STATE OF CALIFORNIA

STATE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION

In the matter of: Notice of Intention of San Diego Gas & Electric Company to File an Application for Certification of the Sundesert Nuclear Plant together with Transmission Lines and Necessary Appurtenances DOCKET NO. 76-NOI-2 Written Testimony of:

Andrew A. Marino

Subject of Testimony:

Biological Effects of Extremely Low Frequency Electric and Magnetic Fields

The staff of the State Energy Resources Conservation and Development Commission hereby offers the attached testimony in the above entitled matter.

June 17, 1977

Respectfully Submitted by:

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MARK URBAN STAFF COUNSEL

		TNDFY							
1	INDEA								
2	1.	1. PRELIMINARY MATTERS							
3		PERSONAL BACKGROUND AND DESCRIPTION OF QUALIFICATIONS • • • •	4						
4		PURPOSE OF THIS TESTIMONY	2						
5	2.	EXPERIMENTAL STUDIES OF THE BIOLOGICAL EFFECTS CAUSED BY							
6		ELECTRIC AND MAGNETIC FIELDS SIMILAR TO THOSE ASSOCIATED							
7	÷	WITH THE PROPOSED SUNDESERT 500 KV TRANSMISSION LINES							
8	1	INTRODUCTION	6						
9		ELECTRIC FIELD EFFECTS							
10		A. <u>Acute Exposure</u>	7						
11		B. Chronic Exposure	10						
12		MAGNETIC FIELD EFFECTS							
13		A. Acute Exposure	18						
14		B. Chronic Exposure	20						
15		COMBINED FIELD EFFECTS AND SPECIAL TOPICS							
16		A. Epidemiological Investigations	23						
17	÷.	(a) Soviet Studies	23						
18		(b) Other Studies	25						
19	N .	B. Bird Orientation	26						
20		C. <u>Plants</u>	26						
21		CONCLUSION	27						
22	3.	THE BIOLOGICAL SAFETY FACTOR OF 100 AND ITS APPLICATION TO THE							
23		LITERATURE DESCRIBING BIOLOGICAL EFFECTS DUE TO ELF FIELDS							
24		INTRODUCTION	30						
25		BASTS FOR SAFETY FACTOR OF 100	31						
20		BIOLOGICAL AND ENGINEERING SAFETY FACTORS DISTINGUISHED	33						
26		APPLICATION OF SAFETY FACTOR OF 100	33						
27		AT BIOATION OF DATBIT THOTOLOGY CE -COUL OF COUL OF COUL							

1.

URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72)

1	4.	RULES IN THE SOVIET UNION GOVERNING MAXIMUM PERMISSIBLE EXPOSURE							
2		TO POWER FREQUENCY ELECTRIC FIELDS							
3		SOVIET RULES	5						
. 4		BASIS OF THE SOVIET RULES	5						
5		CONCLUSION	7						
6	5.	SYNERGISTIC EFFECTS							
7		ANALYSIS							
8		CONCLUSION	1						
9	6.	6. TRANSMISSION LINE RADIATION							
10		THE PHYSICAL PHENOMENON							
11		THE POSSIBLE BIOLOGICAL CONSEQUENCES							
12		CONCLUSION							
13	7.	7. ARGUMENTS PURPORTING TO SHOW THAT THERE WILL BE NO HARMFUL							
14	*	BIOLOGICAL EFFECTS IN SUBJECTS EXPOSED TO THE ELECTRIC AND							
15		MAGNETIC FIELDS OF HIGH VOLTAGE TRANSMISSION LINES							
16		INTRODUCTION							
17		SPECIFIC ARGUMENTS							
18		A. Experimental Scientific Studies 4	7						
19		B. Biophysical Calculations	9						
20		C. Utility Operating Experience	0						
21		D. Difference Between an 'Effect' and 'Hazard' 5	1						
22	8.	THE TESTIMONY OF APPLICANT'S WITNESSES MICHAELSON AND CARSTENSEN	, t						
23		SOL MICHAELSON							
24		A. Substantive Arguments	2						
25		B. Professional Background	8						
26		C. Other Matters	2						
27									

DURT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72)

(in second

- 2 -

× 1		EDWIN CARSTENSEN
2		A. Substantive Arguments and Professional Background 69
3	9.	ADDITIONAL MATTERS
4		AVAILABILITY OF INFORMATION
5		BIOLOGICAL RESEARCH SUPPORTED
6		BY THE ELECTRIC POWER RESEARCH INSTITUTE
7		HEREDITARY PREDISPOSITION
8	10.	RECOMMENDATIONS
9	11.	REFERENCES AND FOOTNOTES
10	12.	TABLES AND FIGURES
11		APPENDIX A - RESUME
12		
13		
14		
15		
16		
17		
18		
19		
20		
21	1 - S	
22		
23		
24		
25		
26		
27		
URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72)		- 3 -

1	1. PRELIMINARY MATTERS
2	PERSONAL BACKGROUND AND DESCRIPTION OF QUALIFICATIONS
3	My name is Andrew A. Marino. My business address is the Veterans
4	Administration Hospital, 800 Irving Avenue, Syracuse, New York, 13210.
5	
6	I received a bachelor's degree from St. Joseph's College, Philadelphia,
7	Pennsylvania, in June, 1962. I received a master's degree and a
8	doctorate in physics from Syracuse University in 1965 and 1968
9	respectively. My field of specialization is biophysics. Since September.
10	1964, I have been employed full-time as a research biophysicist by the
11	United States Government at the Veterans Administration Hospital in
12	Syracuse. I am also an Assistant Professor in the Department of
13	Orthopedic Surgery of the Upstate Medical Center at Syracuse.
14	
15	Our research laboratory was founded in 1960 to study the interaction
16	of electricity and biological systems. Presently, our interdisciplinary
17	staff is composed of three Ph.D's in biophysics, one Ph.D in anatomy,
18	two M.D.s, and four support personnel. Additionally, we have routine
19	consultation with specialists in bioelectrochemistry, veterinary medicine,
20	materials science, and electrical engineering.
21	
22	I graduated from the College of Law of Syracuse University in May 1974,
23	and subsequently was admitted to the practice of law in New York.
24	
25	During the course of my employment at the Veterans Administration Hospital
26	I have co-authored approximately 35 scientific publications dealing with
27	electrical effects and electrical measurements in animals and human beings.

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URT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72)

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Included among such publications are three reports which describe the 1 results of subjecting mice and rats to an electrical environment similar 2 to that created by high voltage transmission lines (1,2,3). Included 3 also are publications which describe the nature of the energy flow along 4 high voltage transmission lines (4), and which describe the results of 5 mathematical calculations of the effects of electrical exposure on 6 animals (5). I have written a review of the world-wide scientific 7 literature dealing with the biological effects associated with exposure 8 to an electrical environment similar to that created by high voltage 9 transmission lines (6). We have also investigated the stimulation of 10 bone growth by minute electrical current (7). 11 12

Presently, I am the principal investigator responsible for five ongoing
laboratory experiments designed to study the effects of the electrical
environment of high voltage transmission lines on animals and plants.

PURPOSE OF THIS TESTIMONY

I will describe the biological effects that have been observed in a 18 variety of organisms, including man, when exposed to electric and magnetic 19 fields such as will be produced by the proposed Sundesert 500 kv trans-20 mission lines. I will describe the inadequacy of our present information 21 to predict specific effects in specific people exposed along the right-of-22 way of the proposed transmission lines, and the reasons therefore. I will 23 describe the available Soviet literature in the area, and its implications 24 for the proposed transmission lines. I will describe two possible global 25 impacts of the radiation from the proposed transmission lines. I will 26 recommend against construction of the transmission lines as proposed. I 27

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will show that all arguments raised by the Applicant's witnesses to the contrary have no merit. I have reviewed the materials relating to biological effects of the proposed Sundesert transmission system. Included in this were portions of the Notice of Intent, the informational and adjudicatory hearing record and other materials furnished me by the staff.

2. EXPERIMENTAL STUDIES OF THE BIOLOGICAL EFFECTS CAUSED BY ELECTRIC AND MAGNETIC FIELDS SIMILAR TO THOSE ASSOCIATED WITH THE PROPOSED SUNDESERT 500 KV TRANSMISSION LINES

INTRODUCTION

11 The proposed Sundesert 500 kv transmission lines will produce electric 12 and magnetic fields in the air surrounding the energized wires extending 13 outward for considerable distances (see Figure 1). It is therefore 14 necessary to consider whether the presence of the fields will induce 15 biological changes in the human population, or will influence natural ecological systems. Such questions can be answered only by a review and 16 17 assessment of the scientific literature which deals with the consequences of exposing biological organisms under controlled laboratory conditions 18 to an electrical environment similar to that which would be created by 19 the proposed transmission lines. 20

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The proposed transmission line would operate at a frequency of 60 hertz, which is in the extremely low frequency (ELF) portion of the electromagnetic spectrum (generally limited to frequencies less than 100 hertz). An assessment of its impact therefore requires consideration of the scientific literature which describes the observed biological effects due to exposure of ELF electric and magnetic fields. I have endeavored

- 6 -

URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72) to provide a reasonably complete review of such literature. Some ELF field research has been reviewed elsewhere (8-10).

With few exceptions, ELF field biological research did not exist prior 4 5 to about 1967; since then numerous such studies have appeared. In what follows, the ELF electric and magnetic field reports will be described 6 separately to emphasize that the electric and magnetic field are two 7 different and distinct physical entities, each of which must be 8 considered with regard to the causation of biological effects. Within 9 each group of reports a further distinction is drawn between acute and 10 11 chronic exposure, with the dividing point generally assumed to be about 12 3 days. ELF electric field exposure was usually accomplished through the medium of air. In some cases an aqueous solution such as seawater or 13 nutrient media was employed. In all instances the electric field listed 14 herein is that to which the test organism was exposed. The epidemological 15 studies and the reports of ELF field effects on bird orientation end on 16 plant growth are described separately. 17

ELECTRIC FIELD EFFECTS

A. Acute Exposure

A variety of biological organisms including man have been shown to be sensitive to relatively brief exposure to ELF electric fields. Solov'ev (11) demonstrated that several hours exposure to 5000 volts/cm at 50 hertz was fatal to mice and <u>Drosophila</u>. Lethal consequences have also occurred with bees (12,13); above 500 volts/cm* bees sting each other to death, whereas 30-500 volts/cm at 50 hertz produces changes in metabolic rate * 100 volts/cm = 1 kv/meter

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RT PAPER C OF CALIFORNIA 113 (REV. 8-72)

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1 and motor activity.

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The mitotic index of liver and corneal epithelial cells in mice was tripled following application of 200 volts/cm at 50 hertz for 4 hours (14).

The influence of ELF electric fields on various forms of animal behavior 6 has received some attention. Spittka et al. (15) studied the effect of 7 500-700 volts/cm at 50 hertz on the drinking behavior of operantly 8 trained rats, and observed a significant decrease in the response rate 9 when the field was applied. The operant response rate of rhesus monkeys 10 was increased by 0.0035-0.35 volts/cm at 7-75 hertz (16,17). Employing 11 classically conditioned cardiac deceleration techniques, McCleave et al. 12 (18) showed that eels and salmon were able to perceive 0.0007-0.00007 13 volts/cm at 60-75 hertz. The perception, which occurred only when the 14 15 field was applied perpendicularly to the body axis, is the most sensitive ELF electric field induced biological effect yet reported. Friend et al. 16 (19) found that amoebae exhibited changes in shape and orientation within 17 a few minutes of the application of 10 volts/cm at 1-100 hertz. The 18 question whether the observed effects were due to simple physical forces 19 20 or arose from cellular activity was not resolved. Sazonova (2) examined 21 the results elicited by 300-400 volts/cm at 500 hertz on motor performance of rabbits. After cumulative exposure of 18 hours he observed a 22 23 statistically significant decrease in the rabbits' ability to do work (lift a fixed weight). 24

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26 There are five controlled laboratory studies which treat the interaction 27 of ELF electric fields and human subjects (21-25). In each instance

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1	alterations in human reaction time nonformance ware and the
2	et al (21) expand subjects in tal 1 is to 200
-	ct al. (21) exposed subjects in toto to about 1000 volts/cm at 50 hertz
3	for 75 minutes. The results suggested a decrease in performance which
4	was however, not statistically significant. Also employing full body
5	exposure at the same frequency, but at field strengths ten times less
6	intense, Hauf (22) reported that after 3 hours he observed an improvement
7	in performance which he attributed to a nonspecific stimulatory effect.
8	Hauf's subjects, unlike those of Johansson et al., were electrically
9	grounded throughout the exposure period.
10	
11	Hamer (23) and Konig (24) both utilized extremely weak ELF electric
12	fields (0.01-0.04 volts/cm). Konig observed decreased performance at
13	3 hertz as compared to the field-free situation, and increased performance
14	at the higher frequency as compared to the lower frequency.
15	
16	Parsinger et al. (25) looked for changes in the reaction time of 70
17	subjects as consequence of 0.003-0.03 volts/cm at 3-10 hertz, applied
18	for 40 minutes. Mean reaction times were not affected, however
19	significant sex, intensity, and frequency interactions were seen in the
20	amount of reaction time variability.
21	
22	Two animal studies described direct effects of brief ELF electric
23	field exposure on the central nervous system (26,27). Gann (26)
24	subjected dogs to a small controlled hemorrhage and examined the
25	effect of 150 volts/cm at 60 hertz for 5 hours on the physiological
26	compensatory control mechanism invoked by the hemorrhage. Blood
27	pressure and heart rate were found to be significantly different in the

RT PAPER C OF CALIFORNIA 113 (REV. 8.72) exposed dogs indicating a central nervous system disturbance which
resulted in an inability to employ effective compensatory cardiovascular mechanisms in response to the hemorrhage. Lott and McCain (27)
applied an inhomogeneous field of 0.4 volts/cm maximum at 640 hertz to
anesthetized rate. Recording from implanted microelectrodes, they
measured a significant increase in hypothalmic activity during the
hour exposure period.

9 Short-term <u>in vitro</u> studies have disclosed ELF electric field induced
10 alterations in calcium release (28) and biochemical function (29).
11 In the former study, exposure of brain tissue from chicks and cats
12 to 0.05-1.0 volts/cm at 1-75 hertz for 20 minutes significantly reduced
13 the release of calcium from both tissues to the surrounding medium.
14 In the latter study, 1.55 volts/cm at 60 hertz caused complete loss
15 of biochemical function in brain mitochondria after 40 minutes.

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B. Chronic Exposure

18 Behavior was the most frequently studied biological parameter in the 19 acute exposure experiments, whereas in the chronic exposure experi-20 ments growth or some physiological aspect of a developing biological 21 system was studied more often.

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Utilizing the most intense ELF electric field yet employed in controlled
animal research, Knickerbocker et al. (30) intermittently applied to
mice a vertical field of 1600 volts/cm at 60 hertz. The field was
applied to male mice only, for 6.5 hours/day, 5 days/week, for a
duration of 10.5 months. During the non-exposure periods the mice

URT PAPER TE OF CALIFORNIA), 113 (REV. 8-72)

- 10 -

were mated with non-exposed females and the offsprings were reared in a field-free region. It was found that the male progenies but not the female progenies of the exposed males were smaller in weight when compared at 30, 60 and 87 days postpartum to male and female progenies respectively, of the control males.

