Hence the Polish Military study gives conclusive and strong associations of RF/MW exposure and increases in a host of cancers and a large increase in cancer death. Table 20 shows the incidence ratios (Odds Ratio: OR) for the ratio of exposed to non-exposed personnel, after Szmigielski (1996).

The analysis here identifies the likely highly exposed regime as being between 7 and 14$\mu W/cm^2$. Professor Szmigielski forms the following conclusions concerning cancer risk from this study, Szmigielski (1996):

> **"The main results obtained in the present study were a doubled incidence of all neoplasms, with a three fold increase of cancers of the alimentary tract and a six-fold increase of malignancies of the haemopietic system and lymphatic organs in 20-59 year old career military servicemen exposed to pulse-modulated 150 - 3500 MHz RF/MW radiation."**

17.2.3.4 Conclusions:

Dr Szmigielski states that this does not prove a causal link but the high incidence of certain forms of neoplasms in personnel exposed to pulse-modulated RF/MW radiation clearly shows a need for urgent identification of causal factors present in the occupational environment. However, in the context of the studies presented in this review, there are plausible mechanisms to relate the observed increases in cancer to altered cellular behaviour, these results are consistent with animal experiments, and with many other epidemiological studies.

17.3 Residential Studies:

17.3.1 North Sydney Study:

17.3.1.1 Introduction:

Hocking et al. (1996) undertook a population based study of people in three municipalities which surround three TV and FM radio towers in North Sydney. The health status for leukaemia and brain tumour in the three inner municipalities was compared to the health status in a ring of six outer municipalities, Figure 30.

17.3.1.2 Effects Associated:

Among children, the rate ratio for total leukaemia incidence was 1.58 (CI: 1.07-2.34) and for total leukaemia mortality it was 2.32 (CI: 1.35-4.01). For childhood lymphatic leukaemia, the most common type, the rate ratio was 1.55 (CI: 1.00-2.41) for incidence and 2.74 (CI : 1.42-5.27) for mortality.

The exposed population compared to the New South Wales population has a non-statistically significant increase in childhood brain tumour incidence of 30% (SIR/SMR= 1.3; CI:0.7-2.3), while the "outer" group has a 20% increase (SIR/SMR= 1.2; CI:0.9-1.6). Total leukaemia incidence for all ages was 1.24 (95%CI: 1.09-1.40), Table 16.

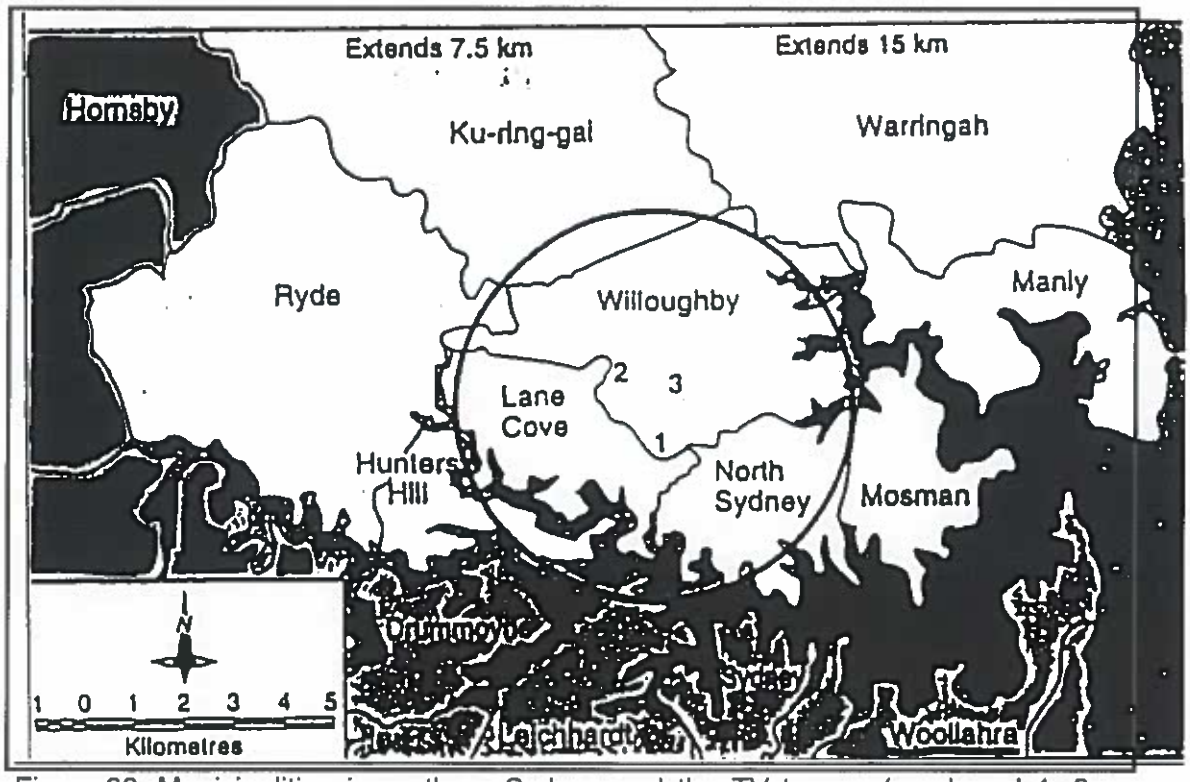

Figure 30: Municipalities in northern Sydney and the TV towers (numbered 1, 2 and 3). The circle has a 4 km radius and is for reference only. Willoughby, Lane Cove and North Sydney are the inner "exposed" municipalities, Hocking et al. (1996).

Table 23: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	0.89 (0.71-1.11)	740
Total Leukaemia	1.24 (1.09-1.40)	1206
Lymphatic Leukaemia	1.32 (1.09-1.59)	536
Myeloid Leukaemia	1.09 (0.91-1.32)	563
Other Leukaemia	1.67 (1.12-2.49)	107
Mortality		
Brain Tumour	0.82 (0.63-1.07)	606
Total Leukaemia	1.17 (0.96-1.43)	847
Lymphatic Leukaemia	1.39 (1.00-1.92)	267
Myeloid Leukaemia	1.01 (0.82-1.24)	493
Other Leukaemia	1.57 (1.01-2.46)	87

These data clearly show the greater susceptibility of children to leukaemia in association with RF exposure than adults, Table 24.

Table 24: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in childhood (0-14 years) in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	1.01 (0.59-2.06)	64
Total Leukaemia	1.58 (1.07-2.34)	134
Lymphatic Leukaemia	1.55 (1.00-2.41)	107
Myeloid Leukaemia	1.73 (0.62-14.81)	9
Other Leukaemia	1.65 (0.33-8.19)	8
Mortality		
Brain Tumour	0.73 (0.26-2.10)	30
Total Leukaemia	2.32 (1.35-4.01)	59
Lymphatic Leukaemia	2.74 (1.42-5.27)	39
Myeloid Leukaemia	1.77 (0.47-6.69)	11
Other Leukaemia	1.45 (0.30-6.99)	9

17.3.1.3 Exposures:

Exposure levels were calculated for the 4 individual TV stations. They were combined and plotted against the geographic centre of the three TV towers, Figure 31. The frequencies involved are in the range 63 - 219 MHz and 626-633 MHz.

Within a radius of about 1 km or so the area is inside the circle of the towers themselves. The high readings between 4 to 8 $\mu W/cm^2$ at about 1 km are the areas immediately adjacent to each of the towers where few, if any, people reside. At the geographic centre, between the towers, the calculated exposures are in the range 1 to $2\mu W/cm^2$.

Outside the circle of the towers themselves their combined calculated level of exposure falls from about $1\mu W/cm^2$ at 2 km from the centre, to $0.2\mu W/cm^2$ at 4 km and $0.08\mu W/cm^2$ at 8km. Thus the exposed population resides in calculated outdoor levels between 0.2 and $2\mu W/cm^2$. Measurements found that in the region of Tower 1 the actual levels, among the rolling terrain, trees and buildings, were 5 times lower than those calculated. Indoor exposures would be 4 to 8 times lower again. Hence mean residential exposure for the inner group is in the range 0.01 to $0.2\mu W/cm^2$, or less.

People who reside on ridgetops will receive greater exposure than those who live in valleys. Dr Hocking is following this study up through more detailed interviews and locations of those identified with cancer.

