetic fields from household wiring and appliances. In some cases, the field from the distribution lines was "more significant" than that from the transmission lines. It was important that EMF health risks from both transmission lines and other sources be determined. "The Commission must not gloss over this issue as a result of the inconclusive nature of the current scientific literature. The matter [deserved] attention and coordinated scientific study." There was "much work ongoing throughout the world."

A list of some of the ongoing studies followed.[14]

Rerouting Issue

There was no "compelling reason" to reroute the line (through the Courtenay, Cumberland or

Merville area). BC Hydro might "find it advantageous to consider rerouting of its transmission lines at a future date when the final routing of the Island Highway is complete." BC Hydro should reconsider the routing of its transmission lines in conjunction with the appropriate agencies to determine if there were any "socio-economic advantages" in locating the utility and transportation corridors adjacent to each other (in keeping with the BC Government's "Guidelines for Linear Developments").[15]

BC Hydro's Buyout Proposal

Neither BC Hydro nor the BCUC "[perceived] an actual health risk from EMF emissions, however, it [was] clear that the good intentions of BC Hydro in making the buyout offer [had] resulted in heightened public concern with respect to both the EMF health issue and land values."[16] BC Hydro should continue to honor its commitment to purchase properties because: the offer had created expectations and some recipients might have made financial commitments; and "in fairness -to those who failed or were unable to respond" by the deadline, and to those who qualified but were unaware, and "to those who were unable to reach an informed and reasoned decision because of the continuation of uncertainty caused by the inquiry process." The offer should be continued with a deadline for response of September 15, 1989.

"The appraised purchase price should reflect the market value of the property as of May 8, 1989. In addition, BC Hydro should ensure that all those involved in the buyout scheme are given a clear understanding of their options. Purchases should be completed expeditiously."

If property values in the Courtenay area had "appreciated significantly from May 8 to the data of individual binding agreements to sell, the property values [were] to be adjusted by a percentage value to account for the upward market movement" (using the District Real Estate Board as a reference). Valuations should be based on the three existing transmission lines in the corridor and exclude any impact the proposed new 230 kV line might have on the property values. Given the purpose of the buyout offer, eligibility of properties for the buyout should be based on a "consistent rationale," that is, on proximity to the lines.

Table 1 (of the report) showed how peak and average load PF E/MF levels for alternative line configurations varied with distance from the ROW.[17]

Treatment of Buyout Costs

"BC Hydro acted imprudently in its decision to make the buyout offer... The scientific evidence with respect to health hazards from EMF [was] such that no identified risk to human health [had] as yet been substantiated." The BCUC should exclude the cost of the buyout program from

any determination of BC Hydro's revenue requirements or 'cost of service.'" By doing so, the BCUC could "ensure"that the buyout costs would not affect "the rates of consumers generally" within BC. The action would also "ensure there [was] no precedent established or emanating" with respect to other transmission lines in BC.[18]

The inquiry did not pursue "on this occasion" the question of whether the buyout offers fell within the provisions of the Utilities Commission Act as "constituting unduly preferential conduct," although the issue might have "potential significance."

Because there was "no reliable evidence" that powerlines posed a human health risk, "it [could] be expected that any impact on land values [would] be alleviated as a result of the conclusions of this Inquiry."[19]

BC Hydro Research into EMF

BC Hydro's recent appointment of Kelly Gibney as Manager, EMF Issues, was noted.[20]

"Dr. Marino and others pointed out that it [was] important that any scientific research be undertaken with complete independence from utility control or influence in order to assure the public that the research [was] not biased in favor of any vested interest. (However, other strident sweeping allegations by Dr. Marino in regard to utility funded research [were] emphatically rejected. Such unfounded opinion [was] irresponsible since no tangible evidence was presented to substantiate the allegation.)"

BC Hydro should collaborate with the BC MOH "to devise and fund research programs which [would] complement research elsewhere in North America on EMF-related issues." BC Hydro should also develop "public awareness information programs... and seek a leadership role" by the BC MOH. The BCUC should request that the BC government "clearly state its objectives and priorities with respect to the EMF issue so as to facilitate an appropriate environment for the implementation of BC Hydro's programs and those of other government agencies and public bodies."

"It [was] very important that research be done in a coordinated manner so as to maximize the capability to resolve the EMF issue... BC Hydro should investigate ways to assist in the coordination of studies and funding through the [CEA], other government agencies, or perhaps a new independent agency funded from many sources."[21]

Future Transmission Line Extensions of 138 kV and Greater

Until scientific research provided sufficient evidence "to make reasonably certain

determinations" about EMF health hazards, the BCUC might receive complaints whenever BC Hydro proposed to build a high voltage transmission line in new or existing corridors. Because the current evidence did not support "the establishment of specific standards with respect to EMF emissions and ROW widths," the BCUC should require BC Hydro to seek a Certificate of Public Convenience and Necessity (CPCN) for lines 138 kV and greater. The BCUC, in considering whether to issue a CPCN and whether to hold a hearing, would assess the scientific, environmental and socio-economic evidence available at that time, and the specific physical considerations related to the proposed line.

"In making application for a CPCN, BC Hydro should allow sufficient lead time to ensure adequate input from all parties is obtained."[22]

Application for Costs of Intervenors

Residents made an "Application" to have the BCUC pay the costs of Dr. Marino. The BCUC recognized that the costs of hiring Dr. Marino would be "onerous for the public participants and that the evidence of Dr. Marino ensured that all sides of the EMF scientific literature and positions of experts were brought to the attention of the Inquiry Officer." Under the Utilities Commission Act, the BCUC could not absorb the costs of Dr. Marino nor could it order that BC Hydro pay those costs.[23]

3.3.3 Post-BCUC Ruling[1]

On July 28, Marton told the Vancouver Sun, that the BCUC decision was the "best" that residents could have expected. People were given the option of staying; new residents would be aware of the line. In the future, BC Hydro would take into consideration residents' concerns. McIntyre said that a "step forward" had been made. There was now an "opportunity" for government to examine the issue and facilitate research.[2]

Fay Clifford, a cancer patient and wife of Jack Clifford, told the Province that she would not allow BC Hydro on her property.[3] BC Hydro was "happy" with the decision but declined to comment on Clifford's stance.[4]

Robertson told the Province that people were being treated like guinea pigs. Although he was unsure if the power lines were causing his wife's and child's health problems, there was an "element of risk." According to Thate, a rabbit-breeder, his animals' birth deformities were "too much of a coincidence." Both Robertson and Thate had accepted BC Hydro's buyout offer.

Delta, BC, residents who had bought houses in the Sunshine Hills area next to power lines were worried. One resident planned to speak to his doctor about the possible links to stress.[5]

3.3.3.1 Day in Court - 1

On July 31, 30 Courtenay area residents, including the Kavkas, Cliffords, and Walsh, physically blocked BC Hydro crews from resuming construction of the line. Boatman told the Sun that only "as a last resort" would the RCMP be called in to remove the protestors. Although the blockade was down by August 1, residents were prepared to set up again on short notice.[6]

Meanwhile, BC Hydro crews had been working on other properties. By August 2, they were ready to place a transmission line pole on the Clifford's property but were turned back twice by the protesters. Frank Kavka told the Free Press that the poles should not be raised until the buyout was completed and, if they were raised, the protesters would consider cutting them down.[7]

Walsh told the Record that the BCUC report was a "complete sham." There were "factual problems" and "things [were] taken out of context." The report failed to prove that the line was "safe." Until the residents had a guarantee of safety, they would not stop protesting until the line was rerouted.[8]

Walsh informed the BCUC of the CVRC's dissatisfaction with the report. They took

exception to the fact that the BCUC relied heavily on evidence provided by Savitz who did not even testify at the inquiry. In addition, 1400 pages of testimony and evidence submitted by the CVRC had been used as background information and not as evidence.[9]

Darlene Kavka told the Free Press she believed the decision to let BC Hydro's line go through was made before the "hearing" was ever held. "Kangaroo courts come up with kangaroo decisions."

By August 2, more than 70 homeowners had expressed interest in BC Hydro's buyout offer. Some residents were not confident BC Hydro would base its buyout offer on real estate values prior to May 8.[10]

Art Meyers, "one of the Block Brothers" and a member of BC Hydro's board of directors, told the Free Press that the process by which the BCUC reached its conclusion was fair. Opponents of the line consisted of "pressure groups" and "self- interest groups." It was unfair "to preach fear, and to use tactics that [affected] our value system." They "were not qualified to speak on scientific matters." Hagen agreed with Meyers that the inquiry process was fair.[11]

An August 2 editorial in the Record called for the BCUC to prove that the line was safe before building it. There was "more than enough scientific evidence to strongly suggest a link between power line EMF and health problems." Why did the burden of proof rest on the homeowners who might suffer the consequences, rather than on those who might cause them?"[12]

The same day, an editorial in the Free Press commented that the BCUC decision "wasn't a surprise to anyone." "Multi-million dollar projects to service multi- million dollar pulp mills don't just get thrown off track for unverifiable health concerns." The precedent set by rerouting the line would have "rocked utility companies across North America." "Enough of a precedent" had been set in halting construction during the inquiry and in BC Hydro's offering of a buy-out. The residents "gained victory in forcing a major corporation to listen seriously to their concerns," which might be vindicated by future studies. BC Hydro and other power suppliers would think twice when planning routes for new transmission lines and more effort might be put into some conclusive health effects studies.[13]

A small poll conducted by the Free Press similarly revealed a broad spectrum of opinion among residents. About half considered the BCUC ruling fair (there was no proof of harm; the buyout offer had been made) while the other half felt that it was unfair (construction was nearly complete; the needs of the pulp mill took precedence; an energy corridor should be created).[14]

By August 3, work had still not begun on the Clifford property. Frank Kavka told the Free Press that the CVRC preferred "to sit down and work things out." They hoped that BC Hydro would move the lines to the Island Highway utilities corridor when completed. BC Hydro also preferred "to negotiate its way through" rather than resort to court action.[15]

Verne Prior, Senior Communications Coordinator, BC Hydro told the Record that the BCUC had dealt thoroughly with the protesters complaints. The BCUC did not chastise BC Hydro in any way. BC Hydro was considering the BCUC's recommendation that they become involved in health-related studies.[16]

An editorial in the Free Press on August 4 questioned what purpose the blockade served and suggested that BC Hydro might pay more for a property. The protesters "fought a good, lawful fight, raised an important issue, changed BC Hydro policies, and, in fact, won a victory. Not the one they wanted perhaps, but that's the way it goes in a democracy." As one judge had pointed out in the abortion cases, people could not just "pick and choose" what laws they were going to obey. They could protest the laws "but deliberately breaking them [was] an affront to everything we in this country [held] valuable. The basis of democracy [was] that the majority [ruled]."[17]

In response, an August 9 letter to the editor commented that Free Press Editor Debra Martin had "once again" expressed her naive support for the bureaucracy in an editorial attacking those who [used] civil disobedience to draw attention to their plight." The road through Strathcona Park was blockaded "precisly because the democratic process had failed." Where was the democratic process before the bulldozers cleared a 100 mile long swatch" for the power line? "Those decisions were made, as [were] many others in this bastion of democracy, behind closed doors." Perhaps if the editor "exercised her brain before opening her mouth," she would realize, "that the abortion protests [stemmed] directly from the lack of legislation." What alternative was there for those who saw that the democratic process has failed? Many who have risked jail for their beliefs did so after all other possible avenues were exhausted. The author supported citizens who had to resort to "peaceful demonstrations to exercise their rights as free and equal members of a civilized society." Civil disobedience and protesting got Martin the vote and "paved the way" for her job in a previously "jealously guarded old boys club."[18]

On August 8, BC Hydro filed a writ in BC Supreme Court against four of the residents, including Frank Kavka, who had denied BC Hydro permission to erect line poles on their property. McMullan told the Free Press that if the injunction was granted and residents still refused to let

BC Hydro erect the poles, a restraining order would be obtained and that would "involve the police." Kavka told the Record that he hoped for the order because a judge would then "have to hear both sides of the story."[19]

In an August 9 letter to the editor of the Free Press, Marton wrote that experts from one side said the fields were not harmful and "anyone afraid of them [was] ignorant or hysterical." Experts from the other side said the fields were harmful and the other side's experts had been "bought off" and were "suppressing information." The only certainty the residents were left with was that no one knew "for sure." The residents had not "lost." They helped set a precedent for more scrutiny of the need for lines and their routing. "Powerlines became the lightning rod for a much broader based unease.... People came to see opposition to the powerline as a concrete way to express their unease about what unchecked industrial development [was] doing to the planet." The "emotional force" of realizing that people were killing their "mother" could not be ignored. "Just as there was no certainty about the effects of powerlines and no shielding from whatever adverse effects they [might] produce," there was no certainty about the results of the changes so rapidly being produced on the planet and no escape if those changes turned out "badly." Very soon, people would need to "figure out ways to reduce the growth rate of [their] energy addiction."[20]

On August 9, BC Hydro was granted an injunction ordering the Kavkas, John Genge, Bruno and Helga Winnig, and the Cliffords to stop blocking construction of the 230 kV line. Copies of a related restraining order that was also granted were delivered on August 11 to members of the CVRC. They would be subject to contempt of court charges if they continued to block access to the ROW and were prohibited from counselling anyone to interfere with BC Hydro's "performance of contract." Failure to abide by the conditions of the order would result in police action. Justice John Cowan also ordered Courtenay RCMP to enforce the order and to gather any evidence of contempt. Construction crews were due back on the site August 10 and had seven days of work left on the line.[21]

Work began, without incidence, on August 10 on the Genge property. Genge told the Record, "We're just small people and Hydro is a big outfit." Selling his property "might be an option."[22]

Edith Clifford told the Record that she disliked injunctions because "both sides of a story" were not heard but it would cost $30 000 to take BC Hydro to court. BC Hydro should not route lines through residential property when Crown lands were available. Furthermore, the compensation paid by BC Hydro for the property" was ridiculous;" they were "still battling

over the mess."[23]

Bruno Winnig told the Free Press that he was "unhappy with the whole thing" and that residents had "other battles" with BC Hydro unrelated to "EMFs." Their conflicts with BC Hydro dated back to WWII with the BC Power Commission, BC Hydro's predecessor. According to Winnig, BC Hydro had never adequately compensated him for trees removed from his property and now planned to take up to 1/8 of his 200 acres for a ROW and danger zone. BC Hydro had hurt his livelihood because he could no longer tree farm. "I don't believe they have any right on my property. They never paid for it. But I don't know what to do. You can't do anything against fascists." In addition, BC Hydro's buyout offer amounted to "expropriation" because the process ignored bargaining and relied exclusively on figures arrived at by appraisers.[24]

Bruno Winnig later told the Record, "The inquiry is on their side, Vander Zalm is on their side and the Ombudsman is on their side. What can you do?" He was particularly upset about the state BC Hydro left his property in after clearing the ROW for the new 230 kV line and they had gone beyond the ROW.[25]

By August 11, Frank Kavka had not yet been served with the court order. He told the Vancouver Sun that he would continue to ask BC Hydro crews to leave if they arrived on his property but had no intention of physically attempting to remove crews. Kavka told the Record, "If they [BC Hydro] try to attack me they will show their true face. Why should I go to jail? It's completely ludicrous. This is not what Canada is supposed to represent." He thought they should "sit down in the shade and have a lemonade together. I think we should be able to take a civilized approach to the problem."[26]

BC Hydro had opened a special Courtenay office by August 11, to assist residents who wished to accept the buyout offer.[27]

McMullan told the Upper-Islander that BC Hydro planned to work through the weekend so the line would be completed as close as possible to the new August 16 deadline. (The July 31 deadline had been extended because of the inquiry.)[28] Line construction costs were running under budget. Any loses to the mill owners due to delays, claimed to be $115 000 per day in capital and manpower costs alone, would not be claimed from BC Hydro.[29]

The order was served to the Kavkas on the morning of August 12. On the evening of August 13, Darlene Kavka stopped work crews by stepping on the pulley rope used to string power cables on top of new poles seconds after a helicopter let it swing to the ground.[30] She stood on the pulley

for three hours until the work crew and helicopter (which had landed a short distance away) left. Kavka told the Free Press that she had decided to "be arrested" because otherwise she would not be heard by a judge before the line was completed. Kavka told the Vancouver Sun that a group of area residents "stood with their children in their arms and cried" that afternoon because they had "no rights." After the crew left, she pitched a tent directly over the pulley and slept in that night. Except for a few visits with her children, Kavka stayed in the tent until about 4 pm the following day.[31]

On August 14, Boatman told the Sun that the police would be called if the crews were blocked. He hoped the situation would not arise. Darlene Kavka stated that she felt like a "cornered rabbit" but would not back down from her fight. If the line was completed, the Kavkas planned to leave their home of 2-1/2 years as soon as the line was charged. The Sun also reported that Marino and Phillips, "two American cancer specialists," agreed that there was "serious concern" about EMF health effects.[32]

BC Hydro went back to court to get language in the order clarified so that the RCMP would enforce it. The RCMP had not acted on the injunction because it was a civil and not a criminal matter.

On the afternoon of August 14, the Kavkas were served with a notice stating that at 10 a.m. on August 15, they would "have a chance to be heard by a judge in the Supreme Court. The Kavkas did not have time to consult a lawyer nor could they afford one. Darlene Kavka told the Sun that they were $6 500 in debt, an amount nearly equal to their income thus far that year. They lived on a disability pension because her husband was physically disabled with a "chronic pain condition." She added, "If Hydro wishes to take it that far, that a housewife is arrested for protecting her family, then so be it."[33]

Frank Kavka, Roy Genge, and a few other residents left for Vancouver early August 15 hoping to convince a BC Supreme Court judge to overturn the order. County Court Judge H.A.D. Oliver ruled that he could not hear them on the merits of the injunction because that would be retrying a matter already tried by the Crown. It was an issue for the Court of Appeal.[34] The Supreme Court amended the injunction, giving the RCMP specific direction to enforce the civil process and arrest and remove anyone interfering with the project.[35]

3.3.3.2 Day in Court - 2

On August 15, Darlene Kavka was again at the tent site by the line. She realized that residents would not be able to force BC Hydro to reroute the line. Some were looking for firmer, written

guarantees that BC Hydro would honor its buyout proposal and base it on fair market value.[36]

According to the Record, Kavka had a college certificate for dental assistance. She was "pale and weary," joking casually with a "gaggle" of press people, "rattling off facts and figures" about EMF biological effects, making "quotable quotes," and telling reporters what they should print and how "the competition" (i.e., the Free Press) had misrepresented the CVRC. Kavka said that, prior to the construction of the new line, she had not been an activist; she had never felt her "life was threatened before." Although her husband occasionally took her place so she could visit their children, Kavka did not encourage other people who supported her protest to join her because of the health and legal hazards. She continued not because she wanted "to be a martyr" but because there was no one else who would obstruct the line on behalf of the 257 property owners affected.[37]

That afternoon, BC Hydro spoke briefly with Darlene Kavka, asked for a written list of the property owners' requirements, and sent idle work crews home. BC Hydro would return later in the week to discuss ending the blockade. Kavka told the Province that she had not been promised an acceptable deal, only that BC Hydro was receptive to hearing her "grievances." Although she felt that BC Hydro's request to continue a dialogue was a personal victory, she told the Free Press that she refused to move until they responded in writing.[38]

Early August 16, BC Hydro was reviewing the list of "demands" presented by the Kavkas the previous day. Five uniformed RCMP officers and two plainclothes officers arrived around noon on the Kavkas' property and Darlene Kavka for contempt of the court injunction. According to the Free Press, Darlene Kavka told them that she was "glad" they were finally there; she had been "expecting" them since Sunday. Kavka later told the Province that the RCMP gave her "every opportunity" to avoid arrest, but she was determined to go to court.[39]

Kavka was held at Courtenay police station where refused to promise to stay away from the line without an opportunity to appear before a judge. She was released within the hour on notice to appear in BC Supreme Court on August 18. No formal charges were laid. Kavka later told the Free Press she was very "cordially treated." Prior told the Province that BC Hydro regretted the arrest.[40]

An editorial in the Record commented that BC Hydro's power line presented "a perfect example of the delicate balance between an individual's right to unencumbered enjoyment of private property and society's right to upset, or even destroy, that enjoyment in the name of some greater good." Although pleasant, "the biggest guy on the block [BC Hydro] has used a big stick [the BC Supreme Court] to force many John and Jane Does to accept something they want no part

of." The line was being built for the public good and most people supported construction, but those who lived along the ROW were "paying a terrible price".

Those worried about EMF biological effects would have to sell their homes. Others, because they loved their homes, would remain even though they would "always wonder how the powerline EMF [was] affecting them and their family." Those who stayed behind would "never enjoy their homes the way they once did." It was "too bad the people in high places didn't put more value on the average person's enjoyment of life when they first considered whether to run the powerline through a residential neighbourhood." If they had, the line might have been routed through an undeveloped area.