We have confirmed and extended Knickerbocker's results in our experiments involving the continuous exposure of three successive generations of mice to a 60 hertz electric field (1). Initially, male and female mice were split into horizontal, vertical and control groups. Mice in the horizontal group were allowed to mate, gestate, deliver, and rear their offspring in a horizontal field of 100 volts/cm. At maturity, randomly selected individuals from the first generation 13 were similarly allowed to mate, gestate, deliver, and rear their offspring while being continuously exposed. Randomly selected 15 individuals from the second generation were mated to produce the third 16 and final generation. A parallel procedure was followed for the vertical group wherein three generations were produced in a vertical 18 electric field of 150 volts/cm, and for the control group wherein three 19 generations were produced in the ambient electric field. In the first 20 and second generation, males and females reared in both the horizontal 21 and vertical electric field were significantly smaller than the 22 comparable control group when compared at 35 days postpartum. In 23 the third generation, the males exposed in the vertical field 24 exhibited depressed body weights at 35 days postpartum (after birth). 25 (See Table 1 and Figure 22). 26

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Elerrant growth responses following chronic exposure have been reported 1 in rats (31), Dugesia (flatworms) (32), and Physarum polycephalum 2 (slime mold) (33,34). McElhaney and Stalnaker (31) intermittently 3 applied 70 volts/cm at 3 and 30 hertz to the immobilized but intact 4 femurs of rats. Most of the exposed rats developed bone tumors, whereas 5 no tumors were seen in the control rats. In the second study (32), two 6 species of <u>Dugesia</u> were sectioned traversely and subjected to 3.1-4.2 7 volts/cm at 60 hertz applied along the antero-posterior regeneration 8 axis. In a significant number of animals the normal regereration 9 pattern (head anterior, tail posterior) was altered resulting in 10 bipolarity (the production of a head at both the anterior and 11 posterior surfaces). In the experiments on Physarum polycephalum 12 (33,34), the investigators simultaneously applied 0.007 volts/cm and 13 2 gauss at 45, 60 and 75 hertz. At all three frequencies they observed 14 delays in the mitotic cycle and retardation in protoplasmic streaming. 15 16

Different consequences of ELF electric field exposure have been seen 17 in chick growth depending on the strength of the applied field (35,36). 18 Day old chicks were exposed continuously for 22 days to 400 and 800 19 volts/cm at 60 hertz (35). Growth appeared to be affected, and gross 20 motor activity measured after the birds had been removed from the 21 field was reduced relative to that of the control birds (35). These 22 observations led to experiments on male and female chicks separately. 23 Female chicks were exposed continuously to 200 or 800 volts/cm for the 24 first 14 days posthatching, and body weights were obtained at 1-8 weeks 25 of age. The mean body weight of the chicks exposed at both field 26 strength was greater than that of the control birds (35). The results, 27

URT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72)

- 12 -

which were on the order of 5-10%, became statistically significant during the second week. Male chicks were then exposed to 400 or 800 volts/cm for the first 20 days posthatching, and body weights were obtained during the exposure period. A significant enhancement in the early growth response was observed (35).

Giarola and Krueger (36) observed that one day old chicks exposed to a nonuniform field of maximum value 35 volts/cm exhibited depressed body weights when compared to unexposed chicks. The effect became significant after 22 days at 45 hertz and 28 days at 60 hertz. In another study (37) the same group found that exposure of egg-laying hens to 16 volts/cm at 60 hertz for 16 weeks caused a decrease in egg production during the first half of the test period, but not 13 during the second half. Durfee (38) exposed chick eggs during incubation, hatching, and development through 4 weeks of age, to a uniform field 15 of 36 volts/cm, and found that any differences between the exposed 16 and control birds with regard to rate of growth were masked by the 17 effects of crowding. Similar studies by the same group involving 18 uniform fields of 0.01-0.10 volts/cm at 60 and 75 hertz (38), and 19 at 72-80 hertz (39) reported some effects on chick growth response. 20

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In vitro observations of the impact of chronically applied ELF electric fields have been made at widely different intensities. Utilizing the most intense fields yet employed in chronic exposure experimentation, Gann and LaFrance (40) found that the threshold of a 100% lethal effect on mammalian cells exposed for 1 week at 60 hertz in cell culture was between 2,000 volts/cm and 6,000 volts/cm. At 1,000 volts/cm, a 12%

JRT PAPER OF CALIFORNIA increase in the growth of embryonic chick tibiae (e.g. bones) was seen (41). Growth inhibition and growth acceleration were seen following exposure of chick embryo cells to 0.01-0.10 volts/cm at 60-75 hertz for 1-3 days (38).

Earlier work had revealed the ability of a magnetic field to function 6 as a biological stressor (42). We therefore undertook to determine 7 whether an ELF electric field could produce a similar response. 8 Twenty-one to twenty-four day old rats were exposed to 150 volts/cm 9 at 60 hertz for one month in ten separate experiments (2,3). A 10 variety of statistically significant effects were found including 11 depressed body weight, depressed water consumption, increased adrenal 12 and pituitary weights, and altered serum levels of albumin, hydroxy-13 corticosterone, and glutamic oxaloacetic transaminase (see Tables 2 14 and 3, and Figure 3). The results indicated that exposure to the ELF 15 electric field produced a physiological stress response. Noval et al. 16 (43) independently performed similar experiments at much lower field 17 strengths and reached essentially the same conclusion. They exposed 18 30-35 day old rats to 0.005-1.0 volts/cm at 45 hertz for 30-40 days. 19 The treated rats exhibited depressed body weights, decreased levels 20 of brain choline acetyltransferase activity and elevated levels of 21 liver tryptophan pyrrolase. 22

Mathewson et al. (144) exposed 49 day old rats for 28 days to 0.02, 0.10, 0.20, 0.50, and 1.0 volts/cm, and reported that they failed to 25 observe effects comparable to those of Noval et al. Since, however, 26 the 60 hertz background present at both Mathewson's control and 27

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1 emerimental cages was as high as 0.07 volts/cm (45), it is appropriate 2 to regard the rats exposed to 0.02 volts/cm as part of the control 3 group for the purposes of comparing them jointly to those animals 4 exposed at 0.5-1.0 volts/cm (whereas the applied field was sufficiently 5 greater than the background). Under this approach the data of 6 Mathewson et al. reveal a variety of statistically significant changes 7 including a decrease in blood glucose in three consecutive replicative 8 experiments, and changes in blood hemoglobin and hematocrit (red blood cell count) in two of the three experiments. Changes also 9 10 occurred in at least one of the experiments in each of the following 11 parameters; blood globulin, total lipids, triglycerides, final body 12 weight, and red blood cell count.

It seems most reasonable to conclude that Mathewson et al. (44)
generally confirmed Noval et al. (43), with the chief difference
between them being that the effects observed in the latter study were
more severe than those found in the former. This has led to an effort
to delineate the specific differences between the two studies which
could arguably be responsible.

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The Noval study was performed inside a Faraday cage (131) formed by the steel wall construction of the facility at which the test and control animal populations were housed. The possible significance of the electrical shielding was not recognized <u>ab initio</u> and therefore was not incorporated in the experimental design of the Mathewson study. To the extent that Faraday shielding can of itself produce biological changes, it may account for the observed differences in

DURT PAPER ATE OF CALIFORNIA D. 113 (REV 6-72)

- 15 -

severity between the two studies. Such effects due to shielding have been reported in humans (46-48), guinea pigs (49), and mice (50).

4 In the most thorough study of the phenomenon, Wever (46-48) isolated 5 human subjects in undergound bunkers for 3-8 weeks and measured 6 their temperature and activity circadian rhythms. He found that 7 subjects living in a shielded bunker exhibited significantly different 8 periodicities in body temperature than subjects living in a non-9 shielded bunker. He also reported that desynchronization between 10 the two rhythms occurred only in the shielded bunker. Both effects 11 ceased when an artificial electric field of 0.025 volts/cm at 10 12 hertz was applied, indicating that the total ambient electromagnetic 13 environment on the one hand and the artifical field on the other 14 influence human circadian rhythms similarly in the respects investigated. 15 Altman and Soltau (49) exposed guinea pigs to 2.4 volts/cm at 10 hertz. 16 and maintained parallel groups under Faraday conditions and under normal 17 ambient conditions. They found that shielding produced changes in 18 the hematocrit and the distribution of blood proteins, but that both 19 parameters returned to normal in the presence of the artificially applied 20 field. Lang (50) exposed mice to 35 volts/cm at 10 hertz and 21 maintained parallel groups under Faraday conditions and under normal 22 ambient conditions. Shielding produced changes in body water content, 23 blood hemoglobin, and blood sodium levels. The effects were eliminated 24 following exposure to the artificial electric field.

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Blanchi et al. (51) found that after 1000 hours of exposure to 1000 volts/cm
at 50 hertz, the electrocardiograms (EKG's) of mice were significantly

URT PAPER TE OF CALIFORNIA) 113 (REV 8-72)

Eltered. In particular, there was a lengthening of the PR interval, R wave's duration, and duration of the QRS complex. These waves are identified patterns on an EKG that are interpreted to represent various heart functions. It has also been reported that after 192 hours of exposure at 400 and 800 volts/cm. chicks exhibited significantly altered electroencephlagrams (35). The spectra of the experimental and control animals were compared in 512 frequency bands between 0-62.5 hertz. Four significantly different bands were found in the animals exposed to 400 volts cm, while seventeen signifi-cantly different bands were observed in the animals exposed at 800 volts/cm. Early works suggested that weak electric and magnetic fields produced genetic aberrations in fruit flies (52), however subsequent work at 1 gauss and 0.1 volts/cm (53) and at 2 gauss and 0.2 volts/cm (54) have failed to confirm

these observations.

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MAGNETIC FIELD EFFECTS

A. Acute Exposure

The consequences of acute exposure at high field strengths has received some attention in connection with the phenomenon of magnetic phosphenes (production of a visual response due to a magnetic field). Most studies of the biological effects of magnetic fields however, have involved relatively brief exposure to low strength fields. In such instances the effect of the field on behavior or perception is usually studied.

D'Arsonval (55) first reported that a sensation of light could be produced 10 when a magnetic field was applied to the region of the head (magnetic 11 phosphene). Subsequently the production of magnetic phosphenes by a 12 field of 1000 gauss was reported by Thompson at 50 hertz (56) and Dunlap 13 at 60 hertz (57). Barlow et al. (58) described the production of magnetic 14 phosphenes by 400-900 gauss at 10-90 hertz, and reported that the threshold 15 for the effect did not change depending on whether the subject's eyes were 16 open or shut. Recently, Lovsund et al. (59) reported the production of 17 magnetic phosphenes by a field of 150-300 gauss at 10-50 hertz in 13 18 subjects. There are presently many unanswered questions concerning the 19 nature and the characteristics of the phenomenon of magnetic phosphenes (60). 20

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Utilizing 60 human subjects, Friedman et al. (61) demonstrated that 3 gauss at 0.2 hertz superimposed on a static field of 5 gauss significantly affected reaction time in both male and female human volunteers. When behavioral instructions to monkeys are substituted for verbal instructions to humans however, the resulting variability in response makes it very difficult to observe effects. Grissett and deLorge (62) performed reaction

JRT PAPER TE OF CALIFORNIA 113 (REV. 8-72) time measurements on 3 monkeys exposed for 10 hours to 3 gauss at 7 and 45 hertz, but failed to uncover any influence of the magnetic fields. Even chronic exposure (42 days) of the monkeys to 10 gauss failed to elicit an effect (63).

The effect of full-body exposure on human cognitive and psychomotor functions was examined by Gibson and Morony (64). They discovered that after 24 hours exposure to 1 gauss at 45 hertz, both the ability to perform addition, and short term memory, were altered.

Milburn (65) investigated the ability of human beings to perceive magnetic fields (1 gauss) and electric fields (2.3 volts/cm). He employed a forcedchoice testing procedure and found that 2 of 48 subjects studied were able to perceive a magnetic field at 400 hertz. No subjects sensitive to the electric field were found.

Smith and Justesen (66) exposed mice to 17 gauss at 60 hertz and found that locomotor activity levels increased immediately upon application of the field. Persinger et al. (67) found that rats exposed for 21-30 days to 3-30 gauss at 0.5 hertz displayed greater activity upon removal from the field as compared to the control rats.

In a series of experiments involving 4 monkeys, deLorge utilized operant conditioning techniques to study the effect of 8.2-10 gauss and 0.01.0.3 volts/cm at 10-75 hertz (68-71). He failed to demonstrate that the fields were detected by the monkeys or that the fields consistently affected the stimulus control of the operant schedules. Marr (72) similarly failed to

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istect effects on operant behavior of pigeons and rats as a consequence of 葱 exposure to 2 gauss and 1 volt/cm at 45-76 hertz. Persinger has pointed 2 out that the failure to detect effects indicates that the response measures 3 studied were not sensitive to the physiological systems which mediate the 4 stimulus effect (74). 5 6 B. Chronic Exposure 7 8

Chronic exposure to low strength magnetic fields is generally associated with some effect on growth or physiology of the test organism.

Udintsev et al. (75) found that exposure of rats to 200 gauss at 50 hertz 12 for 1 day increased the lactate dehydrogenase activity in the cardiac and 13 skeletel muscles. Rats exposed to 200 gauss at 50 hertz exhibited a 14 significant increase in hydroxycortiscosterone in adrenal tissue and blood 15 plasma after 1 and 7 days of exposure. Lantsman (77) explored the effect of exposure to 200 gauss at 50 hertz on the phagocytic function (ability to 17 destroy harmful bacteria) of the reticulo-endothelial system (the system that includes all phagocytes except the white blood cells) of mice. He found that 8 hours of exposure per day for 4 days inhibited the efficiency of phagocytosis in several organs.

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Bassett et al. (78) investigated the effect of a magnetic field on the organization and strength of the repair process which occurs during the healing of a bone fracture. They applied an asymetrically pulsed field repeating at 65 hertz, with a peak value of several gauss, to dogs which had undergone fibular osteotomies (surgical breaking of the fibular bone).

T PAPER OF CALIFORNIA 13 (REV. 8.72) They found that the field accelerated the time course of the repair process. In a subsequent study (78), a magnetic field with similar characteristics was applied to patients suffering from pseudarthroses (similar to arthritis), and markedly beneficial results were observed. Patients were exposed for 12-16 hours per day for 3-6 months and a success rate of 73-76% in the induction of new bone growth was seen.

There are two other reports involving chronic exposure of human beings to a low intensity magnetic field (80, 81). Erhman et al, (80) examined the effect of a magnetic field on the amount of medication used by several hundred patients. With regard to ten typical medical complaints, they found that a field of several gauss at 4-12 hertz brought about a reduction in the amount of medication consumed which greatly exceeded the reduction achieved with placebos. Beischer et al. (81) exposed subjects to 1 gauss at 45 hertz for 1 day and observed a significant increase in serum triglycerides 1-2 days after the exposure in 9 of the 10 subjects. In a subsequent study (82), it was found that exposure of mice to 1 gauss at 45 hertz for 1 day did not affect the concentration of liver triglycerides.

Persinger et al. (83) exposed rats for 10-26 days to 1-30 gauss at 0.5 hertz and observed progressive changes in total body weight, thyroid weight, testicle weight, and water consumption. Ossenkopp (84) explored the influence of 3-12 gauss at 0.5 hertz on rats exposed <u>in utero</u> for 22 days. A number of physiological and behavioral effects were manifest by the pups after birth including retardation of time of eye opening and teeth eruption, and depression of motor activity.

IRT PAPER IE OF CALIFORNIA 113 (REV. 8-72)

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Harola et al. (36) found that exposure of one day old chicks to 1.3 gauss at 45 and 60 hertz for 28 days depressed their growth rate by 9-11% as compared to unexposed birds.

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COMBINED FIELD EFFECTS AND SPECIAL TOPICS

A. Epidemiological Investigations

(a) Soviet Studies

Soviet investigators have conducted medical and physiological surveys of personnel occupationally exposed to strong electric fields emanating from components of the Soviet electrical power system.

Physical examinations of high voltage switchyard workers revealed that 41 of 45 subjects studied presented some neurological or cardiovascular disorder during and shortly after field exposure (85). No organic pathologies were found, however examination did reveal instability of the pulse and blood pressure, tremors of the extremities, and hyperhidrosis (excessive sweating). Accompanying these observations, the electrocardiograms showed bradycardia (slowness of heart beat) in 14 subjects and slowed atrioventricular conduction in 10 subjects. Laboratory studies of the peripheral blood showed mild changes from normal except for marked spherocytosis in 60% of the subjects examined. A physiological study of 54 occupationally exposed workers showed that the electric field produced functional changes in the autonomic nervous system (that part not subject to voluntary control) which were related to the duration of exposure (86). Medical surveys carried out at 16 high voltage substations involving a total of 286 people revealed adverse effects of exposure to the electric field on the central nervous system and the cardiovascular system (87). A physiological survey of 319 people who worked at high voltage substations and overhead transmission lines also revealed unfavorable changes in health (87). Twenty-three men were exposed to power frequency electric

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fields while various central nervous system and cardiovascular system indices were measured; the results showed that fields stronger than 50 volts/cm have an adverse effect on man (87). A clinical study of personnel of 330 kv substations revealed a variety of harmful effects of field exposure manifested by alterations in blood pressure and electrocardiogram (88).