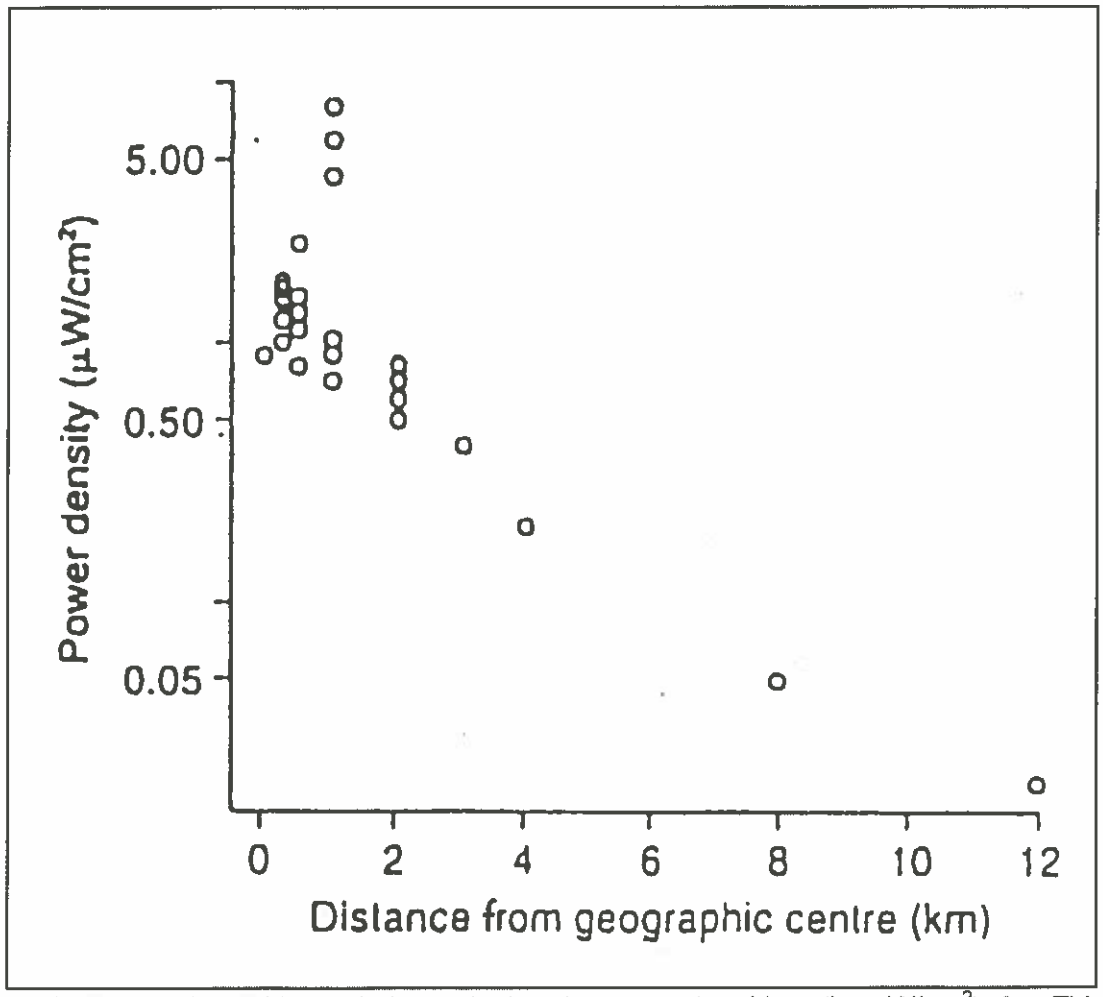

Figure 31: Logarithm of the calculated power densities (in $\mu W/cm^2$) for TV signals from the three TV towers against distance from the centre of the towers.

17.3.1.4 Dealing with confounders:

Hocking et. al (1996) searched diligently to find confounders to explain these results. They investigated and found no bias due to socio-economic class, proximity to industry, density of traffic (and hence benzene levels), air pollution, ionising radiation, high voltage power lines, population movement, nor the location of hospitals.

Recent suggestions that the increase in incidence and mortality of leukaemia was caused by a high incidence in one municipality (Lane Cove) was checked with the primary author, Dr Bruce Hocking. Dr Hocking says that this is not true. The team checked this out and stated in the paper:

> **"To see whether results within each municipality were similar, we performed tests of homogeneity for childhood leukaemia incidence and mortality. No significant heterogeneity was found (P=0.10 for incidence and P=0.13 for mortality)."**

17.3.1.5 Conclusions:

It came as a complete surprise to the research team that 39 children had died of lymphatic leukaemia when only 14.2 were expected in the exposed population, especially when the mean measured RF exposure levels are in the range of the MW exposures found within a few hundred metres of a cell site.

This is a highly significant study, carried out very carefully, with no pre-determined view of a positive association being expected. The study was originally sponsored by Telstra (formerly Telecom Australia) as a "toe in the water study" to ally fears about health effects of cell sites according to Dr Bruce Hocking on National Radio with Kim Hill. The results prove the opposite conclusions, that there is a probable but not proven effect from RF exposure from cell sites of increased risk of childhood leukaemia and lower, but still statistically significant increased risk of adult leukaemia.

Consistency with other, less detailed and less comprehensive studies, which have also found positive associations with cancer, including leukaemia and brain tumour in association with elevated RF/MW radiation exposure, provides compelling evidence of increased risk of cancer, especially leukaemia in children, from chronic low level RF exposure at the level of a probable to highly probable human carcinogen.

The Planning Tribunal in settign the 2 $\mu W/cm^2$ condition in the McIntyre case was not aware of this study as it had not been published at that time. It was also not told of the desire of a U.S.E.P.A. review team to have RF/MW radiation classified as a possible human carcinogen in 1990. With the Hocking and other more recent studies E.P.A. officials agree that the evidence in now even stronger.

17.3.2 The Skrunda Radar Study:

17.3.2.1 Introduction:

A radar location station in Latvia, near the town of Skrunda, has been operating for over 20 years. People live on the land in front of the radar, with villages, farms and forestry being the predominant features.

17.3.2.2 Associated Human Effects:

Although the local population have recorded many health complaints, the health effects have not been reported yet. A study has been carried out on children's performance, comparing the children in a village up to 20 km from Skrunda but in front of the radar, with children who live behind the radar.

Kolodynski and Kolodynski (1996) studied a group of 966 children (425 males and 541 females) aged 9-18 years. A total of 609 children were examined from the Kuldiga and Saldus regions within a 20 km radius of the Skrunda RLS. Of these, 224 pupils live in directly exposed areas to the west of the radar. The control group were 357 pupils from the Preili region, behind the radar.

For the populations living in front of the radar and behind it, and for the control group, groups of similar age and sex were selected. They examined similar social groups of farming communities, and 95 % of subjects lived on small farms.

They conclude that "the weak correlations between the distance from the children's homes to the RLS, and the children's responses, are certainly consistent with the idea of an electromagnetic field effect."

Statistically significant differences were observed between the performance of exposed and control groups of children which leads to the conclusion:

> **"The children living in front of the Skrunda RLS have less developed memory and attention, slower reaction times and decreased endurance of neuromuscular apparatus. On the basis of the data obtained, one could propose the working hypothesis that the decreased endurance of muscular apparatus, slower reaction time and less developed memory and attention are the results of chronic electromagnetic radiation effects. Evidence for a**

factor other than electromagnetic field having caused the observed results was not found, but its existence cannot be ruled out, for example, differences in the past experiences of the children, local small pollution effects, differences in family behaviour, etc."

While confounding effects cannot be ruled out, the evidence for the changes in children's performance is most plausibly related to the very low emissions of pulsed RF radiation from the Skrunda radar. Whether it is the RF energy or the pulse rate or size is not known. The pulse rate is unlikely to have had the operative effect on plants, people and animals. The "working hypothesis" proposed constitutes evidence of a potential adverse environmental effect.

17.3.2.3 Human Exposures:

Exposures were measured with frequency sensitive equipment, Kalnins et al. (1996), and so the measured readings relate to the output of the radar as against the broad band ambient radiofrequency exposure from all emissions which is likely to be around 0.001μW/cm^2. Hence measurements or estimates of radar signals below this level will be irrelevant, unless the effects are frequency specific. Any levels above 0.001μW/cm^2 are localized exposures above the ambient whose effects can potentially be associated with the radar irrespective of whether or not the effects are frequency sensitive.

Children living in the exposed zone have been tested for a range of performance parameters. The children lived and went to school in a zone about 4 to 15 km from the radar, with open exposure measurements in the range 0.0008-0.41 μW/cm^2, mean in the 0.0028- 0.039μW/cm^2. The measurements range is far wider than the mean range because of short-term variations in the output of the radar and weather conditions, etc. The local measurements (for the radar signal) among the trees and buildings, are in the range 1.7x 10^{-6} - 0.0027 μW/cm^2. The frequency was in the range 156-162 MHz and the radar is pulsed at a rate of 24.4 Hz and pulse width of 8 ms.

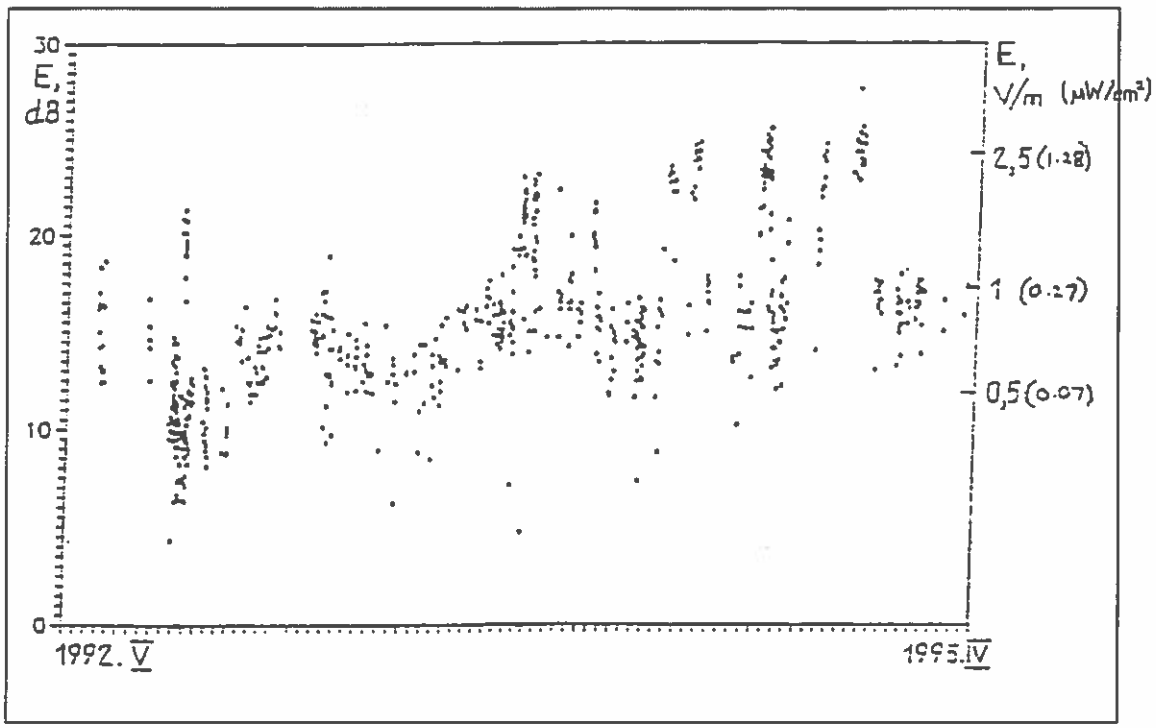

Figure 32: Maximum RMS electric field intensities (E) of electromagnetic radiation at 2 km from the Skrunda RLS between May 1992 and April 1993 at a height of 1.5 m above ground level (AGL).