Many more people in BC, including BC Hydro planning staff, were now aware of the "sensitivity of the EMF issue." BC Hydro would be "more careful" how close future lines were to residential neighborhood. If they were not, "the people affected [would] be a lot quicker to react in defence of their rights."[41]

In an interview with Bruce McLean, a Province columnist, Frank Kavka said that the Kavkas decided that Darlene would risk going to jail because the property was in Frank's name. Frank Kavka had immigrated from Czechoslovakia in 1968 after a compulsory stint in the army. A genetic spinal disorder provided him with $1158 per month disability pension. McLean likened Kavka to Schweik, the "illustrious" hero of the Czechoslovakian novel about a wheelchair-bound soldier in the Austrian army in WWI. Mid-interview, Kavka said, "You're leading me around like a donkey. Instead of writing about me, you should be writing about the issue." McLean wrote that perhaps he "had it coming" because earlier Kavka had said he did not want to be "hogging the limelight."

According to McLean, when he told Kavka he could not share his conviction that power line EMF were a health hazard "causing" migraine headaches and cancer because it was a minority opinion among scientists, Kavka said, "OK then, write about Schweik. Write about the time Schweik tells the other soldiers, 'Don't be crazy. Don't shoot. There are people in there.'" The Kavkas and their neighbors were trying to relay a similar message to BC Hydro. "Don't be crazy. Don't put that power line up there. There are people down here."[42]

On Aug 19, Darlene Kavka appeared in BC Supreme Court in Vancouver expecting to deal with a contempt citation, but BC Hydro had not yet submitted a contempt motion. Instead, Kavka requested and received leave from the court to motion that the injunction be set aside. She told the court she feared EMF levels would increase four-fold in her home after the line was activated and BC Hydro could not give her satisfactory assurance that they would not "cause" cancer. Lawyer Linda Loo, representing BC Hydro who opposed the motion, told Justice

Sherman Hood that the obstruction of the line was not based on health concerns but on an attempt to increase a financial settlement. Loo based her allegation on an affidavit filed with the court and documents relating to the "sale" of Kavka's property to the Browns on May 2.[43] She claimed the documents showed the Kavkas hoped to almost double an agreed sale price by bargaining with BC Hydro. Kavka disputed the validity of the affidavit.[44]

Hood told Kavka he could only set aside the earlier order by BC Supreme Court if she were able to produce compelling evidence, not previously put before the Court, that the injunction should never have been granted. Kavka raised other complaints about BC Hydro trespassing outside the boundaries of the ROW easement and cutting down trees for which it had not paid compensation. She was told those complaints would have to be dealt with under legislation covering BC Hydro, i.e. the BCUC Act. Later, Kavka told the Record that she and her husband were planning further legal action but she would not give details.[45]

According to the Record, Hood ruled that "monetary gain and not health concerns" were the prime motivations behind the Kavkas' blockade. The statement was retracted and correctly attributed to BC Hydro's lawyer the following day.[46]

Darlene Kavka ended her protest and construction of the line resumed. BC Hydro expected the line to be in full service by the end of the week.[47]

3.3.3.3 Epilogue

An editorial in the North Island News on August 20 commented that civil disobedience was "back in vogue" but "unfortunately" was unsuccessful. "Private enterprise and big government [had] become too wise to protest tactics. They [held] public hearings to appease the masses... under the guise that they [were] doing something." Thus, "no one was surprised that Hydro was allowed to continue despite no conclusive evidence about the safety of electromagnetic fields." Private citizens needed to "come up with some new tactic. Civil disobedience worked in the past because government and big business were not "wise to it." Environmentalists needed to "organize en masse... and find a spokesperson" with a "few new ideas." Someone "high profile," in a "position of authority" and respected by all. "Perhaps Dr. David Suzuki would like the job."[48]

Robinson, in a letter to the BC Attorney General (and published in the August 23 Free Press), questioned why Darlene Kavka had to appear in BC Supreme Court in Vancouver rather than Provincial Court in Courtenay. She had to be away from her family and children, and incur

travelling and living expenses. Was Kavka so dangerous that the Provincial Court in Courtenay was not capable of providing justice? Robinson requested that the Attorney General ensure BC Hydro enjoyed no special "preference" in the federal and provincial court system.[49]

An August 23 Free Press guest columnist wrote that the effects one metre from a television set or wall outlet were "far greater" than the effects 100 metres from the line. Why did "residents rise up under the environmental banner" and try to force a corporation that the people owned to stop doing the job that the people formed it to do in the first place? Why did a public school trustee speak out on the issue, creating "a little more fear and worry amongst the people she [was] elected to serve?" Were the protesters willing to forbid their children to watch television and to ban the use of electricity in schools in order to avoid being hypocrites?

Were the roots of the protest related to "a noble concern for the welfare of our common man?" How did a "trivial" difference of opinion over compensation for trees grow into the "costly construction delays, public inquiries, injunctions, and court battles?" It was "easy to see... how a quiet, rural family, when confronted by an inflexible, monolithic giant like BC Hydro could perceive a degree of injustice that warranted protest. Similarly, an ill-informed remark by a school trustee, when faced by a concerned parents' group, [could] command the public's attention and blossom under the light of press coverage."

The "whole affair" did prove that an individual had "tremendous power within our democratic institutions to be heard and treated fairly. However, although the protests raised awareness of, they did not improve knowledge about "electromagnetic effects" on humans. The "hundreds of thousands of dollars" that were "frittered away" could had been spent on a world class research facility in BC that would investigate EMF effects.

People knew that "protesting for the sake of protesting, for public attention, or to right trivial wrongs, [was] irresponsible" because it cost everyone. Some good might result if BC Hydro withdrew their property purchase offers and instead agreed to commit an equivalent amount of funds towards the development of a research facility. In the meantime, the author speculated that he would sit a few centimetres further away from his television set.[50]

An article titled "Bunnies born defected, powerline suspected," reported that Aneliese Thate, a hobby rabbit breeder, believed her rabbits' increased birth defects and reduced birth and conception rate was caused by the power line 55 metres away.[51] She said that the rabbits' housing was kept clean and that she paid close attention to their diet. Thate agreed that BC Hydro's buyout offer, which the Thates had accepted, was fair but the line should have been rerouted because other people would be living long the line after she had left. The Province also reported on the Thates in addition to another rabbit breeder who attributed the death of her

400 rabbits that summer to the noise from construction on Highway 97 along property expropriated from her by the Ministry of Highways.[52]

In an August 25 letter to the editor of the Free Press, the author stated that he was confused by the "continuing saga of the Kavkas versus BC Hydro as reported by the press and BCTV." Why did the Kavkas move onto the property if there was a power line nearby? Why did the Kavkas not accept one of the two offers for their property? Frank Kavka had refused to attend the inquiry as a "form of protest." "You had your chance, so keep quiet! Was all the headline grabbing garbage, about the donating of their land for a cemetery, the act of a rational and reasonable person?" How could the Kavkas afford so much time off to protest, "while the rest of us are at work?" "Here are a few suggestions: accept one of the offers of a buyout. Next time there is a public meeting, speak up, or shut up. If you go out to sit on the power line again, wait until they turn it on -- you'll get a real charge out of it! To sum it up: I have some very good friends, who live as close to the power line as you do, and they are not protesting. Nor do they glow in the dark! Methinks they do protest too much."[53]

Another letter to the editor of the Free Press, addressed to McIntyre, asked why a transmission line "costly in mileage... and environmentally" was being "pushed" to fuel a pulp mill while at the same time the building of a natural gas pipe line was being considered "to which the Island's pulp mills would be obligated to hook into?"[54]

On August 26, 1989, the $30 million Dunsmuir/Gold River 230 kV transmission line was energized at 2:55 p.m. No difficulties were encountered. According to Barker, the contractor delay "cost lots of money."[55]

By August 15, 15 of the 144 eligible property owners accepted BC Hydro's buyout offer. The offer had been extended to people with BC Hydro ROW charges against their land title plus a few others in close proximity to the line. According to the Free Press, some residents, living close to the line but not eligible, felt their property values had fallen during the four months of controversy and they now had no prospects of selling. Neither were they convinced that the increased EMF from the line would not harm their and their childrens' health. Marg Roberts had filled out the appropriate forms in May but was not informed by BC Hydro that she was ineligible until August 15. She did not want her two children exposed to "electromagnetic fields 24 hours a day."[56] McMullan told the Free Press that Hydro had no record of offering to purchase the Roberts' property and that it was well outside the distance BC Hydro would consider for a buyout. However if a letter was sent offering a buyout, BC Hydro would honour it.

Roberts could not remember if she received the May buyout letter.[57]

Teresa Beaver also was not eligible for the buyout although her property was closer to the ROW than the furthest edge of her eligible neighbor's property adjacent to the ROW. McMullan told the Record that although exceptions were being made to the 50-metre limit in cases where houses were as close to the lines as houses on properties bordering the 50-metre limit, he understood that Beaver's property did not fit the criteria. She had filed a complaint with the Provincial Ombudsman and the BCUC; the BCUC was dealing with her complaint. Beaver believed she not be able to sell her property because of the publicity and would not be comfortable selling it to a family with small children. (Beaver told the Record that when she inquired about the buyout offer because she had not received a letter, she was told that only 35 were sent out because BC Hydro had trouble finding mailing addresses.)[58]

Although Ken Barkley and his girlfriend were not eligible for the buyout, they planned to sell.[59] He told the Record that they had no choice, especially if they decided to have children. (Barkley also said that he did not receive a response to the letter he sent to BC Hydro when the buyout was first offered. McMullan said that BC Hydro had no record of the letter and suggested that anyone concerned about their eligibility contact BC Hydro.)

The Provincial Ombudsman told the Record that several homeowners had appealed to him because they were unhappy with the buyout but he was unable divulge any details.[60]

In a September 8 letter to the editor of the Record, Walsh thanked the residents of West Courtenay, the MEC, and the Comox Valley businesses for their donations which enabled the CVRC to bring in Marino. She wrote that Marino had said that "'the Courtenay Group [had] done a remarkable thing.'" She was honoured to have played a role in the "magnanimous effort" and was "disappointed" that BC Hydro, the pulp mill, the provincial government and the BCUC did not agree that rerouting the lines away from residential areas was, in this case, practical and possible.[61]

By late September, of the 140 eligible properties, a total of 64 home owners, including the Kavkas, had officially asked BC Hydro to buy them out. BC Hydro had purchased its first home and would soon close on five more. BC Hydro did not plan to make buyout programs a standard practice, but neither were they ruled out in the future. They knew the issue would not "go away."[62]

By November 17, owners of about 71 properties had accepted the buyout offer and 21 properties had been purchased. (BC Hydro had also received requests from an additional 150 in-eligible property owners.) According to Barker, BC Hydro "might even make money" after resale. (By February 14, 4 of the 21 properties had been sold for a profit.)[63]

4.0 DISCUSSION

4.1. Risk

Risk can been defined as "a measure of both the hazard to health from exposure to a substance and the probability of its occurrence." Hazard can be defined as "the adverse impact on health that can result from exposure to a substance" and exposure, as "contact between a substance and an individual or a population." Managing the process of technological innovation in modern industrial societies can be thought of as the assessment, management and communication of risks. Industries, regulatory authorities and citizens must determine levels of acceptable risk, that is, how to balance estimated health and environmental risks against estimated economic and social benefits "in full knowledge of the likelihood that new information accumulated in the future will show that certain earlier choices were incorrect." Attempts to do this are commonly classified as risk assessment, risk management, risk communication, and risk perception.[1]

The processes of risk assessment and risk management can be described by the framework shown in Figure 4-1. Risk assessment consists of two stages: risk analysis, involving identification of a specific environmental hazard and estimation of the corresponding levels of risk, based on scientific treatment of toxicological and epidemiological data; and option evaluation, involving consideration and selection of alternative risk management strategies.[2] Risk assessment "attempts to provide rational scientific estimates of health and environmental risk, and to identify sources of uncertainty inherent in scientific data."[3]

Risk management involves selection of a particular risk management strategy and its implementation. Risk management takes risk assessment as one of its principal decision inputs and includes political, economic and social considerations - some quantitative, some qualitative. Risk management strategies may be regulatory, economic, advisory or technological.[4] The essential feature of risk management is its effort to clearly state the nature and quality of the information base, together with the assumptions and values that form the basis for the decision.[5] Risk management is inherently focused on the nature and adequacy of risk communication flows.[6]

Risk communication can be defined as "any purposeful exchange of information about health or environmental risks between interested parties."[7] Risk communication encompasses most forms of communication within the process of risk assessment and risk management, and also focuses on the communicative processes through which interested parties negotiate their interests and

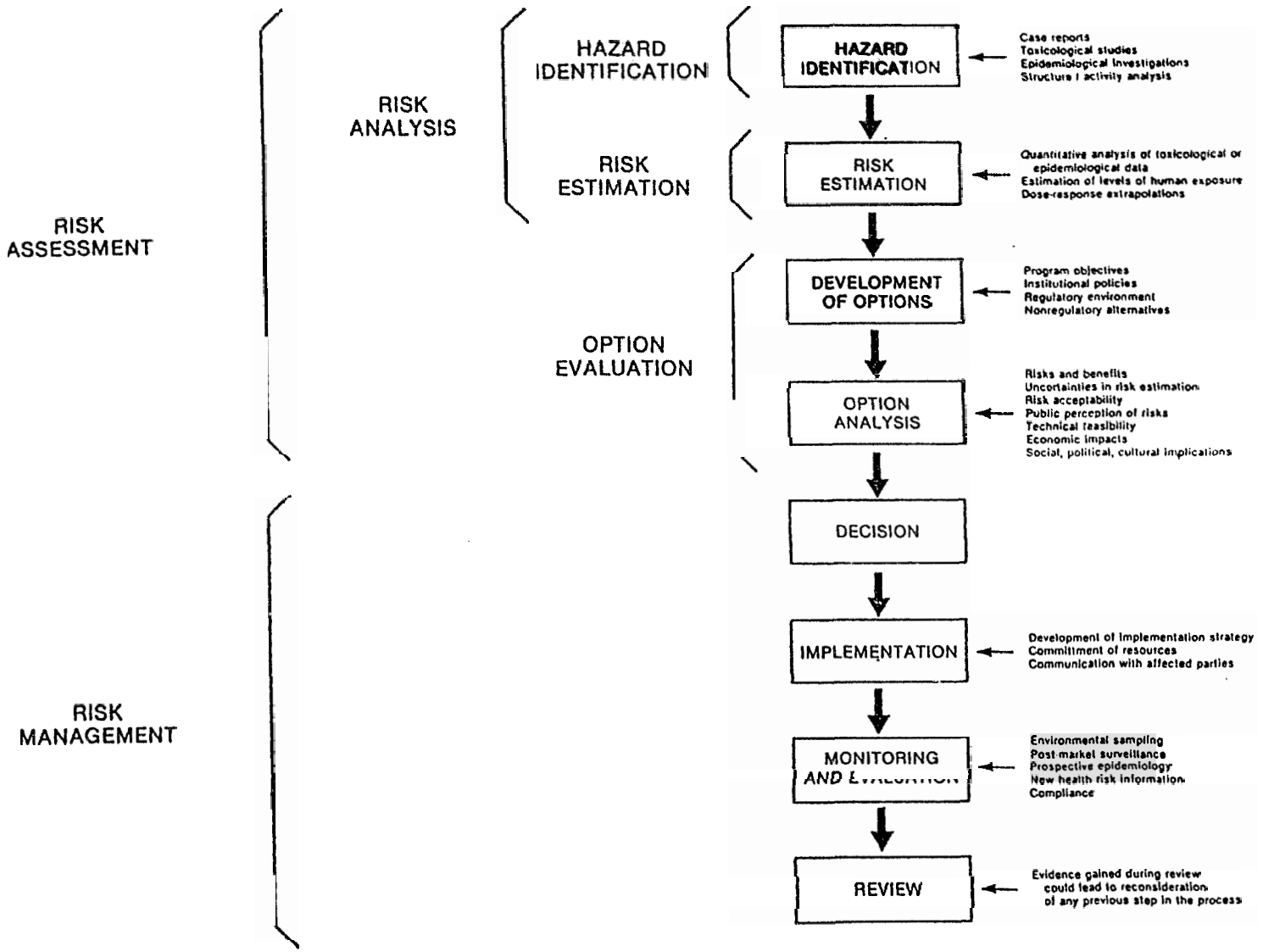


Figure 4-1. A model for risk assessment/risk management.

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concerns about the assessment and management of risks.[8] Effective communications is critical not only in terms of the decisions made and the basis for the decisions, but throughout the decision-making process, between all interest groups.[9]

Perceived risk can be defined as "an impression or intuitive judgement about the nature and magnitude of a health risk. Perceptions of risk involve the judgements people make when they are asked to characterize and evaluate hazardous substances and activities."[10] The way that people respond to risk depends largely on their perception of risk. The very act of science turning its attention to risk changes the public view of risk.[11]

In general, information processing is hindered by biases and limitations which affect subjective evaluations of probabilities. People tend to simplify complex and uncertain information and have difficulty "in detecting omissions in information received, in evaluating opinion, and detecting inconsistencies in debates about risk." Even so, existing information may be utilized to form strong attitudes about risks, often resistant to change.[12]

Certain characteristics of risk are also know to influence risk perception, including the degree to which a hazard is understood, the degree to which it involves feelings of dread, and the number of persons exposed.[13] Morgan et al. found that providing information about possible health effects from transmission line and electric blanket E/MF fields increased people's concerns that existing control measures were inadequate and increased the tendency to feel sure that there was a health risk.[14] Perceived health effects may actually produce their own health effects.

Other factors also shape public attitudes to risk. Furby et al. identified some of the key elements in determining attitudes toward the siting and construction of transmission lines, including property values, aesthetics, human health and safety issues, environmental concerns, economic benefits, equity issues, symbolic meaning, information and knowledge, and characteristics of the siting and construction process.[15]

Judgements made by non-experts are often contrasted with those made by experts with professional training in natural science or engineering disciplines using quantitative methods for analyzing and assessing risks.[16] Disagreements between experts and non-experts about the assessment of risks, ultimately framed in terms of acceptable risk, pose a major problem to achieving consensus on managing risks. Risk managers must choose between and factor the state of societal risk perception and acceptance, i.e., the way in which citizens understand the nature and variety of risks in the environment, how they rank each type of risk, and how they expect public authorities to conduct the risk management process,[17] into their decisions. The decision-making process is further complicated because experts often disagree with each other over facts or their interpretation due to incomplete and uncertain scientific knowledge. Trust and

confidence is undermined by highly visible disagreements. Expert disagreement occurs even when the facts are not in dispute because judgements by experts as well as by non-experts can be affected by pre-existing biases and cognitive limitations.[18] Human values and concerns inevitably enter into the analytic process.

As shown in Figure 4-2, the communication processes model of risk communication involves the interplay of two domains called perceived risk and technical risk. Perceived risk, essentially the domain of the general public, is determined by society through the political decision-making process, while technical risk, normally the domain of experts, is determined by professional technical experts. The actors are arranged in either domain according to the language each normally uses in speaking about risk, i.e., scientific, engineering and mathematical versus ordinary, everyday language. There is a two-way flow between and within each domain. Most risk communications problems arise with respect to communication between the expert and public spheres with the interplay "constrained both by the nature of the risk problem and by the conventional institutional channels that direct the flow of information and opinion in... society."[19]

4.2. Scientific Uncertainty

By December 1989, research had clearly established that, at least under some circumstances, PF E/MF could interact with and produce effects in biological systems. However, there was no definitive evidence that such effects could in turn give rise to significant health consequences. On the other hand, the possibility of significant health consequences could not be convincingly negated by superior research. Research was underway in an attempt to provide more definitive answers; results were not likely for a number of years.

It should be noted that uncertainties are not unusual in a scientific context; it is uncertainty that drives all of science. In fact, all scientific results are only provisional, subject to better data, better methods, and better frameworks.

In the face of scientific uncertainty, political, economic, and social decisions must still be made to address the concerns of all interested parties, decisions that are beyond the formal bounds of science. Risk managers call upon experts to assist them in this process.