In a recent experiment (89,, the electric field associated with 330-750 kv 7 transmission lines was measured and found to be 15-75 volts/cm at 10 meters 8 distance, and 1-3.5 volts/cm at 50 meters distance. Male rats were then 9 exposed for up to 4 months in an effort to assess the human health hazard 10 posed by such high voltage transmission lines. Unusual motor activity and 11 hyperemia of the nasal mucosa were observed in rats exposed to 50 volts/cm. 12 In the groups exposed to 10-50 volts/cm, a variety of alterations in normal 13 physiology were seen including a reduction of blood cholinesterase activity 14 and an increase in urinary corticoids. Dystrophy was seen in a variety of 15 tissues at the conclusion of the exposure period, the extent of which was 16 proportional to the intensity of the applied field and the duration of 17 exposure. The results suggested to the authors that the field around 18 high voltage transmission lines poses a potential health hazard to 19 adjacent populated areas. 20

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Within the Soviet Union at least some occupational exposure to power frequency electric fields is regulated by a set of Hygienic Rules which govern the permissible duration of exposure at various field intensities (90). Although as early as 1970 the modern Soviet literature contained more than 100 reports of the influence of ELF electric fields on biological systems (91), it appears that the rules are based principally

JRT PAPER TE OF CALIFORNIA 1. 113 (REV. 8-72) In the medical and physiological surveys discussed above (90). Standards . governing the exposure of agriculture workers and the general public are being developed (92). A variety of other rules relating to the design and construction of high voltage transmission lines presently provide some protection to both groups (92, 93, 130).

(b) Other Studies

Strumza (94) searched the health records of 142 employees occupationally 9 exposed to power frequency fields, and found no correlation between such 10 exposure and the number of visits to a physician. In one of the first 11 studies of any kind involving the biological effects of fields, 12 complete physical examinations were given to 11 linemen who serviced 13 345 kv transmission lines. No effects related to exposure were found (95), 14 nor did any such effects develop after cessation of the occupational 15 exposure (96). Exposure to the fields of the Project Sanguine antenna (73), 16 apparently did not seriously affect the health of the operating personnel 17 (97-99), nor did it alter the metabolic rate of 5 species of soil-dwelling 18 animals gathered from the general area of the antenna (100). 19

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B. Bird Orientation

Several investigators have inquired into the possible effects of the electro-2 magnetic near-field of the Project Sanquine antenna on bird orientation. 3 4 Sanguine was a project proposed by the Navy. It was to make possible communi-5 cations with submerged submarines from a land based stations using ELF energies. 6 In pilot studies (101), it was observed that the headings of homing pigeons were 7 slightly altered in the vicinity of the antenna. In more detailed studies, 8 Southern (102) constructed cages on the ground directly over the buried antenna 9 to explore the effect of the field on the instinctive directional preference of 10 3-9 day old ring-billed gull chicks. When the chicks were released in the center 11 of the cage with the antenna turned off they showed a directional preference for 12 the southeast. When the antenna was energized the birds dispersed randomly and 13 exhibited no mean bearing. Larkin and Sutherland (103) carried out radar tracking of individual migrating birds flying over the antenna at altitudes of 80-300 14 15 meters. They observed that when the antenna was activated or when its operating 16 condition was being changed (off to on or on to off) departures from straight 17 and level flight occurred significantly more often than when the antenna was 18 turned off. In radar tracking studies which are not yet fully analyzed, 19 Williams and Williams (104) reported changes in the flight direction of migrat-5-25° when the antenna was activated. 20 ing birds of No studies have yet 21 investigated the effect of duration of exposure, nor, has it been determined 22 whether the birds sensed the electric or magnetic field of the antenna, or both. 23

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C. Plants

25 Remarkably little attention has been devoted to the effects of ELF fields on 26 plants. Gardner et al. (105) studied the effect of 0.1 volts/cm at 45 hertz on 27 the growth of beans. When the seeds were planted in soil, the growth of the

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URT PAPER TE OF CALIFORNIA 113 (REV. 8-72)

plants were 40% greater than that of the control plants after 64 days of 1 When the soil was replaced with a nutrient solution however, no I erposure. 3 significant effects were seen after 37 days of exposure. The latter result has been partially confirmed by Miller (106) who reported that 1-144 hours of 4 exposure of beans in nutrient solution to 0.1 volts/cm at 75 hertz did not affect 5 Rosenthal (107) applied 0.01-0.1 volts/cm and 1 gauss at 75 hertz to 6 growth. sunflower seeds planted in soil and observed differences in seedling mortality, 7 and stem and root length, between the exposed and unexposed populations. 8

10 A survey of plant life near the Project Sanguine antenna in Wisconsin suggested 11 that the antenna near-field did not affect the normal vegative pattern (108). A 12 survey of the plant life near high voltage transmission lines suggested that the 13 fields caused a slight enhancement of growth (109).

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CONCLUSION

16 Based on the reports described in the foregoing review, I conclude that the 17 electric field and the magnetic field of the proposed transmission line will each 18 probably cause biological effects in the subjects exposed to them.

20 The ELF experiment studies are summarized in Table 4. It can be seen that there 21 are a very large number of scientific experiments which show that ELF electric 22 and magnetic fields cause biological effects. The experiments were performed by 23 reputable scientists at reputable scientific institutions (see Table 4). A heavy 24 majority of the reports were subjected to the peer review process prior to 25 publication. The strength of the field used in each cited experiment was such 26 that it will occur somewhere on the right-of-way of the proposed transmission 27 line (Table 4, colume D_i). If a particular field strength causes a certain

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resigned effect in a laboratory, then the same field strength will cause the same biological effect near the right-of-way of the proposed transmission line if \mathbb{Z} the same biological system is exposed under the same circumstances. This follows 3 from the universal inability of biological systems to distinguish between two 4 sources of an applied field when the parameters and circumstances of the field 5 presented from each source are identical. Under these conditions of identity, 6 specific effects due to exposure to the fields of the proposed transmission line 7 could be predicted. The actual biological systems that will be exposed to the 8 fields of the proposed transmission lines include people. The exposed group will 9 consist of the old, the young, the sick, the healthy, men, women, children -- a 10 completely uncontrolled set of exposed subjects. Since the particular biological 11 systems that will be exposed and the conditions of such exposure will both differ 12 from the corresponding systems and conditions studied in the laboratory, no human 13 agency can predict the specific biological consequences that will occur in 14 specific subjects exposed along the right-of-way. Notwithstanding our inability 15 to predict specific effects in specific subgroups of exposed subjects, the 16 foreshadowing of the literature are ominous and avoidable. In each individual 17 report described in Table 4, ELF fields interacted with and influenced the 18 physiology or behavior of a biological system. In no case is the mechanism of 19 20 interaction understood. With respect to each individual experiment listed in Table 4, a biological mechanism of interaction was invoked in the laboratory 21 which could be invoked along the right-of-way as a consequence of exposure to the 22 fields of the proposed transmission line. In view of the number and diversity of 23 the experiments listed in Table 4, and bearing in mind the relatively short 24 exposure times that are normally employed in laboratory experimentation (Table 4, 25 column 7), as compared to the very long-term exposure that will occur in subjects 26 living along the right-of-way, it is probable that biological effects will occur 27 in some exposed subjects.

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URT PAPER 28

is not possible to foresee the precise biological effects that will likely 2 secur in individual subjects because no free-world company, organization or 3 government has conducted a systematic study of the question. With minor exceptions the research in the literature cited above was performed by 4 5 investigators for reasons other than evaluating the safety of transmission lines. 6 The problem of safety of transmission lines did not influence the design of such 7 experiments and in most cases the results were not related to transmission lines 8 by the individual investigators. Nevertheless, it is possible to analyze the 9 literature and to inquire into its implications for the issue of the safety of 10 the proposed transmission lines. This I have done, and my conclusion above is so 11 based.

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13 It is not possible however, to go beyond this conclusion and assert that specific effects are scientifically certain to occur in particular individuals. There is 14 no scientific base to permit definitive answers to the myriad of very specific 15 16 questions that can be asked (i.e., will a farmer be adversely affected by the 17 proposed transmission line if he passes under such a line once a day, three days 18 a week, thirty-two weeks a year, except on holidays, in a tractor with tires four 19 feet in diameter made of carbonized rubber, traveling at five miles per hour; if 20 so, how so?). Such specific information will come only from studies 21 appropriately designed to furnish it. It is not realistic to expect that answers 22 to very specific questions will be deductible from the general literature.

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RT PAPER E OF CALIFORNIA

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3. THE BIOLOGICAL SAFETY FACTOR OF 100 AND ITS APPLICATION TO THE

LITERATURE DESCRIBING BIOLOGICAL EFFECTS DUE TO ELF FIELDS

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. 5	The electric and magnetic fields of the proposed transmission lines have the
6	capability of altering biological function. In such a situation the propriety
7	and necessity of employing a safety factor is well recognized (Michaelson New
8	York, 9927 *). Such necessity is based upon the unacceptability of permitting
9	the public to be involuntarily exposed to levels of a substance or agent that has
10	been shown to produce biological effects in experimental enirgies and that has
11	which presumably would produce such effects (or related effects) (5
12	performed. It is therefore percentary to evolve of the second sec
13	permissible chronic human evaluating
14	following analysis it can be seen that a set of the set
15	analysis it can be seen that a safety factor of 100 to 1 is the most
16	appricable and suitable choice.
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24	+ Theorem
25	26529 and 26559 - Common Record Hearings on Health and Safety of 765 kV
26	transmission lines - Public Service Commission of New York. Citations herein to the testimony of all witness in the New York Proceeding will be identical in
27	torm. All reference herein to hearings in New York refer to the enumerated cases.

URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72)

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BASIS FOR SAFETY FACTOR OF 100

I are evaluating the safety-in-use of food additives, a safety factor of 100 has Speen explicitly chosen by the federal government (110). The federal rule seeks to balance the desire of a manufacturer to gain an economic advantage with the 4 desire of the government to protect the public health. The numerical value of 5 100 was chosen as the appropriate balance point, and it is therefore significant 6 as a precedent when a similar balance must be struck. I am not urging that the 7 safety factor for food additives be adopted, but rather that the policy 8 considerations underlying the adoption of a safety factor of 100 for food 9 additives are also present in connection with involuntary exposure of the general 10 public to power frequency fields, and therefore that the same numerical value 11 should be adopted. In further analyzing the question of the appropriate 12 numerical value of the safety factor for permissible field exposure, the value of 13 100 should be viewed as the starting point because it is a precedent. The 14 appropriate question would then be whether the particular facts presented to the 15 Commission warranted some other choice based on a reexamination of the balance 16 17 described above.

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It should be noted that no attempt is being made here to balance the economic 19 gain against the danger to public health associated with exposure to the fields 20 of the proposed transmission lines. My intention is to identify a situation 21 which is presented to the Commission, and to recommend that since it is 22 confronted with a similar qualitative situation as that which led the federal 23 government to adopt a safety factor of 100, that therefore the Commission should 24 also adopt the safety factor of 100 as a starting point. This level could then 25 be raised or lowered depending on the particular weight that the Commission 26 chooses to give the economic considerations and the public health considerations 27

IRT PAPER TE OF CALIFORNIA 113 (REV. 8-72)

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in this case. A brief consideration of some other safety factors illustrates the pertinence of the safety factor of 100. The Occupational Safety and Health 22 Administration (OSHA) has promulgated an occupational safety standard for 3 4 permissible microwave exposure of 10mW/cm (111). This standard is based on the known ability of microwaves to cause heating in biological tissue at levels 5 ten times higher (112), and thus the safety factor is 10. While a safety factor 6 7 of 10 may be appropriate for occupational exposure, it is inappropriate for the general population because the general population is uncontrolled (113). It 8 9 contains the old, the young, the healthy, the sick and all variations thereof. Additionally, the whole range of exposure periods is possible, from occasional to 10 11 This is to be contrasted with the occupational setting in which it is chronic. presumed that the employees are healthy, and wherein their exposure can be 12 .13 controlled and monitored by the employer (113). The Soviet and East European safety factor which is comparable to the OSHA standard is 10,000 (0.01 14 mW/cm^2). 15

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The federal safety factor for new microwave ovens is $100 (1.0 \text{ mW/cm}^2) (114)$. 17 It is based on the rationale described above (113) (i.e., more protection for an 18 uncontrolled population) and on the possibility that the Soviet microwave 19 standard and not the American microwave standard is the correct one (113). The 20 federal safety factor for carcenogenic substances is infinite (115). That is, if 21 a substance causes cancer in animals if can not be used in food. Thus, putting 22 aside the special cases (carcenogenic substances, for which the safety factor is 23 infinite, occupational exposure, for which the safety factor is 10), the 24 precedent is well established in the United States that a safety factor of 100 is 25 the appropriate numerical value with relation to the public at large when a 26 27 balance must be struck between economic advantage and the public health, unless there is evidence to justify a different value. 28

JRT PAPER FE OF CALIFORNIA 113 (REV. 8-72

BIOLOGICAL AND ENGINEERING SAFETY FACTORS DISTINGUISHED

The biological safety factor of 100 proposed here must be distinguished from the 2 somewhat more familiar but distinctly inapplicable engineering safety factor. If 3 one envisions the appropriate safety factor for the thickness of the wall of a 4 5 steam vessel so as to insure that it doesn't rupture, or the appropriate 6 thickness of a strut on a transmission line tower so as to insure that the tower 7 doesn't collapse, then a safety factor of 1.5 to 5 would be typical. Such engineering safety factors are relatively low because they rest on a certain 8 9 informational base, namely the known physical properties of the materials. On 10 the other hand, biological safety factors are necessarily higher because our data 11 base concerning the properties and responses of biological objects is not nearly 12 as certain. Clearly when we speak of a safety factor to protect against 13 involuntary exposure of the general population to the electric fields of the 14 presently proposed transmission lines, we are talking of a biological safety 15 factor.

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APPLICATION OF THE SAFETY FACTOR OF 100

18 Since the most appropriate safety factor for use in connection with the 19 literature describing biological effects due to exposure to ELF fields is 100, 20 column D, indicates the distance from the proposed transmission line at which the 21 line's field strength will have decreased to 1/100 of the value that produced the 22 biological effect in the corresponding experiment. Column D_3 (=2D₂) gives 23 the total width of the zone of effect; that is, the width of the strip of land 24 within which the field from the proposed transmission line will exceed the 25 corresponding safety level listed in D₂.

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27 While it appears necessary and appropriate for the Commission to utilize a safety factor of 100 in determining permissible chronic human exposure to the 60 hertz

RT PAPER 28 tor California 113 (REV. 8.72)

12	fields, I do not recommend that the safety factor be applied to any specific
2	research report listed in Table 4. The application of the safety factor of 100
3	to a specific report listed in Table 4 would produce a design criterion, and I do
4	not urge any specific design criterion. I believe that the particular report or
5	group of reports in Table 4 which are chosen must reflect consideration of the
6	entire record in the hearing. In view however, of the effects reported in the
7	70-200 volt/cm range (Table 4), it is my judgment that the application of the
8	safety factor of 100 to this range of experiments is an absolute upper limit on
9	the available choices notwithstanding any financially oriented considerations.
10	That is, the narrowest possible right-of-way that could safely be chosen is that
11	within which the electric field diminished to about $(70-200 \text{ volts/cm} \times 10^{-2}) =$
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4. RULES IN THE SOVIET UNION GOVERNING MAXIMUM PERMISSIBLE EXPOSURE TO POWER FREQUENCY ELECTRIC FIELDS AND THEIR BASIS.

SOVIET RULES

5 It is recognized by the Soviet government that power frequency electric fields 6 cause undesirable effects in exposed workers. The Soviets believe that power 7 frequency electric fields affect people's health, and that the reaction is non-8 specific and can develop after two-five months exposure (92). They further 9 believe that the effects of exposure are cumulative, dose-related, and depend 10 strongly on individual physiological differences (92). Such effects include 11 disturbances in the cardio-vascular system, the central nervous system, blood 12 composition, and lower sexual capability (85-86). In 1970 the Soviet 13 government promulgated nationwide Rules and Regulations regulating the nature 14 and extent of permissible occupational exposure to power frequency electric 15 According to the Rules, working conditions are not limited or fields (90). 16 controlled where the electric field is less than or equal to 50 volts/cm. If 17 the electric field is greater than 250 volts/cm, all work must be done with the 18 worker protected by screening or some other device. For fields between the two 19 values, the permissible duration of field exposures with protective measures is 20 limited as follows. At 250 volts/cm, 5 minutes; at 200 volts/cm, 10 minutes; 21 at 150 volts/cm, 90 minutes; at 100 volts/cm, 180 minutes. Thus for instance, 22 after spending 90 minutes in an electric field of 150 volts/cm, the worker must 23 spend the remaining portion of the 24 hour period in an electric field of less 24 than 50 volts/cm.