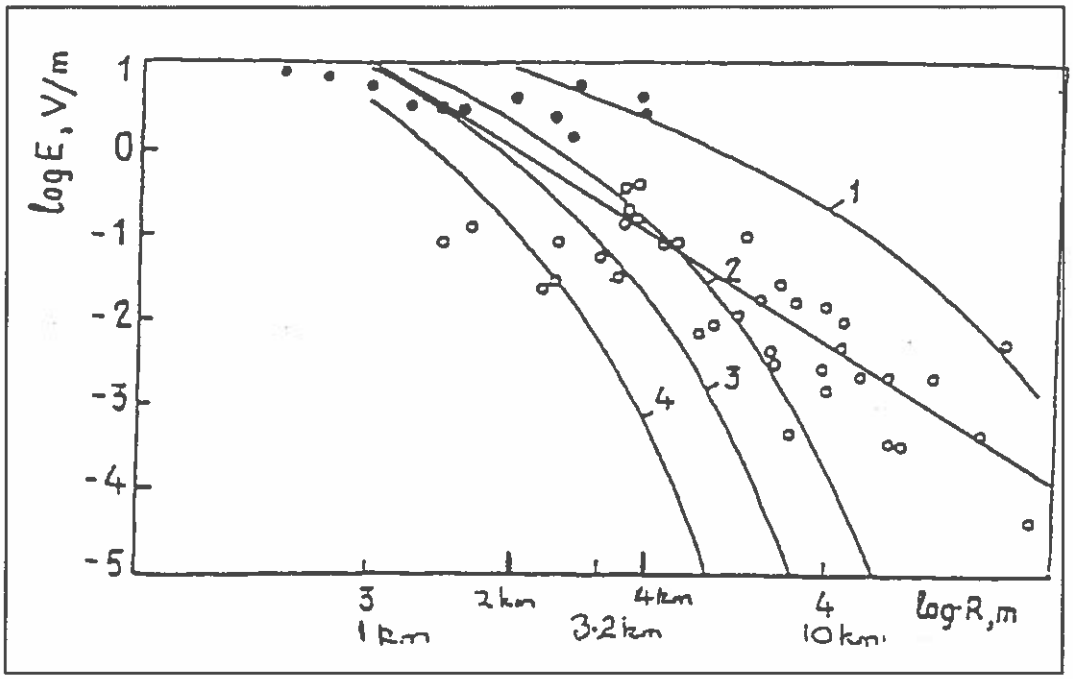

Figure 33: Measured maximum RMS electric field intensity (E) at 2 m AGL, plotted against distance from the Skrunda RLS. Theoretical curves (1-4) for different forest cover, 1 being the least and 4 being the most. A linear fit has been superimposed to estimate mean actual measurements with distance from the 2 km site.

17.3.2.4 Bovine Effects:

A herd of female Latvian Brown Cows were studied, Balode (1996), using cytogenetical evaluate of chromosome breakage in blood, using a micronuclei method. Comparing a herd of the same type of cows from in front of the radar with a herd housed behind the radar, they found a small incidence of broken chromosomes in the peripheral erythrocytes of the exposed cows of 0.6 per 1000. However this was six times that of the unexposed cows, which is significant at the $p<0.01$ level.

17.3.2.5 Bovine exposures:

Assuming the herd was within 1 to 2 km of the front of the radar, in open grassy pastures, the measured exposure would be in the range 0.042 to 6.6$\mu W/cm^2$, mean exposures in the range 0.157 to 0.63$\mu W/cm^2$.

17.3.2.6 Pine tree growth increments:

Many stands of pine trees were studied and reduction in growth ring increment was found. A particular set of stands lie at a radius of about 4 km from the radar, Balodis et al. (1996). Figure 34 shows the growth response of a set of stands of pine trees at a 4 km distance from the radar, where measured exposure levels are in the order of 0.0027$\mu W/cm^2$.

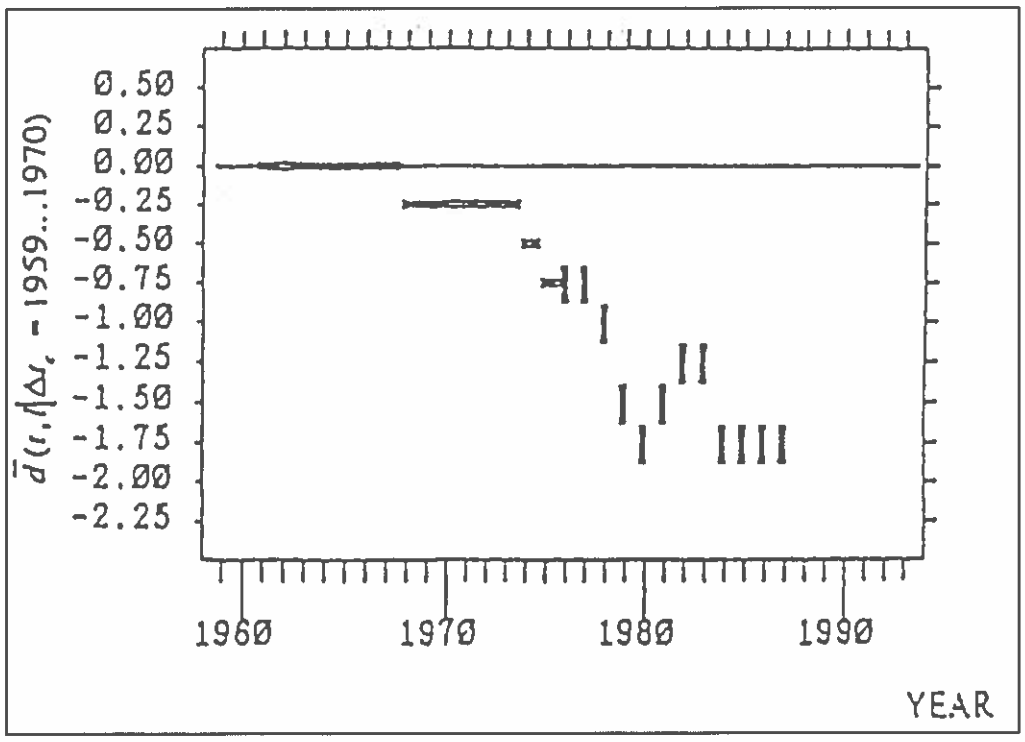

Figure 34: The mean relative additional increment of pine trees for a plot 4 km distance in from of the Skrunda RLS radar. The solid bars depict significant deviations from normal growth.

They conclude,

> **"There is a statistically significant (P<0.01) negative correlation between the relative additional increment in tree growth and the intensity of the electric field. The radial growth of pine trees is diminished in all plots that received electromagnetic radiation. This decrease in growth began after 1970, which coincided with the start of the operation of the Skrunda RLS, and was subsequently observed throughout the period of the study."**

The study team investigated other environmental and anthropogenic factors but found no significant effects to relate to tree growth.

Selga and Selga (1996) investigated the effect of RF exposure on the needles of *Pinus sylvestris L.* They found physiological changes with exposed trees which they state would explain the difference detected in tree ring width. They conclude:

> **"Evidently, EMF induces modification of the Golgi apparatus and switches its functions from synthesis of predecessors of cell walls (lignins) to formation and export of resin predecessors. The stress due to the RF EMF generated by the Skrunda RLS causes an unspecific response - accelerated resin production and promoted senescence (aging) of pine trees." ... "Phenol-induced senescence of pine trees can explain the decrease in tree ring increment width and viability of pine forests caused by direct pulsed RF EMF irradiation."**

Hence there is strong evidence from plant physiology that gives a biological mechanism to explain the observed decrease in growth rate of pine tree which are exposed to pulsed RF radiation.

17.3.2.7 Plant reproductive damage:

Magone (1996) investigated the vegetative growth and morphology of the duckweed *Spirodela polyrhiza (L.) Schleiden* . These plants have high vegetative reproduction rates, and genetically uniform clones can be used for experimentation. The results of exposure to the Skrunda RLS irradiation was dramatic.

> **"At 55 days, various morphological and developmental abnormalities appeared in 60 to 100 % of the exposed plants and 1 % of the control plants. Plants developed completely from daughter fronds under exposure from the electromagnetic field had a shorter life-span (67 days compared to 87 days in the controls) and fewer subsequent daughters (8 compared to 10 in the control group)."**

It is also noted that the decrease in reproduction rates and the occurrence of deformities in future generations after 30 days of exposure to pulse-type RF irradiation comes from small cellular changes that become evident only after replication in cell division. This was also supported by the fact that in the experiment to determine life-span, where only the daughters directly produced from the mother were observed, the number of deformities was almost two times lower than when all descendants were observed.