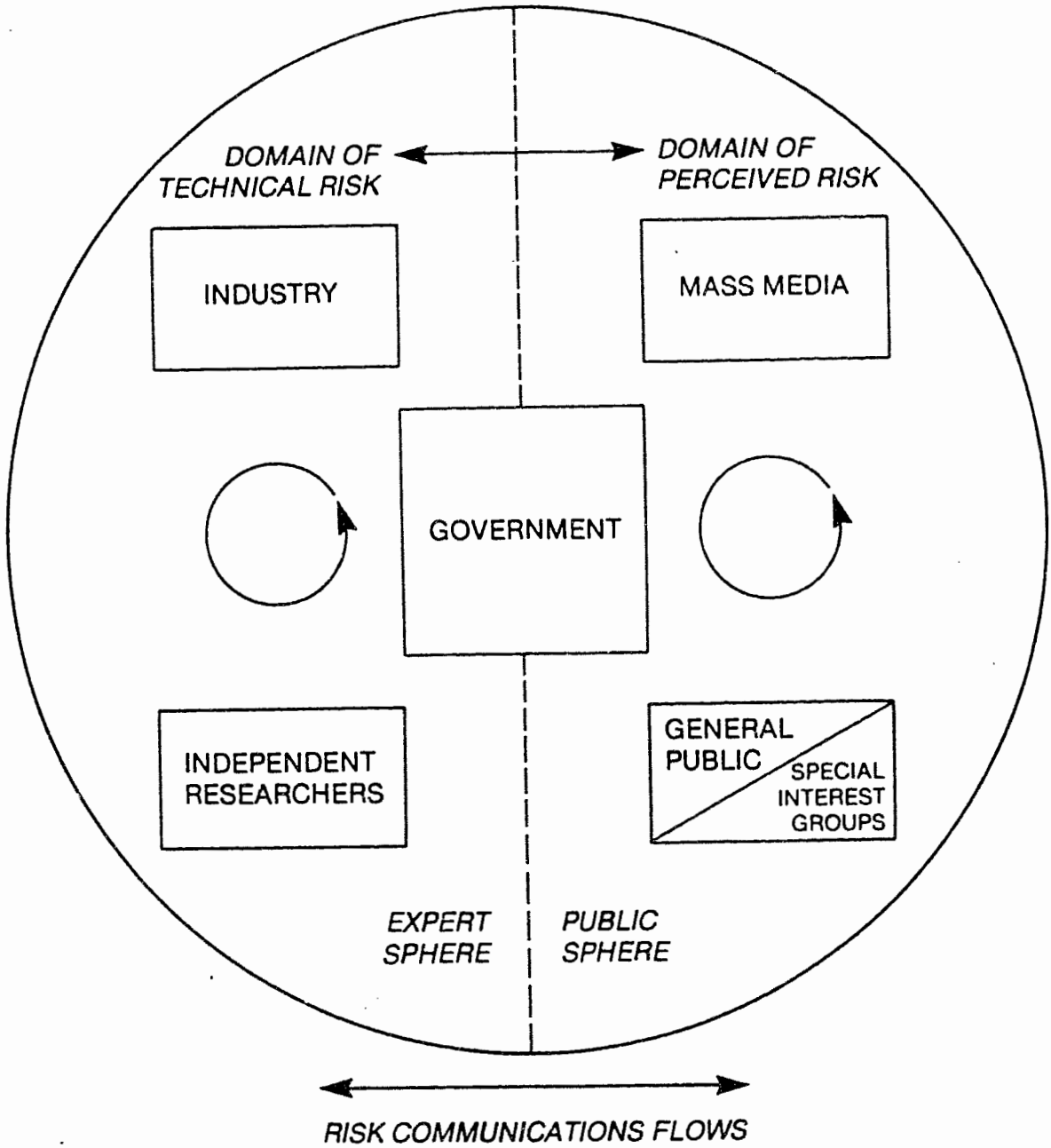

Figure 4-2. The communications processes model of risk communication.

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4.3. Technical Expertise

The term "expert" can be used to refer to individuals who, by virtue of their being technically trained within an academic discipline, have "technical expertise." In this sense, most experts draw heavily on the authority and/or prestige of science, in general, or their individual fields, in particular.[20]

The principal experts on PF E/MF health effects who directly participated in the Courtenay controversy were Marino, Erdreich, Sastre, and Gallagher. They were engaged in risk analysis, while the BCUC (and BC Hydro) were engaged in option evaluation and risk management. There were a number of other experts who played a less direct, but by no means less important, role in the controversy, for example, Savitz and the NYSPLP SAP. Technical expertise was used by all parties throughout the controversy to form, support and alter their own and others' views on the PF E/MF health effects issue.

According to some, technical expertise was simply a resource exploited by all parties in the Courtenay controversy to justify their views, to create legitimacy, and to control the terms of the debate. Influence depended on the ability to manipulate knowledge or challenge evidence presented to support a particular position on the PF E/MF health effects issue.[21]

Because of the state of scientific understanding about the issue, it did appear that studies were lined up on either side of the public debate about regulations, or, at least, that evidence could be found to support any value position in the regulatory debate. The credibility of the experts was questioned, in both their roles as researchers (because studies were "rigged") and as expert witnesses or advisors (because of "selective" use of studies). Furthermore, it appeared that the results of the experts' work reflected the views of their sponsoring agencies. It was often observed that "science could be bought."[22]

Because some scientific work is influenced by interests, it is necessary to identify specific instances when this occurs. Yet, to consider all science and scientists as "interested" or "biased" discredits the scientific enterprise, not because it is untrue, but because research "need not always reflect the economic or political interests of the researchers or those who fund them." Science is a strategy for seeking knowledge and, at its best, it is a particularly useful strategy, whatever its other limitations.[23]

For specialized knowledge, society must depend on experts. There are certain technical issues relevant to policy decisions that the average citizen is not capable of understanding in depth.[24] Furthermore, science often provides the ability to question a particular position.

The following discussion is premised on the notion that there was at least some scientific

basis for expert disagreement on the PF E/MF and human health issue and, as a result, there was a legitimate basis for both concern and for a lack of concern about possible health effects.

4.4. BCUC Report and Recommendations

Marino, Erdreich and Sastre, although agreeing on the need for more research, differed in their analyses as to whether the PF E/MF associated with the Dunsmuir/Gold River lines posed a risk to human health. The BCUC considered them "interested;" Gallagher was a "neutral arbiter." It should be kept in mind that Gallagher was only in an advisory position. McIntyre, a layperson, made the final decision about the "correct" risk analysis.

In the BCUC's (that is, McIntyre's) final report, the uncertain state of the science concerning PF E/MF health effects was given as the rationale for its risk assessment. The scientific evidence was "insufficient," "inconclusive," and "unreliable." Yet, scientific uncertainty was the basis for risk management decisions made elsewhere in Canada and the US which ranged from limiting transmission line E/MF levels to restricting school playground use by children to "business as usual."[25] None of those decision makers concluded that PF E/MF were a definite health risk.

It was not made clear in the BCUC's final report why its risk analysis was more "correct" than any other, especially Marino's. Furthermore, Gallagher's analysis was hidden. The BCUC had a public obligation to give a full explanation for its decision in the final report. The rationale given was especially inadequate for an informed public.

Each expert based his or her risk analysis on the standard scientific paradigm of their respective fields. For example, Erdreich and Sastre considered PF E/MF as the only relevant exposure, while Marino included PF, RF, and microwave exposures. Even if industry-associated research were included in Marino's analysis, he was not even using the same body of data as Erdreich and Sastre. Furthermore, many experts had considered the same body of data as Erdreich and Sastre, but concluded there was enough evidence to indicate that PF E/MF was at the least, a hazard, and possibly a risk, to human health. (Marton raised a number of the issues routinely debated by experts who, while limiting relevant exposures to PF E/MF, differed in their conclusions regarding health effects.) Not only was the BCUC unclear in their final report about the reasons for their choice of risk analysis, they did not acknowledge the broad range of risk analyses that existed among the experts.[26]

Science is used to support public policy. A government body must justify its actions in the political process, and consequently seeks a science capable of being justified and explained to a wide variety of publics and interest groups. This science must be intelligible to non-scientists

and facilitate clear choices. It must represent a body of evidence on which decisions can rest and be seen as rational. Only an ideal science could serve these non- scientific intentions.[27]

The BCUC's final report was framed in an ideal picture of the scientific enterprise. Throughout the Courtenay controversy, science was used by the BCUC, Gallagher, BC Hydro, Erdreich and Sastre (and others) as a source of legitimacy and credibility. However, they presented a picture of the scientific process, and of the relationship between science and policy decisions that was exclusively "rationalist" in form. On the other hand, Marino (and others) presented a picture of science that emphasized what were, in his view, its irrational dimensions. Yet, after discounting all industry-associated research, he too relied on an ideal picture of the scientific enterprise to support his position.[28]

Presenting the scientific enterprise as such was not always an easy task. There were some obvious contradictions during the inquiry. Why did Becker and Savitz refuse to testify? Why did BC Hydro not talk to the public once the inquiry was called? Why did BC Hydro refuse to bring in an expert chosen by the public? Why was it "inappropriate" for Erdreich and Sastre to contact Marino? If Marino and Erdreich and Sastre were "interested," why was Gallagher not?

4.5. Mandated Science

Risk analysis is not a "neutral process," whether deriving a quantitative analysis of risk, or concluding that there is not enough information to do so. There are many uncertainties and assumptions, and considerable social and economic interests involved. Indeed, "either or both scientific and policy considerations may emerge at any time and in any setting where risk management issues are at stake."[29]

In analyzing risks, choices must be made concerning which studies to commission, how extensively to review the scientific literature, how to interpret the findings of studies if they are conflicting, uncertain, ambiguous or not directly applicable to the decision being made, how to bring together scientific material from different disciplines to reach a single decision, and where the burden of proof lies, that is, is the potential risk in question considered safe or hazardous until proven otherwise. These choices must all be made within the constraints imposed by the time and resources available.[30]

The "scientific activity of an expert committee, of the scientists who testify for regulators, of the regulators or courts that assess scientific information, and the studies used for purposes of making public policy," whether commissioned by government officials and regulators to aid in their decision making or produced in more conventional scientific settings, are all examples of "mandated science."[31] Mandated science or "the role of science and scientists in the making of

public policy" alters the relationships between science, values and public policy in significant ways.[32]

Salter, in a case study investigating the setting of chemical standards, argues that "a mandate to develop recommendations or decisions for public policy exerts a pressure reflected both in the activities of scientists and in their work or its interpretation." Four characteristics of mandated science distinguish it from the conventional view of science.[33]

The idealization of science

Mandated science relies upon an image of science as value-free, as producing invariably credible results, and, most importantly, as an inherently public enterprise. However, mandated science conforms to none of these ideals. The "moral dilemmas posed by scientific knowledge are made explicit, and few assume that science is fully independent." The conventional methodologies of science "often produce conflicting reports that cannot be resolved by further properly conducted studies." A proportion of mandated science is neither peer reviewed, published, nor part of the open literature.[34]

The legal substratum of scientific debates

The decisions made in the context of mandated science are influenced by economic and social interests. More notably, the decisions, and therefore the debates leading up to them, are "deeply infused with legal issues that compound their economic and social implications many times over." They result from "discussions about liability for harm, and about measures that might be taken to restrict both harm and limit liability for it." They determine to what degree court action can be taken for possible negligence or damage to human health and the environment. The reports and conclusions of mandated scientists are used as legal evidence and therefore are "subject to the standard of proof required by the courts."[35]

Salter found that "to be considered as good science, scientific information must be developed and presented without regard for its legal implications." However, testimony of experienced participants in mandated science is "shaped by an awareness of legal standards of proof and by knowledge about how to use scientific information effectively in a court or regulatory setting." "Scientists compromise their claim to independence to the extent that they openly recognize the legal constraints" yet they must function in a legally informed manner "if their work is to be valuable to the legally-oriented bodies that mandate or use their scientific work."[36]

The peculiar nature of the debate itself

The nature of discussion and debate within mandated science is unique. Scientific debate is

neither scientific, legal, nor public policy debate. It has its "own style, methods of argumentation and uses of language." For example, scientific information is presented "as if it were evidence in a public policy debate infused with interest group considerations" and emphasis is placed on closure. "Scientific conclusions will often be justified as reflecting a consensus of interested parties or a democratic process of decision-making." Finally, emphasis is on "the evaluation of science rather than its conduct."[37]

The unusual character of the debate in mandated science is reflected in the use of particular words and phrases. The words and phrases "lend themselves to being battlegrounds for conflicting interpretations of science that benefit some political or interest groups and not others." For example, in a scientific context, the term "scientific uncertainty" is unexceptional; the existence of contrary scientific views is not sufficient to call research into question. However, by referring to scientific uncertainty, a lawyer in cross-examination can challenge the credibility and usefulness of a study, or a regulator can justify action or inaction.[38]

Salter found that to maintain their credibility, scientists participating in mandated science "must adhere closely to conventions of scientific debate that are acceptable to other scientists." However, to be effective in the policy arena they must also speak with an awareness that others "will use what they say to further goals that are unrelated to science." "Scientists who regularly give expert testimony for regulators or for expert committees speak to at least two different audiences simultaneously, and know that their words can be subject to conflicting interpretations by each."[39]

The manifest interplay of science and values

Mandated science makes explicit the moral dilemmas posed by science. For example, members of an expert committee are chosen "because they can rely upon their scientific training to render themselves relatively free of interest group and moral constraints." However, because they are working in the sphere of mandated science, "they conduct assessments that are only partly scientific, and make decisions that have direct political and moral consequences." In accepting their task, they "agree to recognize constraints that scientists seldom recognize or acknowledge explicitly, and to relax constraints that scientists publicly claim to abide by." Salter argues that the knowledge that "a statement about scientific issues is inherently also a statement which privileges some interests and not others" affects the expert committee's "recommendations as much as does their knowledge about the characteristics of the natural phenomenon."[40]

Salter makes several observations which are particularly relevant when considering the use of technical expertise in disputes between parties. First, the nature of mandated science

discourages participation by conventional scientists, and for those who do participate, the experience is frustrating. Research is likely to be conducted in a highly conservative manner because scientific conclusions must be justified to many different audiences or in a courtroom.[41]

Participation is also frustrating because scientific statements could have significantly different meanings in scientific, regulatory and legal discourse. Information is presented in different ways in each, and arguments effective in one discourse are often not effective in another. Only scientists experienced in mandated science could withstand the scrutiny applied in an expert hearing and court.[42]

In addition, conventional scientists are committed to conducting relatively dispassionate inquiries. However, as citizens, and as a result of their research, they are often compelled to "take a position" or to make recommendations for regulators. They observe government or regulatory scientists offering their opinions about regulation freely and company expert witnesses reaching favorable yet scientific conclusions. "At the same time, any association with advocate or interest groups, or attempts to make regulatory recommendations is seen to corrupt their own science and threaten its scientific credibility." It is easiest for conventional scientists to simply refuse to become involved in any aspect of mandated science. (Salter observed that advocacy and science clashed in the public presentation of research to a non-scientific community, not in the conduct of research.)[43]

Second, a cursory review of the academic literature is often made by policy makers and regulators. Studies designed for regulatory purposes which yielded the types of conclusions required are submitted for review to regulators. Limited resources are available for detailed examination of the wide-ranging academic literature and there is little scope for discussion of the implications of studies not lending themselves to suitable conclusions for regulators. As a result, questions remain unaddressed and unanswered.[44]

Third, scientists take an "unusually critical perspective" on the studies reviewed because they are used to support legal actions and to evaluate regulations. When faced with inconclusive data or conflicting interpretations of it, scientists "often chose to identify problems in the conduct of the research, or to refer to scientific uncertainty." (If this is true and advocate groups view science and scientists as conservative and unsupportive of stringent regulation, Salter observes that it is perhaps because "statements about scientific uncertainty could be easily used in mandated science as a reason for government inaction.")[45]

In conclusion, Salter found that mandated science is "not well understood, and that it is characterized by an ideal picture of the scientific enterprise, by reliance upon overly rational

procedures of risk assessment, by insufficient understanding of the difficulties in resolving mixed disputes [involving both scientific and legal issues] and by an almost naive perception that scientific statements have the same meaning, regardless of who interprets them."[46] In addition, "the discussion of the relationship between science and values is too limited, and the reliance on institutional procedures to handle economic, trade and interest group issues in mandated science is highly problematic." Mandated science has some norms quite different from either those of the scientific or legal process "that should be extended and articulated to deal with the constraints imposed by a policy mandate upon scientists and scientific work." It is important to distinguish when the conditions of practising mandated science are so constrained they are impossible.[47]

4.6. Recommendations

Risk managers and their publics are increasingly dependent on science and technology yet there is growing concern or skepticism about the answers that science can provide, at least at the time when regulatory decisions are required. If the public is to have full confidence in decisions, they need to know how the pressures and constraints to reach conclusions that can lead to public policy or government regulation are felt by decision makers and experts alike. These realities must be understood by all parties, and taken into account when evaluating "the adequacy of scientific assessments and their fairness in both procedural and substantive terms."[48]

Risk managers should ensure that the inherent limitations of the risk assessment process (beginning with the limitations of science itself) are acknowledged explicitly by all parties and, as best can be achieved, compensated for. Certainly, all parties could and should contribute to this process, including the media, public, politicians and lawyers, but it is the risk managers who have the major responsibility and the resources to fulfill their obligation.

In particular, the BCUC had an obligation to provide a comprehensive rationale for its decision in its final report. The broad range of scientific opinion on the PF E/MF and human health issue should have been acknowledged, and the basis for the differences of opinion explained. (Because it is likely that more time than was available would be required to do this, a detailed report could have followed a preliminary report outlining the decision in more general terms. A detailed report would provide the opportunity to adequately explain the state of the science on PF E/MF health effects and its many uncertainties, which may or may not have been the focus of expert disagreement.) Furthermore, Gallagher's contribution to the decision-making process should have been visible throughout the inquiry.

BC Hydro should not have simply let the "facts" speak for themselves. The PF E/MF

issue was complex and the "facts" supported a number of possible "truths." Although a wide range of information was made available to the public on request, a much more active role should have been played by BC Hydro in communicating with the public and the media about the disagreement among experts on the issue.[49] In particular, they should have brought their own experts in earlier and made them accessible to the public.[50]

The BC MOH should have been more directly involved in the Courtenay controversy, especially given its mandate.[51] They also had some expertise in the area.[52]

The expert witnesses and advisors also were responsible for recognizing and compensating for the inherent limitations of the risk assessment process. They should have made no more claim for their knowledge than was warranted. In particular, although Marino advised concerned residents that if they were unsuccessful in their bid to reroute the new transmission line, an "excessive" reaction was not called for and that other, perhaps more significant, risk factors in their lives should be reduced, he waited until the end of his testimony to offer the advice. Furthermore, the experts should have shared their knowledge about those aspects of the PF E/MF health effects issue over which scientists were not in agreement.[53]

In addition, risk managers should ensure that all parties, especially the public, are involved in the decision-making process, not only for reasons of fairness but because of the very nature of mandated science. Technical choices are inherently value-laden.

In particular, the CVRC should have been provided with funds by the BCUC to cover Marino's expenses. His presence was necessary especially during cross-examination (of both BC Hydro's experts and of himself) to allow for full disclosure of information.[54]

Disclosure of the fees paid by BCUC and BC Hydro for their expert witnesses should also be required, especially since BC Hydro and BCUC are provincial agencies.

The BCUC should have recognized that informed public opinion, such as that given by Marton, had much to contribute to the discussion of PF E/MF health effects. The issues that Marton raised should have been addressed further, or at least acknowledged in the BCUC's final report, even though he was not an "expert." Several other residents also put forth knowledgeable questions and arguments. It was difficult for an informed public to accept, as stated by the final report, that "all sides" of the debate were heard. Marino, Erdreich and Sastre did not represent "all sides;" Gallagher's contribution was essentially unknown.

Furthermore, and perhaps most importantly, the public perception of risk from PF E/MF, in contrast to the technical assessment of risk, should not have so easily been dismissed by BC Hydro, the BCUC, and others as irrational or unscientific. The two determinations of risk

should have been given equal status because, in mandated science, it is difficult, if not impossible, to separate the scientific and non-scientific components of risk assessment. Experts will include and exclude their own values. Furthermore, the public is capable of understanding the limitations and trade-offs involved in balancing health benefits with health risks.

With all parties participating and therefore responsible for the decisions made, there is a higher probability for acceptance of the decisions by a broad segment of the public.[55]

4.7. Outlook (to 1990)

The BCUC's ruling on the Dunsmuir/Gold River line alleviated or at least suppressed much of the public concern about PF E/MF health effects in the Courtenay area and elsewhere in BC. Still, concerns were raised at recent public meetings held by BC Hydro regarding the planned routing of several transmission lines.[56] In particular, BC Hydro refused to buy the homes of residents along the proposed route of a 138 kV line in the Duncan area, citing the BCUC's criticism that they had acted "imprudently" in the Courtenay controversy. One area resident, reacting to the proposed routing, threatened to shoot anyone from BC Hydro setting foot on his property.[57]

Certainly, some of the public concern during the Courtenay inquiry was influenced by factors not directly related to the PF E/MF health effects issue, for example, inaccurate and unbalanced information, the lack of trust and credibility of the BCUC, BC Hydro, and their experts, and the public's lack of understanding of the associated science, and of science, in general. It was also possible that some of the participants used the health risk debate as surrogate for debate about more general social, economic, and political issues and concerns.[58] However, improved risk management and risk communication should help reduce concerns related to these aspects of the issue.[59]

By 1990, at least 22 major occupational and residential epidemiologic studies were underway in 12 countries examining the possible link between PF E/MF and cancer, especially leukemia and brain cancer. (See Table 4-1.) Electric utilities were funding most of the studies, for example, EPRI funded all or parts of 6 of the 10 US and Canadian projects. The majority involved direct measurement of PF E/MF as opposed to using surrogates such as job title or wire codes, for determining magnetic field exposures. A great deal of emphasis was also being placed on controlling for possible confounders. In addition, a number of laboratory experiments were planned or in progress.[60]

Furthermore, some scientists were re-evaluating the assumptions and adequacy of methodologies used to study the PF E/MF health effects issue. For example, the US DOE

TABLE 4-1

PF E/MF - Cancer Epidemiological Studies in Progress

I. Residential studies

Institution	Principal investigator(s)	Sponsor(s)	Endpoint(s)	No. of cases/ controls	End date
University of Leeds, UK	David Clayden	CEGB	All childhood cancer	374/588	1989
USC	John Peters	EPRI	Childhood leukemia	232/232	1990
University of Leeds, UK	Ray Cartwright	CEGB	ALL, AML, CLL, CML, NHL	3200/3200	1990
Maastricht Medical School, Netherlands	Jan Meijers	Maastricht Medical School	All leukemia, brain cancer	3459 people, 32-yr. follow-up	1991
Karolinska Institute, Sweden	Anders Ahlbom	Karolinska Institute, National Board of Energy	Adult leukemia, adult brain cancer; all childhood cancer	300, 425/725; 200/140	1991
National Taiwan University, Taiwan	Ruey Lin	National Science Council	Childhood leukemia, childhood brain cancer, lymphoma in children	216/422	1991
USC	Susan Preston-Martin	State of California	Childhood brain cancer	300/300	1993
University of Toronto	Anthony Miller	Ontario Hydro	Childhood leukemia	200/400	1993
University of Helsinki, Finland	Markku Koskenvuo	Imatran Voima Oy (a Finnish power company)	Cancer, childhood cancer	not available	1993
NCI/ Children's Cancer Study Group, USA	Martha Linet, Zdenek Hrubec	NCI	Leukemia, ALL in children	1000/1000	1994
CCA of BC	Richard Gallagher	EPRI, CEA, HWC	Childhood leukemia	395/395	1994
IARC, France	Peter Boyle	IARC	All leukemia	1500/1500	1994

Abbreviations: ALL: acute lymphocytic leukemia; AML: acute myelogenous leukemia; ANLL: acute non-lymphocytic leukemia; CLL: chronic lymphocytic leukemia; CEGB: Central Electricity Generating Board; CML: chronic myelogenous leukemia; IARC: International Agency for Research on Cancer; NHL: non-Hodgkin's lymphoma; USC: University of Southern California.