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The Soviet exposure standards are based upon measurements utilizing a Soviet
 Electric Field Meter and a specific measuring technique (90, 116). Taking into

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JRT PAPER TE OF CALIFORNIA 113 (REV 8-72)
account both the particular technique of measurement utilized by the Soviets, and the difference in frequency between the Soviet and American power systems, 2 is necessary to employ a conversion factor to permit a direct comparison 3 it between American and Soviet electric field measurements (Driscoll, New York, 4 Thus, in terms of the American method of electric field measurement, 11176). 5 the actual Soviet exposure levels are: 6 Permissible Duration of Electric Field 7 Personnel Stay in Electric Intensity (volts/cm) Field During 24 Hours 8 (minutes) 9 Unlimited 28 10 56 180 11 83 90 12 10 111 13 139 5 14 Exposure standards for agriculture workers and for the general public are being 15 developed (92). 16 17 In the Soviet view, knowledge of the effect of the electric field of high 18 voltage transmission lines on the flora, fauna, and on the ecological balance 19 the area along the right-of-way, is practically nonexistent, and therefore, of 20 laboratory and field studies should be conducted (92). The Soviets believe 21 that being exposed to the electric field of high voltage transmission lines 22 only occasionally, and not periodically, does not present a health hazard (92). 23 24 BASIS OF THE SOVIET RULES 25 From the existence of Rules governing field exposure within the Soviet Union, I 26 infer that there exists scientific evidence within the Soviet Union from which 27 they were drawn. It appears that the Rules are based on medical and physiological 113 (REV. 8-72) - 36 -

URT PAPER

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surveys of occupationally exposed workers (85-88). Neither the number of such studies however, nor adequate details of their conduct are presently available 2 in the United States. Some studies may have been performed and not published, 3 and studies may have been published but not translated in English. There is no 4 agency or organization which systematically translates the Soviet literature in 5 this area and makes it generally available. Literature becomes available only 6 7 when some agency or organization becomes interested in a specific study, 8 translates it, and chooses to disseminate it. A prominent spokesman for the American utility company engineers, in dealing with the Soviet engineers, 9 appears to be Howard Barnes of Charles T. Main Inc., Boston, Massachusetts. 10 His correspondence with the Soviet power engineers regarding their views of the 11 health hazards associated with high voltage transmission lines has been made 12 13 part of the hearing record in New York. Based thereon, it seems clear that the American utility companies have been unusually circumspect in inquiring into 14 the nature and scope of the Soviet data base on high voltage transmission line 15 health hazards. It does not appear that there has ever been a formal request 16 to the responsible Soviet authorities for all available information dealing 17 with health hazards of high voltage transmission 18 lines. Consequently, 19 exceedingly little of such information has appeared in the American scientific community under the auspices of the American utility companies. Sometimes, 20 even when information is obtained from the Soviet Union, it circulates very 21 Both Barnes and applicant's witness Michaelson have obtained copies 22 narrowly. of specific Soviet reports but have not honored requests to make them 23 available. 24

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26 Informal contacts between individual scientists in the Soviet Union and those 27 in the United States and Europe have produced some Soviet reports in the ELF

JRT PAPER TE OF CALIFORNIA . 113 (REV. 8-72)

1	area. The process of obtaining information in this manner however, is quite
2	haphazard and often results in translations of unverified reliability. Thus,
3	while the basis of the Soviet Rules appears to be the medical and physiological
4	surveys conducted within the Soviet Union, the studies cannot be independently
5	assessed on their own merits.
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CONCLUSION

2 There are Rules within the Soviet Union governing the maximum permissible occupational exposure to high voltage transmission line electric fields. 3 Exposure standards are being developed for agriculture workers and for the 4 From the existence of the Rules, I infer the existence of a general public. 5 data base within the Soviet Union concerning the biological consequences of 6 exposure to ELF electric fields. I have been able to identify only a part 7 thereof (11, 14, 20, 75, 76, 77, 85-93). In view of the very small percentage 8 of the Soviet literature dealing with ELF biological effects that is available 9 to me, and the poor quality of the translations on many of such Soviet reports, 10 and the possible differences that may exist between American and Soviet 11 scientists in terms of scientific methods and procedures, I am unable to reach 12 any conclusion concerning the likelihood of biological effects from the 13 electric field of the proposed transmission line directly from an analysis of 14 the Soviet literature. Nevertheless, one cannot gainsay the existence of the 15 Soviet Rules, or the plans for more research and for additional rules. I 16 assume that the Soviets are not unintelligent, scientifically backward, or 17 prone to needlessly interfere with their industrial progress. It follows, 18 therefore, that sufficient evidence exists in the Soviet view to warrant the 19 measures that have been and are being taken to protect workers and the general 20 indicates the existence of a data base within the Soviet Union This 21 public. showing that the proposed transmission line will probably cause biological 22 There has been no serious attempt to uncover the Soviet data base. effects. 23 It is my understanding that Allen Frey may relate information gained on his 24 recent visit to the Soviet Union to study research methods employed there to 25 these proceedings. 26

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ANALYSIS

The proposed transmission lines will carry about 1000 megawatts of electrical 4 The power will be manufactured at one location, transported, and 5 power. ultimately used or consumed at the terminus of the transmission line. The 1000 6 megawatts' will travel from the point of generation to the point of consumption 7 not through the conductors, but rather through the space surrounding them (4) 8 The region which the transmitted power occupies extends a (See Figure 1). 9 considerable distance outward from the transmission line. When an individual 10 is within this region, a portion of the electrical power being transmitted 11 impacts him. The amount of energy which impacts the individual depends on his 12 size, his distance from the transmission line, and how long he stands there. 13 Transmission line energy is composed of an electric field and a magnetic field. 14 Thus, when subjects are exposed to the energy of the proposed transmission 15 lines, they will actually be exposed to simultaneous electric and magnetic 16 It has been shown that ELF electric fields and ELF magnetic fields fields. 17 The "real life" situation separately cause biological effects (Table 4). 18 however, namely, the simultaneous and phased application of both fields, has 19 not been studied. The biological response to the simultaneous application of 20 the fields may be equal to the summation of the effects produced by each field, 21 or may be greater than the summation of the independent effects of the two 22 The latter response is called potentiation and represents the 23 fields. condition whereby one agent is made more potent in the presence of another 24 25 agent. Thus, the situation which will actually occur under the proposed transmission lines, namely, the phased simultaneous application of the electric 26 and magnetic fields, has not been studied experimentally. We do not know whether 27

URT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72)

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there will be a synergistic effect between them. Moreover, we have no idea whether synergistic effects will occur between the energy flux of the proposed transmission lines (i.e., the electric and magnetic field taken together) and other agents present in the environment at various locations along the rightof-way. Such agents may be electrical (radar, radio stations, etc.) or nonelectrical in nature (air pollution, drugs, etc.).

CONCLUSION

Substantial and significant energy levels due to the proposed transmission 9 lines will exist within the right-of-way and for considerable distances beyond. 10 The energy levels are composed of phased, simultaneously present, electric and 11 While experiments have shown that each field separately can magnetic fields. 12 cause biological effects, no experiments have been performed to test the 13 possible synergistic effects. Thus, we have no basis for assessing whether the 14 effects occurring under the proposed transmission line will equal or exceed the 15 sum of the effects observed when each field is applied separately. Moreover, 16 the possibility of synergistic interaction between exposure to the energy flux 17 proposed transmission line, and other factors present in the the 18 of environment, has yet to be considered. 19

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6. TRANSMISSION LINE RADIATION

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3	THE PHYSICAL PHENOMENON
4	Robert Helliwell of the Radioscience Laboratory, Stanford University, has
5	investigated the propagation of Very Low Frequency (VLF) (300 hz-30khz)
6	electromagnetic waves between Roberval, Quebec, and Siple Station in the
7	Antarctic (117). The two stations are conjugate, each being located at the end
8	of a magnetic field duct (See Figure 4). Very Low Frequency (VLF) energy which
9	enters the duct is channeled along it and passes into the magnetosphere where
10	it interacts with electrons to produce a variety of new frequencies and time
11	variations which are detectable at the conjugate point.
12	
13	Lightning discharges produce VLF electromagnetic waves which enter the ducts.
14	It is also possible to deliberately inject such waves into a magnetic duct such
15	as via the 21.2 km antenna located at Siple. Helliwell found that
16	electromagnetic radiation from the Canadian power system is inadvertently being
17	injected into and channeled along the particular magnetic duct which he employs
18	in his measurements (117).
19	
20	The VLF electromagnetic waves which enter the duct pass into the magnetosphere
21	where they interact with trapped electrons and the frequency of the VLF wave,
22	Helliwell has found that the magnetospheric amplification process occurs for an
23	input power as small as ten watts, and can result in a gain of more than three
24	orders of magnitude. Some electrons which have surrendered energy to the wave
25	drop out of the magnetosphere and rain down on the ionosphere. This in turn
26	causes collision processes which produce a spectrum of bremsstrahlung x-rays
27	(117).

URT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72)

1 There is a normal background of precipitated electrons due to galactic sources 2 and natural electromagnetic noises, and there are intermittently higher counts 3 when a nearby lightning discharge occurs. Thus, the electron precipitation 4 caused by power lines is additive to that which occurs naturally.

6 No research has been performed to determine either the magnitude or the 7 biological significance of the electron precipitation caused by high voltage 8 transmission lines.

We need to know first the amount of power that will be radiated by the proposed 10 transmission lines at the fundamental frequency and at the first 100 harmonics. 11 Second, we need to know the magnitude of the natural versus artificially 12 Third, we need to know the spatial electron precipitation. 13 induced distribution of the precipitated electrons. Fourth, we need to know the nature 14 of the interaction process which occurs when the electrons precipitate onto the 15 ionosphere, and the biological consequences thereof. There are plans to use 16 satellite to measure the electron Electrodynamics Explorer 17 the NASA precipitation caused by specific Siple Station transmissions (118). This will 18 provide the first measurements of the magnitude of the electron rain, and its 19 relationship to electromagnetic energy of specific frequency and amplitude. 20 There are, however, no plans to conduct measurements useful for directly 21 evaluating the proposed transmission lines. Satellite observations have shown 22 that VLF electrical activity has the highest probability of occurrence in 23 regions threaded by geomagnetic field lines that intersect industralized areas 24 The results tend to confirm recent land-based observations of the (119). 25 influence of transmission line radiation on magnetospheric dynamics (120). 26

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- 43 -

I Thus, there are strong indications (117, 119, 120) that radiation from transmission lines plays a significant and hitherto unsuspected role in the dynamics of the magnetosphere.

THE POSSIBLE BIOLOGICAL CONSEQUENCES

The precipitated electrons will be scattered by particles in the upper 6 ionosphere; and in that process will emit x-rays of about 2 kev. Such photons 7 have a radiation length of less than 1/2 km, and are, therefore, absorbed far 8 above the earth's surface. The absorption gives rise to secondary processes 9 which involve the production of ultraviolet light (UV) which can pass through 10 the atmosphere and strike the earth. One effect of the electron rain would, 11 therefore, be expected to be an increase in the total amount of UV which 12 strikes the earth. Qualitatively, an increase in the UV that strikes the earth 13 is quite capable of causing biological effects. The number of instances of 14 human skin cancer depends in part on the amount of UV at ground level (121). 15 Interest in this relationship has been stimulated by the possible link between 16 freon and depletion of the ozone layer of the atmosphere, a process which also 17 has the effect of increasing the UV which strikes the earth via a completely 18 different mechanism. Thus, the radiation from the proposed transmission lines 19 could increase the amount of UV that strikes the earth in sufficient amounts so 20 as to increase the incidence of human skin cancer. 21

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23 There is another possible effect associated with the proposed transmission 24 line, which is related to the earth's climate. Solar emission of UV and 25 charged particles varies with sunspot activity (122). A number of workers have 26 shown a relationship between these variations and changes in the earth's 27 climate (122-124). Thus, the physical factors which appear to be related to

URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72)

	· · · · · · · · · · · · · · · · · · ·
1	climatic change also occur as a consequence of the radiation from high voltage
2	transmission lines, thereby raising the possibility that such lines may cause
3	changes in global weather patterns.
4	
5	Professor Helliwell's reaction to the possibility of biological consequences
6	arising from the physical phenomenon which he discovered appears to be an
7	opinion that such consequences have not been demonstrated and are unlikely to
8	occur (125). It is readily apparent, however, that the question has not been
9	adequately considered.
10	
11	CONCLUSION
12	The proposed transmission lines may cause increases in human skin cancers and
13	may cause modification of global weather patterns. It appears wise to
14	impartially consider both possible global impacts of the proposed transmission
15	lines prior to their construction.
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IRT PAPER	- 45 -
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51	7. ARGUMENTS PURPORTING TO SHOW THAT THERE WILL BE NO HARMFUL
2	BIOLOGICAL EFFECTS IN SUBJECTS EXPOSED TO THE ELECTRIC AND MAGNETIC FIELDS
3	OF HIGH VOLTAGE TRANSMISSION LINES
4	SUCH AS THE PROPOSED SUNDESERT TRANSMISSION LINES
5	
6	INTRODUCTION
7	Four distinct arguments have thus far been advanced by proponents of high
8	voltage transmission lines to show that such lines are safe.
9	A. Experimental Scientific Evidence. It is argued that there exists
10	laboratory evidence upon which one may confidently base a judgment that high
11	voltage transmission lines such as the proposed Sundesert 500 kV transmission
12	lines will not cause biological effects in subjects exposed to the electric and
13	magnetic fields thereof.
14	B. Biophysical Calculations. It is argued that it is possible to do
15	mathematical calculations which are properly applicable to subjects exposed to
16	high voltage transmission lines such as the proposed Sundesert 500 kV
17	transmission lines which establish that, according to the laws of physics and
18	engineering, such transmission lines will not cause biological effects in the
19	exposed subjects.
20	C. Utility Operating Experience. It is argued that high voltage transmission
21	lines such as the proposed Sundesert 500 kV transmission lines are safe because
22	there are no recorded instances of death or injury or disease of any kind
23	attributable to exposure to their electric or magnetic fields.
24	D. Difference Between "effect" and "hazard." It is argued that not every
25	biological effect that may be caused by the electric or magnetic field of high
26	voltage transmission lines in subjects exposed thereto is necessarily
27	hazardous, and therefore, if a determination of the existence of a biological

- 46 -

JRT PAPER TE OF CALIFORNIA . 113 (REV. 8-72)

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1	effect is made, there must be a further determination that the effect is a
2	hazard before the utility company may be required to cease the production of
3	the effect.
4	
5	SPECIFIC ARGUMENTS
6	A. Experimental Scientific Evidence
7	There are two distinct issues which arise with regard to the biological effects
8	of the electric and magnetic fields of high voltage transmission lines such as
9	the proposed Sundesert 500 kV transmission lines. <u>Can</u> such fields cause
10	biological effects; and, will such fields cause such effects? When we turn to
11	the relevant scientific literature in an attempt to examine these issues, we
12	find two general categories of studies. There are experimental studies in
13	which the investigator observed a cause and effect relationship between the
14	applied field and the parameter being measured ("found an effect"), which I
15	shall refer to as ELF-plus reports. Similarly, there are studies in which the
16	investigator failed to observe such a relationship (ELF-minus). Thus, there
17	arises the question of which group of studies logically constitutes acceptable
18	scientific for each issue.
19	
20	ELF-minus reports have scientific value on the issue whether high voltage
21	transmission lines, such as the proposed transmission lines, can cause
22	biological effects in exposed subjects in only two cases, (1) wherein ELF-plus
23	reports do not exist, and (2) wherein both ELF-minus and ELF-plus exist and
24	contradict one another. Neither case applies in the present hearing (Table 4).
25	In all cases other than those enumerated above, the ELF-minus reports merely
26	establish the existence of certain conditions for which a specific effect is

27 not observed. The establishment or enlargement of this limited class does not

- 47 -

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RT PAPER E OF CALIFORNIA 113 (REV. 8-72) make it more likely that the class of all conditions will be unproductive of a biological effect, because the ELF-plus already exists. Thus, the ELF-minus serve no evidentiary purpose with respect to the issue of the possibility of biological effects.

The ELF-minus reports have significance with regard to the issue of whether the 6 7 proposed transmission line will cause physiological, growth, or behavioral effects in the exposed subjects. The weight accorded: to each report will 8 9 depend on how closely it relates to the actual conditions that would prevail if the proposed transmission line were to be constructed. Thus, the ELF-minus 10 experiments performed in connection with Project Sanguine (Sanguine-ELF-minus), 11 will clearly have significance and some weight on the issue whether the 12 Sanguine antenna will cause biological effects. The Sanguine experiments, 13 14 however, were performed at Sanguine field strengths, which are about one million times less intense than the field strength of the proposed transmission 15 16 line. Therefore, the Sanguine-ELF-minus reports, although of significance in this proceeding on the issue stated, can be accorded little weight. Indeed, 17 all ELF-minus reports thus far cited, in the present proceeding and in the New 18 York proceeding, can be afforded little weight with respect to the issue 19 20 whether the electric and magnetic fields of high voltage transmission lines will cause biological effects in subjects exposed thereto because, in each 21 instance, the studies were performed under laboratory conditions of exposure 22 that were vastly less intense than those that prevail near typical high voltage 23 transmission lines with respect to applied field strength and duration of 24 25 exposure (126).