They conclude:

> **"Our work suggests that studies of non-thermal radiofrequency electromagnetic fields on organisms must be comparable to the life-span of the organism. If short-term observations are made, only the organism response to electromagnetic radiation as a stress factor can be seen. Long-term studies can yield different conclusions due to more effects becoming evident only at later times."**

These results are consistent with observed chromosome damage in plants exposed to RF radiation, Haider et al. (1994), who used 10 to 27 MHz broadcast antennae with very high, but sub-thermal exposures of at least 424μW/cm^2 (40 V/m).

17.3.2.8 Plant exposure levels:

The Pine trees at 4 km were exposed to a range of 0.011 to 0.41μW/cm^2, a mean open field exposure of 0.039μW/cm^2 and measured distance exposure of 0.0027μW/cm^2 (for the radar signal). Indications are that the duckweed study was done closer to the radar and so the bovine exposure levels would be likely to apply, i.e. range 0.042 to 6.6μW/cm^2, mean exposures in the range 0.157 to 0.63μW/cm^2.

17.3.2.9 Summary and conclusions:

The Skrunda Radar provides a living laboratory for the chronic low level effects of exposure to RF/MW radiation. To date investigations have revealed a number of statistically significant changes associated with exposure to the radar signal. These include:

- Impaired scholastic performance of children in the open field exposure range of 0.0008-0.41 μW/cm^2, mean measured level in the range 0.0028- 0.039μW/cm^2.
- A 6-fold increase in broken chromosomes in the peripheral erythrocytes of the exposed cows ($p<0.01$). for a measured exposure would be in the range 0.042 to 6.6μW/cm^2, mean exposures in the range 0.157 to 0.63μW/cm^2.
- A statistically significant ($P<0.01$) negative correlation between the relative additional increment in tree growth and the intensity of the electric field. The Pine trees at 4 km were exposed to a range of 0.011 to 0.41μW/cm^2, a mean open field exposure of 0.039μW/cm^2 and measured distance exposure of 0.0027μW/cm^2 (for the radar signal). A probable biological mechanism was identified through observed changes in physiological conditions.
- Chromosome and reproductive damage in plants exposed RF/MW in the range 0.042 to 6.6μW/cm^2.

Chronic exposure to pulsed RF radar signals is associated with chromosome damage in plants and animals, with associated reproductive aberration in plants, and growth reduction in pine trees linked to observed physiological changes, and scholastic impairment of school children occurs in relation to exposure levels which fall well below 2μW/cm^2, below 0.1μW/cm^2. and even below 0.01μW/cm^2.

17.3.4 Chinese Study:

Chiang et al. (1989) studied subjects living and working near radio antennae and radar installations. Most of the studied exposures were above 10μW/cm^2, and they included microwaves and AM EMF. The tests carried out included visual reaction time, standardized written tests and white blood cell (WBC) phagocytosis. Visual reaction time increased significantly for Male Soldiers exposed to microwaves in the range 10-15μW/cm^2 ($p<0.01$) and Male College students exposed to 13-42μW/cm^2 of microwaves ($p>0.05$). Memory Function scores were also significantly reduced for both of these high exposed groups, $p<0.01$ for both groups. Secondary school boys and girls showed non-significant changes in visual reaction time (0-4μW/cm^2) but a significant improvement in memory Function Scores ($p<0.05$ for boys and $p<0.01$ for girls).

Blood tests associated with microwave exposure showed significantly elevated white blood cell counts for high school students ($p<0.05$) for exposure 0-4μW/cm^2. Male Soldiers in the middle range showed no effect and Male College Students in the high range showed a significant reduction in WBC.

AM exposure was associated with a 15 % increase in WBC in kindergarten children exposed to 3-4 V/m (2.4 - 4.2μW/cm^2) and a significant ($p<0.05$) 31.2 % increase at 4-11 V/m (4.2-32 μW/cm^2). Non significant reductions in WBC were found in 3rd year high school students at moderate exposures 10-18 V/m, but WBC were significantly reduced to 45.7 % for boys ($p<0.01$) and to 81.2 % for girls ($p<0.05$) in the range 22-23 V/m (128-140μW/cm^2).

The authors conclude "The data indicate that chronic exposures to EMFs are associated with significant changes in some physiological parameters."

Increased WBC at low exposures have been observed for example in the staff of the U.S. embassy in Moscow, exposed to mean exposures of somewhat less than 1/5th of the outdoor, upper floor measure mean exposures of 1 to 2.4μW/cm^2, i.e. less than 0.2 to 0.5μW/cm^2, produced a total WBC 25 % higher than average, with a 41 % increase in lymphocytes and 31 % increase in monocytes, Lilienfeld et al. (1978).

17.3.5 U.K. TV/FM studies:

The Small Area Statistics Unit, Department of Epidemiology and Public Health at Imperial College, London, Dolk et al. (1997a), was contracted to study the possible health effects in the population living around the regional TV/FM transmitter in Sutton Coldfield, just north of Birmingham. Peak exposures for the TV signal were measured at 2.5 m AGL at 1.3 μW/cm^2, and for the FM signal at 5.7 μW/cm^2. These don't occur at the same radius and so the total exposure peaks between 6 and 6.5 μW/cm^2. Mean exposures amongst built-up areas, because of the scattering and absorbing effect of tree and buildings, is around 1/5th of the measured well exposed value. That is, residential mean exposures will peak at around 1.2 to 1.4 μW/cm^2, between about 1 and 3 km from the tower, and decrease with distance at higher distances. At 10 km it is expected to be around 0.05μW/cm^2.

17.3.5.1 Study 1: The Sutton Coldfield Tower.

Primary findings of the study are:

"the results of this study confirm that there was an excess of adult leukaemia within the vicinity of the Sutton Coldfield TV/FM transmitter in the period 1974-1986, accompanied by a decline in risk with distance."

The risk of adult leukaemia within 2 km was 1.83 (CI: 1.22-2.74) and the decline with distance was significant at $p<0.001$.

Table 25 shows the results for cancer.

Table 25: All cancers, all leukaemias, and non-Hodgkin's lymphomas near the Sutton Coldfield transmitter, West Midlands, England: observed and expected numbers of cases, observed/expected (O/E) ratios, and cumulative O/E ratios, by distance of residence from the transmitter, in person aged >= 15 years, 1974-1986. Dolk et al. (1997a).

Distance from transmitter	All cancers*				All leukemias				Non-Hodgkin's lymphomas			
(km)	Obs.	Expd	O/E ratio	Cumulative O/E ratio	Obs.	Expd	O/E ratio	Cumulative 0/E ratio	Obs.	Expd	O/E ratio	Cumulative O/E ratio
0-0.5	2	5.61	0.36	0.36	1	0.11	9.09	9.09	0	0.11	0.00	0.00
0-5-1.0	96	137.19	0.70	0.69	5	2.72	1.84	2.12	3	2.60	1.15	1.11
1-0-2.0	605	504.59	1.20	1.09	17	9-76	1.74	1.83	5	9.46	0.53	0.66
2-0-3.0	282	279.01	1.01	1.06	9	5.56	1.62	1.76	9	5.76	1.56	0.95
3.0-4.9	1,002	1,050.86	0.95	1.00	25	20.22	1.24	1.49	20	20.25	0.99	0.97
4.9-6 3	2,414	2,301.25	1.05	1.03	54	41.96	1.29	1.38	45	40.60	1.11	1.04
6.3-7.4	2,734	2,650.62	1.03	1.03	48	46.54	1.03	1.25	57	43.95	1.30	1.13
7.4-8.3	2,827	2,798.65	1.01	1.02	51	49.22	1.04	1.19	52	47.19	1.10	1-12
8.3-9.2	3,363	3,213.75	1.05	1.03	40	57.35	0.70	1.07	80	54.56	1.47	1.21
9.2-10	4,084	3,919.59	1.04	1.03	54	68.90	0-78	1.01	86	66.02	1.30	1.23

* All cancers excluding non-melanoma skin cancer.

Secondary findings of the study were: "**declines in skin melanoma and bladder cancer with distance from the transmitter site.**"

An excess risk ratio (O/E) close to the tower, with a decline in risk (incidence) with distance, is an extremely significant result. It is a dose-response relationship as it follows the ground level exposure of low exposure close to the tower, rising to a peak some distance from the tower and thence decreasing with the inverse square law with additional distance from the tower. The study found these highly significant results for adult leukaemia, skin melanoma and bladder cancer.

These results prompted a follow-up study of 20 other regional TV/FM transmitters throughout the U.K.

Table 26: Skin Melanoma and bladder cancers in the vicinity of the Sutton Coldfield transmitter, West Midlands, England: observed and expected numbers of cases, observed/expected (O/E) ratios, and cumulative O/E ratios, by distance of residence from the transmitter, in person aged >= 15 years, 1974-1986. Dolk et al. (1997a).

Distance from	Skin melanoma	Bladder cancer

transmitter (km)	Observed	Expected	O/E ratio	Cumulative Observed	Cumulative Expected	Cumulative O/E ratio	O/E ratio
0-0.5	0	0.09	0.00	0.00	0	0.24	0.00	0.00
0.5-1.0	2	2.02	0.99	0.95	4	5.96	0.67	0.65
1.0-2.0	11	6.99	1.57	1.43	39	22.17	1.76	1.52
2.0-3.0	12	5.03	2.39	1.77	11	11.94	0.92	1.34
3.0-4.9	16	16.16	0.99	1.35	43	45.27	0.95	1.13
4.9-6.3	26	28.77	0.90	1.13	119	100.31	1.19	1.16
6.3-7.4	28	27.93	1.00	1.09	131	114.85	1.14	1.15
7.4-8.3	32	30.90	1.04	1.08	117	120.64	0.97	1.10
8.3-9.2	28	35.66	0.79	1.01	169	140.13	1.21	1.13
9.2-10	34	43.08	0.79	0.96	155	167.45	0.93	1.08

17.3.5.2 Study 2: The 20 tower study:

Dolk et al. (1997b) carried out a similar analysis to Study 1, for 20 other regional TV/FM transmission towers throughout the U.K.. These towers have a range of output powers and arrangements of TV and FM signals. The results are presented for all towers combined and for groups of towers according to power groupings, Table 27.