TABLE 4-1, continued

II. Occupational Studies

Institution	Principal investigator(s)	Sponsor(s)	Endpoint(s)	No. of cases/ controls	End date
USC	Joseph Bowman	EPRI	ALL, ANLL, CLL, CML	not available	1990
Johns Hopkins University School of Public Health	Genevieve Matanoski, Patrick Breysse	EPRI	All leukemias except CL L	200/600	1990
Johns Hopkins University School of Public Health	Genevieve Matanoski, Patrick Breysse	National Institute of Environmental Health Sciences	All cancers	391 cancer	1990
University of Bern, Switzerland	Christoph Minder	Swiss National Fund	Leukemia; lymphoma	23/177; 207	1990
Monash Medical School, Australia	Michael Salzberg	Not available	Glioma	425/850	1991
McGill University	Gilles Theriault	Hydro Quebec, Ontario Hydro, Electricite de France	Leukemia, brain cancer, skin melanoma	6000/17000	1991
University of North Carolina	David Savitz	EPRI	Leukemia; brain cancer	215; 186	1991-92
National School of Public Health, Osvaldo Cruz Foundation, Brazil	Swergio Kolfman	Brazilian Research Funding Council	All cancers	347/1129	1992
Wellington Medical School, New Zealand	Neil Pearce, Peter Bethwaite	Wellington Medical School	ALL, AML, ANLL	300/600	1992
National Institute of Occupational Health, Sweden	Birgitta Floderus	National Energy Administration, National Institute of Occupational Health	ALL, AML, CLL, CML, glioma	200 brain cancer, 300 leukemia/ 1000	1992

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sponsored research on "meta-analysis," a technique that combines data from studies regardless of merit and outcome. Traditional approaches, which often only consider studies with positive and statistically significant results, fail to detect real effects when the effect size is small to moderate, and errors increase as the number of studies increase. The advantage of this methodology is that it is quantitative, can be standardized and is repeatable, and increases statistical power.[61]

Another study was investigating how measures of public health impact (or APt) were estimated from epidemiological data. Such estimates are controversial because they assume that a causal relation exists between 60 Hz magnetic fields and cancer. Exposure misclassification in a case-control study will bias the OR, helpful in evaluating causality, towards the null. Therefore, some scientists have argued that the APt, a function of the OR and exposure prevalence, is underestimated. Researchers were examining ways to minimize such errors.[62]

It is still not possible to conduct a formal quantitative risk analysis primarily due to the lack of a sufficient data base upon which to calculate risk.[63] In particular, a dose-response relationship has not been established because an appropriate exposure parameter has not been determined. Most experts agree that more and better research will provide better answers to the question of possible PF E/MF health effects. However, concern has been raised that present levels of research activity are inadequate. Funding in the US is down due to decreasing overall federal expenditures. HWC has yet to set up a multi-stakeholder advisory committee to advise on future PF E/MF research, as recommended by the Working Group on Electric and Magnetic ELF Fields.[64] Even if it is assumed that present research efforts are adequate, few of the current studies will begin to yield results until the mid-1990s. Furthermore, even if research efforts are increased, it is quite possible that, given the complex nature of the PF E/MF health effects, the results will only further confuse the issue. For example, a recent epidemiological study by Obrams found no evidence that telephone linemen had increased leukemia risk.[65] However, interim results from another study conducted by Johns Hopkins University researchers indicated that telephone linemen, specifically cable splicers, had significantly elevated rates of all cancers.[66] Another study, recently completed by Savitz and Loomis at the University of North Carolina, found an increase of brain cancer risk among electric utility workers.[67]

The prevalence and integral role of electric energy in industrialized society makes the potential health effects issue a matter of serious scientific and public health policy concern. As long as scientific uncertainty and the accompanying expert disagreement remain unresolved, the problem will persist and grow as more power lines are constructed and the public becomes better informed. In the US and increasingly in Canada, vigorous public intervention and litigation

have continued to significantly impede the ability of private and public construction of new lines due to concerns about health effects and potential decreased property values due to perceived health effects.[68] According to an EPRI poll of 100 utility CEOs, customer inquiries and press calls had tripled and employee concerns were up 50 %. A recent CEA survey placed the issue as number one with utilities across Canada.[69] Yet, even if adopted as policy for the siting of new transmission lines, "prudent avoidance" of all populated areas is nearly impossible. And what should be done with existing lines? Furthermore, recent research has indicated that distribution lines may be a more significant source of exposure.[70] Better scientific understanding is the only possible way to resolve the issue in the long term. In the short term, an understanding of where the experts agree and disagree is critical to making an informed decisions about what level of risk is acceptable and for whom.[71]

4.8 Recommendation for Further Research - Risk Assessment

A number of proposals, both specific to PF E/MF health effects and general to mandated science, have been made which may help resolve some of the disagreement among experts. (Of course, there will always be some difference of opinion.) This section provides an overview of some of these proposals.[72]

Expert Committee Membership

According to Banks, membership of the five panels of scientific, medical, and engineering expertise assembled since 1977 to examine the issue of PF E/MF health effects was invited and thus fixed at the outset, limiting the scope and depth of scientific expertise that could be applied. With the exception of the NYSPLP SAP, members were almost exclusively drawn from the very small bioelectromagnetic research community. As a result, there has been an increasing polarization of views without sufficient depth and diversity, especially with respect to the 60 Hz magnetic field/cancer hypothesis. making the exchange of views increasingly difficult. It is difficult for a scientist to evaluate his or her own work, or even field of work. In an effort to address some of these problems, Banks has suggested a major interdisciplinary peer review project of the state-of-the-science, conducted by academic institutions not presently active in the area. The project should be published by the institution in an archival scientific journal.

Conversely, Marino believe that only "insiders" can make a "correct" analysis, given the intricacies and nuances of the area. It took many years for scientists working in the area of ionizing radiation to accept that non-ionizing radiation could have biological effects, and that thermal effects were not the only effects of concern.[73]

Regardless of whether insiders or outsiders are involved, the US NRC similarly recommends independent peer review of risk analyses because "one cannot assume that experts are significantly more self-conscious about the subtle distinction between value judgement and scientific consensus in complex analyses than non-experts are.[74] Jasanoff further suggests that risk assessments made by regulatory agencies should be subject to "peer review."[75]

Science Court

The science court is a procedure proposed by Kantrowitz and others in which one or more reputable scientists without vested interests or strong biases in the "policy arena" examines opposing arguments from other experts assumed to be committed to one outcome rather than another. The relatively objective group of scientists then comes up with its own pronouncements as to which argument is scientifically "correct."[76]

The science court was originally based on the following premises: scientific- related controversies are best resolved by adversarial methods; the scientific (truth-seeking) component can be separated from the political, ethical and evaluative (justice-seeking) components; adjudication is performed by a distinguished scientist; the roles of the adversaries should be separate from that of the adjudicators in the proceedings; and the court should be conducted in full public purview.[77] A major criticism of the science court is that the scientific component cannot be separated from the non-scientific components. In addition, the scientific adjudication may have little impact if the crucial information is lacking.[78]

According to Nelkin, the science court invites an adversarial procedure in which polarization of views would likely precede any movement toward closure. Although scientists often argue and generate controversy, there are pragmatic constraints involved (breadth of topics, reliance on staff) and most disputes do not hinge on science but on different values and power positions. Hence, the science court, because it cannot bring closure, would disappoint the public and frustrate scientists. There are some "effective" mechanisms already in place, such as panel reviews by the US NAS, but they lack visibility and notoriety. Nelkin prefers to work on improving such mechanisms (for example, involving an ethicist in the risk assessment process to help identify values, often implicit and unacknowledged.) but is not against experimenting with the science court proposal, such as Mazur et al. have done.[79]

According to Mazur, the science court can be realized because only a separation of "blatant evaluative or normative statements from statements of fact" is required. Mazur attempted to promote such an exchange between technical experts involved in a 1979 controversy over the health effects of high voltage transmission lines in Minnesota. Mazur acted as an independent mediator between Becker and Marino (who considered transmission line E/MF hazardous) and

four experts who were, based on hearings and published accounts, "closely associated" with the position that transmission line E/MF was not hazardous. Mazur provided a list of alleged statements of facts which was revised by Becker and Marino based on critiques received from the involved experts. The revised list was sent to the four pro-line experts for comments; three responded.

A somewhat better understanding of the technical differences between the positions was achieved. Subsequently, however, the pro-line experts did not want any involvement in a science court procedure. Mazur speculated that proponents of technological development did not want to debate scientific differences because the debate would publicize and perhaps legitimize criticism of the lines. He concluded that the controversy was primarily a dispute over political goals and only secondarily concerned with the veracity of scientific issues. Mazur also speculated that although the science court final report would probably not alter the position of the adversaries and their interest groups, it could have an important impact on that portion of the public which had not yet taken a side in the controversy, but whose interests were at stake.[80] (Marino has been an active proponent of the science court.)[81]

Technology Tribunal

Shrader-Frechette suggests that a "technology tribunal," a variation of the science court, be considered because the scientific component cannot be separated from the other components of [technology-related] controversies. In addition, the technology tribunal would be adjudicated by "intelligent and educated" citizens, informed by expert opinion. Although the science court would be an important and potentially useful experiment, Shrader-Frechette believes that society should also examine the political, educational and scientific consequences of adversarial proceedings conducted in a democratic rather than elitist manner, regardless of whether any final answers were arrived at.[82]

Regulatory Negotiation

Jasanoff proposes "regulatory negotiation" as a way of resolving the value conflicts inherent in disputes about technical risk. All parties, including the public, directly participate in the decision-making process. Because the opposing parties are drawn into a working relationship, a narrowing of issues and softening of positions is often brought about. Jasanoff commented that negotiation has shown its practical benefit in environmental dispute resolution concerning siting controversies.[83]

Other suggestions to help resolve expert disagreement include training scientists to be effective participants in the courts and certifying "public" scientists.[84]

Ideally, the risk assessment process combines the best attributes of scientific discussion with the legal norms of fairness, due process and natural justice. As Salter observes, this is not an easy combination. "Neither the importation of the norms and values of science into the legal process nor the importation of legal norms into a scientific assessment" resolved the problems of mixed disputes. The search for fairness demands considerably more innovation than experiments combining truth and justice-seeking procedures (such as the science court or regulatory negotiation) can demonstrate. Methods other than those which pay attention to administrative procedure and institutional design are required.[85] The most successful experiences should be studied to "determine how mixed disputes have been resolved, and how both fairness and adequate science have been achieved."[86]

APPENDIX A

ABBREVIATIONS

ac	alternating current
AIBS	American Institute of Biological Sciences
BC CCA	BC Cancer Control Agency, now the BC Cancer Agency
BCUC	British Columbia Utilities Commission
BEMS	Bioelectromagnetics Society
BPA	Bonneville Power Administration
BPNWL	Battelle Pacific Northwest Laboratories
CEA	Canadian Electrical Association
CPFP	Canadian Pacific Forest Products
CMU	Carnegie Mellon University
CSA	Canadian Standards Association
C-S RD	Comox-Strathcona Regional District
CVRC	Comox Valley Rerouting Committee
DC	direct current
DOE	Department of Energy
DOH	Department of Health
EHC	Environmental Health Criteria
EHV	extremely high voltage, 345-1000 kV
ELF	extremely low frequency, 30-300 Hz
E/MF	electric and magnetic fields
EMF	electromagnetic fields
EMR	electromagnetic radiation
EPA	Environmental Protection Agency
ERCB	Energy Resources Conservation Board
EPRI	Electric Power Research Institute
ERI	Environmental Resources Information, Inc.
FP	Comox District Free Press
HWC	Health and Welfare Canada
Hz	hertz
IEEE	Institute of Electric and Electronics Engineers
INIRC	International Non-Ionizing Radiation Committee, IRPA
IR	ionizing radiation

IRPA	International Radiation Protection Association
LF	low frequency
MEC	Merville Environmental Committee
MOH	Ministry of Health
MW	megawatts
MWN	Microwave News
NAS	National Academy of Sciences
NCI	National Cancer Institute
NCRP	National Council for Radiation Protection
NEP Act	US National Environmental Protection Act
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIR	non-ionizing radiation
NRC	National Research Council
NSF	National Science Foundation
NYS	New York State
NYSPLP	New York State Power Line Project
OR	odds ration
OTA	Office of Technology Assessment
PF	power frequency, 50 and 60 Hz
PIAC	Public Interest Advocacy Centre
PMR	proportional mortality rate
PSC	Public Service Commission
Record	Courtenay Comox Valley Record
RF	radio frequency, 30 kHz-300 GHz
ROW	right of way
RR	relative risk
SAC	Science Advisory Commission
SAP	Scientific Advisory Panel
TDHSR	Transmission/Distribution Health and Safety Report
UHV	ultra high voltage, 1000 kV and above
WHO	World Health Organization

G	if prefixed to a symbol, multiply by 10^6	μ	multiply by 10^{-6}
K	multiply by 10^3	n	multiply by 10^{-9}
m	multiply by 10^{-3}	p	multiply by 10^{-12}

APPENDIX B

PEOPLE INVOLVED IN THE CASE STUDY

Barker, Jeff	Project Manager, Transmission Projects, BC Hydro
Bauman, RJ	Lawyer, representing CPFP
Beavan, Pat	Land Representative, BC Hydro
Becker, Robert	Physician, Orthopedic Surgeon
Bell, Larry	Chair, BC Hydro
Boatman, Chris	VP, Corporate and Environmental Affairs, BC Hydro
Burns, Kathy	MEC
Carpenter, David	MD, Office of Public Health, New York State DOH; Head, School of Public Health Sciences, State University of New York; Executive Secretary, NYSPLP
Carswell, Peggy	Director, C-S RD
Clifford, Jack and Edith	Courtenay residents
Curley, Ken	Area Manager, BC Hydro
Davis, Jack	BC Minister of Energy, Mines and Petroleum Resources
Edwards, Ann	MLA, Kootenay, Opposition critic for Energy, Mines and Petroleum Resources
Erdreich, Linda	Ph.D., Epidemiologist, ERI; BC Hydro expert witness
Gallagher, Richard	Ph.D., Epidemiologist, BC CCA; BCUC expert advisor
Gathercole, Richard	Executive Director and General Counsel, BC PIAC, representing CVRC
Grant, W.J.	Director, Engineering and Accounting, BCUC
Gustafson, Carl	Lawyer, representing BCUC
Hagen, Stan	MLA
Kavka, Darlene	Courtenay resident; Chair, CVRC
Kavka, Frank	Courtenay resident
Klassen, Tim	VP, Administration, BC Hydro
MacKenzie, Ken	Lawyer, representing BC Hydro
March, Lorne	Director, Environmental Service, BC Hydro
Marino, Andrew	Ph.D., Biophysicist; CVRC expert witness
Martin, Debra	Editor, Record
Marton, John	Courtenay resident; Psychologist
McIntyre, John	Chair and CEO, BCUC; Inquiry Chair

McMullan, Peter	Manager, Corporate Communications, BC Hydro
Meyers, Art	Manager, Block Brothers; Board of Directors, BC Hydro
Phillips, Brian	Director, Radiation Protection Services, BC MOH
Phillips, Jerry	Senior Scientist and Director of Biochemical Research, Cancer Therapy and Research Foundation, San Antonio, Texas
Phillips, Richard	Ph.D., Physiologist, Director, Developmental and Cell-Toxicology Division, Health Effects Research Laboratory, Office of Research and Development, EPA
Prior, Vern	Senior Communications Coordinator, BC Hydro
Ross, Randy	Radiation Protection Services, BC MOH
Sastre, Antonio	Ph.D., Laboratory Scientist, ERI; BC Hydro expert witness
Savitz, David	Epidemiologist, University of North Carolina
Shannon, Elizabeth	Trustee, School District 71
Smith, Neptune	Manager, Engineering and Project Review - Electrical, BCUC
Swanson, Milt	Lawyer; Commissioner, BCUC; Inquiry Commissioner
Vance, Joan	Lawyer, BC PIAC; representing CVRC
Walsh, Karen	Courtenay resident; Treasurer, CVRC
Wertheimer, Nancy	Ph.D., Epidemiologist, University of Colorado
Winnig, Bruno and Helga	Courtenay residents
Wong, Paul	Electrical Engineer, PowerTech Labs, BC Hydro

BCUC	British Columbia Utilities Commission
ERI	Environmental Research Information, Inc.
EHD	Environmental Health Directorate
Free Press	Comox District Free Press
HPB	Health Protection Branch
HWC	Health and Welfare Canada
MWN	Microwave News
OTA	Office of Technology Assessment
PIAC	Public Interest Advocacy Centre
Record	The Courtenay Comox Valley Record
TDHSR	Transmission/Distribution Health & Safety Report

NYSPLP is an abbreviation for NYS, DOH, Biological Effects of Power Line Fields: New York State Power Lines Project Scientific Advisory Panel's Final Report, Albany, July 1, 1987.

OTA Biological Effects is an abbreviation for US, Congress, OTA, Biological Effects of Power Frequency Electric and Magnetic Fields - Background Paper, OTA-BP-E-53, Washington, DC: US Government Printing Office, May 1989.

OTA Oversight is an abbreviation for US, Congress, OTA, "Health Effects of Power Frequency Fields," in US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, Electric Power Lines: Health and Public Policy Implications: Oversight Hearing, 101st Cong., 2nd Sess., March 8, 1990.

TR is an abbreviation for BCUC, BC Hydro and Power Authority Proposed 230 kV Transmission Line Dunsmuir/Gold River: Proceedings at Inquiry, Courtenay, BC, July 11-14, 1989, Vol. 1-6 (Vancouver: Allwest Reporting Ltd., 1989).

R&R is an abbreviation for BCUC, BC Hydro and Power Authority Proposed 230 kV Transmission Line Dunsmuir/Gold River: Report and Recommendations, Vancouver, July 26, 1989.

1.0 INTRODUCTION

1. R. Hauf, "Electric and magnetic fields at power frequencies, with particular reference to 50 and 60 Hz," p. 176.
2. David E. Janes, Jr., "Background Information on High Voltages Fields," p. 141.
3. Energy Information Administration, Washington, DC, quoted in Randy Ross, "Do Power Line-Generated Electromagnetic Fields Have Any Association with Certain Disorders?," p. 1132.

2.0 PF E/MF AND HUMAN HEALTH

2.1 GENERAL CONCEPTS

1. At present, the interaction between these fields and biological systems is largely unknown (Hauf, p. 176).
2. OTA Biological Effects, p. 4; HWC, HPB, EHD, Electric and Magnetic Fields and Your Health: A Report of the Working Group on Electric and Magnetic ELF Fields, p. 2,39.