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27 The ELF-plus reports are the only proper scientific evidence on the first issue

stated above. They establish beyond reasonable doubt that ELF fields <u>can</u> cause biological effects. They are obviously evidence on the issue whether high voltage transmission lines such as the proposed Sundesert 500 kV transmission lines <u>will</u> produce such effects in the exposed subjects, and are open to the same test for weight as described above.

6

7 I conclude therefore that the ELF experimental literature affords the 8 proponents of high voltage transmission lines such as the proposed Sundesert 9 500 kV transmission lines no substantial support that exposure of the general 10 population to the electric and magnetic fields of such lines will not cause 11 biological effects.

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B. Biophysical Calculations

By biophysical calculations are meant mathematical computations involving 14 biological systems on the basis of which it is argued that some effect can, or 15 will, or cannot, or must, occur as a consequence of ELF field exposure. 16 Arguments based on theoretical calculations of necessity depend on numerous 17 unverified and unverifiable assumptions concerning the nature of the physical 18 system under investigation. Theoretical calculations of the possibility of ELF 19 electric or magnetic field biological effects are properly employed to guide 20 They are, however, not evidence scientists in the choice of experiments. 21 because they are incapable of conveying information bearing on the likelihood 22 of any biological effect due to ELF field exposure. Before any theoretical 23 calculation, one knows that any given biological effect is either impossible, 24 definite. The calculation leaves the situation possible, probable, or 25 unchanged. This chronic infirmity of theoretical calculations is recognized in 26 other forums. A review of the major environmental health issues raised in the 27

- 49 -

URT PAPER TE OF CALIFORNIA 113 (REV. 8-72) Finited States has not revealed a single example wherein a state or federal regulatory agency or court has given decisional impact to theoretical calculations showing the absence of the possibility of a biological effect when competent investigators have reported such effects. Theoretical calculations are, therefore, not evidence on either issue discussed above.

6

C. Utility Operating Experience

While it is true that no documented instances of harm to members of the public 8 have resulted from exposure to the electric or magnetic field of existing high 9 voltage transmission lines, such as the proposed Sundesert 500 kV lines, it is 10 likewise true that no significant epidemiological studies have been performed 11 upon which a claim that no such harm has occurred might be based. At best, 12 therefore, the claim rests upon brief and uncontrolled observations to the 13 general effect that existing lines do not appear to be causing harm in the 14 exposed subjects. The absence of gross, immediate, acute, and obvious effects 15 on health when one passes near a high voltage transmission line is indeed a 16 kind of low-level indication that such lines are not obviously hazardous. Even 17 though most people probably do not know what electric or magnetic fields are, 18 if very gross sorts of things happened to people or animals in the vicinity of 19 a transmission line, then surely a connection between them and the line would 20 When one entertains the idea of more subtle effects occurring, then 21 be made. brief and uncontrolled observations are utterly inadequate for the purposes of 22 By way of example, if the absence of proper epidemological 23 assessing hazard. studies together with brief and uncontrolled observations were sufficient to 24 indicate the absence of subtle hazard, then the absence of parallel studies, 25 with parallel observations in the controversy surrounding the 26 together depletion of atmospheric ozone or surrounding the contamination of the 27

JRT PAPER TE OF CALIFORNIA 113 (REV. 8-72) 1 watershed by chlorinated hydrocarbons could be viewed as evidence that these
2 phenomena are not hazardous to human health. Since such an argument is
3 unreasonable, I conclude that the operating experience of the utility companies
4 affords no substantial evidence that high voltage transmission lines such as
5 the proposed Sundesert 500 kV transmission lines are safe.

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D. Difference Between "Effect" and "Hazard."

The proposed transmission lines are a regulatory-public health problem with the 8 following aspects. A private corporation (applicant) is manufacturing a 9 product (electric power). As a consequence of the production of its product, 10 the corporation emits or causes to be emitted a substance or entity (electric 11 and magnetic field) into the environment. Let us assume that the entity causes 12 a biological effect (otherwise there would be no hazard) in some part of the 13 general population exposed thereto. The assumed biological effect may be any 14 physiological, growth, or behavioral effect. Finally, the affected part of the 15 general population has neither given informed consent to the production of the 16 biological effect within themselves, nor are they aware of the production of 17 such effects. 18

19

In such a situation, there is a strong presumption that the biological effect is potentially hazardous. I have found no instances which a state or federal court, or administrative agency indulged in the contrary presumption. there is no precedent for an argument by the private corporation that they should not be regulated because the effect that they caused in the exposed subjects had not been proved hazardous.

26

27 The presumption of hazard arises directly from the proscription against

involuntary human experimentation. To urge that a biological effect induced in subject exposed to the fields of high voltage transmission lines should not a 2 be prevented until it has been shown to be hazardous is tantamount to urging 3 the performance of human experimentation to evaluate the degree of biological 4 insult caused by the transmission lines. Moreover, such human experimentation 5 would be involuntary since, in the setting described above, informed consent is 6 Since involuntary human experimentation is a completely not obtained. 7 unacceptable alternative, it follows that any biological effect caused by high 8 voltage transmission in exposed subjects is strongly presumed to be hazardous. 9 I conclude therefore that there is no basis for a distinction between an 10 "effect" and a "hazard" in the context of high voltage transmission lines such 11 as the proposed Sundesert 500 kV lines, and that such a distinction is 12 medically unethical (Becker, New York, 9004) and unprecedented. 13 SOL MICHAELSON 14 SUBSTANTIVE ARGUMENTS 15 Based on an analysis of scientific experiments, applicant's witness Michaelson 16 has concluded that the proposed transmission line's electric and magnetic field 17 will not cause significant biological effects in exposed subjects (Michaelson, 18 Based on an analysis of two surveys, he concluded that the proposed 5*). 19 transmission lines will not interfere with farm workers, reduce crop growth or 20 milk production, or harm farm animals (Michaelson, 22). Based on the work of

Dalziel and Underwriters Laboratories, Michaelson has concluded that six 22 milliamperes of steady-state shock current is safe for the general public 23 26). In each instance, however, the bases cited by Michaelson do (Michaelson, 24 Additionally, conclusion. significant support for his not furnish any 25 26

Citations herein to the testimony *Page 5 of Michaelson's prefiled testimony. 27 of all witnesses will be identical in form.

- 52 -

OURT PAPER TATE OF CALIFORNIA TD. 113 (REV. 8-72)

Michaelson has given testimony regarding the Soviet experience with high
voltage transmission lines which may be misleading to the Commission
(Michaelson, 16-17), and he has urged the Commission to adopt a distinction
between an "effect" and a "hazard" which is wrong because it is ethically
impermissible (Michaelson, 6).

6

Scientific Experiments. Michaelson cited the work of Kouwenhoven, Singewald, 7 Hauf and colleagues, Knickerbocker, Johansson, and Beischer. Hauf and his 8 colleagues have reported that ELF fields caused a nonspecific stimulatory 9 response in human subjects after three hours of exposure (22). Knickerbocker 10 has reported that ELF fields produced stunted growth in mice (30). Johansson 11 reported that exposure to ELF fields for 75 minutes appeared to alter human 12 reaction times (21). Beischer reported that ELF fields caused increased serum 13 triglycerides in humans after one day's exposure (81). It is therefore not 14 logical to cite the work of Hauf, Knickerbocker, Johnasson, or Beischer as 15 support for the view that the proposed transmission line will be safe. The 16 Kouwenhoven-Singewald survey (95-96) was an uncontrolled clinical study, and 17 thus at most could reveal only gross biological effects. 18

19

20 Inasmuch as the reports described above are a complete listing of those cited 21 by Michaelson, it must be concluded that he has not furnished any significant 22 support for his conclusion that the proposed transmission line will not cause 23 biological effects in exposed subjects.

24

25 Agriculture Impact. Based on a survey by Busby (127), and on a utility company 26 internal report (128), Michaelson has testified that the proposed Sundesert 500 27 kV transmission lines will not adversely affect farm operations. In the Busby

RT PAPER E OF CALIFORNIA 113 (REV. 8-72)

survey, two dairymen reported that milk production had increased following 1 construction of the transmission line, and two reported that there had been no 2 change (129). Additionally, 11 crop farmers reported that they were satisfied 3 with their crop yield, however, seven farmers reported dissatisfaction with 4 5 crop yield. Of the nine farmers who grazed animals under the transmission line, three farmers reported that the line altered the pattern of grazing. In 6 the utility company report, 125 farmers were surveyed with regard to their 7 attitude toward high voltage transmission lines. The company said that 77 8 percent of the respondents found that the transmission lines caused no farming 9 10 problems, but that 23 percent complained of some interference in farming 11 operations due to the transmission line.

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13 It is not reasonably possible to rely on the two studies to conclude that the 14 proposed transmission lines will not adversely affect farming. On the 15 contrary, they indicate that the impact of high voltage transmission lines is 16 largely unexplored and potentially significant.

17

18 <u>Steady-State Shock Current</u>. Michaelson stated that six milliamperes is a safe 19 current for an adult or child to experience when touching an ungrounded 20 metallic object near the right-of-way of the proposed transmission lines. He 21 believes that the six milliampere level may be painful, but will not lead to 22 any serious after-effect (Michaelson, 25). Michaelson gives no relevant 23 literature citations however, and thus provides no basis whatever for his view. 24

25 It is quite clear that testimony regarding the biological consequences of 26 steady-state shock current is useless in the absence of a specification of both 27 the magnitude and duration of current flow. In our laboratory we apply direct

URT PAPER ATE OF CALIFORNIA D. 113 (REV. 8.72)

entrents of the order of 0.0001 milliamperes to patients according to a strictly regulated and monitored human experimentation protocol. Utilizing 2 such currents, we have caused bone to grow in cases in which standard 3 orthopedic procedures had failed and amputation was the only other alternative 4 (7). Normally, such currents were applied for about 1,000 hours. 5 6 It should be noted that Michaelson has testified in New York that currents on 7 the order of 0.005 milliamperes may have been responsible for the stunting of 8 growth of mice (1) (Michaelson, New York, 11644). 9 10

Soviet Experience with High Voltage Transmission Lines. Based on an analysis 11 of the Soviet literature, Michaelson has concluded that the Soviet research is 12 because it lacks details concerning methods, procedures and unreliable 13 (Michaelson, 16). The implication of his testimony is that the statistics 14 Commission should afford the Soviet scientific literature very little weight. 15 however that it is quite possible that the Soviet Michaelson has conceded 16 literature which he read and found wanting in descriptive detail was so lacking 17 because he did not read the actual Soviet reports, but read only a summary 18 thereof in a Soviet literature review article (Michaelson, New York, 9875-76). 19 Consequently, the implications of Michaelson's testimony with regard to the 20 Soviet scientific literature should be rejected. 21

Quoting uncited documents, Michaelson states that Soviet high voltage transmission lines produce more intense ground-level electric fields than those that will be produced by the proposed transmission lines, and he states that the Soviets have had no problems of biological significance as a consequence of such fields (Michaelson, 17). The implication of his testimony is that since

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- 55 -

The Soviet design criteria permit ground-level fields higher than those proposed for the Sundesert 500 kV transmission lines, and since the Soviet 2 experience has not uncovered any biological problems, that, operating 3 therefore, the Soviet experience supports the applicants position that the 4 proposed transmission lines will be safe. Michaelson chooses to ignore, 5 however, the applicable Soviet rules and regulations which are part of the 6 Soviet regulatory response to high voltage transmission lines. The Soviets 7 have work rules governing the extent of exposure to high voltage transmission 8 They are developing comparable rules for other line electric fields (90). 9 Soviet high voltage transmission lines are built 984-1,640 feet groups (92). 10 They are not built within 328 feet of from planned population sites (92). 11 inhabited dwellings (92). For 1100 kV transmission line referred to by 12 Michaelson, the Soviet Zone of Influence is 756 feet (130). Within the Zone of 13 Influence, unauthorized people are not permitted (130), and agriculture is 14 limited and must be carried out in shielded machinery (92). Beaches and shops 15 must be located a sufficient distance from the edge of the Zone of Influence 16 (92). Buildings are not permitted within the Zone (92). It is within a set of 17 rules and regulations and procedures, that the favorable operating experience 18 referred to by Michaelson has been achieved. To the extent therefore, that 19 Michaelson's testimony implies that the Soviet operating experience with regard 20 to high voltage transmission lines supports the position of the applicant, his 21 testimony is in error. 22

23

24 <u>Distinction Between "Effect" and "Hazard</u>." Michaelson urges that there is a 25 distinction between an effect and a hazard (Michaelson, 6. It would be grossly 26 improper, however, for the Commission to draw such a distinction in the context 27 of this hearing (Section 7, <u>supra</u>). A biological hazard in the context of the

- 56 -

JRT PAPER TE OF CALIFORNIA 1. 113 (REV 8-72)

proposed transmission lines is any biological effect induced in the bodies of exposed subjects, or likely to be so induced based upon an evaluation of laboratory experimentation, which has not been shown clearly and convincingly to be harmless (Carstensen, New York, 6428). Michaelson, would reverse the usual burden of proof (Michaelson, New York, 3721, 10407). His view however, is alien to our system because its implementation would constitute involuntary human experimentation. 57 -URT PAPER TE OF CALIFORNIA). 113 (REV. 8-72.

B. Professional Background

Michaelson is a veterinarian, and he has published 26 articles in the field of veterinary medicine.

Early in his professional career, Michaelson acquired an interest in the biological effects of ionizing radiation. He subsequently published 35 papers dealing with the clinical symptoms manifest by laboratory animals, principally dogs, when they have been subjected to very large doses of X-rays. In almost all of his experiments, the procedure followed was identical. The animals were irradiated for several minutes, following which the dead animals were removed for autopsy and the remaining animals were observed closely to determine how long they could survive and, when death occurred, the precise cause thereof. In one of his first studies involving X-rays (p-3), Michaelson irradiated 100 dogs and found that only about 20 survived for one month following the exposure. In another experiment (p-4), he obtained comparable results. In experiments involving 95 dogs (p-16), Michaelson reported that 250 r (roentgen, a measure of ionizing

* Publication number 8 in the list of publications appended to the prefiled testimony of applicant's witness Michaelson. All citations herein to the list of publications will be identical in form.

OURT PAPER TATE OF CALIFORNIA TD. 113 (REV. 8-72)

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energy) of X-rays killed 50% of the dogs tested when the X-rays were directed against the dog's entire body, whereas 1775 r was required to kill the same percentage when only the head was irradiated. Comparable results were obtained when a different source of X-rays were employed (p-17). Michaelson developed a technique for irradiating the dog's heart with 20,000 r so as to produce cardiac necrosis (p-24). He described the neurological and clinical changes observed in dogs exposed to 5,000-50,000 r X-rays to the head (p-27). During exposure there was an increase in respiratory rate with continuous salivation. Immediately after exposure there was evidence of disturbance in equilibrium and vomiting occurred.

The dogs survived for 12-16 days. Comparable results were obtained in a related experiment (p-36). Michaelson has reported that dogs irradiated with 1,800 r were not able to perform exercises as efficiently as dogs that were not irradiated (p-40). In studies involving 52 dogs, Michaelson concluded that X-rays can damage the thryoid gland and thereby induce hypothyroidism (p-45).

About ten years after the beginning of his professional career, Michaelson became interested in the biological effects of microwave radiation. Since then he has published 51 papers which deal with the effects of microwaves. In 13 of the papers, Michaelson reported the results of laboratory experiments in which he participated. In the remaining 38 publications, which are all essentially identical, Michaelson expressed opinions concerning microwave effects and microwave safety. His 13 laboratory studies of microwave effects closely parallel his ionizing radiation studies. That is, in almost all instances the animals under study were given short duration, high intensity doses of microwaves. The frequency and intensity of the microwaves used by Michaelson were both comparable to those employed in normal

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house-hold microwave ovens, and the effects on the test animals were comparably obvious. When Michaelson exposed dogs to 2-1200 mM/cm² for 2-3 hours, he observed that the dogs began to pant as soon as the irradiation was begun (p-19). As the exposure was continued the rate of panting increased, and the dog's body temperature rose. Salivation occurred and the dogs became restless. Weakness developed, and the animals became prostrate; thirst increased. In another study (p-37), Michaelson reported that 100 mM/cm² at 2800 MHz caused extreme agitation, excessive salivation, labored panting, frequent rasping, impairment of locomotion, acute distress, and exhaustion. In the dogs exposed at 1285 MHz however, the effects were less severe. Michaelson has shown that animals exposed to microwaves experience thermal stress, and deep burns sometimes develop (p-43). Utilizing 165 mM/cm² at 2800 MHz, Michaelson found that about 85 minutes is required to kill dogs, whereas rabbits survive for 10 minutes and rate survive for 20 minutes (p-51). Comparable results were obtained in later studies (p-73, p-84).