Study 2 produced the following conclusions:

> **"A decline in risk of adult leukaemia, with distance, was found for all transmitters combined (p=0.05), two of the transmitter groups, and tree single transmitters; for all transmitters combined, observed excess risk was no more than 15 % at any distance up to 10 km.".**

The highest O/E ratio for the group of leukaemias was 1.20 for Chronic Lymphatic Leukaemia, for skin melanoma was 1.11 (within the 2km radius) and no relationship was found for bladder cancer. For the group of high powered transmitters (Group 1) the peak ratio for all leukaemias was 1.29 at 2-3 km; Moderate power group TV (Group 2), 1.17 at 2-3 km; Moderate Power Group FM (Group 3), 1.28 at 3-4.9 km and Low Power group (Group 4), 1.28 at 3-4.9 km. For all combined and Groups 1 and 2 the cumulative O/E ratio is still positive at 10 km. In comparing the 20 site results with Sutton Coldfield the following was stated:

> **"In conclusion, while there is evidence of a decline in leukaemia risk with distance, the pattern and magnitude of the risk associated with residence near the Sutton Coldfield transmitter do not appear to be replicated around other transmitters."**

TABLE 27: Cancer incidence near 20 high power radio and TV transmitters In Great Britain-all leukemias: observed (0) and expected (E) numbers of cases, 0/E ratios, and cumulative O/E ratios, for all transmitters combined, for transmitter groups, and selected individual transmitters, by distance of residence from transmitter, in persons aged ≥15 years, 1974-1986.

Distance

from transmitter (km)	Cumulative O	Cumulative E	O/E ratio	Cumulative O/E ratio	O	E	O/E ratio	Cumulative O/E ratio	O	E	O/E Ratio	Cumulative O/E ratio
	All transmitters				*Group 1 **				*Group 2**			
0-0.5	2	2.3	0.87	0.87	2	1.9	1.08	1.08	2	2.2	0.91	0.91
0.5-1.0	12	13.8	0.87	0.87	11	12.0	0.92	0.94	12	13.4	0.90	0.90
1.0-2.0	65	65.5	0.99	0.97	53	52.6	1.01	0.99	63	63.2	1.00	0.98
2.0-3.0	155	135.3	1.15	1.08	125	97.1	1.29	1.17	155	132.0	1.17	1.10
3.0-4.9	539	494.1	1.09	1.09	377	342.7	1.10	1.12	516	476.1	1.08	1.09
4.9-6.3	623	589.7	1.06	1.07	376	341.0	1.10	1.11	607	562.6	1.08	1.08
6.3-7.4	547	518.0	1.05	1.07	315	297.1	1.06	1.10	503	404.8	1.01	1.07
7.4-8.3	434	453.4	0.96	1.05	220	245.0	0.90	1.06	414	429.2	0.96	1.05
8.3-9.2	497	493.5	1.01	1.04	304	296.8	1.02	1.06	465	450.1	1.02	1.04
9.2-10	431	427.9	1.01	1.03	259	254.1	1.02	1.05	393	398.7	0.99	1.04
	Group 3				*Group 4**							
0-0.5	0	0.2	0.0	0.00	0	0.1	0.00	0.00				
0.5-1.0	0	0.6	0.0	0.00	0	0.2	0.00	0.00				
1.0-2.0	6	5.8	1.03	0.90	4	3.6	1.12	1.02				
2.0-3.0	11	13.9	0.79	0.82	11	10.7	1.03	1.03				
3.0-4.9	78	61.0	1.28	1.16	55	42.9	1.28	1.22				
4.9-6.3	103	123.3	0.84	0.97	87	96.2	0.90	1.02				
6.3-7.4	134	120.7	1.11	1.02	90	86.4	1.04	1.03				
7.4-8.3	83	100.0	0.83	0.98	63	75.9	0.83	0.98				
8.3-9.2	83	97.5	0.85	0.95	51	62.1	0.82	0.95				
9.2-10	80	96.0	0.83	0.93	42	65.8	0.63	0.91				
	Crystal Palace				*Wenvoe*				*Rowridge*			
0-0.5	1	1.6	0.62	0.62	0	0.1	0.00	0.00	0	0.02	0.00	0.00
0.5-1.0	11	11.7	0.94	0.90	0	0.2	0.00	0.00	0	0.02	0.00	0.00
1.0-2.0	50	48.5	1.03	1.00	4	2.9	1.38	1.25	0	0.1	0.00	0.00
2.0-3.0	116	87.4	1.33	1.19	9	9.2	0.98	1.05	1	0.5	2.08	1.54
3.0-4.9	343	310.4	1.10	1.13	35	27.0	1.30	1.22	12	7.9	1.52	1.52
4.9-6.3	346	311.2	1.11	1.12	61	54.6	1.12	1.16	17	15.6	1.09	1.24
6.3-7.4	273	259.2	1.05	1.11	58	51.7	1.12	1.15	3	7.2	0.42	1.05
7.4-8.3	184	207.1	0.89	1.07	49	48.5	1.01	1.11	1	2.8	0.35	1.00
8.3-9.2	244	250.4	0.97	1.05	20	36.4	0.55	1.02	2	3.4	0.58	0.96
9.2-10	190	185.1	1.03	1.05	16	30.3	0.53	0.97	6	10.9	0.55	0.67

* Group 1. Highest power TV transmitters of 870-1,000 kW erp; Group 2, all TV transmitters of 500-1,000 kW erp; Group 3, all FM transmitters of 250 kW erp; Group 4, all transmitters with a combination of TV (≥500 kW erp) and FM (250 kW erp) transmission.

17.3.5.3 Result Conflict Resolution:

It might be tempting to discount the results of both of the projects on the grounds of the inconsistencies in the results. This would be scientifically incorrect. Natural variability of the transmission powers, frequency, and antennae patterns makes the exposures quite different from site to site. Within this variability there is a great deal of consistency between the results and the differences could well be explained in terms of these physical factors.

For example, a cellsite transmitter at 20m above ground level, produces a 2m AGL side-lobe peak at about 20-60m from the tower, and the main-beam ground level peak is at 120 to 210m from the tower base. In proportion, the ground level exposure peaks from a 240m tower are likely to be in the range 240-720 m for the side lobes, and 1400 to 2500m for the main beam peak. The populations exposed to the main-beam peak is generally far greater because it covers a much larger area. With a range of 1400 to 2500 m the

area within this range inside 2km (6.4 km^2) is close to the area outside 2 km (7.0 km^2). Hence, depending on the physical arrangement of the antennae, the peak exposed population is almost equally likely to live inside or outside the 2 km ring.

In addressing the 2km/3km inconsistency it should be noted that in relation to leukaemia, the All Transmitters, Group 1, Group 2, Rowridge and Crystal Palace peak O/E ratios occur in the 2-3 km zone, whereas at Wenvoe, Group 4 and Sutton Coldfield have O/E peaks in the 1-2 km zone. The highest peaks are clustered around 2 km (1-2 km and 2-3 km). The significantly different antenna powers, mixtures of TV and FM stations and physical configurations are likely to be more than sufficient to account for these differences.

Consistencies include finding an excess of adult leukaemia at some distance from the towers, which then decreases with distance. Skin melanoma was higher in the first 2 km in both cases. Bladder cancer incidence was elevated but did not decrease with distance nor attain statistical significance in the 20-site study.

The primary inconsistency is with bladder cancer which is significant in the Sutton Coldfield study and erratically related to distance in the 20 site study.

The very high rate ratios associated with <2 km for the Sutton Coldfield transmitter involves 11 people. The cumulative rate ratio does not become statistically significant at p=0.05 until the 4.9 km radius (RR=1.49, 95%CI: 0.99-2.42). Hence the difference between adult leukaemia incidence at the Sutton Coldfield site and the "All transmitters" data, is not statistically significant.

These papers do show excess incidence of adult leukaemia in association with living in proximity to TV/FM towers, with a decrease in incidence with distance from individual towers and from all transmitters combined. This is consistent with the excess of adult leukaemias found by Hocking et al. (1996), Milham (1985, 1988) and Szmigielski (1996). The increase in skin melanoma is consistent with De Guire et al. (1987) and Szmigielski (1996).

It is hopeful that Dr Hocking can repeat this level of radial analysis in a follow-up study in North Sydney. If this is accomplished then the results will be highly significant in the light of the U.K. and other residential leukaemia studies.

17.3.6 The Moscow (U.S.) Foreign Service Workers Study

For many years in the late 1960's through to the 1970's the Soviet government aimed radar signals at the US embassies in Moscow and other European cities. State Department staff worried about the increasing incidence of cancers in the staff, spouses and children of diplomatic staff working in Moscow and other Eastern Block countries. This led to an extensive epidemiological study. The first stage was controversial but was ended with the death of the team leader, Professor Lilienfeld. Lilienfeld (1978) himself recommended follow-up studies because of the cancer latency periods. The Moscow Group appeared to be most highly affected. Blood tests revealed statistically significant increases ($p<0.001$) in hematocrit and decreases in neutropil, for example, Goldsmith (1995). White blood cell counts were strikingly higher in the Moscow group.

Professor Goldsmith was not directly involved at that time, but after Prof. Lilienfeld's death he was asked to become more involved with individual staff as rates of cancer appeared to increase, Goldsmith (1995). Professor Goldsmith's most recent analysis shows significant increases in cancers in adults and children, some of which were not evident in the earlier study because of the case reference approach taken and because the latency period for some cancers being 8 to 20 years, Goldsmith (1995,1996).