3. In Europe and Japan, electric current alternates at 50 Hz.
4. ac current can be contrasted to the DC or direct current produced by batteries. DC does not change strength and direction over time. DC current is also used to transmit and distribute electric energy but is much less common than ac. In North America, there are five DC transmission lines.
5. US, Congress, OTA, Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition, p. 228.
6. The effects may be beneficial, adverse or negligible, depending on, for e.g., frequency, wavelength, waveform and intensity. With the exception of visible and audible radiation, humans possess no organ for specific perception of such fields.
7. Although technically, ELF includes frequencies 30-300 Hz, some sources use "ELF" to refer to 0-300 Hz, 1-300 Hz, or 19-300 Hz.
8. US, BPA, DOE, Electrical and Biological Effects of Transmission Lines: A Review, June 1989, p. 12.
9. TDHSR, 6, 8 (Sept 1988):7.
10. M. Granger Morgan, Electric and Magnetic Fields from 60 Hertz Electric Power: What do we know about possible health risks?, p. 5.
11. C. Andrew L.Bassett, "Premature alarm over electromagnetic fields," p. 38.
12. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 53-4.
13. Paul Wong, "Electric and Magnetic Fields - what are they and how are they measured?," paper from BC Hydro, in cooperation with B.C. Ministry of Health, "Symposium on the Biological Effects of Electric and Magnetic Fields."
14. Edwin L. Carstensen, Biological Effects of Transmission Line Fields, p. 10.
15. OTA Biological Effects, p. 15.
16. Wong, "Electric and Magnetic Fields."
17. OTA Biological Effects, p. 16.
18. Leonard Sagan in US, Congress, House, Subcommittee on Water and Power Resources, p. 112; Dan Bracken, "Properties and Effects of A.C. and D.C. Line Fields," paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields: Research, Communication, Regulation. Ground currents arise because neutral (or grounded) wires of distribution lines are usually physically connected to earth. These ground connections provide alternate paths for distribution currents to return to local transformers or substations and leads to PF currents in water and gas plumbing (OTA Biological Effects, p. 15).
19. Unlike power line electric fields which are very nearly vertical at all times, the magnetic fields on the ground are largely confined to planes parallel to the lines where, due to the phase difference of currents flowing in the individual line conductors, the horizontal and vertical components combine to give a total magnetic field which rotates at the PF (NYSPLP, p. 39). Phase refers to the timing with which the alternating current, voltage or field is changing strength and direction.
20. Carstensen, p. 19.
21. Hauf, p. 183.
22. Morgan, Electric and Magnetic Fields, p. 13, 14.
23. Ibid., p. 14.
24. The remainder of section 2.1.2 is excerpted, unless otherwise noted, from OTA Biological Effects, p. 16-19.
25. Morgan, Electric and Magnetic Fields, p. 8.
26. Jack M. Lee, Jr., "High-voltage Transmission Lines: The Ongoing Search for Biological Effects," p. 36; A.R. Sheppard and M. Eisenbud, Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency (New York: New York Univ. Press, 1977), quoted in Rish and Morgan, p. 1417.
27. Sheppard and Eisenbud, quoted in Rish and Morgan, p. 1417.
28. The "let-go" threshold is the current above which a person loses voluntary muscle control and cannot "let go" of a gripped contact (OTA Biological Effects, p. 19). There is some concern that even 5 mA is too high because it is greater then the "let-go" threshold for

some children and can result in a very unpleasant shock.

29. H. Keith Florig, "Management options for power-frequency fields."
30. NYS, DOH, "New York State Power Lines Project: Questions and Answers."
31. Bracken, paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields.
32. This section is excerpted, unless otherwise noted, from OTA Biological Effects, p. 19-21.
33. Morgan, Electric and Magnetic Fields, p. 22.
34. OTA Biological Effects, p. 76. With a chemical, dose is typically defined as the amount of chemical that enters into the body or, if the body is able to metabolize or get rid of the chemical, the rate at which the chemical enters the body.
35. Frequency windows are also associated with muscle contraction. Frequencies less than 20 Hz or greater than 200 Hz require a larger level of current to cause tetany than the "optimum frequencies" of 50/60 Hz (Feero).
36. Taylor Moore, "Pursuing the science of EMF, p. 9.
37. Karen Fitzgerald, M. Granger Morgan and Indira Nair. "Special report - electromagnetic fields: the jury's still out," p. 31-2.
38. Moore, "Pursuing the science of EMF, p. 6.
39. Michael Shepard, "EMF and Human Health," p. 4.
40. Hauf, p. 183-184.
41. Moore, "Pursuing the science of EMF, p. 6.
42. Carstensen, p. 48-49.
43. Sheppard, "Studies of Cells and Tissues Exposed to (ELF) Fields."
44. US, Congress, OTA, Electric Power, p. 233.
45. US, BPA, DOE, Electrical and Biological Effects, Oct 1985, p. 24.
46. Andrew A. Marino, "Are Power Lines Dangerous to Health? Probably So," p. 18.
47. NYSPLP, p. 52.
48. J.G. Wilson, "Review of in vitro systems with potential for use in teratogencity screening," J. Environmental Pathology & Toxicology 2 (1978): 149-167, quoted in NYSPLP, p. 62.
49. Larry Anderson, "Studies of Laboratory Animals Exposed to ELF Fields," paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields.
50. Carstensen, p. 56.
51. M. Granger Morgan, H. Keith Florig, Indira Nair, and Gordon. L. Hester, "Controlling Exposure to Transmission Line Electromagnetic Fields," p. 84-85.
52. R. Kavet, "Biological Effects of Electric Fields: EPRI's Role," p. 2118; M.J. Free, W.T. Kaune, R.D. Phillips, and H.C. Cheng, "Endocrinological Effects of Strong 60-Hz Electric Fields on Rats," Bioelectromagnetics 2, 2 (1981): 105-122, quoted in US, BPA, DOE, Electrical and Biological Effects, Oct 1985, p. 25.
53. R. Sander, J. Brinkmann, and B. Kuhne, "Laboratory Studies on Animals and Human Beings Exposed to 50-Hz Electric and Magnetic Fields," CIGRE, 1982 Session, 1-9 Sept, 36-01, quoted in Anderson, paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields; Kaune et al., 1978, quoted in Ibid.; H.B. Graves, P.D. Long and D. Poznaniak, "Biological Effects of 60 Hz Alternating Current Fields: A Cheshire Cat Phenomenon, in R.D. Phillips et al, Biological Effects of Extremely Low Frequency Electromagnetic Fields, CONF-78 10 16, (Springfield, Virginia: NTIS 1979), p. 184-197, quoted in Ibid.; Stern, 1983, quoted in Anderson, paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields; US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 28.
54. Moore, "Pursuing the science of EMF, p. 9.
55. US, BPA, DOE, Electrical and Biological Effects, Oct 1985, p. 32.
56. Morgan, Electric and Magnetic Fields, p. 10.
57. Carstensen, p. 47.
58. TDHSR, 2, 10 (Oct 1984):2.
59. TDHSR, 1, 4 (Apr 1983):2-3.
60. Liora Salter, Mandated Science: Science and Scientists in the Making of Standards, p. 30-31.
61. TDHSR, 1, 4 (Apr 1983):3.
62. NYSPLP, p. 73. In particular, if the exposure measure is imprecise, the strength of

association is weakened.

63.A statistically significant finding is one that, according to certain assumptions and based on a mathematical probability, has a low likelihood of being due to random sampling variation .

64. Carstensen, p. 47.

65. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 3; OTA Biological Effects, p. 102. Epidemiology may measure effects on an absolute level (in terms of incidence rate, cumulative incidence, or prevalence) or a relative scale. Strictly speaking, attributable risk should only be calculated only if the causation has been established.

66 Fitzgerald, Morgan and Nair, p. 23.

67. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 39; OTA Biological Effects, p. 102.

68. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 39; TDHSR, 1, 4 (Apr 1983):3-4.

69. Salter, p. 30-31.

70. Carstensen, p. 47.

71. OTA Biological Effects, p. 100.

72. Salter, p. 30-31.

73. OTA Biological Effects, p. 66.

74. A.B. Hill, "The environment and disease: Association or causation?",p. 295-300. All epidemiological studies involve some level of statistical uncertainty, represented as "confidence intervals," a range of values from the lower to upper confidence limits. A 95% confidence interval or CI means that one can be 95% sure that the actual value lies within that interval. An extremely wide CI including an RR of 1.0 suggests caution in its interpretation (Morgan, Electric and Magnetic Fields, p. 17; TDHSR, 2, 5, May 1984, p. 2; Fitzgerald, Morgan and Nair, p. 24).

75. TDHSR, Jan 1985, p. 2, 11-12. Epidemiology has only begun to emerge as a sound methodology in the past three decades (OTA Biological Effects, p. 100). For example, Rothman, noting that the theoretical foundation for epidemiology lies in statistics, has suggested that some methods are not theoretically sound in biological applications although they making sense in other applications (Ibid., p. 101).

76.Philip Cole, testimony from US, Congress, House, Subcommittee on Water and Power Resources, Health Effects of Transmission Lines, p. 122-3.

77. TDHSR, 3, 1 (Jan 1985):2, 11-12.

2.2 STATE OF THE SCIENCE

1. The purpose of this section is to give the reader a general idea of the research that had been conducted to December 1988. Unless otherwise noted, the discussion is based on US, Congress, OTA, Electric Power Wheeling and Dealing:Technological Considerations for Increasing Competition. The OTA report is, in turn, based on Biological Effects of Power Frequency Electric and Magnetic Fields- Background Paper, an OTA contractor report by Indira Nair, M. Granger Morgan and H. Keith Florig, Department of Engineering and Public Policy, Carnegie Mellon University (CMU). The OTA report is cited for two reasons: the OTA is a US federal agency and the OTA report further reviews the CMU report. Although the OTA report itself was not widely available until early to mid-1989, the literature reviewed was available in one form or another to December 1988.

   Not all experts would necessarily agree on the effects reported by the studies, let alone the interpretations. (See, for example, US, BPA, DOE, Electrical and Biological Effects.) There are even some subtle differences between the OTA and CMU reports. If nothing else, the OTA report indicates the range of scientific opinion when compared to the various reports presented during the Courtenay controversy. (I deal with expert disagreement in the Courtenay controversy; to deal with expert disagreement in any detail in the wider controversy is beyond the scope of this paper.)

2. Morgan, Electric and Magnetic Fields, p. 10.
3. W.R. Adey, "Electromagnetic Fields, Cell Membrane Amplification, and Cancer Promotion," paper from the National Council on Radiation Protection and Measurements Annual Meeting, NAS, Washington, DC, 1986, quoted in US, Congress, OTA, Electric Power, p. 232.
4. Calcium flows regulate physiological processes such as muscle contraction, egg fertilization, cell division, and activate certain enzymes important during cell development and growth.
5. The cell's primary biomolecules are DNA and RNA. DNA carries the genetic code; RNA transcribes the DNA command codes into proteins for cell physiological functioning.
6. W.R. Adey, quoted in US, Congress, OTA, Electric Power, p. 233.
7. A "mutagen" is an agent that provokes an immune response.
8. The circadian timing system synchronizes the daily cycle of various physiological and biochemical processes. Although many aspects of the biology of timing systems are not well understood, considerable understanding of some system elements has occurred in the last two decades.
9. Banks, quoted in TDHSR, 6, 8 (Sept 1988):2.
10. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 41. One study found that although most workers in 230 kV and 500 kV transmission line environments were exposed to electric fields greater than 4 kV/m for "only minutes per day," accumulated exposure was roughly three orders of magnitude greater than exposures for office workers (T.D. Bracken and V. Chartier, "Occupational Exposure of High Voltage Workers to 60-Hz Electric Fields. Part 2 - Analysis and Results," paper from the Twenty-Third Hanford Life Sciences Symposium, Oct 2-4, 1984, Richland, Washington, quoted in US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 49; V.L. Chartier, T.D. Bracken, and A.S. Capon, "BPA Study of Occupational Exposure to 60-Hz Electric Fields," IEEE Transactions on Power Apparatus and Systems, PAS-104, 3 (1985): 733-744, quoted in US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 49)

    Another study reported that total cumulative exposure for farmers working near 500 kV and 765 kV transmission lines was comparable to cumulative domestic exposure. About half of domestic exposure was related to electric blanket use. Exposures from recreational activities, including jogging, bicycling, horseback riding, skiing, were, in general, lower than estimated for both agricultural and domestic exposures (M. Silva, Enertech Consultants, AC Field Exposure Study: Human Exposure to 60 Hz Electric Fields, RP79-16 (Palo Alto, CA:EPRI, 1985, quoted in US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 49-50)

    A third study found that 230 kV substation operators were exposed to an average daily magnetic field of 410 nT. In contrast, office workers were exposed to 74 nT (T.D. Bracken, Measurement of Occupational Exposure of Substation Workers to 60-Hz Magnetic Fields, Vancouver, WA:BPA, 1988, quoted in US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 50).
11. Adult brain cancer is rare (1% of all cancer incidence, 5 in 100,000 risk), peaking at about 60 years of age. Brain cancer is the second highest risk cancer for children between 0 to 8 years of age.
12. Metastasis refers to secondary growth of cancer that spreads from a primary site.
13. Even the exposure of electricians may not be significantly higher than those not in the electrical field because they often work with circuits turned off. Various types of occupations involve the construction, operation or repair of electrical equipment and devices (TDHSR, 3, 1, Jan 1985, p. 2).

2.3 GENERAL HISTORY

1. As of December 1988, no comprehensive history about the PF E/MF health effects issue had been written. A considerable amount of information was available on very specific events

and activities but there was little information on their interrelationships. For a detailed chrononlogy of events to Fall 1988 see Christina Chociolko, "The Controversy Regarding Power Frequency Electric and Magnetic Fields and Human Health: Risk and Communication," p. 37-100.

2. Kavet, "Biological Effects of Electric Fields: EPRI's Role," p. 2115.
3. OTA Biological Effects, p. 24; Morgan et al., "Controlling Exposure to Transmission Line Electromagnetic Fields," p. 82; Louis Slesin, "Power Lines and Cancer: The Evidence Grows,"p. 55, 58.
4. OTA Biological Effects, p. 1.
5. Andrew A. Marino and Robert O. Becker, "High Voltage Lines: Hazard at a Distance," p. 6-7.
6. Ibid., p. 7.
7. M. Granger Morgan, "Public Perceptions of Risk from Electric and Magnetic Fields," paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields. Popular literature was critical of the ways in which transmission lines were sited, constructed and operated (US, BPA, DOE, Electrical and Biological Effects , June 1989, p. 22). See, for e.g., L.B. Young, Power over People, New York: Oxford University Press, Inc., 1974.
8. Granger M. Morgan, H. Keith Florig, Indira Nair and David Lincoln, "Power line fields and human health," p. 62.
9. Lita Furby, Paul Slovic, Baruch Fischhoff and Robin Gregory, "Public Perceptions of Electric Power Transmission Lines," p. 22.
10. Janes, p. 141. The US electric utility industry began research as early as 1962. The American Electric Power Co. funded two small-scale studies at Johns Hopkins University investigating the general health of extra high voltage transmission line workers and the effects on mice of strong 60 Hz electric fields exposure. AEP was the first US utility to build an extra high voltage transmission line several years earlier (US, Congress, OTA, Electric and Magnetic Fields, p. 69).
11. Corona is a sometimes visible electric discharge resulting from a partial electric breakdown in a gas, as in the air surrounding a high voltage power line.
12. William Feero, "The Evolution of Electromagnetic Effects Issues," paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields, p. 2.
13. Reported effects included nausea, fatigue, headaches, irritability, insomnia, and decreased sexual drive. As a result, regulations were established for Soviet substation workers limiting exposure to fields greater than 5 kV/m (US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 22; US, Congress, OTA, Electric Power, p. 227).
14. Like the Soviet studies, Spanish studies reported changes in CNS and physiological function in workers exposed to (500 kV and) 750 kV transmission line electric fields.
15. Janes, p. 144; US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 22.
16. US, Congress, OTA, Electric Power, p. 228; US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 22.
17. A.O. Bulawka, W.G. Wisecup, L.A. Rosen and W.E. Feero, "The U.S. Department of Energy 60-Hz Electric Fields Bioeffects Research," p. 4432.
18. Kavet, p. 2115.
19. Project Sanguine was later renamed Project Seafarer, and, more recently, Project ELF (US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 30). Original plans were to locate 6,200 miles of cable and 100 transmitters in Northern Wisconsin (MWN, x, 1, Jan/Feb 1990, p. 5-6).
20. Marino and Becker, p. 7. A group of civilian experts, including Becker, reviewed the studies for the US Navy in 1973 and recommended further research.
21. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 30. Project ELF remained controversial, with the Navy commissioning another literature review on ELF bioeffects. The conclusions reported by the American Institute of Biological Sciences (AIBS) in 1985 were consistent with the earlier NRC report. Project ELF was eventually completed with a 28 mile long transmitter in Wisconsin and a 56 mile long transmitter in Michigan (MWN, x, 1, Jan/Feb 1990, p. 5-6).

22. The NYPA is the largest US non-federal public power organization, providing nearly one-third of the electricity in NYS (James M. Cunningham, testimony from US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, Electric Power Lines, p. 202).
23. By the mid-1970s, health effects had become a central issue in transmission siting hearings in several states (OTA Biological Effects, p. 1).
24. Carstensen, p. 5; William Feero, "The Evolution of Electromagnetic Effects Issues," paper from Ontario Hydro, Health Effects of Electric and Magnetic Fields, p. 2.For example, Marino and Becker reported decreased growth, increased mortality, and changes in blood composition in rodents exposed to 15 kV/m electric fields. However, they also reported that some effects may have been due to shocks received while drinking and eating (US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 22).

    In 1980, an out of court settlement with the PSC approved licensing conditional on NYPA funding a one-time program of research on PF E/MF health effects. The $5 million program (later known as the New York State Power Line Project or NYSPLP) was underway in 1982 (Feero, p. 2; Cunningham, testimony from US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, p. 205-6).
25. Carstensen, p. 46, 50-51. The investigator could be looking for the wrong endpoint under the wrong exposure conditions, or using methods that are not sensitive enough to detect subtle effects.
26. EPRI is a nonprofit research organization. Its 600 member companies together account for 2/3 of US electric power sales (Sagan, testimony from US, Congress, House, Subcommittee on Water and Power Resources, p. 111). Some Canadian utilities are also members.
27. OTA Biological Effects, p. 35; US, Congress, OTA, Electric Power, p. 234. Artifactual interference would thereby be minimized (Feero, p. 2).
28. Feero.
29. Ibid.; Bulawka et al., p. 4433; OTA Biological Effects, p. 35; US, Congress, OTA, Electric Power, p. 234.
30. Morgan, Florig, Nair and Hester, p. 89. BPA is the US federal power marketing agency. As required by the NEP Act, BPA has prepared literature reviews on transmission line health effects. The first, published in 1975, found that few biological studies were directly related to transmission line E/MF and only a handful of literature reviews had been published(US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 1, 22). From 1977 until 1984, BPA would operate a prototype 1200 kV transmission line . BPA now operates nearly 15,000 miles of high voltage lines to the US, Canada and elsewhere (Jack M. Lee, Jr., testimony from US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, p. 179).
31. OTA Biological Effects, p. 69.
32. Tim Aldrich, "E/MF - Epidemiologic evidence for occupational and non-occupational health impacts and cancer mortality," paper from BC Hydro, "Symposium on the Biological Effects of Electric and Magnetic Fields."
33. US, Congress, OTA, Electric Power, p. 232.
34. Since the EPA's inception, NIR has been an important element. RF was the initial focus with some modest efforts on ELF. EPA is responsible for providing advice to the US president (Richard Guimond, testimony from US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, p. 134).
35. NYSPLP, p. 86. From 1979-84, some studies also examined fertility problems, suicides, and other health effects(TDHSR, 2, 6, June 1984). The suicide study received considerable criticism from the scientific community on methodological and statistical grounds (TDHSR, 2, 4, Apr 1984, p. 4).
36. Wertheimer and Leeper found that children with high exposure levels were 2-3 times as likely to develop cancer, particularly leukemia, lymphomas, and nervous system tumors. Several potential confounders, including social class, neighborhood, could not account for the results. However, their findings were considered questionable because it was not clear

if wire code configuration corresponded to magnetic field exposure and because wire codings were not conducted blind, i.e., the surveyor knew the case and control homes(TDHSR, 2, 9, Sept 1984, p. 2).

37. They found an association between cancers of the nervous systems, uterus and breast with systematically increasing risk for higher current configurations, i.e., a dose-response relationship. The results did not appear to be due to age, urbanicity, or socioeconomic level (US, Congress, OTA, Electric Power, p. 236; TDHSR, 2, 9, Sept 1984, p. 8).
38. US, Congress, OTA, Electric Power, p. 235. Earlier studies of electrical workers examined general employee health and were generally not designed to detect possible increases in rare diseases such as leukemia (Ontario Hydro. Electric and Magnetic Fields and Human Health Research).
39. OTA Oversight, p. 182.
40. NYSPLP, p. 86. In the residential studies, exposure was classified on the basis of the characteristics of and proximity to nearby distribution and transmission lines or other electrical facilities at the birth, death and/or diagnosis address (TDHSR, 2, 9, Sept 1984, p. 2). In addition, leukemia was the only endpoint examined, sample populations were small, and there were confounders (David O. Carpenter and Anders Ahlbom, "Powerlines and cancer. Public health and policy implications," p. 97-8).