Michaelson conceded that he has done no original research in the ELF area (Michaelson, 5208), but claimed that he had published two review articles dealing with ELF (Michaelson, 5207). His statement is not correct, however, because notwithstanding their titles neither of the two articles which he cited (p-86, p-92) deal with the ELF literature.

One can find nothing in Michaelson's professional experience as a veterminarian or researcher which indicates that he posesses knowledge or expertise in the area of the biological effects of the electric and magnetic fields associated with ELF radiation. Additionally, there is no indication from Michaelson's publications or his academic background as he has described it in his various testimonies which gives evidence that he posesses the mathematical or biophysical tools necessary to appropriately analyze the

- 60 -

URT PAPER TE OF CALIFORNIA 113 (REV. 8-72)

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research of others in the ELF area for the benefit of the Commission. In proceedings involving the health hazards of various electrical devices and systems, Michaelson has testified on behalf of the Association of Home Appliance Manufacturers (132), Rockland Utilities Company (133), Raytheon Company (134), Rochester Gas and Electric Corporation (135), Niagara Mohawk Power Corporation (135), as well as SDG & E. In none of these testimonies is there an indication that Michaelson posesses the requisite educational background in physics or electrical engineering to attempt to integrate and synthesize the work of other researchers.

The research which Michaelson performed utilizing X-rays and microwaves 11 deal with phenomena not observed in dealing with ELF experimental data. 12 invariably involved the production of immediate and obvious effects 13 following very acute exposure. In such research, both the existence of 14 an effect, and its cause, are absolutely certain. There is no dispute 15 concerning the seriousness and life-threatening nature of the effect. 16 The study of such biological phenomena may make it difficult to appreciate 17 the original research of others in which the biological effects do not 18 occur immediately upon application of the radiation, and in which the 19 effect may be consistent with the survival of the test animal for the 20 21 duration of the experiment.

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C. Other Matters.

2 Michaelson has evolved two chronologically distinct but substantively 3 identical careers as an advocate for the corporate viewpoint concerning the 4 health hazards on nonionizing radiation at both ends of the electromagnetic 5 spectrum. Sometime around 1968 he became a spokesman for the corporate 6 interests in the microwave frequency portion of the spectrum. Thereafter, 7 all his public testimony and articles espoused the corporate view that only 8 thermally induced effects were possible in biological systems. This public 9 posture was a reversal of his pre-1968 public posture to the effect that 10 non-thermal (low-level) effects were possible. Michaelson's post-1968 11 position in regard to microwaves is distinguished by three characteristics; 12 (1) he consistently espouses the corporate view but never provides analysis, 13 arguments, or data to support his view, (2) he has performed no research 14 at the exposure levels at which he says no effects exist, and (3) he has 15 organized all investigators in the field into two classes; those who agree 16 with his view, and those who perform poor research or are otherwise incompe-17 tent.

Sometime around 1974 Michaelson became a spokesman for the corporate interests in the power frequency portion of the electromagnetic spectrum. Thereafter, all his public testimony and articles espoused the corporate view that no biological effects are possible as a consequence of exposure to the electric or magnetic fields of high voltage transmission lines. This public posture was a reversal of his pre-1974 public posture that such biological effects were likely. Michaelson's post-1974 position in regard to the power frequency of 60 hertz is distinguished by the same three characteristics enumerated above.

- 62 -

JRT PAPER TE OF CALIFORNIA . 113 (REV. 8.72)

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Infference Between Michaelson's pre- and post-1968 Posture on Microwaves.

In 1967 (136), Michaelson wrote;

Sufficient factual data are not available to establish a comprehensive safe level for microwave exposure because of factors related to microwave frequency which influence the biological response to this energy.Certain findings such as a possible effect on bone marrow and the thyroid must be carefully evaluated because of their subtle nature and questionable relationship to thermal effects... ... Further knowledge of microwave hazards especially those of a subacute nature are required to establish safety regulationsThe present "safe" (sic) level of 10 mw/cm² for whole body exposure, which is based on the average power density for all frequencies, has remained unchanged since its adoption.....

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In 1973 however, on behalf of the Association of Home Appliance Manu-

11 facturers he testified that (137);

It is important to realize that the standard of 10 mw/cm² is a factor of ten below threshold of damage, assuming a long duration of exposure. This is an exceedingly safe level of exposure. It should be pointed out that the scientific and medical communities, after intensive investigations, have not been able to produce any substantiated evidence of injury below the level of 100 mw/cm²... As for the question of sensitivity of the nervous system, based on biophysical principles, there just is not enough energy from microwaves to result in any conceivable effect.

Following this testimony, a colloquy occurred between Michaelson and

19 Senator Tunney of California (138).

Senator TUNNEY: Dr. Michaelson, on page 88 of a study authored by you entitled, "Biological Effect is of Microwave Exposure," you state in regard to the studies undertaken by the Soviets, and I quote:

"The occasional reports of headache pains, sleeplessness, and other highly subjective symptoms among workers in the vicinity of microwave generating equipment have not been thoroughly investigated. These findings should not be ignored, as similar vague, mild and undefined symptoms which have been experienced in the course of microwave symptoms in the laboratory. Such symptoms do indicate a basic microwave effect."

Now, I would say that reading that statement and listening to your testimony would make it appear to me 2 that you have changed your opinion since you wrote these words. Have you changed your opinion? 3 Dr. MICHAELSON: Yes; remember, that was written in 1966 and it came out - you are talking about that blue-4 covered report? Senator TUNNEY: Yes; it was written-5 Dr. MICHAEISON: It came out in 1967. Senator TUNNEY: Well, it is "Biological Effects of 6 Microwave Exposure" by Dr. Sol M. Michaelson, Roderick A. E. Thomson, Joe H. Howland, University of Rochester, Depart-7 ment of Radiation, Biology and Biophysics. Dr. MICHAELSON: Yes that's all right. I know which 8 one it is. I have written extensively since then and I have been very fortunate in having had the opportunity to read and 9 survey the literature extensively and intensively in the last several years. I have also been very fortunate to be affil-10 iated with many organizations in which these problems are being discussed, and I have been able to critically analyze 11 many, many of the problems and I feel more confident now than what I appear to have been in 1967. I tend to be 12 conservative in thinking biologically and scientifically. We were asked to review the literature at that time and 13 we did the best job that we could. However, we do have six more years of experience now and we feel much more 14 secure. 15 A few moments before the colloquy with Senator Tunney, Michaelson 16 stated (139); 17 There is no reason to believe that current standards are inadequate for protection of the public No new 18 data from the literature and no new valid arguments have been presented to change the situation from what it was 19 last year, four years ago, or 15 years ago. 20 Difference Between Michaelson's pre- and post-1973 posture in MLF. 21 In 1973 (140), referring to a planned Nevy study of the offects of TLF 22 fields on human volunteers, Michaelson said; 23 It may be argued that man has been exposed for nearly 3 generations to electrical utility fields without apparent 24 ill effects. However, at no time have suble effects of LAF radiation been investigated carefully. It appears entirely 25 possible that these fields are involved in the etiology of certain human illnesses which have increased spectacularly 26 during the last century. Assenova in the USSR found cardiovascular effects and the asthenic syndrome in 50 persons 27 - 64 -JURT PAPER OF CALIFORNIA

113 (REV. 8.72)

(exposed) off and on for 2 to 4 years to the fields of electric power stations (50 hz, a few gauss and 2 to 40 kV/m). Besides serving the needs of an environmental statement by 2 the Mavy, the study may shed light on Previously unrecognized effects of utility power. 3 Human participants will be exposed exclusively to conditions under which millions of people live all over the world. However, 4 the laboratory environment allous to control (sic) the environmental conditions and to make tests which are expected to reveal 5 subtle changes in the clinical physiological and psychological make-up of exposed persons. Thus, the services of a few may benefit 6 the public in general and the specific purposes of the Navy. At no time before have the biological effects of magnetic 7 and electrical fields in the utility power frequency range been investigated in the throughness planned in this project. If 8 certain effects should be found, and our preliminary investigation indicates the possibility, many people will benefit from 9 the suggestion of precautionary measures. 10 In 1975 however, on behalf of the Rochester Gas & Electric Corporation 11 and the Niagara Mohawk Power Corporation, Michaelson said that exposure to 12 the electric and magnetic fields of high voltage transmission lines would 13 not produce biological effects in the exposed subjects. (Michaelson, New 14 York, 3718). Referring to the Sundesert 500 kV transmission lines he said 15 (Michaelson, 5268); 16 As far as these power lines are concerned, I still think we have had a lot of experience. We have had 50 years 17 of power lines, from very low voltage power lines to high voltage power lines. 18 This is worldwide, goes for populated areas, goes over farmland; and we really haven't seen anything. If there 19 were any overt responses, I am sure it would have been . recognized by now. 20 He also testified that (Michaelson, 5212); 21 ... we also have to understand that people have lived 22 in the vicinity of power lines for many, many years; if anything were to develop, it would be noticed by now. 23 Michaelson's position as regards the Assanova study (85) has similarly 24 undergone a transformation; he now believes that the study is virtually 25 worthless (Michaelson, 5252). 26 The Navy study to which Michaelson referred when he testified before the 27 - 65 -

Committee on Commerce led ultimately to two reports. One report showed that ELF fields caused elevated levels of serum triglycerides in human subjects (81). The other report showed that ELF fields caused alterations in the ability of human subjects to perform standard psychological tests. (64).

Michaelson did not address the latter report in his testimony, but said that the former report was deficient in both its design and conduct (Michaelson, 18-19). At the time the Navy study was designed and conducted, Michaelson was hired as a consultant by the Navy to assist in its design and conduct.

Absence of Support.

Michaelson's prefiled testimony is similar to that which he prefiled in New York in December, 1975 (141). Both testimonies contain almost no data and literature citations to support the conclusions stated therein. On January 27, 1976, interrogatories concerning his testimony were propounded to Michaelson by the Staff of the Public Service Commission. In particular, Michaelson was asked to:

> A. Provide citations to all reports or studies upon which the following statements are based:

 "It is my opinion that there will be no significant biological effects resulting from exposure to the electric and magnetic fields of the proposed lines."

In his reply of March 6, 1976, Michaelson cited only 2 reports (p-86, p-92), neither of which were relevant to the issue in support of

which they were cited.

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Response to Colleagues

Michaelson has not been completely fair in his evaluation of the work of his colleagues. For example, there was his evaluation of the work of Dr. Z. V. Gordon,

of the Institute of Labor Hygiene, Academy of Medical Sciences of the USSR, 11 Moscow. It occurred on July 10, 1975, during the course of his testimony 12 before the Board of Public Utility Commissioners of New Jersey on behalf 13 of Rockland Utilities. Michaelson had testified that only thermal effects 14 were possible as a consequence of microwave exposure, and that therefore 15 the microwave tower which Rockland sought to build would not be a health 16 hazard. Dr. Gordon however, had co-authored a book (146) in which she 17 described her experiments and those of her colleagues involving non-thermal 18 biological effects. During cross-examination Michaelson was highly critical 19

of Gordon, and the following colloquy occurred;

QUESTION: Now, doctor, did you say before that another one of the faults that you found in her testing methods was that she put the animals in cavities? MICHAELSON: No, I didn't say that. I said the fault with her testing method is that she put them in a battery of cages, not that she uses cavities. I didn't say that she uses cavities.

QUESTION: Well, what is the defect in that type of operation? MICHAELSON: As I mentioned before, you have no way of knowing, of getting a good assessment of the field by the interaction of one animal against another. That's one problem. She uses metal cages. Metal will act as an antenna.

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1	QUESTION: Would you have recommended plastic cages?
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	QUESTION: What is polystymone?
4	MICHAELSON: That's a plastic.
	QUESTION: That's a plastic?
	MICHAEISON: Yes.
e	in her tests. is that right?
	MICHAELSON: Most of her tests she uses metal cages.
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8	3
c	QUESTION: I'm quoting from page 10 of her introduction. She
	says "For irradiation with microwaves, and particularly with
10	dielectric loss angle of 0002 0002 Druging relief
	this quality there was negligible reflection of the waves
11	from the front (irradiated) wall of the cage and losses of
12	state that this woman used steel accor?
2.7	MICHAELSON: Yes. If you will look through there, you will
13	see the setup. There is a picture there of the way she had
14	OUESTION: Doctor, do you mean to tall me from Link to the
35	picture you can tell whether it's a metal or polystymene cage?
15	MICHAFISON: Yes.
16	uses polystyrene, she uses metal cages is that mights
17	MICHAELSON: Yes
17	JUDGE: Is it possible that she had the wrong picture in the
18	MICHAELSON: No. she has - this is - there is a lat of
	she's done many studies. I'm trying to find out if these are the
13	rats or rabbits she's talking about.
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D. 113 (REV. 8-72)	- 68 -
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### EDMARD CARSTENSEN

# A. Substantive Arguments and Professional Background.

Carstensen has concluded that the fields of the proposed Sundesert transmission lines will not produce biological effects in the exposed subjects. His conclusion is based on a series of biophysical calculations contained in a Report attached to his testimony. The calculations contained in the Report, however, are only arbitrary, unverified, and unverifiable hypotheses, and have virtually no predictive value with respect to the safety of the proposed transmission lines. Additionally, Carstensen has given substantially prejudiced testimony with respect to the ELF biological literature.

# Biophysical calculations.

In his Report Carstensen described some theories of physics, and then applied them to uniform oblate and prolate spheroids. In setting forth his various theories however, Carstensen dealt from a stacked deck. From among the infinity of scientific laws, rules, mathematical models, numerical data, assumptions, and hypotheses, he arbitrarily chose a specific subset of information which predicted that the proposed transmission lines would induce very small electric fields inside spheroids. No significant consequences however, flow therefrom because Carstensen's informational subset is not 19 unique, original, or prototypal, and because people are vastly more complex 20 than uniform prolate spheroids. There exists an indeterminately large num-21 ber of informational subsets, every one of which is equally correct, which 22 lead to an indeterminately large number of values of internal electric field 23 strength. It is possible to utilize equally valid informational subsets 24 and thereby demonstrate in inexorable fashion that the electric field that 25 would be induced by the proposed transmission line in various mathematical 26 models exhibits a variation of one billion per cent (5). Carstensen has 27

RT PAPER OF CALIFORNIA

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therefore literally assumed that which he purported to prove, namely, that the electric field induced inside his model by the proposed transmission line would be small. Carstensen has conceded that there has been no verification by measurement of any value of the electric field strength that he predicted would be induced inside animals or people exposed to the fields of high voltage transmission lines. (arstensen, New York, 7069).

7 A further and distinct error in Carstensen's analysis is his assumption, 8 sub silento, that if he could calculate the electric field strength induced 9 inside subjects exposed to the fields of the proposed Sundesert lines; then 10 he could determine whether that particular intensity would be hazardous to 11 health. For virtually all systems within the body, we lack knowledge of the 12 mechanism of action and control. Carstensen of course shares our ignorance. 13 For example, the mechanism by which the body controls the healing of bone 14 fractures is unknown. It therefore cannot be predicted whether the presence 15 of any specific intensity of electric field inside such healing tissue 16 would be safe. A similar comment applies to all healing tissue. The 17 mechanisms regulating the production of insulin by the pancreas and the 18 production of adrenalin by the adrenal glands are unknown. It therefore 19 could not be predicted whether the presence of a specific intensity of 20 electric field inside the pancreas or adrenals would affect their function, particularly when the field was applied for long periods of time. Similar comments apply to all the glands and organs of the body. The etiology of many human diseases is unknown. It could not therefore, be predicted whether the occurrence of such diseases would be altered by the presence of a specific intensity of electric field within the subject's body. The mechanisms underlying the processes of learning and memory are presently not understood. It could not therefore, be predicted whether these processes

- 70 -

URT PAPER 3 (REV 6-72)

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would be affected by the presence within the body of a specific intensity of electric field. Since the mechanisms underlying the great multitude of biological processes are unknown, Carstensen has no rational basis upon which to evaluate the impact of any specific intensity of internal electric field on physiological function.