The State Department arrange for exposure reading to be taken.

Table 28: Maximum exposure and exposed areas by time period as estimated by the State Department, Lilienfeld et al.(1978).

Time Period	Exposed Area of Chancery	Maximum Exposure
1953 to May 3, 1975	West Facade	5 - 14 $\mu W/cm^2$, 9h/day
June 1975 to Feb 7 1976	South and East Facade	15 $\mu W/cm^2$, 18 h/day
Since Feb 7, 1976	South and East Facade	< 1 $\mu W/cm^2$, 18 h/day

The peak values were 5 to 15 $\mu W/cm^2$.

Assuming the latter period ended in December 1978, and assuming the maximum exposures are the means, there was 281 months at 1.88$\mu W/cm^2$, 20 months at 11.25$\mu W/cm^2$ and 23 months at about 0.5$\mu W/cm^2$. This gives a highest possible mean exposure over the whole period of 2.4$\mu W/cm^2$ and a likely mean exposure of less than about 1$\mu W/cm^2$. These exposure readings are for the outside walls of the embassy. The beams were always directed at the upper floors of the chancery. Staff and children would be inside most of the time, not often on the upper floors, and therefore would be exposed to a fraction of this, probably less than 10 %, or 0.1 to 0.24$\mu W/cm^2$. Whether it is this low or slightly higher, it is within the range of that produced at ground level near this cell site.

I have received copies of reports on the analysis of the blood of the Moscow Embassy staff. These reports were classified and have only been released and stamped "declassified" a few years ago, even though they were written in 1969 and 1976. Both reports found major mutagenic changes in blood samples. The George Washington University report (August 4, 1969) entitled "Final report on contracts between the medical division, Department of State and the Reproductive Genetics Unit, of the George Washington University". It covered analyses of blood from between 21/2/66-30/6/69. This covers the period when the external wall exposure was 5-14$\mu W/cm^2$ for 9 hours/day, averaging then 1.9-5.3$\mu W/cm^2$. They were analysing for mutagetic effects by identifying chromosomal damage. The results were expressed as:

Table 29: Hematological Tests of chromosome and other damage in the blood of U.S. Foreign Service Workers from Moscow and other Eastern Embassies.

Scale	Mutagenic Level	Clinical Significance	Patient X-Numbers
5	Extreme	Definite	None
4	Severe	Questionable	73,74,76,79,84,102
3.5	Intermediate		72,83,91,99,103
3	Moderate	Suspect	70,71,93,97,98,100,104
2.5	Intermediate		75,87,90,94,96
2	Mild	Questionable	69,81,85,92,95
1	Normal	None	77,78,80,82,86,101

The report includes the comment: "The Contractor's opinion lies between these two extremes and the current risk is in a human adult population most likely exists solely in reproduction, however, some workers cite similarities in early malignancy."

The later, 7 October 1976 report by James Tonascia and Susan Tonascia, titled "Hematology Study", and included all employees who arrived in Moscow before December 1975. This totaled 213 individuals from Moscow and they were compared with 981 other Foreign Service employees. They found :

> **"There was a marked difference in white blood cell parameters. The total count as well as the counts for each individual cell type were substantially higher in Moscow than in the comparison group. This was especially true for the eosinophil (granular leukocyte) and lymphocyte counts."**

Leukocytes changes are related to Leukaemia and lymphocytes are involved in the immune systems.

What was the resulting health effects. Goldsmith (1995) reports:

Adult foreign service workers and their spouses showed marked increases in a number of cancers compared with the number expected for the same age-adjusted population:

- Two leukaemia deaths in Moscow when 0.8 are expected (RR = 2.5).
- Three leukaemia deaths in other eastern block embassies when 1.7 are expected (RR=1.8).
- Four deaths due to female genital cancer in Moscow compared with 0.8 expected (RR=5.0).
- Three deaths due to female genital cancer in other embassies compared with 1.3 expected (RR=2.3).
- Four dependent children died of cancer among Moscow families compared to 1.5 expected (RR=2.7).

Table 30 gives a break down of the cancer deaths of the children involved.

Table 30: Cancer Mortality of the Children Exposed to Microwave Radiation in the Moscow and Western Embassies, Goldsmith (1995).

	Moscow Embassy			Other E. European Embassies		
	Observed	Expected	Risk Ratio	Observed	Expected	Risk Ratio
Leukaemia						
Line in	1	0.2	5.0	1	0.3	3.3
Live out	1	0.3	3.3	2	0.4	5.0
Sub-Total	2	0.5	4.0*	3	0.7	4.2*
Brain Cancer						
Live in	0	0.1	<1.0	0	0.2	<1.0
Live out	0	0.2	<1.0	0	0.2	<1.0
Sub-Total	0	0.3	<1.0	0	0.4	<1.0
All other cancer						
Live in	1	0.2	5.0	0	0.8	<1.0
Live out	1	0.33	3.0	0	1.1	<1.0
Sub-Total	2	0.53	3.8*	0	1.9	<1.0
All Cancer						
Live in	2	0.5	4.0*	1	1.3	<1.0
Live out	2	0.83	1.36	2	1.7	1.17
Total	4	1.33	3.0*	3	1.0	3.0

Overall these reports include 16 cancer deaths when 6.1 were expected, an overall risk ratio of 2.62 . Hence the hematological samples showing increased mutations in exposed foreign service workers is reflected in significant increases in the incidence of cancer in the exposed population. ***This is very compelling evidence***.

These are very significant increases in the incidence of cancer mortality which are hard to dismiss or ignore, and the exposures to the pulsed microwave radiation are extremely low, between 0.1 and 0.24 $\mu W/cm^2$, based on 10 % of the external, one exposed wall only measurements of less than 1 to 2.4 $\mu W/cm^2$ on average and between 5 and 15 $\mu W/cm^2$ for peaks. Remember that the radar was directed at the top floor only.

These very low mean exposures are associated with a 4- to 5-fold increase in childhood leukaemia, a 3.8 fold increase in all cancers in Moscow and an overall increase in cancer of 4.0 for living in and 1.36 for living outside the compound in Moscow. This is a low level does-response relationship with risk increasing with increasing mean probable exposure. Note that the readings were taken on the outside walls of the embassy chancellery, not inside where the people were. Hence the increased health risk is associated with somewhat lower mean exposure levels than are reported in Table 28.

17.3.6 Parental Occupation and Risk of Birth Defects in Offspring:

Schnitzer et al. (1995) state that several epidemiological studies indicate some parental occupations are associated with an increased risk of birth defects. They review a large number of papers and extend the analysis using data collected as part of the Metropolitan Atlanta Congenital Defects Programme between 1968 and 1980. Of particular interest here are the group known as Electricians and Electrical workers. "Electronic equipment operators is another category in this exploratory analysis that has elevated odds ratios for several birth defects.

Table 31: Birth defects associated with parental occupations, Schnitzer et al. (1995).

Electricians, electrical workers (N=229)			
Anencephalus	7	1.3	0.6-2.8
Spina bifida	10	1.2	0.6-2.5
Atrial septal defect	3	0.6	0.2-1.9
Coactation of aorta	6	3.0	1.2-7.5
Rectum, anus atresia/stenosis	4	1.7	0.6-5.0
Electronic equipment operators (N=123)			
Anencephalus	4	1.6	0.5-4.8
Spina bifida	6	1.9	0.7-4.7
Atrial septal defect	4	2.6	0.9-7.9
Cleft Palate	3	2.1	0.6-7.3
Cleft lip and palate	4	1.7	0.6-5.4
Pyloric Stenosis	7	1.7	0.7-3.9
Reduction defects upper limb	4	4.2	1.3-13.7

This group includes announcers, air traffic controllers; and broadcast equipment computer and telephone operators. Some or all of these workers are potentially exposed to electromagnetic fields, including radiofrequency radiation. The electricians and electrical workers category has similar potential exposures.

The authors acknowledge the limitation of parental occupation as an indicator of exposure and the existence of many potential confounders. What they have done is to identify potential risk factors which are significant for some industrial exposure situations.

Savitz and Chen (1990) summarize studies of parental occupations and childhood nervous system cancers. The following table covers electrical and electronic workers:

Table 32: Results of studies of parental occupation and childhood nervous system cancers, Savitz and Chen (1990).

Electrical Occupation	Cancer site	No.Cases	OR
Electronics Workers	Neuroblastoma	6	11.8*

Electrical assembling, installing and repairing	Brain	19	2.7*
Electromagnetic fields, narrow definition	CNS tumors	15	1.7
Electromagnetic fields, broad definition	CNS tumors	19	1.6

The results mean that we can't ignore the possibility of birth defects in offspring for parents exposed to electromagnetic radiation. That potential clearly exists.

17.3.7 Summary of Epidemiological Evidence:

These studies together show statistically significantly increased risk and incidence in many important health and well-being factors in human beings exposed to a range of frequencies and intensities of residential expose and school exposure at levels well below $2\mu W/cm^2$, being in the range of about 0.04 to $0.2\mu W/cm^2$ in the North Sydney cancer study; $0.0034\mu W/cm^2$ (the bottom on Zone B) in the Schwarzenburg Study (though Zone C also shows sleep disturbance effects); in Latvia at similar exposure levels, school children's performance is impaired and pine trees show decreased growth rates in mean measured exposure of $0.0027\mu W/cm^2$ at 4 km from the radar, in the Skrunda Study, and in the U.K., with increased adult leukaemia out to 10 km, about $0.05\ \mu W/cm^2$.

The U.S. embassy in Moscow provides additional consistency evidence for childhood leukaemia, in addition to the Hawaii, and North Sydney studies. It also adds biological plausiblity to the many other studies showing chromosome aberrations and DNA breakage. Adult cancer increase in Moscow is not unusual in the light of the scores of other studies associating adult cancers to RF/MW exposure.