    The occupational studies appeared as letters to the editor. Letters typically do not undergo as rigorous a peer review process as published articles nor do they provide many specific details of study method and analysis. They were PMR studies; one was also case-control. No personal risk factors other than age and sex differences were considered. Personal exposure was not measured; it was assumed that "electrical workers" had excess exposure (TDHSR, 2, 10, Oct 1984, p. 2).
41. TDHSR, 3, 1 (Jan 1985):12. There had been an apparent increase in a few types cancer over the past several decades but it did not appear that the rates of most types of cancer had increased.
42. Ibid., p. 2, 12.
43. Rish and Morgan, p. 1416.
44. In 1988, the line was approved to operate at 16% of capacity, i.e.,1.56 kV/m and 160 mG at maximum load and 37 mG at the edge of a 100 foot ROW (MWN, ix, 2, Mar/Apr 1989, p. 1; MWN, viii, 4, July/Aug 1988, p. 3). Rulemaking for the state continued, with limits for transmission lines and substations proposed in 1988.
45. Michael Freeman, "The courts and electromagnetic fields," p. 21. In 1987, the Texas Court of Appeals denied the award of punitive damages but upheld the lower court's finding that there were potential health effects. HL&P was prevented from using the line pending appeal of the decision. Meanwhile, the utility rerouted the line around the school property at a cost of $8.6 million (MWN, vii, 6, Nov/Dec 1987, p. 1). In 1988, the Texas Supreme Court refused the school district's request for review of the Court of Appeals decision to overturn the punitive damages judgement against HL&P (MWN, viii, 4, July/Aug 1988, p. 10).
46. Morgan, Electric and Magnetic Fields, p. 37-8.
47. The basic problem with risk analysis was the inability to define dose. Bounding analysis attempted to set upper and lower bounds on the magnitude of effects that might exist if there were adverse health consequences (Morgan, Electric and Magnetic Fields, p. 76). CMU would also design a new study of public risk perception and conduct background work on decision-analytic problems such as "stopping rules."(TDHSR, 4, 7, Aug 1986, p. 11).

    Both the Florida DER and US OTA would later contract CMU to help deal with assessment and regulatory problems related to 60 Hz fields (Morgan, Electric and Magnetic Fields, p. 37-8).
48. OTA Oversight, p. 127-8. The DOE research program included: exposure, instrumentation and dosimetry; scaling and modeling; non-human screening studies; human studies; mechanistic studies; ecology and agriculture (BPA took the lead); and risk analysis methodologies (Robert L. San Martin, testimony from US, House, Subcomm. on General

Oversight and Investigations, Comm. of Interior and Insular Affairs, p.127-8).

49. MWN, viii, 6 (Nov/Dec 1988):16.
50. OTA Oversight, p. 191.
51. US, BPA, DOE, Electrical and Biological Effects, Oct 1985, p. 18.
52. Bulawka et al., p. 4432.
53. OTA Oversight, p. 191.
54. Morgan et al., "Controlling Exposure to Transmission Line Electromagnetic Fields."
55. "Strategies to Reduce Population Exposure to 60 Hz Electric and Magnetic Fields," Final Report of the EPP/SUPA/SDS Project Course, Fall 1984, Dept. of Engineering and Public Policy, CMU, quoted in H. Keith Florig, "Management options for power-frequency fields," p. 87.
56. M.G. Morgan et al., "A Framework for Thinking About, and Making Regulatory Decisions About, Power-Frequency Electromagnetic Fields," Tech. Report, Briefing Paper 2, prepared for the Florida DER under DER Contract SP117 (March 1987), quoted in Florig, p.88.
57. MWN, vi, 5 (Sept/Oct 1986):2.
58. OTA Biological Effects, p. 70. BPA's level of funding continued at about $200,000/year. The US Navy continued to sponsor ecological field studies in the vicinity of Project ELF; funding remained at about $2 million/year (OTA Biological Effects, p. 70).
59. Carpenter and Ahlbom, p. 96.
60. The 5-year research program, funded largely by NYS electric utilities, was administered by the NYS Department of Health (DOH) and overseen by a SAP of scientists and engineers.
61. Both wire coding and actual field measurements in homes with the lights and appliances on and off were used to characterize the residential field environment. A relation was found between wire coding and all cancers (OR=1.7) and between wire coding and leukemia (OR=2.1). A positive but lesser relation was found between wire coding and brain tumors. There was some indication of a dose-response relationship. No relation was found between lights turned on/off and all cancers. A relation was found between appliances turned on/off and all cancers, slightly lower than between wire coding and all cancers (Carpenter and Ahlbom, p. 97-8).
62. Carpenter and Ahlbom, p. 97-8. An attempt to control for several major potential confounders (for eg., socio-economic class, family cancer history, exposure to x-rays, local traffic density, use of appliances) was made. Coding was done blind. Other measures of potential field exposures were assessed - electric heat and hot water use, use of heating pads and electric blankets by children and pregnant women, and the total number of electric appliances in home. Savitz later investigated and rejected traffic density as a possible confounder (MWN, x, 1 (Jan/Feb 1990):5).
63. Slesin, "Power Lines and Cancer," p. 52.
64. Providing that the RR's reported by Savitz were correct and representative of the rest of the US, and if the number of homes with elevated magnetic fields due to distribution systems in Denver was similar to other parts of the country (Carpenter and Ahlbom, p. 99). An analysis of total childhood cancers occuring in the Denver area was also done later; they were found to share the same overall risk as elsewhere (US, Congress, OTA, Electric Power, p. 236).

    David Carpenter, director of the NYSPLP, research physician, NYS DOH, and Dean, School of Public Health, State University of New York, estimated that exposure from LF EMF such as power lines could account for 30% of all childhood cancers. Carpenter was one of the many SAP members who changed their position on PF E/MF health/magnetic field effects because of Savitz' results (Carpenter and Ahlbom, p. 100; Louis Slesin, "The danger of ignoring non-ionizing radiation," p. 22).
65. Morgan, Electric and Magnetic Fields, p. 57. The NYSPLP had looked for genetic/chromosonal changes in animals and isolated humans cells. The results were uniformly negative, suggesting that PF E/MF was unlikely to cause cancer through genetic change (Carpenter and Ahlbom, p. 98).

66. US, Congress, OTA, Electric Power, p. 236. Although the study (by Stevens) had fewer design flaws, it was criticized for having few subjects and possible misclassifications of exposure. In 1988, Wertheimer and Leeper re-evaluated Stevens' data and found evidence for cancer risk from residential exposure (TDHSR, 6, 6, June/July 1988, p. 3).
67. OTA Biological Effects, p. 36, 69-70.
68. Slesin, "Power Lines and Cancer" p. 56.
69. The Working Group was set up in response to a request from Canadian labour. Members included labour, electric utilities, academia, and federal and (some) provincial governments. The purpose was to assess the existence and scope of PF E/MF health effects to identify gaps in knowledge, to foster research to fill the gaps, and to educate the Canadian public on the state of scientific understanding (HWC, HPB, EHD, Electric and Magnetic Fields and Your Health, p. 2).
70. Ontario Hydro began a six-year $7 million program of research including occupational health, public health, and laboratory studies (Ontario Hydro, "Information: Electric and Magnetic Fields"). Both Ontario Hydro and Hydro Quebec had previously conducted some research on PF E/MF health effects. In 1984, the Quebec government required Hydro Quebec to undertake an epidemiological study, in conjunction with the Quebec Departments of Environment and Health and Social Services, on power line/human health effects as a condition of certification for a disputed transmission line. By 1985, Electricite de France had expressed interest, followed by Ontario Hydro. The Ontario Ministry of Health had conducted a literature review.
71. Carpenter and Ahlbom, p. 98. The NYSPLP had not addressed occupational exposure.
72. Ibid., p. 99.
73. Scientists whose research was sponsored by DOE or EPRI presented their research at the joint Contractor's Review. The Review was open to the public.
74. US, Congress, OTA, Electric Power, p. 228; OTA Biological Effects, p. 3. If there was a risk of human cancer, most scientists believed the risk was likely small.
75. US, Congress, OTA, Electric Power, p. 233; OTA Biological Effects, p. 1, 2.
76. Carpenter and Ahlbom, p. 98, 99; MWN, ix, 4 (July/Aug 1989):7. Ontario Hydro would co-sponsor a laboratory study on cancer promotion in rodents with HWC (Ontario Hydro, "Information: Electric and Magnetic Fields.").
77. US, Congress, OTA, Electric Power, p. 239-40; US, BPA, DOE, Electrical and Biological Effects, June 1989. Countries included the US, Sweden, West Germany, UK, Canada, Japan, Italy, France, Finland, and Norway.
78. TDHSR, 6, 6 (June/July 1988):10.
79. MWN, ix, 1 (Jan/Feb 1989):1, 14.
80. TDHSR, 7, 1 (Jan 1989):2. The program would include a study on exposure assessment, a case-control study of childhood cancer in NYS, replication of an earlier study reporting retarded learning performance in exposed rats, replication of a study on adult cancer and residential exposure, and a study on brain cancer and residential exposure.
81. David A. Savitz, Neil E. Pearce, and Charles Poole, "Methodological issues in the epidemiology of electromagnetic fields and cancer," p. 74-5. Residential exposure assessment generally relied on coding wiring configurations while occupational exposure assessment was limited to the generally uncorroborated assumption that various groups of electrical workers had elevated field exposures. A persistent criticism of Savitz' study was that the association with wire codes was greater than with measured fields. A few scientists, including Savitz, speculated that if wire codes were a surrogate measure then the surrogate would be linked even more strongly (MWN, viii, 6, Nov/Dec 1988, p. 6). In addition, if PF E/MF caused cancer, improved exposure estimation should provide evidence of a stronger association.
82. TDHSR, 6, 7 (Aug 1988):1; Savitz, Pearce, and Poole, p. 59.
83. US, BPA, DOE, Electrical and Biological Effects, June 1989, p. 4.
84. US, Congress, OTA, Electric Power, p. 227.
85. For example, in early 1987 a group of 58 (later, 135) NY landowners filed a $66.5 million

(later, over $100 million) class-action lawsuit against the NYPA claiming that the fear of health effects had had a negative impact on the value of property along a new 345 kV transmission line. (The 345 kV Marcy South transmission line connected to the 765 kV transmission line that spurred the NYSPLP.) Crowell and Moring, one of the NYPA's attorneys, claimed that landowners were not entitled to compensation because it could not be established that there was reason for fear because there were no significant effects, that fear actually existed, and that fear affected property values.

Crowell and Moring had worked with regulatory and utility counsel in PF E/MF health effects litigation throughout the US over the past 10 years. Before the NYPA case, they began a worldwide search for experts in disciplines thought key to resolving the scientific and legal issues. From over 1,000 experts, over 125 were interviewed, and 7 were selected, 3 of whom were NCI employees. In their own special data base, they have over 4,000 PF E/MF health effects-related studies and an index of litigation.

By late 1988, the NYPA had spent $1.2 million on attorney and witness fees while landowners had spent $300,000, ($65,000 on expert testimony, $100,000 on land appraisal) The decision would be made in late 1989 (MWN, viii, 2, Mar/Apr 1988, p. 6; Cunningham, testimony from US, House, Subcomm. on General Oversight and Investigations, Comm. of Interior and Insular Affairs, p. 208-9; MWN, viii, 5, Sept/Oct 1988, p. 1; TDHSR, 6, 6, June/July 1988, p. 2).

86. OTA Biological Effects, p. 73.
87. Fitzgerald, Morgan and Nair, p. 28.
88. John Weiss, "The power line controversy: Legal responses to potential electromagnetic field health hazards," p. 378-9. For example, a new California law allocated $2 million for a 2/3 year project to study medical risks that may be related to exposure produced by electrical utility facilities. The State PUC, with the assistance of the Department of Health Services, would review and summarize E/MF research and related biological theories. State utilities would fund the project through a one-time tax, to be added to the $100,000 government budget (MWN, viii, 6, Nov/Dec 1988, p. 7; MWN, viii, 5, Sept/Oct 1988, p. 7).
89. Florig, p. 87.
90. TDHSR, 7, 1 (Jan 1989).
91. TDHSR, 5, 10 (Nov/Dec 1987):10, 11-12.
92. EPRI was currently sponsoring ELF research on statistical studies of human disease patterns, measurements of actual human exposure, and laboratory studies on animals and cells (US, Congress, OTA, Electric Power, p. 239).
93. In response to these concerns, EPRI had eased restrictions on disclosure of research results and appointed a scientific advisory panel to oversee their research program.
94. A separate cancer assessment group within EPA would still conduct studies on NIR (Slesin, "The danger of ignoring non-ionizing radiation," p. 22). EPA scientists in the Office of Health and Environmental Assessment were preparing an assessment of the human cancer threat posed by "LF" (including PF E/MF) and "HF" NIR. A draft report was expected by the end of 1988 (MWN, viii, 5, Sept/Oct 1988, p. 13).
95. Slesin, "The danger of ignoring non-ionizing radiation," p. 23. Furthermore, concern had been raised about the planned NIH/NCI study because several key NCI officials had been paid witnesses in legal proceedings (including the "cancerophobia" case) on behalf of electric utilities.
96. Morgan, Electric and Magnetic Fields, p. 79.
97. See Florig.
98. Ontario Hydro, quoted in MWN, viii, 4 (July/Aug 1988):9.
99. Fitzgerald, Morgan and Nair, p. 28.
100. Savitz, Pearce and Poole, p. 29; Florig, p. 86; Carpenter and Ahlbom, p. 99.
101. M.G. Morgan et al., "Power Frequency Fields," p. 81-91.
102. Florig, p. 89. See Morgan, Electric and Magnetic Fields.
103. TDHSR, June/July 1988, p. 12.

3.0. CASE STUDY

3.1 PRE-INQUIRY EVENTS

1. Much of the information in this chapter was taken from local newspapers and inquiry transcripts. It was often unclear what frequencies were being referred to when information sources used the terms electromagnetic radiation (EMR) and electromagnetic fields (EMF). Technically, EMR refers to all electromagnetic energy, EMF refers to non-ionizing radiation, and power frequency electric and magnetic fields (PF E/MF) refers to 50 and 60 Hz E/MF. I did not attempt to clarify terminology.
2. TR, p. 546-7, 553-4. The partnership included a number of international newspaper publishers.
3. The ROW was acquired between 1947 and 1961.
4. Exhibit 14, Response to "Information Request of BCUC Re: Proposed 230 kV Transmission Line - Dunsmuir/Gold River by BC Hydro, July 4, 1989, tab 2, quoted in R&R, p. 1; Exhibit 22, CPFP - Prepared Testimony, p. 2, quoted in R&R, p. 2; TR, p. 446-7, 547.
5. R&R, p. 3.
6. R&R, p. 2; TR, p. 461, 546-551, 553.
7. TR, p. 551, 564, 625; Exhibit 22, p. 2, quoted in R&R, p. 2. A "fast track" approach infers that construction commences immediately after or before design completion.
8. TR, p. 677; Robert Pellatt, quoted in "Hydro ordered to halt transmission line job."
9. TR, p. 449-451, 794; Exhibit 14, tab 2, quoted in R&R, p. 2-3.
10. "Canadian Utility Offers to Buy Homes Next to Power Line ROW," MWN, ix, 3 (May/June 1989):1; "British Columbia Utilities Commission Gives Go-Ahead to 230-kV Line," TDHSR, 7, 6 (July 31, 1989); TR, p. 489.
11. The full width of the ROW crossed Marton's property. The house in which he, his wife and three children resided was 55 metres from the edge of the ROW. Marton was aware of the scientific debate over PF E/MF health effects.
12. TR, p. 650-1, 653. BC Hydro was not required by law to pay compensation (Zig Hathorn, telephone interview).
13. March was also chairman of BC Hydro's Biological Effects of Electromagnetic Fields Task Force. BC Hydro had been following scientific developments, evaluating public and employee exposure, and participating in utility and technical forums on the PF E/MF and human health issue for several years.
14. See Ontario, MOH, Health Effects of Extremely Low Frequency Electromagnetic Fields and US, BPA, DOE, Electrical and Biological Effects, June 1985.
15. TR, p. 654, 657-8, 641-2; John Marton, telephone interview. BC Hydro provides information on PF E/MF health effects to the public on request.
16. TR, p. 657-8.
17. John Marton, letter to L.I. Bell, Chairman, BC Hydro, March 16, 1988; TR, p. 617-8, 653-5.
18. The letter was requested by the NYS PSC and put on file for future public queries after Savitz' findings were released in 1987 as part of the NYSPLP SAP Final Report.
19. Marton, letter to L.I. Bell; TR, p. 657-8; Linda S. Erdreich and Antonio Sastre, "Prepared Evidence and Report of Linda S. Erdreich and Antonio Sastre," p.5; David A. Savitz, letter to "Persons concerned about reports of electromagnetic fields and childhood cancer," undated. Savitz also stated in the letter a safe distance from power lines could not be determined with any certainty. Ultimately, a person's response to a "possible, but unproven hazard" required an "individual judgement about risk, much as a decision regarding suspected dietary hazards, flying in airplanes, or drinking alcohol or coffee reflects differing individual judgements." If it were learned that PF E/MF did increase risk, it would be of "great concern" as a public health issue; fortunately, childhood cancer was a very rare event, with "about 1 in 10,000 children developing cancer [per year]. If the risk really were 1.5 to 2-fold greater among persons with elevated magnetic field levels, the risk would be 2.5 or 2 cancers in 10,000 children. Again, this would be "very important

but minor relative to childhood injuries or risks from known cancer hazards to adults such as cigarette smoking or asbestos exposure" (emphasis added). Savitz also stated, "The only readily changed personal exposure to magnetic fields would be through avoidance of electric blankets or heated waterbeds."

20. Marton, letter to L.I. Bell; TR, p. 660.
21. Marton, letter to L.I. Bell.
22. The BCUC is the regulatory body responsible for energy projects in BC.
23. R&R, p. 3; Richard Gathercole, personal interview. The BC PIAC, funded largely by the Law Foundation of BC, "provides [free] counsel to assist unrepresented or under-represented public interest groups in areas of practice generally not served by the private bar, the Legal Services Society or other organizations (BC PIAC, Annual Report, p. 4).
24. Robert Freeman, "Hydro gets fight over new line," p. 1. Although Jack Clifford had already signed an agreement, he wanted control of the land under the new line. His position was that if BC Hydro wanted control of the land then BC Hydro should buy the land rather than just the trees. The Ombudsman was reviewing his demand.
25. Freeman, "Hydro gets fight over new line;" TR, p. 856-7, 866. The home where Kavka, his wife Darlene and their two children resided was 100 metres from the ROW.
26. BC Hydro originally offered $1,296 for the trees after inspection by an independent timber cruiser.
27. Freeman, "Hydro gets fight over new line;" Jeff Barker, personal communication; Derek Cowan, "Owner calls it theft," p. A3.
28. Robert Freeman, "Ombudsman probes Hydro," p. 1,2.
29. R&R, p. 4.
30. TR, p. 866; Lee MacKenzie, "Hydro roasted at last session on power line," p. 1.
31. The scientists were Wertheimer, Andrew Marino, Ph.D., biophysicist and lawyer, and Jerry Phillips, senior scientist and director of biochemical research, Cancer Therapy and Research Foundation, San Antonio, Texas. Phillips was known for his research on oncology. The articles and reviews included Wertheimer and Leeper's studies on childhood cancer and adult cancer, Savitz' study, and the NYSPLP SAP Final Report.
32. TR, p. 868-873. Until early 1988, Marton had been unaware of any widespread concern in the community. He had not publicized his dispute with BC Hydro because he did not want to use his position as a psychologist to increase concern (TR, p. 660).
33. The health effects included learning disabilities, irritability, headaches, dizziness, depression, "general malaise," death of cells, and cancer.
34. Russ Paradice, "Hydro-line concerns RD: Radiation, cancer link questioned;" "Region joins call for move of Hydro line."
35. The motion was made by the mayor of Gold River.
36. Paradice, "Hydro-line concerns RD: Radiation, cancer link questioned;" "Region joins call for move of Hydro line; R&R, p. 4.
37. Sharon Carmichael, "Cancer threat not imagined says resident," p. A1, A2. Carpenter made his remarks in Carpenter and Ahlbom, "Forum for Applied Research in Public Policy." Adey made his remarks at the 1987 US congressional subcommittee hearing on health effects of transmission lines.
38. Carmichael, "Cancer threat not imagined says resident."
39. The schoolyard was 300 metres away from the ROW.
40. TR, p. 866+, 947-9, 839; Karin Wilson, "No voltage risk to school kids;" Sharon Carmichael, "Hydro reviews powerline impact," p. A1, A2.
41. "Public split on powerline," p. A5; D.H. Moore, letter.
42. Editorial, "Why take risk?"
43. Ibid.
44. "Public input denied on line: Angry resident claims." The minutes of the meeting showed that BC Hydro was a late addition to the agenda.
45. TR, p. 657-667, 880; Gathercole; "B.C. Hydro to Purchase Property of Landowners Concerned about EMF," TDHSR, 7, 5 (May 31, 1989):1-2.

46. Carmichael, "Hydro reviews powerline impact."
47. Linda Erdreich, telephone interview; Erdreich and Sastre, tab 1, p. 1; TR, p. 48; Antonio Sastre, telephone interview. ERI, organized about five years ago, has offices in Watertown, Mass. and Palo Alto, Calif., and employs about 30 scientists and other staff. Clients can purchase legal counsel, scientific counsel, and guidance on risk communication. ERI produces written reports for both informal and formal settings, makes presentations to utilities and state health officials, educates the public and regulators, and provides expert witnesses. The states of Minnesota, Vermont, Massachusetts, and Maryland have retained ERI.