# Biological literature.

7 Carstensen has evinced an ambivalence towards the ELF literature, to 8 which he is a stranger. Sometimes he testified that ELF fields could not 9 possibly cause a biological effect because his biophysical calculations 10 precluded the possibility (Carstensen, New York, 6451, 6452, 6453, 6454, 11 6460, 6491, 6463, 6462). This view led him to conclude that the approxi-12 mately 65 research groups around the world who have reported such biological 13 effects were all wrong (Carstensen, New York, 6450-6465). Indeed, Carstensen 14 reached his conclusion prior to having read the great majority of the ELF 15 literature (Carstensen, New York, 6476). At other times Carstensen adopted 16 a varient of this testimony. He fastened onto the maximum ground-level 17 electric field that would be created by his client's high voltage transmission 18 line, and asserted that the experimental ELF Studies performed at electric 19 field strengths below that level were all examples of poor research, and 20 those performed at electric field strengths above that level did not apply to the high voltage transmission line for that reason. Thus, when Carstensen testified on behalf of Quebec Hydro-Electric Corporation and the Niagara Mohawk Power Corporation (148), he fastened onto 10 kV/m. This choice resulted, in Carstensen's view, in a breakdown of the ELF reports into about 65% wrong and 35% irrelevant. (Carstensen, New York, 7005, 7017) (149))150). On behalf of SDG & E, Carstensen fastened on 8  $kV/m_{\star}$  and was led therefore to essentially the same numerical breakdown. Carstensen exhibited still a

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a third face during which he testified that there were valid reports of a biological effects occurring at field strengths below his client's ground-level maximum, but that all such effects were innocuous and not medically significant (149, 151).

5 Carstensen has baselessly condemned many experienced and competent 6 scientists as people who commit glaring and obvious errors during the con-7 duct of their research. It is clear that the fault lies with Carstensen who 8 harbors a heavy bias against those who report biological effects which his 9 calculations forbid. Common wisdom dictates that it is Carstensen's claims 10 that his calculations are relevant to high voltage transmission lines, and 11 not the experimental literature which ought to be rejected.

12 Carstensen's comments regarding confirmation of experimental results 13 represent a view through the wrong end of the telescope. If there is a 14 necessity to duplicate any research, the responsibility rests with the 15 applicant and not with the individual scientist who first observed the 16 biological effect. If the applicant claims that some research report may 17 be invalid, it incurs the responsibility to duplicate the work to attempt 18 to sustain its position. A scientific report can not be vitiated by a mere 19 assertion of invalidity unsupported by contradictory data. Furthermore, it 20 is only the applicant, the utility industry, and the governmental agencies 21 with an interest therein who posess the resources to support duplication of 22 ELF research. Many investigators who have published reports describing 23 biological effects no longer have research support. Carstensen is well 24 aware that there are only three groups in the United States today with 25 significant research funds available in the ELF area, namely the Energy 26 Development Research Agency, the Electric Power Research Institute, and the 27 Office of Naval Research, and that all three generally do not fund projects

- 72 -

JRT PAPER TE OF CALIFORNIA 1. 113 (REV. 8.72)

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in the laboratories of investigators who have previously reported a biological effect due to ILF exposure.



#### 9. ADDITIONAL MATTERS

## Availability of Information

There are three important sources of information regarding the biological effects of ELF electric and magnetic fields that are available to Applicant's witnesses but are not available to me.

8 The Electric Power Research Institute (EPRI) is currently supporting a 9 number of biological experiments. EPRI was requested by the staff of the 10 Public Service Commission of New York to supply copies of the research 11 protocols and interim results for each project, but refused to supply a 12 substantial amount of the requested information on the ground that it was 13 privileged. I believe that all such information is available to Applicant's 14 witness Michaelson who is a member of EPRI's Scientific Advisory Committee.

During the course of the New York Hearing in Cases 26559 and 26529 a

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witness for the utility companies testified that a Committee of the National Academy of Sciences (NAS) formed at the request of the Navy in connection with Project Sanguine had accumulated more than three linear feet of material dealing with the effects of ELF fields on biological systems. The NAS was requested by letter from the Chairman of the Public Service Commission of New York to supply a copy of the materials to the Staff of the Commission, but refused to do so because it was against NAS policy to disseminate information prior to the final Committee Report. All the NAS information is available to Applicant's witness Michaelson who is a member of the NAS Committee.

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- 74 -

During the New York Mearing, Applicant's witness Michaelson cited a large number of Soviet reports dealing with the biological effect of ELF fields (Michaelson, New York, 9842-9845, 9865-9878, 10473-10477). He refused however, to supply copies of the Soviet literature to the staff of the Public Service Commission when requested to do so. My inability to obtain the information described above, which I believe is possessed by the Applicant's witnesses, and which I believe is substantially adverse to their position in this hearing, has interfered with my presentation of the issues. JRT PAPER 113 (REV. 8-72) - 75 -

BIOLOGICAL RESEARCH SUPPORTED BY THE ELECTRIC POWER RESEARCH INSTITUTE

The initial research project sponsored by EPRI in the bioeffects area was 3 RP-98, located at John Hopkins University. In 1974, the project investiga-4 tors reported that 60 hertz electric fields were fatal to mammalian 5 cells (40). Subsequently, the project investigators found that only 5 hours 6 exposure to an electric field comparable to the ground level field under 7 the proposed Sundesert 500 kv transmission lines significantly interfered 8 with a normal physiological response in dogs (26). At the end of February 9 1976, after 5 years of support totaling about \$533,000.00, RP - 98 was 10 terminated by EPRI and no official final report was issued. 11 12 EPRI has two other major projects concerning which it has released some 13 detailed scientific information. They are RP - 799 and RP - 129. In 14 both cases the experimental protocols have been designed in such a way 15 that no possible result of the experiments will be adverse to the utility 16 industry. It is not possible for either experiment to furnish results 17 showing that exposure to the fields of high voltage transmission lines 18 is hazardous. Moreover, it will be several years before the projects 19 will be completed. It appears that the strategy of EPRI's research 20 program is to provide a false sense of movement towards resolution of the 21 issue of safety of high voltage transmission lines. 22

Under the claim of privilege EPRI has refused to supply any information regarding several other projects. I have therefore, been unable to analyze their experimental designs.

- 76 -

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	1	Research funded by EPRI is highly unlikely to be of use to the Commission
	2	in assessing the safety of high voltage transmission lines. EPRI's
	3	Scientific Advisory Committee is heavily weighted in favor of the interests
	4	of the electric utility industry. Its currently funded research does not
	5	reflect concern for the actual problems created by high voltage trans-
189	6	mission lines. Moreover, the propriety of EPRI's action of terminating
	7	RP-98 at precisely the point at which the investigators began to report
	8	adverse effects in animals, reflects questionable policies, and undermines
	9	any confidence in the objectivity of their program.
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	11	Finally, EPRI cannot be relied upon because it makes available only a
	12	carefully selected portion of its information concerning ELF field
	13	induced biological effects, and the material furnished cannot be presumed
	14	to reflect the character of the material withheld.
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## HEREDITARY PREDISPOSITION

Applicant's witnesses claim that hereditary factors do not alter their 3 conclusion that it is safe for all members of the general population to 4 be exposed chronically to the fields of high voltage transmission lines. 5 The record however, tends to establish that hereditary factors render 6 chronic exposure to such fields of greater potential hazard to certain 7 portions of the general population. For instance, black people exhibit 8 9 higher than average rates of high blood pressure and related cardiovascular disorders. Robert O. Becker, MD, has testified in the New York hearing 10 11 that the changes produced within the bodies of laboratory animals and people, exposed to ELF fields, are similar to those observed clinically 12 13 in people having high blood pressure and related cardiovascular disorders. Consequently, chronic exposure to the fields of the proposed transmission 14 lines may be particularly hazardous for those groups in the population 15 16 having inherited or other systemic factors predisposing them to the 17 development of high blood pressure and other cardiovascular diseases. 18 There are other examples in the record tending to indicate that particular 19 groups within the general population are more susceptible than the average 20 to chronic exposure to the fields of high voltage transmission lines, but 21 the area generally is unexplored. There are for instance no published 22 reports in the United States involving the study of the health consequences to various groups within the general population of living or working near 23 24 the transmission lines.

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### 10. RECOMMENDATIONS

I make the following general recommendations to the Commission: 2 1. The proposed Sundesert 500 kv transmission lines should not be 3 built as proposed because the design takes no account of the 4 biological effects that will likely be produced by its electric 5 or magnetic fields in the bodies of people who live or work or 6 otherwise come in proximity to the proposed transmission line. 7 8 As an independent basis, the proposed Sundesert 500 kv transmission 2. 9 lines should not be built as proposed because its proponents have 10 not considered the possibility of the production of a synergistic 11 interaction between the electric and magnetic field of the line 12 in the bodies of the exposed people. The Applicants have further 13 failed to consider the possibility of a synergistic interaction 14 between both fields associated with the proposed transmission 15 line and other factors present in the environment which are known 16 to have biological significance. 17 18 As an independent basis, the transmission lines should not be 3. 19 built as proposed because its proponents have failed to adequately 20 consider the knowledge and information which exists within the 21 scientific literature of the Soviet Union which indicates that 22 the proposed transmission line would be a health hazard. 23 24 As an independent basis, the transmission lines should not be 4. 25 built as proposed because the proponents have failed to consider 26 the consequences that radiation therefrom will cause specific 27 - 79 -

URT PAPER TE OF CALIFORNIA ). 113 (REV. 8-72)

physical processes to occur in the ionosphere, thereby possibly 1 causing an increase in the incidence of human skin cancer, and 2 possibly causing a modification of global weather patterns. 3 4 I make the following specific recommendations to the Commission: 5 1. A notice of Dispute should be sent to every person living or 6 working adjacent to the proposed right-of-way, and the general 7 public should be appropriately informed that there exists a valid 8 scientific dispute between competent scientific and medical 9 authorities concerning whether chronic exposure to the electric 10 and magnetic fields of the proposed high voltage transmission 11 lines and existing high voltage transmission lines and existing 12 biological effects in the bodies of exposed people, and also, 13 a dispute whether specific biological effects so produced are. 14 a health hazard. The Notice should be given to the people of 15 California, many of whom are unaware of even the existence of 16 electric and magnetic fields, regardless of the decision of the 17 Commission in this case, so that the people may decide for them-18 selves the extent to which the proposed lines will be a health 19 hazard. 20 21 22 23 24 25 26 27

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A panel of independent* scientific experts should be appointed by 2. 1 the Commission to evaluate whether the radiation from the proposed 2 transmission lines will likely effect the incidence of human skin 3 cancer. or will likely effect global weather patterns. 4 5 3. A panel of independent scientific experts should be appointed by 6 the Commission with the responsibility to assess all obtainable 7 scientific literature within the Soviet Union which is relevant 8 to the question of the extent of the health hazard that will be 9 created by the proposed transmission lines. The panel should be 10 instructed by the Commission to contact directly the proper Soviet 11 officials and, if necessary, consult directly with the proper 12 Soviet scientists and other officials. 13 14 In the event that the Commission finds that direct medical opinion 4. 15 is needed, a panel of independent * medical experts should be 16 appointed by the Commission to evaluate the extent of the potential. 17

hazard posed by the proposed transmission lines as determined from the information currently available in the open scientific literature concerning the existence of biological effects.

* By the term independent is meant that the scientists selected by the Commission not be employees, agents, consultants, advisors, major stockholders or grantees of any electric utility company or related industry. The individuals selected should be outside the orbit of both the electric utility industry and state and federal agencies such as the Energy Development and Research Agency, which are intimately associated in interest.

JRT PAPER TE OF CALIFORNIA 113 (REV. 8-72)

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- 5. The Commission should explicitly adopt and apply a Safety Factor . of 100.
- 6. The right of way chosen or approved by the Commission should be such that the strength of the electric field at the edge will be less than 1 volt/cm.
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1	8.	The Commission should create an Administrative Research Council
2		(ARC) to oversee the performance on basic and applied research
3		concerning the effects of electromagnetic energy on people and
4		the environment in connection with the manufacture and transport
5		of electrical power. The ARC should be authorized to fund
6		research by competent independent * investigators to furnish the
7		information necessary to properly and efficiently regulate high
8		voltage transmission lines and simultaneously protect the health
9		of the people of California. The ARC should contain a Review
10		Section composed of independent* individuals possessing the
11		expertise necessary to offer advice to the Commission based on
12		the results of the research performed by ARC investigators
13		and that performed by others.
14	production of the	ŧŎŧŧŎĸŎĸĊĸĊĸĊĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸŎĸ
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16	* Ibid	
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3%	126.	There is a further and equally fundamental basis for assigning
25		reduced evidentiary weight to negative reports. Consider for
36		example, the report by Miller (106) who found that when bean
		plant roots were exposed to ELF fields of up to 17 gauss or

- 99 -

1 0.1 volts/cm for six days, root growth was unaffected. One may ask what the effect on growth would have been if a stronger 2 3 electric field had been used, or if the roots had been exposed 4 longer, or if pears or tomatoes had been studied instead of 5 beans, or if the exposure techinque were changed to simulate 6 the kind of exposure that the beans would receive under the 7 proposed lines, or if some parameter other than that studied. 8 were measured. In each instance there is no answer because 9 there is no experiment. Thus, the precise and limited set of 10 conditions for which we know, based on Miller's work, that no 11 effect occurs, is a dimunitive increase in the body of knowledge 12 dealing with ELF field induced biological effects. The comment 13 of Applicant's witness Cartensen on this point is particularly 14 apt; "negative results may simply mean that the investigator 15 was not looking in the right place for the right things." (Carstensen, New York, 3396). 16 17 127. K. Busby, D. Driscoll and W. Washbon, A Field Survey of Farmer 18 Experience with 765 ky Transmission Lines, Agriculture Resources 19 Commission, Albany, New York, November, 1974. 128. B. Ware, Effects of 765 kv Transmission Lines on Animal Grazing 20 21 Habits, AEP Service Corp., December, 1974. 129. The survey form sent to the farmers did not ask whether the 22 23 numbers of cows had changed. 24 130. A. S. Zelichenko, B. I. Smirnov and I. M. Smirnov, Design 25 Conditions and Calculation Methods of Conductors, Cables, Supports. and Footings for Overhead Lines, Energoset'proekt Institute, 26 Proceedings of the Symposium on EHV Power Transmission, 27 . 100

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4		fields which exist in the environment from penetrating the
5		interior of the enclosure.
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7		the United States Senate, March 8, 9, and 12, 1973.
8	133.	Testimony of Sol Michaelson before the Board of Public Utility
9		Commissioners of New Jersey, May 15, and July 10 and August 14,1975.
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DURT PAPER ATE OF CALIFORNIA D. 113 (REV. 8-72) OSP	- 102 -

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FIGURE 1. THE 500 KV TRANSMISSION LINES PROPOSED BY SDG&E FOR THE SUNDESERT PROJECT ILLUSTRATING THE EXISTENCE OF THE ELECTRICAL ENERGY BEING TRANSPORTED. The energy is composed of an electric and magnetic field. For simplicity, only the electric field strength at each lateral distance is shown. (Phase array ABC-ABC, conductor configuration horizontal-horizontal, conductor height 35 feet, subconductor spacing 18 inches.)



RE 2. EFFECT ON MICE OF CONTINUOUS EXPOSURE TO 60 HERTZ ELECTRIC FIELDS. . . oth mice were 35 days old when the photograph was taken. The mouse in the upper part of the photograph was conceived, gestated, born and reared while being continuously exposed to a 60 hertz electric field, as were its parents. The mouse in the lower part of the photograph was a normal unexposed mouse, as were its parents. See reference number 1.



Figure 3. Apparatus Employed to Generate the Power Frequency Electric Field A metal plate was permanently mounted between two sheets of plywood, with provisions for applying and measuring the working voltage. Vibration isolation pads which supported the cage, were glued to the upper wood surface. Three designs were employed for the grounded cage top: (1) an all stainless steel top (Type A), (2) a modification of Type A in which the metal feed trough was replaced with one of plastic (Type B), (3) a modification of Type B in which a stainless steel lid covering the plastic feed trough was added (Type C). The approximate electric field profiles corresponding to each type of cage top are shown. Perturbing effects due to the presence of the various dielectric materials, and due to the water bottle, have been neglected.



- 105 -

FIGURE 4. SCHEMATIC ILLUSTRATION OF RADIATION FROM CANADIAN POWER SYSTEM TRAVELLING BETWEEN CONJUGATE STATIONS AT ROBERVAL AND SIPLE IN A DUCT IN THE MAGNETOSPHERE.