There is also gowing evidence of childhood defects being associated by parents' EMR exposure.

18. Classification of Carcinogens:

The task now is to place the evidence in a more objective assessment context. A classification scheme for carcinogens has been assembled to assist with this.

18.1 Background:

Many substances, originally assumed to be benign, are now classified as carcinogens. The classification as several levels or ranking from a possible human carcinogen to a proven human carcinogen. The vast majority of listed substances are potential carcinogens in various stages of investigation and weights of evidence of possible or probable carcinogenicity. Associate Professor Neil Pearce, epidemiologist at the Wellington Clinical school, says that about 19 of the 20 major human carcinogens were first identified by epidemiology, pers comm. Classification of human carcinogens must involve human epidemiological studies to receive a high classification. Animal studies give toxicological and biochemical evidence of processes which can give reinforcement to human epidemiological studies.

An epidemiological study which finds a statistically significant increase in cancer incidence in association with an identified risk factor may well be equivocal because of unknown confounding factors. The search to resolve this issue can involve further

epidemiological studies and/or animal experiments when test animals are challenged with known levels of the possible carcinogen. If the results of a replicated animal experiment point strongly to the risk factor present and not discounted in the epidemiological studies then the risk factor would be classed as a Class C, possible human carcinogen.

Stronger animal data accompanied by stronger epidemiological evidence, moves the classification further up the scale.

18.2 A classification scheme:

A recent comprehensive review by a team of Swedish researchers, Hardell et al (1995), applied criteria for evaluating groups of epidemiological studies to identify (a) no association, (b) probably no association, (c) possible association and (d) association. The US EPA use a class C to A classification. The following table illustrates the US EPA approach, which combines animal and epidemiological input:

Possible Carcinogen: Class C.: The human evidence is inadequate but there is some "limited" animal experiments indicate increased cancer with increased exposure.

Probable Carcinogen: Class B2: Sufficient animal experiments with some, but not adequate human evidence.

Probable Carcinogen: Class B1: Sufficient animal experiments and limited human epidemiological evidence.

Table 33: Potential Carcinogens
EPA "Weight-of-Evidence" classification and Hazard Ranking

Class A: Human Carcinogen	Class B: Probable Human Carcinogen		Class C: Possible Human Carcinogen
	B1: Limited Epidemiologic Evidence	B2: Sufficient Animal Evidence	
Arsenic (H)	Acrylonitrile (M)	Beryllium (M)	Methyl Chloride (L)
Asbestos (H)	Cadmium (M)	DDT (M)	Tricholoroethane (L)
Benzine (M)	Creosote (H)	PCBs (M)	Saccharin (L)
Diethylstilbestrol (H)	Eythyle Oxide (M)	Carbon tetrachloride (M)	
Vinyl chloride (H)	Ethylene oxide (M)	Dioxin (H)	
	Formaldehyde (M)		

Hazard Ranking: (H)=High; (M)=Medium; (L)=Low. Source Office of Health and Environmental Assessment, EPA June 1988

Human Carcinogen: Class A.: Coherent, strong evidence of human epidemiology, backed up by strong animal evidence.

In relation to the RMA, where a "potential effect of low probability but high potential impact" gives a threshold for level of evidence based on epidemiological analysis. Through decisions of the Planning Tribunal the concept of "potential effect" incorporates a "plausible mechanism". This conforms to the EPA approach thought the plausible mechanism does not necessarily use an animal model, but could equally be a biophysical/biochemical model. For ease of applying these criteria, they have been

slightly modified by combining the epidemiological criteria from Hardell (1995) with the EPA approach.

1. ***No association*** based on: three or more studies showing no association with measured, estimated or evaluated EMF exposure or exposure hygienic classification. Confounding can be ruled out with reasonable confidence. Absence of animal or cell tissue experiments showing biological effects which could be potentially associated with cancer.

2. ***Possible (Potential) carcinogen*** (Class C) based on a "plausible mechanism and not mere innuendo", i.e. animal and cell tissue experiments reveal one or more plausible mechanisms by which the increased EMF exposure can reasonably lead to cancer initiating or cancer promoting cellular behaviour, or an replicated animal experiment showing responses consistent with cancer causing factors, such as impaired immune system, chromosome breakage, DNA damage, gene mutations, etc. A well performed animal experiment exists showing increased carcinomas but beyond this the animal evidence is "limited".

3. ***Probable carcinogen*** (Class B2) based on: three or more studies showing a pattern of an association with measured, estimated or evaluated EMR exposure or hygienic classification, backed up by plausible mechanisms through replicated animal and/or tissue experiments, as for Class C above.

4. ***Highly Probable carcinogen*** (Class B1) based on: consistent results in two or more well-performed studies showing excess risks and a dose-response in terms of measured, estimated or evaluated EMR exposure, or a consistent pattern of an association with excess risks in exposure hygienic classification. Confounding can be ruled out with reasonable confidence; backed up by plausible mechanisms through replicated animal or tissue experiments.

5. ***Human carcinogen*** (Class A) based on: consistent results in four or more well-performed studies showing excess risks and a dose-response in terms of measured, estimated or evaluated EMR exposure, or a consistent pattern of an association with excess risks in exposure hygienic classification. Confounding can be ruled out with strong confidence. Reliably demonstrated consistent causal mechanisms are available from more than one laboratory for each mechanism, through in vitro and/or in vivo experiments.

18.3 A current classification assessment:

Several causal mechanisms are set out and well described above, including melatonin suppression, alteration of the signal transduction process at cellular level, alteration of the cell cycle at critical times such as the s-phase, co-carcinogenic effects with other carcinogens, co-promotion to enhance cancer incidence and chromosome aberrations from the action of liberated free radicals.

Long term animal experiments show statistically significantly increased benign and malignant tumours without chemical initiation, and very much enhanced incidence of lung, skin and breast tumours with chemical initiation, showing cancer initiation and promotional attributes for RF/MW radiation, consistent with the cellular changes observed in vitro.

Szmigielski's results are consistent with the re-evaluation of the U.S. Navy Korean War study, with the increase in Lymphatic and haematopoietic cancers, brain, eye and CNS, cancers, skin cancer and cancer of the respiratory and digestive organs.

Brain cancer associations were also found by Thomas et al (1987), Speers et al. (1988), Tornqvist et al. (1991) and Grayson (1996); skin cancer by Vagero et al. (1985), De Guire et al. (1987), Szmigielski (1996); eye cancer by Holly et al. (1995) and adult leukaemia by Milham (1988), Goldsmith (1995), Szmigielski (1996), Dolk et al. (1997a, 1997b) and Hocking et al. (1996).

Breast cancer in women exposed to radar was significantly raised in Moscow, Goldsmith (1995). It is consistent with the melatonin mechanism and has been found in electrical industries, Cantor et al. (1995) and in men, Demers et al. (1991).

The Moscow Embassy staff and dependents, chronically exposed to low intensity radar signals, experienced statistically significant increases in childhood leukaemia incidence and death, Goldsmith (1995). This is consistent with Hocking et al. (1996), Maskarinec and Cooper (1993), and Anderson and Henderson (1986).

The Moscow Embassy study also involved blood tests which showed significantly elevated hematocrit and monocyte count, and lower neutrophil concentrations. White blood cells were strikingly higher, Goldsmith (1995). He also reports that the occurrence of multiple-site cancers was unusually high, 1.33 sites/person compared to 1.02 expected from the Third National Cancer Survey.

Residential studies finding statistically significant increases in cancer with exposure to RF/MW radiation, some with dose-response relationships (*), include: Lester and Moore (1982)*, Lester and Moore (1985), Maskarinec and Cooper (1993), and Anderson and Henderson (1986), Hocking et al. (1996), Dolk et al. (1997a*, 1997b*)

Together these results, reinforced by animal experiments, make the strong case of classifying RF/MW radiation exposure a highly probable human carcinogen, Class B1, or even Class A, according to U.S. EPA classification.

Exposure levels at which Risk Ratios are significantly raised average less than 10 $\mu W/cm^2$ for military and occupational studies and less than $0.1\mu W/cm^2$ for residential studies. For example Hocking et al.(1996) where calculated exposures of the "exposed" group residences are in the range 0.2 to $2\mu W/cm^2$, but measured outdoor levels were around 1/5th of this, i.e. 0.04 to $0.4\mu W/cm^2$, but mean exposures, including indoor time, will be even lower. This is consistent with the results of Lester and Moore (1982, 1985).

18.4 Mortality statistics significantly under-estimate morbidity:

The absence of specifically directed studies involving a comprehensive assessment of potential health effects probable leads to a major underestimate of the possible adverse effects. This arises because mortality statistics are more robust and more readily available than is the incidence of non-fatal tumors and lesions for example. Demers et al. (1992) demonstrate this using a Tumor Registry verses Death Certificates in an Occupational Cohort Studies in the United States. Their abstract records the following conclusion:

"As expected, an increased ability to study relatively common cancers with low fatality rates was demonstrated by the incidence data. The most dramatic example was seen for bladder cancer. Twenty-four bladder cancers were diagnosed among the study cohort (consisting of 4,528 Tacoma fire fighters and police officers) between 1974 and 1989, whereas only two deaths were attributed to this malignancy."

Hence most studies which are related to mortality statistics grossly underestimate the adverse health effects. Thus studies of the full potential impact of any particular environmental stressor are difficult and rare because of the limitations in available data and the complexity of human subjects. This is more likely to lead to an under-estimate of the impact of a particular stressor than an over-estimate.