    BC Hydro first approached ERI for their assistance in dealing with the PF E/MF health effects issue in November 1988 at the annual DOE-EPRI Contractors' Review. Because of BC Hydro's plans for 500 kV transmission lines and their awareness of the emerging PF E/MF health effects issue, Boatman had asked March to hire an "independent expert" to assist them. (ERI has been funded three times by EPRI but was not at the DOE-EPRI meeting as a result of doing work for EPRI.) Informal contact between BC Hydro and ERI continued sporadically until early April 1989 when contracts were formalized to retain ERI on an ad hoc basis to provide information, in terms of state-of-the-art literature and analysis, and, informally, the results of ERI's own research. BC Hydro also anticipated the possible need for expert testimony at future hearings (TR, p. 37-42, 49-51, 619-20, 822-3; Erdreich and Sastre, tab 1, p. 1).
48. Carmichael, "Hydro reviews powerline impact."
49. The average would be taken if the two appraisals were within 10%. If the difference was greater than 10%, a third appraiser, agreed to by both parties, would be selected. Property owners who changed their mind after the appraisals would be required to reimburse BC Hydro for appraisal costs.
50. "B.C. Hydro to Purchase Property of Landowners Concerned about EMF;" TR, p. 665, 876, 657+, 787-792, 513; Karin Wilson, "Resident skeptical about Hydro plans: Darlene Kavka: residents should be concerned," p. A1; R&R, p. 5; C.W.J. Boatman, letter, May 9, 1989; "Hydro will offer powerline buyout;" Karin Wilson, "Hydro offer 'unique': Residents delighted by property purchase offer to escape high volt lines."
51. Arden Elementary School was not included in the private property buyout offer.
52. TR, p. 835-835, 883; Karin Wilson, "Trustee frustrated by Hydro," p. A3.
53. Boatman wrote the letter after discussing the situation with Bell (TR, p. 633, 838, 507).
54. BC Hydro did not expect many property owners to accept the buyout offer and intended to put any properties acquired back on the market (TR, p. 665, 876, 657+, 787-792, 513).
55. TR, p. 633, 838, 507; "B.C. Hydro to Purchase Property of Landowners Concerned about EMF," p.2.
56. TR, p. 42-3, 240, 192; Robert Kabot et. al., Background report on health issues associated with exposure to power frequency electric and magnetic fields
57. Karin Wilson, "Hydro offer 'unique';" "Canadian Utility Offers to Buy Homes Next to Power Line ROW," p. 14; "New spots for Hydro."
58. The community of Bridlewood, Ontario, have been battling with Ontario Hydro since 1986 over the siting of a transmission line. Darlene Kavka had corresponded and exchanged information with the residents.
59. Zig Hathorn, presentation at Edison Electric Institute Seminar on Transmission Lines in Residential Neighborhoods: Issues in Siting and Environment Planning; "Hydro will offer powerline buyout;" "Canadian Utility Offers to Buy Homes Next to Power Line ROW," p.14; Karin Walsh, telephone interview; "B.C. Hydro to Purchase Property of Landowners concerned about EMF," p. 2.
60. "B.C. Hydro to Purchase Property of Landowners concerned about EMF," p.1-2; Wilson, "Hydro offer 'unique.'"
61. Wilson, "Resident skeptical about Hydro plans;" Wilson, "Hydro offer 'unique.'"
62. Wilson, "Resident skeptical about Hydro plans."
63. Darlene Kavka thought that eligibility would be based on any change in peak PF E/MF

values. The Free Press reported that the buyout letter actually stated this and that property owners along the ROW, whether on an easement or not, could request that BC Hydro purchase their property (TR, p. 890+; Wilson, "Hydro offer 'unique.'"). Later, the Free Press reported that all properties within 300 metres of the ROW were eligible ("Hydro deadline looms;" Pamela Allen, letter, "Buy-out deadline").

64. TR, p. 943, 436, 943, 541, 762-5, 957, 866+, 817.
65. The Upper Islander; TR, p. 844-5. The purpose of the notice was to detect any eligible property owners not sent the buyout letter.
66. TR, p. 866+; see also reference 61. The CVRC created a form letter for concerned property owners to forward to BC Hydro and to Stan Hagen, MP. The letter, available at the ABC Print Shop in Courtenay's Washington Mall, stated, "I am concerned with the dangers associated with electromagnetic radiation. If these lines cannot be rerouted safely away from populated areas, I wish to be placed on your list of potential properties to be purchased" ("Hydro deadline looms;" Allen).
67. The school expansion was scheduled for completion by September 1991 and already had provincial funding approval. A delay of more than a month or two would put the project into jeopardy. A longer delay could result in the money being reallocated. In the meantime, students would continue to use portable classrooms.
68. According to Randy Ross, Radiation Protection Service, BC MOH, the readings from two different meters, after calibration, can differ by as much as 50%. Or, if a reading is obtained that "you don't like," a reading that "you do like" can be obtained simply by shifting the position of the meter. He also said, referring to the measurements taken at Arden Elementary School, that "people don't realize that the levels are high everywhere" (Ross, personal interview).
69. Karin Wilson, "Hydro fears stall work: Arden school kids' health worries board," p. A1; "Cancer fears stall plans for school," p. A1, A2.
70. Wilson, "Hydro fears stall work."
71. Editorial, "How flexible?"
72. "25 seeking Hydro buy-out."
73. Sharon Carmichael, "Father protest forced move."
74. "Hydro facts disputed," p. A3; "Pressure on Hydro is sought."
75. Kavka had originally asked Becker if he would meet with residents but he declined, wishing to avoid any "cross-examination," and suggested that she contact Marino (Darlene Kavka, telephone interview).
76. "Hydro facts disputed;" Wilson, "Many Hydro concerns raised by letters."
77. Karin Wilson, "Many Hydro concerns raised by letters," p. A3; Kavka; Marton.
78. Biolectricity is a recently developed area of biophysics. Biophysics involves using physical methods to understand how living things work. Bioelectricity focuses on understanding the interactions of biological systems with electromagnetic energy.
79. TR, p. 307-315, 328-9, 366-70, 321-2.
80. The MEC was composed of Merville residents who, for the past four years, had met to address various environmental issues.
81. "Powerline fears spreading;" TR, p. 429, 430-31.
82. The Joiners and their children lived 180 metres from the ROW.
83. Karin Wilson, "Worried residents face big decision," p. 1,3.
84. "Canadian Utility Offers to Buy Homes Next to Power Line ROW;" R&R, p. 5.
85. Ibid., p. 14; "90% take the offer."
86. TR, p. 777-8; Neptune Smith, telephone communication, Nov 23, 1989.
87. Brian Phillips, letter to School District 71, June 6, 1989; "Hydro will test school."
88. Wilson, "No voltage risk to school kids;" "Fears keep Arden on hold;" Brian Phillips, letter to School District 71; Randy Ross, personal interview.
89. "Hydro ordered to halt transmission line job," Vancouver Sun, June 15?, 1989.
90. "Forced move angers many;" Walsh, telephone interview. Because Walsh, Kavka and another member of the CVRC were not working, they were able to devote their full time

to the CVRC's activities.

91. Karin Wilson, "Expert cautions against 'drastic' action."
92. Editorial, "New face for Hydro."
93. "Hydro ordered to halt transmission line job;" Erdreich and Sastre, tab 2, p.2; Karin Wilson, "Power line put on hold," p. A1; Carl Gustafson, telephone interview.
94. "Buy-out on hold," p. 3; R&R, p. 5.
95. Usually, inquiries were chaired by senior BCUC staff, not by the Chairman of the BCUC. In addition, it was the first time that a fellow Commissioner had been appointed to act as an advisor (John McIntyre, personal interview).
96. R&R, p. 5, 6; McIntyre; TR, p. 969-70. In contrast, at a hearing, panels consisted of a minimum of three Commissioners; their report was final.
97. Gustafson; McIntyre.
98. TR, p. 2; BCUC, "BC Hydro and Power Authority Proposed 230 kV Transmission Line Dunsmuir/Gold River," Order Number G-44-89; Wilson, "Power line put on hold."
99. "Hydro ordered to halt transmission line job;" "Hearing stalls troubled line;" Wilson, "Power line put on hold." Darlene Kavka noted that if the line E/MF was found to be hazardous, all BC reseidents near high voltage transmission lines would have the right to question the actions of BC Hydro.
100. "Buyout on hold;" Kelly Gibney, personal interview, Sept 12, 1989.
101. "Hydro ordered to halt transmission line job."
102. Keys was examining "different alternatives by changing the sub-division patterns and re-plotting the district. This idea could conceivably give residents the same amount of usable land" (Bev Hollingsworth, "Hydro lines could mean excess ozone").
103. The Free Press had reported earlier that in a 1956 legal agreement the BC Power Commission, now BC Hydro, had agreed to "compensate the grantor [landowner] for any loss or damage." However, the Power Authority Act override the contracts which each land owner had with BC Hydro over easements.
104. R&R, p. 5; Hollingsworth.
105. "Fears keep Arden on hold."
106. "Group imports line expert;" Kavka; "Residents are already sick," p. A1,A8; "Lesson in public advocacy;" Paradice, "B.C. Hydro will have to explain itself;" Walsh, telephone interview.
107. "Hydro fears backed;" TR, p. 430-1; Charlotte Ostrowski, "Line goes in over protest."
108. This requirement was modified after Boatman informed the Chairman that one of BC Hydro's contacts - the law firm of Crowell and Moring - had been following the issue for 15 yr and had spent over $300,000 gathering 5,000 volumes of information (C.W.J. Boatman, telephone interview).
109. W.J. Grant, letter to C.W.J. Boatman.
110. Russ Paradice, "B.C. Hydro will have to explain itself;" "High voltage info available;" TR, p. 1; BCUC, "BC Hydro and Power Authority Proposed 230 kV Transmission Line Dunsmuir/Gold River: Terms of Reference for Public Inquiry," 411A/16; "Hearing stalls troubled line;" Wilson, "Power line put on hold."
111. In a three-part series of articles in The New Yorker, author-journalist Paul Brodeur cited research indicating that exposure to low intc ity RF, microwave, and ELF fields could endanger health. He also suggested that utilities and the US government tried to cover-up or discredit such research.
112. Walsh, telephone interview; Kavka; TR, p. 662.
113. "Residents are already sick;" Lee MacKenzie, "Re-route advocates cite illness cases," p. 1,3; TR, p. 858+.
114. MacKenzie, "Re-route advocates cite illness cases."
115. "Lesson in public advocacy."
116. Gallagher is the principle investigator in a Canada-wide study on childhood leukemia, underway at the time of his BCUC appointment and scheduled for completion in 1994. PF E/MF is one of the factors being studied. Sponsors include Health and Welfare Canada,

EPRI, and the Canadian Electrical Association. The BC CCA is a registered society whose mandate is to treat cancer patients and conduct research. They have representatives at the Children's Hospital and within the BC Hospitals Program. Savitz, the BCUC's original choice of expert,was unavailable but he had suggested Gallagher as someone who had the expertise and was objective.

117. R&R, p. 6; Richard Gallagher, telephone interviews; "EMF-Cancer Epidemiological Studies," MWN, ix, 6, (Nov/Dec 1989):4; Smith, Nov 23, 1989. According to Gallagher, he was hired to be an "independent referee." He had not previously acted as an expert advisor before and avoided participating in assessments because they were "enormously time consuming."
118. According to McIntyre, it was "normal to appoint staff and experts" to assist in an inquiry. According to Gustafson, although it was not uncommon, neither was it usual for the BCUC to bring in "technical expertise." In most instances, the BCUC had in-house expertise, for example, BCUC staff had attended seminars on PF E/MF health effects. Smith was knowledgeable and had "read the literature." However, he had not dealt with the issue in depth. One staff member had attended several conferences and the BCUC was preparing a paper on the subject. Holding a public information session was "not unusual" but had only been practised for the past year and a half. According to Gathercole, the session was inappropriate and indicated that Gallagher's mind was already made up.
119. McIntyre; Gustafson; Smith, Nov 23, 1989; Gathercole.
120. TR, p. 44-8, 25-6; Erdreich and Sastre, tab 1, p. 1-5.
121. TR, p. 137, 29-31; Erdreich and Sastre, tab 1, p. 6-9. Sastre co-authored the report by ERI that was sent to residents with the May 7 buyout letter.
122. Earlier, Gustafson had reviewed the inquiry procedures with BCUC staff and with the "municipality."
123. Gustafson; McIntyre; Smith, Nov 23, 1989.
124. Ross.
125. Lee MacKenzie, "Illness link supported;" Charlotte Ostrowski, "Expert says dangers suppressed," p. A8; Zig Hathorn, telephone interview, Nov 17, 1989; Gibney, personal interview, Sept 12, 1989.
126. Legislature staff, "Dueck: No evidence power-line fields health hazard."
127. BC, Parliament, Legislative Assembly, Debates, p. 8446-7.
128. "City council waits for hydro decision;" "City passes on line," p. A1.
129. Editorial, "Knowledge gap suggests caution," p. A4.

WRITTEN TESTIMONY

1. TR, p. 52-3, 26, 31; Erdreich and Sastre, tab 1, p.3.
2. Erdreich and Sastre, p. 1-5.
3. Ibid., p. 5-7.
4. Ibid., p. 7-10.
5. Ibid., p. 10.
6. Ibid., p. 11-23.
7. Ibid., p. 23-34.
8. Ibid., p. 34.
9. Ibid., p. 35.
10. The style of Marino's written testimony was very different from that of Erdreich and Sastre. In particular, Marino wrote in the first person, while Erdreich and Sastre wrote in third person, typical of scientific writing.
11. Andrew Marino, "Submission to the British Columbia Utilities Commission in the Matter of the Routing of the 230-kV B.C. Hydro Dunsmuir to Gold River Transmission Line," p. 3.
12. Ibid., p. 3, 5.
13. Ibid., p. 5-6.
14. Ibid,, p. 6-8.

15. Ibid., p. 8.
16. Ibid., p. 8-9.
17. Ibid., Appendix 3.

3.2 INQUIRY EVENTS

1. TR, p. 688; R&R, p. 6.
2. R&R, p. i, ii.
3. Ross. According to McIntyre, it was not unusual for transcripts to be prepared.
4. TR, p. 235, 967, 22; R&R, p. 6; McIntyre.
5. TR, p. 3.
6. However, a few of his jokes seemed inappropriate. At times, his banter, primarily with BCUC staff or the lawyers, may have been interpreted by the public as patronizing.
7. See section 2.3, reference 45.
8. TR, p. 12-17; Chociolko, p. 84, 97.
9. TR, p. 17-18.
10. TR, p. 18-19.
11. TR, p. 20-21.
12. TR, p. 26-29, 34.
13. TR, p. 35-6.
14. TR, p. 124, 127.
15. TR, p. 31-2.
16. TR, p. 44.
17. TR, p. 53-4, 150, 152-3.
18. TR, p. 60-1, 92.
19. TR, p. 139-40, 153-4.
20. TR, p. 145-7.
21. TR, p. 65-70.
22. TR, p. 247-9.
23. TR, p. 73-4.
24. TR, p. 180-3, 186.
25. TR, p. 177-9.
26. TR, p. 207-10. Graham's unpublished data was available from his sponsor.
27. TR, p. 186.
28. See Morgan et al., "Controlling Exposure to Transmission Line Electromagnetic Fields."
29. TR, p. 282-6, 288-9.
30. TR, p. 155-6, 158, 161, 245.
31. TR, p. 256-9.
32. TR, p. 286-8.
33. TR, p. 262-9, 214-5.
34. TR, p. 251-6.
35. TR, p. 269-70.
36. TR, p. 272-3.
37. TR, p. 91.
38. TR, p. 93, 102-3.
39. TR, p. 175-6.
40. TR, p. 94-100.
41. TR, p. 108-10.
42. TR, p. 104.
43. TR, p. 105-6, 196.
44. TR, p. 106.
45. TR, p. 195-6.
46. TR, p. 196-8.
47. TR, p. 130-1, 190-3, 239-42.

48. TR, p. 62.
49. TR, p. 81.
50. TR, p. 82-4.
51. TR, p. 86, 88.
52. TR, p. 116-7.
53. TR, p. 132-4.
54. TR, p. 135-6.
55. TR, p. 148-9.
56. TR, p. 212-3.
57. TR, p. 215-220.
58. TR, p. 220-5.
59. TR, p. 225-8.
60. TR, p. 228-233.
61. According to Erdreich, a "regulator's nightmare" occurs when the science is uncertain and there are large economic costs involved (Linda Erdreich, telephone interview).
62. TR, p. 233-4, 304-6.
63. TR, p. 270-71.
64. TR, p. 276-7.
65. TR, p. 277-281.
66. TR, p. 299-304.
67. TR, p. 313-4. Marino's style of oral testimony was decidely passionate compared to that of Erdreich and Sastre.
68. TR, p. 316-320, 350, 372-378, 469-80; Kavka.
69. TR, p. 320-2, 357.
70. TR, p. 232-4.
71. TR, p. 324-5.
72. TR, p. 326-8, 188-9.
73. TR, p. 328-9.
74. TR, p. 329-31. Graves was also the Chairman of the AIBS 1985 study of Project ELF.
75. TR, p. 331-2.
76. Phillips subsequently joined the US EPA.
77. TR, p. 332-334.
78. These "expressions of support," especially for Marino, occurred throughout the inquiry. Expressions of disbelief often followed statements made by Erdreich and Sastre.
79. TR, p. 343-7.
80. TR, p. 349-51, 393-6, 396-401.
81. TR, p. 351-2.
82. TR, p. 352-4.
83. TR, p. 355-6.
84. TR, p. 356-8.
85. TR, p. 358-361.
86. TR, p. 361-5.
87. TR, p. 369-72.
88. TR, p. 379, 385.
89. TR, p. 378-9.
90. TR, p. 385-91.
91. TR, p. 391-3.
92. Sastre forgot that he had a copy of a preliminary study by Hydro Quebec assessing PF E/MF exposure of their workers. Later, he provided Dack with the information (Sastre).
93. TR, p. 293-8, 380-1.
94. TR, p. 405-6.
95. TR, p. 401-5.
96. TR, p. 408-9.
97. TR, p. 409-412. Gustafson knew of Marino and his "conspiracy theory." He was concerned,

along with the other scientists and BCUC staff, that the Chairman would be unable to go beyond Marino's "rhetoric." He had tried to "shock but not aggravate" Marino and thus provide Marino with an opportunity to restore his credibility (Gustafson). According to McIntyre, the conduct of both Marino and Gustafson was questionable (McIntyre).

98. TR, p. 412-5.
99. TR, p. 415-7.
100. TR, p. 418-422.
101. TR, p. 422-4.
102. TR, p. 424-6.
103. TR, p. 426-7. Sastre and Erdreich were impressed with McIntyre's ability to "channel" Marino (Sastre; Erdreich).
104. TR, p. 651.
105. TR, p. 651-658, 661.
106. TR, p. 668-670.
107. TR, p. 671-3.
108. TR, p. 673-4.
109. TR, p. 855-6, 870-3.
110. TR, p. 858-866.
111. TR, p. 873.
112. Louis Slesin is also publisher of MWN.
113. TR, p. 896-905.
114. TR, p. 906-7.
115. TR, p. 907-8.
116. TR, p. 909-10.
117. TR, p. 911-925.
118. TR, p. 925-7.
119. TR, p. 429-436.
120. TR, p. 951-954.
121. TR, p. 533-43.
122. TR, p. 853-4.
123. TR, p. 851.
124. TR, p. 429-?, 700-2.
125. TR, p. 662-3, 704, 706.
126. TR, p. 716-7.
127. TR, p. 613-4.
128. TR, p. 621-2.
129. TR, p. 546-551.
130. TR, p. 606; Exhibit 36, BC Hydro inter-office memo, regarding cost of 230 kV underground cable, July 14, 1989, quoted in R&R, p. 28.
131. TR, p. 462-3; Exhibit 14, quoted in R&R, p. 28; Exhibit 15, BC Hydro - Route Plan - New Alternatives, 230 kV line, Dunsmuir/Gold River, quoted in R&R, p. 28.
132. R&R, p.35. BC Hydro would later identify the furthest owner dwelling to receive the offer as being 245 m from the ROW.
133. TR, p. 802-11.
134. TR, p. 779-802, 736.
135. TR, p. 853, 933, 938, 737, 944, 536-7.
136. TR, p. 937, 732, 737-8, 734, 944, 729-30, 704, 740, 902, 937, 757-8.
137. TR, p. 960, 943, 944.
138. TR, p. 758-9, 796-7, 700.
139. Brian Morton, "Power line study scientist testifies expertise recent," p. C8; Brian Morton, "B.C. Hydro data rigged, American claims," p. A16.
140. Morton, "B.C. Hydro data rigged, American claims;" C.W.J .Boatman, letter, "American's charge without foundation," p. A10.
141. Robertson's house was 70 metres away from the ROW.

142. Afternoon Show, CBC Vancouver Radio; Brian Morrow, "Migraines disappeared away from power line, man says," p. A11.
143. Bruce MacInnis, "Inquiry may set precedent," p. A1, A3; Brian Morton, "'Huge' implications seen if Hydro line moved," p. A2; Lee MacKenzie, "Hydro roasted at last session on power line," p. 1.