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# Table 1

stpartum; F, mortality during 8-35 days	luring first week pos	size; E, mortality d	itter :	age 1	), aver	red; [	live	ıps de	pregnancies; C, number of pu
er of females mated; B, number of	IS OF MICE. A, numbe	UCCESSIVE GENERATION	HREE SI	ON T	FIELDS	CTRIC	ELE	DUENCY	TABLE 1. EFFECT OF LOW FREQ
	+ P< 0.01	* P < 0.001							
	(49) 21.7 ± 3.8	(47) 19.2 ± 3.3	2%	0	12.2	86	8	8	Control
	(43) 23.3 ± 2.9	(42) 20.9 ± 2.5	3%	14%	12.8	102	8	8	Horizontal Electric Field
	(16) 17.3* ± 4.7	(19) 17.6 ± 3.8	35%	0	9.0	54	6	8	Vertical Electric Field
						100			Third Generation
(34) 29.9 ± 2.5 (32) 36.5 ± 2.9	(44) 27.5 ± 2.3	(12) 23.6 + 1.7	4%		111.4	, 10	ω	8	Control
(28) 27.2* ± 2.3 (39) 33.7* ± 3.9	(47) 22.8* ± 2.8	(43) 19.2* + 2.7	Э	3%	11.5	92	ŝ	co	Horizontal Electric Field
(16) $27.5^{\dagger} \pm 2.5$ (15) $29.2^{\star} \pm 2.6$	(15) 15.4* ± 2.9	(17) 13.6* ± 2.8	58%	0	11.5	81	7	ω	Vertical Electric Field
	1								Second Generation
		1							
	(25) 27.0 + 2.0	(26) 24.0 + 1.5	20	15%	12.2	61	თ	ω	Control
	(25) 23.9* + 3.4	(21) 22.0* + 1.8	2%	0	9.4	47	თ	8	Horizontal Electric Field
	(22) 22.3* + 4.9	(23) 17.0* ± 3.2	10%	19	10.4	52	თ	8	Vertical Electric Field
								÷.,	First Generation
AVERAGE WT. 10 WEEKS AFTER BIRTH Female (grams) Male	AYS AFTER BIRTH S) Male	AVERAGE MT. 35 D Female	н.	<b> </b> m	0	IC.	ျပာ	A	TREATMENT

107 -

postpartum. The number of mice is given in parenthesis.

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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	± 24.1       12.4       8.4         ± 27.9       18.0       6.6         ± 14.3       10.4       8.4         ± 15.8       10.4       8.8         ± 15.8       14.5       7.1         ± 26.1       56.8       1         ± 11.3       55.8       1         ± 11.3       53.4       1	$\begin{array}{c} \pm 24.1 \\ \pm 27.9 \\ \pm 14.3 \\ \pm 15.8 \\ \pm 15.8 \\ \pm 11.3 \\ \end{array}$ $\begin{array}{c} 10.4 \\ 14.5 \\ 53.4 \\ \end{array}$ $\begin{array}{c} 8.4 \\ 6.6 \\ 3 \\ 14.5 \\ 53.4 \\ \end{array}$ $\begin{array}{c} 8.8 \\ -1 \\ -1 \\ 53.4 \\ \end{array}$ $\begin{array}{c} 10.4 \\ 8.8 \\ -1 \\ -1 \\ 3 \\ 53.4 \\ \end{array}$ $\begin{array}{c} 8.8 \\ -1 \\ -1 \\ -1 \\ 3 \\ \end{array}$ $\begin{array}{c} 10.4 \\ 8.8 \\ -1 \\ -1 \\ 3 \\ 53.4 \\ \end{array}$ $\begin{array}{c} 10.4 \\ 54.8 \\ -1 \\ -1 \\ -1 \\ 3 \\ 53.4 \\ \end{array}$	± 24.1       12.4       12.4       8.4       4         ± 27.9       18.0       6.6       3         ± 14.3       10.4       8.8       4         ± 15.8       10.4       8.8       4         ± 14.3       10.4       8.8       4         ± 14.3       10.4       8.8       4         ± 14.3       56.8	± 24.1       12.4       8.4       8.4       4         ± 14.3       10.4       8.8       4.5       7.1       3         ± 15.8       10.4       8.8       14.5       7.1       3         ± 26.1       56.8       -       -       -       -       -         ± 11.3       56.8       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -
		IC FIELDS ON SOME BIOLOGICAL PARA bled sera of all rats within each armination of exposure.	IC FIELDS ON SOME BIOLOGICAL PARAM oled sera of all rats within each { ermination of exposure.	IC FIELDS ON SOME BIOLOGICAL PARAM oled sera of all rats within each ermination of exposure.

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	0.0 H	4,58)	4,56)	5,55)	5,56)	2,54)	4,27)	No.
Table	* P ABLE 3 . )F RATS. ;olumn i;	exp. cont.	exp. cont.	exp.	exp. cont.	exp.	exp. cont.	No.
kω	< 0.0 FURT Seru ndicat	(14) (16)	(20)	(16) (14)	(19) (21)	(14) (20)	(15) (18)	s of
ыл. с. ²⁰	HER EFF	٨	A	в	А	A, C	G	Cage T Type
×	ECTS OF coids v in days	1143 1202	1003	901 [*] 1054	819 [*]	749 891	846 [*] 940	op Cor
	CONTIN Vere mea	± 157 ± 107	* ± 82 ± 117	+ + 50 + 84	± 83 ± 104	+ 80 + 93	* ± 68 ± 142	Vater Isumed
L 44	UOUS EXPOSURI sured employ: itiation and	642 [*] ± 31 664 ± 17	614 ± 32 618 ± 43	542 ± 33 545 ± 36	582 ± 29 588 ± 42		587 ± 36 603 ± 40	Food Consumed (grams/rat)
3	70 POWE	294.6 300.4	286.8 290.2	282.4	289.5 287.8	264.8 281.0	293.4 286.7	Final weig
	R FREQUE ools of ion of e	± 15.2 ± 12.0	± 17.9 ± 13.2	± 13.3 ± 12.7	± 14.9 ± 18.4	± 24.1 ± 12.5	± 17.0 ± 22.1	body ht
	NCY ELE 2-3 rat	173.9 179.3	132.1 125.7	155.2 155.8	165.3 168.8	181.6 [*] 158.9	180.1 181.8	Final wei (µg/
	CTRIC FIE s within	± 20.0 ± 15.8	± 15.8 ± 14.3	± 18.4 ± 30.6	± 18.5 ± 20.3	± 21.1 ± 18.3	± 19.8 ± 16.0	Adrenal <u>ght</u> g)
	LDS ON each gr	31.2 30.6	31.4* 29.4	38.0 39.0	32.9 35.2	<b>43.9</b> 40.6	38.7 <b>*</b> 35.2	Fina
	SOME BIOL	+ 1.8 + 1.8	± 2.4 ± 2.9	± 2.4 ± 2.6	± 3.1 ± 2.6	+ 4.1 + 3.1	+ 3.2	1 Pituita weight (ug/g)
	DGICAL PA bers in f	.9.5 9.7	9.1* ± 16.3 ±	6.0 ±	11	7.2 ±	6.8 ±	ry Ser (µg/10
	RAMETER	2.0	2.0	0.7	11	1.5	0.8	um coids 10 ml)
	ь - 109:-	191 133	196 185	137	180 157	18E 157	198 194	SCOT

TABLE 4. SUMMARY OF ELF EXPERIMENTAL STUDIES. The first two columns give the principal investigator and his institution. The third column gives the reference number in this testimony for each study. The fourth column gives the biological system studied, and the next two columns give the strength and frequency respectively of the applied field. The seventh column gives the length of time that each investigator exposed the biological system under study. The eight column gives the observed biological effect.  $D_1$  is the distance (measured laterally from the center of the proposed right-of-way) at which the field from the proposed transmission lines would decrease to the value employed by the investigator in the corresponding experiment.  $D_2$  is the distance (similarly measured) at which the fields from the proposed transmission lines would decrease to 1/100 of the value employed in the corresponding experiment.  $D_3$  is the width of the zone that would be necessary to prevent entry into an area in which the field of the proposed transmission lines exceeded 1/100 of the value employed in the corresponding experiment.

- 110 -

Investigator	Institution	Ref. no.	Animal studied	Field applied (v/cm)	Freq. (hertz)	Duration	Observation	D ₁ (ft.)	D ₂ (ft.)	D ₅ (ft.)
Gann	Johns Hopkins Sch. Medicine	40	cells	6000	60	7 days	cell death	near wíre	119	238
Solov'ev	USSR	11	mice & insects	5000	50	several hours	death	near wire	125	250
Smith	U of Kansas	66	mice	17 gauss	60	several mínutes	altered behavior	near wire	95	190
Knickerbocker	Johns Hopkins Sch. Medicine	30	mice	1600	60	10 1/2 months	altered growth	near wire	165	330
Johans s'on	Inst. High Voltage Res. Uppsala	21	humans	1000	50	75 min.	altered behavior	near wire	180	360
Blanchi	Turin U.	51	mice & rats	1000	50	1000 hrs.	altered physiology	near wire	180	360
Watson	U. of Wales	41	chick tissue	1000	1	9 days	altered growth	near wire	180	360
Spittka	U. of Berlín	15	rats	500	50	several minutes	altered behavior	near wire	215	430
Hilmer	U. of Berlin	152	rats	500	50	10 days	altered behavior	near wire	215	430

TABLE 4.

SUMMARY OF ELF EXPERIMENTAL STUDIES

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- 111 -

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Investigator	Institution	Ref. no.	Animal studied	Field applied (v/cm)	Freq. (hertz)	Duration	Observation	D ₁ (ft.)	D ₂ (ft.)	D ₃ (ft.)
Bankoske	Westinghouse Electric Co.	35	chicks	400	60	3 weeks	altered growth	near wire	225	450
Sazonova	Leningrad U.	20	rabbits	300	50	18 hrs.	altered behavior	0	240	480
Ossenkopp	U. of Manitoba	84	rats	3 gauss	0.5	22 days	altered behavior	0	185	370
Friedman	VA Hosp.	61	humans	3 gauss	0.2	several hours	altered behavior	0	185	370
Persinger	Laurentian University	67	rats	3 gauss	0.5	21 days	altered behavior	0	185	370
Mamontov	Moscow Med. Institute	14	mice	200	50	4 hrs.	altered growth	0	265	530
Gann	Johns Hopkins Sch. Medicine	26	dogs	150	60	5 hrs.	altered physiology	0	315	630
Marino	VA Hosp.	2,3	rats	150	60	1 month	altered growth	0	315	630
Warnke	U. of Saarbrucken	12	bees	110	50	several days	altered behavior	o	340	680
Marino	VA Hosp.	1	mice	100	60	6 months	altered growth	0	350	700

TABLE 4 (continued)

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Investigator	Institution	Ref. no.	Animal studied	Field applied (v/cm)	Freq. (hertz)	Duration	Observation	D ₁ (ft.)	D ₂ (ft.)	D ₃ (ft.)
Hauf	Inst. Electro- Pathology Freiburg	22	humans	100	50 .	3 hrs.	altered behavior	0	350	700
Bassett	Columbia U.	78	dogs	1 gauss	65	28 days	altered growth	0	285	570
Bassett	Columbia U.	79	humans	1 gauss	56.	3-6 months	altered growth	. 0	285	570
Persinger	Laurentian University	83	rats	1 gauss	0.5	10-26 · days	altered physiology	0	285	570
Erhman	Tubingen	08	humans	1 gauss	4-12	several weeks	altered physiology	0	. 285	570
Beischer	Naval Aero- space Res. Lab.	81	humans	1 gauss	45	1 day	altered physiology	0	285	570
Milburn	UCLA	65	humans	1 gauss	400	several minutes	altered behavior	0	285	570
Gibson	Naval Aero- space Res. Lab.	64	humans	1 gauss	45	1 day	altered behavior	0	285	570
Rosenthal	U. of Chicago	5 107	plants	1 gauss & 0.1	75	9-50 days	altered growth	0	285	570

- 113 -

Investigator McElhaney	Institution West Virg. University	Ref. no. 31	Animal studied rats	Field applied (v/cm) 70	Freq. (hertz) 30	Duration 28 days	Observation altered growth	D1 (ft.)	D2 (ft.) 365	
Giarola	Texas A&M University	36	chicks	35	45-60	28 days	altered growth	140		465
Altman	U. of Saarbrucken	153	mice	35	10	3 days	altered behavior	140		465
Lang	U. of Saarbrucken	50	míce	35	10	56 days	altered physiology	140		465
Altman	U. of Saarbrucken	13	bees	30	50	several mínutes	altered physiology	150		480
Kruger	Texas A&M University	37	chickens	37	60	4 months	altered physiology	165		565
Friend	Naval Res. Institute	19	amoebas	10	1-100	10 min.	altered physiology	180		665
Moos	U. of Illinois	154	mice	10	60	10-150 days	altered behavior	180		665
Marsh	U. of Iowa	32	flat- worms	3.1	60	5 days	altered growth	245		1050
Altman	U. of Saarbrucken	49	guinea pigs	2.4	10	13 days	altered physiology	255		1100
Reisen	IIT Res. Institute	29	cells	1.55	60	40 min.	altered physiology	311		1665

TABLE 4. (continued)

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		1		TAI	BLE 4. (con	ntinued)				
Investigator	Institution	Ref. no.	Animal studied	Field applied (v/cm)	Freq. (hertz)	Duration	Observation	D ₁ (ft.)	D2 (ft.)	D ₃ (ft.)
Mathewson	Armed Forces Radiobiology Res. Inst.	44	rats	0.5	45	28 days	altered physiology	415	2065	4130
Lott	N. Texas St. University	27	rats	0.4	640	90 min.	altered physiology	440	2450	4900
Bawin	UCLA	28	brain tissue	0.1	1-75	20 min.	altered physiology	665	> 1 mile	> 2 miles
Gardner	U. of Wisconsin	105	plants	0.1	45	64 days	altered growth	665	> 1 mile	> 2 miles
Hamer	UCLA	23	humans	0.04	2-12	several minutes	altered behavior	870	> 1 mile	> 2 miles
Gavalas	UCLA 16	,17	monkeys	0.035	7-75	several minutes	altered behavior	965	> 1 mile	> 2 miles
Persinger	Laurentian University	25	humans	0.03	3-10	40 min.	altered behavior	1000	> 1 mile	> 2 miles
Wever	Max Planck Institute	46-48	humans	0.025	10	8 weeks	altered physiology	1100	> 1 mile	> 2 miles
Durfee	U. of Rhode Island	38	cells	0.01	60	3 days	altered growth	1400	> 1 mile	> 2 miles
Konig	Technical U. Munich	24	humans	0.01	3-10	several minutes	altered behavior	1400	> 1 míle	> 2 miles

- 115 -

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McCLeave	Williams	Larkín	Graue	Southern	Nova1	Goodman	Investigator
University of Maine	Swarthmore College	Rockefeller University	Bowling Green State U.	Northern Ill. University	Temple U. Med, Sch.	U. of Wisconsin	Institution
18	104	103	101	102	43	13,34	Ref. no.
fish	birds	birds	birds	birds	rats	slime mould	Animal studied
0.0007	0.0007 & 0.2 gauss	0.0007 & 0.2 gauss	0.0007 & 0.2 gauss	0.002 & 0.5 gauss	0.005	0.007 & 2 gauss	Field applied (v/cm)
60-75	45-76	45-76	. 76	45-76	45	45-75	Freq. (hertz)
several minutes	several minutes	several minutes	several minutes	2 mín.	30-40 days	600 days	Duration
altered behavior	altered behavior	altered behavior	altered behavior	altered behavior	altered growth	altered growth	Observation
> 1 mile	> 1 mile	> 1 mile	> 1 mile	3000	2400	2200	D ₁ (ft.)
> 1 mile	> 1 míle	> 1 mile	> 1 mile	> 1 mile	> 1 mile	> 1 mile	D2 (ft.)
> 2 miles	> 2 miles	> 2 míles	> 2 miles	> 2 míles	> 2 miles	> 2 miles	D ₃ (ft.)

- 116 -

### APPENDIX A

# RESUME

Name:	Andrew A. Marino
Position:	Research Biophysicist
Affiliation/Address:	Veteran's Administration Hospital
	Syracuse, New York 13210

# Education

1974		Syracuse University, College of Law, J. D.
1968		Syracuse University, PhD, Physics
1965	8	Syracuse University, MS, Physics
1962		St. Joseph's College, BS, Physics

# Experience

1964 - Present	Biophysicist, VA Hospital
1972 - Present	Assistant Professor, Upstate Medical Center, Department of Orthopedic Surgery
1975 - Present	Practicing Attorney

ANDREW ANTHONY MARINO, PH.D.

### PUBLICATIONS

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- 119 -