Thus it is vital to remember that most epidemiological studies used to assess carcinogenicity use mortality statistics. There is between 10 and 20 times more tumours produced which do not result in death but are a major cost on the health system, extremely worrying to the person and causes loss of earnings.

19. Conclusions

19.1 Standards and standard setting:

The Australia/ New Zealand standards committee for EMR is a technical committee of "stakeholders" which includes a majority of those who derive direct or indirect benefit from the production and use of EMR. It is not independent of industry as a public health protection standards committee should be. The U.K. provides a good alternative model.

The standard derives from western approaches to standards setting which has been dominated by the United States, the Tri Services Program (Army, Navy and Air Force), ANSI and IEEE and relate closely to thermal effects protection. They are not based on epidemiological results for they are, in the main, assumed to be faulty under the mistaken assumption that there are only thermal effects. Recent moves to relax the Australia/ New Zealand standard were based on conforming to these U.S. standards, on the basis that they are "more scientific". This is only true to the extent that they are well based in the science of heating.

19.2 Athermal biological mechanisms:

Observations, reinforced by mathematical models, show that time varying signals interact at the cellular and tissue level producing voltage gradients and cell development changes at extremely low exposure levels corresponding to tissue gradients of the order of 10^{-7} V/cm. Changes in brain function are particularly evident, with altered circadian rhythm associated with the removal of the extremely weak Schumann Oscillations (0.3 pW/cm^2) and altered human EEG at 0.7 $\mu W/cm^2$. Most aspects of cell cycle activity have been shown to be altered by imposed RF/MW signals, including cell cycle time, signal transduction controls of cell development, differential and proliferation, cell ion balance, DNA synthesis, cell membrane permeability, and melatonin reduction and free radical damage, associated with chromosome aberrations.

Calcium ion efflux and melatonin/free radical processes are implicated in impaired immune system performance. This relates to carcinogenesis, spontaneous miscarriage, birth deformity, and a host of other diseases.

Melatonin reduction is a central and primary mechanism, which is also involved with sleep disruption, chronic fatigue syndrome, learning and memory impairment.

This can be well summarized by referring to the following very recent papers. Resonant absorption at the cell membrane was demonstrated by Liu and Cleary (1995). A review of research on effects of microwaves on the nervous system 1990-1995, published in an IEEE journal in October 1996, states:

> **"The use of weak electromagnetic fields to study the sequence and energetics of events that couple humoral stimuli from surface receptor sites to the cell interior has identified the cell membrane as a primary site of interaction with these low frequency fields in the pericellular fluid. Field modulation of the cell surface chemical events indicates a major amplification of initial weak triggers associated with the binding of hormones, antibodies and neurotransmitters to their specific binding sites. Calcium plays a key role in this stimulus amplification, probably through highly cooperative alterations in binding to surface glycoproteins, with spreading waves of altered calcium binding across the membrane surface. Protein particles spanning the cell membrane form pathways for signaling and energy transfer. Fields millions of times weaker than the membrane potential of 10^7 V/m modulate cell responses to surface stimulating molecules.**
>
> **The evidence supports non-linear, non-equilibrium processes at critical steps in transmembrane coupling. Cancer promoting phobol esters act at cell membranes to stimulate ornithine decarboxylase which is essential for cell growth and DNA synthesis. This response is enhanced by weak microwave fields also acting at the cell membrane. There is strong evidence that cell membranes are powerful amplifiers of weak electrochemical events in their vicinity", Vorst and Duhamel (1996).**

Microwaves, 915 MHz, whether pulsed or continuous, open the Blood-Brain Barrier, making the brain more open to toxic polar molecules and weakening the BBB changes the system which controls the stability of the fluid movement of the brain's intracellular compartment. The specific results are, Vorst and Duhamel (1996):

1) Exposed animals are at risk for opening the BBB (Odds Ratio =3.8, p=0.0004).

2) The response is independent of pulse repetition rate, and the response is the same for CW as compared to pulsed modulation.

3) The response is independent of SAR in the interval 0.016< SAR < 2.5 W/kg (Odds Ratio = 3.3), but rises for SAR > 2.5 W/kg.

19.3 Animal Studies:

Long term animal studies have shown increases in benign and malignant tumours (carcinomas) at a multitude of sites, consistent which the whole body coverage of EM radiation; with skin cancer, breast cancer, lung cancer, cancer of the white cells, lymphatic tumours and myeloid leukaemia, atrophy of the testes, lower birth weight, still birth, resorption, hemorrhage and stunted growth, immune system impairment and altered brain activity (EEG), reaction times and learning retention.

Short term exposure experiments have found DNA breakage in living rats brains, associated with free radicals and melatonin reduction.

19.4 Public Health and Epidemiological Studies:

Several human studies show reduction in melatonin directly through blood or urine samples, and indirectly through monitoring sleep quality and scholastic performance. At least three studies show impairment of children's learning and memory functions at residential levels of exposure. The Schwarzenburg study shows sleep difficulties which have a strong dose-response relationship and were confirmed when the transmitter went off unknowingly. The effects were seen as far as 5 km away. Chronic fatigue syndrome was very evident. The effects are seen across the RF/MW spectrum. Sleeping with a mobile phone next to your bed changes your EEG and interferes with REM sleep, causing learning and memory problems, in the same manner as radar in Latvia and SW radio in Switzerland.

Scores of occupational studies have linked RF/MW exposure to increased incidence of cancer and cancer related death. The strongest rate ratios in occupational studies and the strongest results from residential studies involves Leukaemia. Residential studies associate increased incidence of leukaemia in adults and children at measured mean exposure levels down to about 0.04 $\mu W/cm^2$ (0.2 $\mu W/cm^2$ / 5: North Sydney).

With cell changes, animal experiments and scores of epidemiological studies, RF/MW can be classified as a Class B1 (highly probable) human carcinogen or even a Class A human carcinogen. Avoidance or significant risk reduction will only be achieved for chronic residential exposure where mean exposure levels are somewhat less than 0.1 $\mu W/cm^2$.

Some results are grouped in Table 34, with higher exposures corresponding to higher risk ratios, giving a grouped dose-response. These are more than sufficient to establish a potential adverse health effect "of low potential probability and high potential impact".

Table 34: Summary of mean exposures to RF/MW radiation and risk ratio ranges for cancers.

Study	Exposure Range $\mu W/cm^2$	Risk Ratio Range
Polish Military	< 7 - 14	3.0 - 13.9
Moscow Embassy	< 0.1 - 2.4	1.7 - 5.0
Korean War	?	1.9 - 3.3
U.K. 21 sites	< 0.05 - 1.6	1.01 - 3.57
North Sydney	< 0.04 - 1.6	1.61 - 2.74

19.5 Reproduction Studies:

Studies on the adverse effects of RF and MW exposure on pregnancy involving physiotherapists, show MW to be a risk factor for early spontaneous miscarriage and RF to be a risk factor for perinatal death and congenital deformity. Mean exposure levels in the range 0.04 to 0.56 $\mu W/cm^2$, corresponding to 10 treatments per month, is associated with an Odds Ratio of 1.50 (CI:1.04-2.17). This approach to averaging is appropriate because of the very high plausibility of a non-thermal mechanism, such as chromosome aberrations from the release of free radicals. A higher rate of damage from a given MW exposure compared with RF rate of damage, could well explain the early pregnancy effect of MW and the late pregnancy effects of RF.

19.6 Biological Studies:

Human beings are not the only part of the environment which have shown adverse biological impacts of exposure to RF/MW radiation at very low mean ambient levels.

Adverse biological effects on plants and animals have been identified in the Schwarzenburg and Skrunda Studies. Pine tree growth ring annual increments were significantly reduced at 4 km from the Skrunda radar, in mean measured exposure levels of $0.0027\mu W/cm^2$, a six-fold chromosome damage level in cattle blood was found in the absolute range 0.04 to $6.6\mu W/cm^2$, and mean measured exposure range 0.16 - $0.63\mu W/cm^2$, a similar range for the plants which demonstrated massive disruption of their reproductive system.

19.7 Children's performance:

Adverse effects are found at very low mean environmental levels of exposure to RF/MW which relate to performance rather than health. Children's intellectual and physical performance levels were significantly impaired in both the Swiss and Latvian studies, in mean residential exposure levels in the range 0.03 to $9.06\mu W/cm^2$, median $0.1\mu W/cm^2$ and mean $0.24\mu W/cm^2$ in Switzerland and 0.003 to $0.04\mu W/cm^2$ in Latvia.

These results are consistent with the very significant human EEG changes observed by Von Klitzing (1995), at exposure levels of $0.7\mu W/cm^2$.

The Chinese study, Chiang (1988) also showed significant changes in children mental and physical performance, but at slightly higher levels of exposure, $0\text{-}4\mu W/cm^2$.

19.8 Sleep disruption, fatigue, aches and blood pressure:

These Swiss exposures were also associated with significant increases in reported disorders, especially in those over 45 years, involving sleep disruption and chronic fatigue syndrome, related to melatonin reduction, as well as aches, pains, lung problems and heart problems. These were associated with mean exposure levels (Zones A and B) in the range $0.024 - 0.24\mu W/cm^2$.

20. Recommendations:

There is extensive and compelling scientific research which links RF/MW exposure, down to very low mean exposure levels, to severe health problems and mortality risks.

This suggests setting the Public exposure limit at:

$0.1\mu W/cm^2$ if cancer risk is to be reduced, and

$0.01\mu W/cm^2$ if miscarriage risk, sleep disruption, children's performance impairment and chronic fatigue symptoms are to be reduced.

This requires that cell sites, wherever possible, be located away from residential areas. In Australia, with so much open space. There is no practical impediment to placing base stations in open rural settings, outside rural and suburban settlements and towns. The small costs of extra cables is trivial compared to the health costs associated with chronic exposure of residents.

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