3.3 POST-INQUIRY EVENTS

Pre-BCUC Ruling

1. MacInnis, "Inquiry may set precedent," p. A1, A3; Morton, "'Huge' implications seen if Hydro line moved," p. A2; MacKenzie, "Hydro roasted at last session on power line," p. 1.
2. Editorial, "Caution logical."
3. Bruce MacInnis, "Powerline reroute draws support," p. A5.
4. See reference 1.
5. Lee MacKenzie, "Kavka land disputed," p. 1,2; Phil Needham, "Power line protest called bid for money," p. A6.
6. Lee MacKenzie, "'False market' created over line."
7. Stuchly was also Chair of HWC's Working Group on 60 Hz Electric and Magnetic Fields.
8. Anne Mullens, "Power Struggle: Studies aim to learn if electricity harmful," p. B2.
9. Preliminary results of Savitz's study were announced at the 1986 DOE-EPRI Contractors' Review.
10. TDHSR, 7, 5 (May 31, 1989):7; "Around the US and Canada...", MWN, ix, 4 (July/Aug 1989):9. The ERCB concluded that, based on the available research, there was "no evidence of health effects" from the proposed 240-kV transmission line that would "justify denial of the application" nor should the "question of health effects" influence a decision concerning appropriate routing of the line. In this case, the route preferred by both TransAlta Utilities and the citizens was away from residential areas. Bailey, ERI, testified on behalf of TransAlta.
11. Lee MacKenzie, "Residents' stand 'historic.'"

BCUC Report and Recommendations

1. BCUC, "BC Hydro and Power Authority Proposed 230 kV Transmission Line Dunsmuir/Gold River," Order Number G-44-89. According to McIntyre, the other 2 BCUC commissioners had many questions regarding his findings because they did not understand the issue (Mcintyre). The terms EMF, E/MF and EMR were not defined in the Report.
2. R&R, p. 7-8.
3. Ibid., p. 8-9.
4. Ibid., p. 9-20.
5. The summation of oral testimony was 11 pages long, compared to the 600-odd pages of the 970-page transcript related to PF E/MF health effects.
6. R&R, p. 21-2.
7. Marino was referring to industry-associated research.
8. The CEA was founded to "provide a forum for the exchange of technical information and to represent the interests of electric utilities" and their customers. Its mandate includes cooperative marketing programs aimed at enhancing energy efficiency and safety, promotion of electric standards, consumer education, and a substantial research and development program. Volunteer membership includes 46 utilities and 110 supplier companies. CEA is mainly funded by electric utilities and the Canadian government (CEA, Electric and Magnetic Fields).
9. R&R, p. 22-25.
10. Ibid., p. 26-29.
11. Ibid., p. 29-30.

12. In addition to the inquiry exhibits, a large amount of material for review was gathered, in particular from BC Hydro, by the BCUC. However, a list of materials reviewed was not generated. According to McIntyre, he spent the four weeks prior to the inquiry reading materials which included the "slightly biased" New Yorker articles by Brodeur, the Alberta ERCB ruling (see section 3.3, Pre-BCUC Ruling, reference 10), the NYSPLP SAP Final Report, and a report by the Ontario Energy Board. He was also aware of a number of US proceedings. McIntyre only looked at the ERCB ruling in any detail (McIntyre; Smith, telephone communication, Aug 16, 1991).
13. McIntyre was referring to Biological Effects of Power Frequency Electric and Magnetic Fields, a background paper prepared by Nair, Morgan and Florig, Dept. of Engineering and Public Policy, CMU, as part of OTA's assessment of Electric Power Wheeling and Dealing: Technical Considerations for Increasing Competition. The background paper (not reviewed or approved by OTA) discusses the present state of knowledge on PF E/MF, describes current US funding levels and research programs, and provides information on regulatory activity, including existing and proposed field exposure standards. The OTA report focuses on the technical and public policy aspects of proposals to expand access to US transmission systems and to increasing competition in power generation. CMU was contracted by OTA to review the health effects of high voltage transmission lines at the request of the subcommittee on water and power resources of the Committee on Interior and Insular Affairs (OTA Biological Effects, p. iii).
14. R&R, p. 31-2.
15. Ibid., p. 32-3.
16. According to McIntyre, the buyout offer was the same as setting a standard that was so high, it was meaningless. He cited the recently passed Florida E/MF rule as an example (McIntyre).
17. Ibid., p. 33-37.
18. According to Boatman, it is not possible to follow this recommendation. BC Hydro could not charge buyout costs back into its rate structure because it was not investor owned.
19. R&R, p. 36, 38.
20. Gibney, telephone communication, Sept 12, 1989. Formerly Industrial Hygiene supervisor, Gibney was appointed in mid-June 1989. He maintained a low profile for the duration of the Courtenay controversy.
21. Ibid., p. 38-9.
22. Ibid., p. 39; Jeff Barker, personal communication. According to Barker, BC Hydro upper management was expecting the CPCN order for 138 kv lines for other reasons.
23. R&R, p. 40. The BCUC absorbed the cost of the inquiry (McIntyre).

Post-BCUC Ruling Events

1. "British Columbia Utilities Commission Gives Go-Ahead to 230-kV Line," TDHSR, 7, 5 (July 31, 1989):1-3.
2. Brian Morton, "Island hydro powerline route approved."
3. The Cliffords had lived on the property for 38 years (Charlotte Ostrowski, "Order stops dissent").
4. Fabian Dawson, "Power route worries citizens."
5. Ibid.
6. Brian Morton, "Courtenay area residents block hydroelectric line job," p. B1; "Power line fighters drop blockade but stay on guard," p. B1.
7. Lee MacKenzie, "Group to blockade line," p. 1,3.
8. "Hydro battle hasn't ended."
9. Walsh attributed the failure of their bid to Gathercole's (and their own) inexperience (Walsh).
10. MacKenzie, "Group to blockade line."
11. Ibid.

12. Editorial, "Prove it's safe before building."
13. Editorial, "No surprise."
14. "Mixed reactions to hydro line decision."
15. Lee MacKenzie, "Blockade threats cool off."
16. Derek Cowan, "Hydro considering powerline options."
17. Editorial, "That's the law."
18. Ernie Yacub, letter, "Old boys' club."
19. "Hydro looks for legal weapon;" "Order clears way for Hydro," p. A1.
20. Marton, J.P., letter, "Nobody knows for certain."
21. "Hydro granted injunction;" Lee MacKenzie, "Hydro gets court's OK," p. 1,2; "Order clears way for Hydro," p. A1.
22. Olivia Scott, "Homeowners 'helpless,'" p. 3.
23. Ostrowski, "Order stops dissent.
24. Lee MacKenzie, "Hydro gets court's OK," p. 1,2.
25. Ostrowski, "Order stops dissent."
26. "Courtenay man to continue to fight Hydro;" "Order clears way for Hydro," p. A1.
27. See reference 24.
28. See reference 1.
29. Alistair Waters, "Hydro pledges quick end to line."
30. Poles had been raised on the ROW over the weekend. No pole had been required on the Kavkas' property.
31. Russ Paradice, "Protestor awaits arrest;" Charlotte Ostrowski, "Modest martyr battles Hydro;" Jean Kavanagh, "Mom set for jail to stop Hydro from installing line near home," p. B1.
32. Kavanagh; Scott Simpson, "Mother continues power line campout," p. A1, B1; Ostrowski, "Modest martyr battles Hydro."
33. Charlotte Ostrowski, "Powerline holdout arrested;" Russ Paradice, "Protestor awaits arrest;" "Powerline protest resumes;" Simpson, "Mother continues power line campout."
34. The Supreme Court was barred by statute from dealing with the EMF health effects issue because it had already been decided by the BCUC, which by provincial law was binding on the trial courts and could only be appealed to the BC Court of Appeal.
35. Ostrowski, "Powerline holdout arrested;" Olivia Scott and Marc Edge, "She won't quit fight."
36. Paradice, "Protester awaits arrest;" Scott and Edge; Scott Simpson, "Mother continues power line campout," p. A1, B1; Russ Paradice, "Protester arrested," p. 1, 2.
37. Ostrowski, "Modest martyr battles Hydro."
38. See reference 36.
39. Paradice, "Protester arrested;" Scott Simpson, "Courtenay power line protester removed; Hydro hopes to proceed," p. B5; Olivia Scott, "Protestor loses fight;" Ostrowski, "Powerline holdout arrested."
40. Simpson, "Courtenay power line protester removed;" Scott, "Protestor loses fight;" Paradice, "Protestor arrested."
41. Editorial, "Is the balance out of whack?"
42. Scott, "Protestor loses fight."
43. At the inquiry, BC Hydro did not raise the possibility that its dispute with the Kavkas was solely over compensation for timber and damages because it would have been seen as "big, bad Hydro" (Gibney).
44. According to Barker, by the end of the inquiry, the Kavkas had wanted $40,000 plus for their property.
45. Needham, "Power line protest called bid for money;" "For the record;" "Judge slaps blockader."
46. "Judge slaps blockader;" "For the record."
47. "Judge slaps blockader."
48. Editorial, "Protests passe."

49. Robinson, A.W., letter, "Hydro privilege."
50. Len Morrow, "What was the Hydro protest about?"
51. Thate testified at the inquiry.
52. "Bunnies born defected, powerline suspected;" Bob Hendrickson, "Bunnies bugged."
53. B. Lavigne, letter, "Confused by protest 'saga.'"
54. Katherine Capes, letter, "Explain, please."
55. "Line now hot"; Barker, telephone communication.
56. Her property was 310 metres from the line.
57. Lee MacKenzie, "15 accept Hydro buy-out terms."
58. Charlotte Ostrowski, "Hydro buyout faulted."
59. Their property was 215 metres away from the line.
60. Ostrowski, "Hydro buyout faulted."
61. Karen Walsh, letter, "Hydro battlers thanked."
62. "BC Hydro buy-out begins," MWN, ix, 5 (Sept/Oct 1989):3; Gibney, personal interview, Sept 12, 1989; Barker, personal communication; "Power Line Talk," MWN, ix, 6 (Nov/Dec 1989):3; Hathorn, telephone interview.
63. Barker, Nov 21, 1989; "Power Line Talk," MWN, ix, 6 (Nov/Dec 1989):3; Hathorn, telephone interview.

4.0 DISCUSSION

1. William Leiss, "The Management of Innovation," p. 1-2, 9.
2 William Leiss and Daniel Krewski, "Risk Communication: Theory and Practice," p. 92, 93. The term "risk assessment" has been used by others to refer to hazard identification and risk estimation.
3. US National Science Foundation, in Leiss, p. 10-11.
4. D. Krewski and P.L. Birkwood, "Regulatory and nonregulatory options for risk management," in L.R.G. Martin and G.J. Lafond, Risk Assessment and Management: Emergency Planning Perspectives, (Waterloo: University of Waterloo Press, 1988), quoted in Leiss and Krewski, p. 93.
5. Leiss, p. 7.
6. Ibid., p. 26.
7. V. Covello, D. von Winterfeldt, and P. Slovic, "Risk communication: A review of the literature."
8. Leiss and Krewski, p. 90.
9. Leiss, p. 26. Covello identifies four obstacles in communicating about risk: limitations in scientific data about risks; limitations of government, industry officials and other sources of information in communicating information about risks; limitations of the media in reporting information about risks; and limitations of the human mind in assimilating and understanding information about risk (V.T. Covello, "Informing People About Risks From Chemicals, Radiation, and Other Toxic Substances: A Review of Obstacles to Public Understanding and Effective Risk Communication," p. 2).
10. Leiss, p. 13.
11. Frank Press, "Science and Risk Communication," in Clarence J. Davies et al., Risk Communication, p. 12.
12. Leiss, p. 13.
13. For a list of other characteristics, see, for e.g., Covello, p. 5-8.
14. Morgan, Slovic, Nair, Geisler, et.al., p. 142. Research has shown that presenting information on possible PF E/MF health effects results in a somewhat heightened perception of risk and increased concern. Research has also associated lack of control with high risk perception and low acceptance of risk. Furby et al. suggests that the increase in concern would be greater if information was presented within the context of a process not perceived as democratic and genuinely supportive of public participation. Therefore, information presented within the context of a more participative process would not lead

to increased concern and might even result in a decrease (Furby et.al., p. 39-40).

15. Furby, p. 21.
16. Leiss, p. 11. See Baruch Fischhoff in NRC, Improving Risk Communication, Appendix C, p. 211-81, for a discussion of why laypeople and experts disagree about risk. See NRC, Improving Risk Communication, for a discussion of expert judgement.
17. Leiss, p. 8.
18. NRC, Improving Risk Communication, p. 28, 30-1. However, expert dissent is useful, giving non-experts, including government officials, an important tool to check against omissions or excesses in any one expert's analysis.
19. Leiss and Krewski, p. 100, 107. Leiss and Krewski note that recognition of the importance of effective risk communication in risk assessment is increasing. Current limitations of risk assessment are due in part to inherent difficulties in communicating the research findings of experts to a lay audience because the findings are based on theoretical constructs requiring assumptions, probability, ranges of uncertainties, and subjective judgements. Limitations in public understanding occur because people's perceptions of risk are often inaccurate, risk information by its very nature often frightens the public, strongly-held beliefs are hard to modify, and views are easily influenced by the way in which information is presented.
20. Garland E. Allen, "The role of experts in scientific controversy," in H. Tristam Engelhardt, Jr. & Arthur L. Caplan, eds., Scientific Controversies: Case Studies in the Resolution and Closure of Disputes in Science and Technology, p. 169-70.
21. Dorothy Nelkin, "Controversies and the Authority of Science," in Engelhardt and Caplan, p. 283-293.
22. Salter, p. 5-6.
23. Ibid., p. 194-5.
24. Mazur, "Scientific Disputes over Policy," p. 273.
25. In June 1989, a Florida judge, in response to a court action initiated by concerned parents, ordered a school board to prevent the children from playing in a portion of the playground because of the presence of power lines. The judge discounted some evidence presented by school board witnesses due to their ties to the power industry (MWN, ix, 4, Jul/Aug 1989, p. 6, 7; TDHSR, 7, 5, July 31, 1989). Also in 1989, the California State Department of Education adopted a school siting policy setting limits for how close a new school could be to power lines (Weiss, p. 378-9).
26. Of particular note is the emerging view among some scientists that the assumption of "more is worse" may not be appropriate in the case of PF E/MF exposure. See, for e.g., OTA Biological Effects and US, OTA, Electric Power.
27. Salter, p. 5.
28. Ibid., p .198.
29. Leiss, p. 26.
30. Salter, p. 3-5, 8. For eg., a large proportion of HWC's budget is allocated to AIDS research.
31. Mandated science is also referred to by others as "regulatory science" or "mission-oriented science."
32. Salter, p. 1-4. Even science produced in more conventional settings can be altered by its use.
33. Ibid., p. 3-4, 9. This is not to imply that conventional science is a neutral process.
34. Ibid., p. 5-6.
35. Ibid., p. .6.
36. Ibid., p. 6-7.
37. Ibid., p. 7.
38. Even within science, the term "scientific uncertainty" has more than one meaning. Salter distinguished between four types: legitimate scientific uncertainty (with further resources, resolution is possible), practical indeterminism (resource constraints make resolution unlikely), methodological uncertainty (inherent limitations in scientific techniques, for eg., epidemiology, make resolution impossible), and uncertainty due to the tendency of scientific work to result in ever more complex and ambiguous conclusions

(Salter, p. 199-200).

39. Salter, p. 8.
40. Ibid., p. 8-9.
41. Ibid., p. 188-9.
42. Ibid., p. 204-5, 190.
43. Ibid., p. 197, 193.
44. Ibid., p. 189, 195.
45. Ibid., p. 188.
46. Risk assessment is typically portrayed as consisting of two sequential and separate stages. The first stage involves exclusively scientific issues; the second involves exclusively non-scientific, or policy, issues. Such a separation is useful for purposes of analysis but, in practice, does not and cannot occur.
47. Salter, p. 175, 208-9, 7, 196.
48. Ibid., p. 1-5, 209.
49. BC Hydro did not initiate any contacts with the media (Lorne March, telephone interview, Jan 15, 1990).
50. Erdreich and Sastre had little, if any, interaction with the public outside of the formal inquiry (Sastre).
51. BC Hydro did not further direct inquires to BC MOH. Rather, BC MOH directed inquiries to BC Hydro (March, telephone interview, Jan 15, 1990).
52. However, one staff expert held a rather narrow view on possible PF E/MF health effects (Ross).
53. See reference 26.
54. Salter, p. 175. Video depositions, becoming quite common in the US with the small group of scientists and engineers who testify "regularly" on the PF E/MF health effects circuit, are limited for this same reason ("Florida Judge Restricts School Playground Use Based on EMF Concerns," TDHSR, 7, 6, July 31, 1989, p. 14-15).
55. Of course, even if the health effects were fully understood, reaching agreement on an appropriate societal level of control would be difficult since individual values, for e.g., about fairness, differ (Rish and Morgan, p. 1417). Value differences concerning such issues as large or small scale organization and the priority given to economic growth as a goal may never be resolved (Robert C. Mitchell, "Nuclear and Other Energy Sources," in Clarence J. Davies et al., Risk Communication, p. 78).

    See also NRC, Improving Risk Communication, for a general discussion on how to improve risk communication, including a discussion of expert disagreement. See Morgan, Electric and Magnetic Fields, and OTA Biological Effects (also by Morgan et al.) for examples of improved approaches to communicating about PF E/MF health effects. (There is still room for further improvement.) Electric and Magnetic Fields was the first publication intended for public consumption that attempted to explain the expert disagreement over PF E/MF health effects. Note that, in the brochure, Morgan explicitly states his and his colleagues role in the controversy, including sources of funding for their research.
56. BC Hydro's 1989 annual report called for 975 km of high voltage transmission lines at an estimated cost of $600 million (Boatman, telephone interview).
57. "Power line talk," MWN, ix, 6 (Nov/Dec 1989):3.
58. V.T. Covello, in Leiss, Prospects and Problems, p. 12.
59. See R&R for several good recommendations about the management of PF E/MF health effects research.
60. "Ongoing residential and occupational epidemiological studies of EMFs and cancer," MWN, ix, 6 (Nov/Dec 1989):5.
61. TDHSR, 6, 8, (Sept 1988):11, 13.
62. "1988 contractors' Review Technical Summary (Part 8)," TDHSR, 7, 7 (Aug 31, 1989):12-13.
63. OTA Oversight, p. 128.
64. OTA Biological Effects, p. 81; HWC, HPB, EHD, Electric and Magnetic Fields and Your

Health, p. 12; MWN, x, 4 (July/Aug 1990):2. The Bush administration had asked Congress to cut DOE appropriations for EMF health effects research by 26%.

65. Erdreich and Sastre, p. 17-18. Telephone lines are traditionally strung along power lines.
66. "Telephone Linemen Study Boosts Cancer Promotion Hypothesis," MWN, ix, 6 (Nov/Dec 1989):1, 8.
67. "Savitz Links Brain Cancer to Electrical Occupations," MWN, ix, 6 (Nov/Dec 1989):6.
68. MWN, ix, 3 (May/June 1989):5.
69. "Power line talk," MWN, ix, 6 (Nov/Dec 1989):3; MWN, x, 4 (July/Aug 1990):2.
70. At least if distribution lines are a more significant source, any risks would be more equally distributed among society. Morgan predicts that pressure to control house wiring and appliances will likely be slower to build (Morgan et al., "Power-line fields and human health").
71. The problem is more one of how to manage uncertainty rather than how to manage risk. Should the decision be based on sound science or ordinary prudence? "How much proof is needed?" is therefore a central dispute (NRC, p. 71).
72. Research management issues, in particular, those affecting the credibility of research, are not discussed here because sound recommendations have been made elsewhere and are in a few cases being incorporated into new research projects. In addition to the BCUC Report and Recommendations, p. 38-9, see, for e.g., OTA Biological Effects, p. 81. Of course, credibility of past research remains a problem.
73. TDHSR, 6, 8 (Sept 1988):1.
74. NRC, p. 156.
75. Sheila Jasanoff, Risk Management and Political Culture, p. 70-77.
76. Mazur, "Scientific Disputes over Policy," p. 265.
77. K.S. Shrader-Frechette, Science Policy, Ethics and Economic Methodology, chapter 9.
78. Mazur, "Scientific Disputes over Policy," p. 265.
79. Nelkin, p. 283-293.
80. Mazur, The Dynamics of Technical Controversy, p. 37-42.
81. Andrew A. Marino, editorial, "We need a science court," p. vii-viii.
82. Shrader-Frechette.
83. Jasanoff, p. 62.
84. Nelkin, p. 283-93.
85. As already discussed, some work on re-evaluating the assumptions and adequacy of methodologies for studying PF E/MF health effects is underway. Furthermore, Salter suggests that epidemiological research should be given higher priority in the evaluation of risk "for intuitive reasons, and because of the particular type of information it provides about the human consequences." This would mean designing risk assessment procedures "attuned to the methodological constraints of epidemiological research" (Salter, p. 207).
86. Salter, p. 208.

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MWN	Microwave News
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