

Power Density: Radio frequency Non-ionizing Radiation

'... the possibility of harm from exposures [to low levels of radio frequency radiation] insufficient to cause important heating of tissues cannot yet be ruled out with confidence. Furthermore, the anxieties that some people feel when this uncertainty is ignored can in themselves affect their well-being.'

Sir William Stewart (Chairman)
*Mobile Phones and Health:
A report from the Independent Expert Group
on Mobile Phones,
(The Stewart Report, 2000)*

Power Density: Definition

Above 30 MHz, the usual unit of measurement is power density, though electric and magnetic fields can also be measured. It is usually expressed in milli- or microwatts per square centimetre (mW/cm² or µW/cm²), and is defined as the amount of power per unit area in a radiated microwave field or other type of electromagnetic field.

Introduction

Research from abroad, partially replicated (and in some instances expanded on) by scientists in English speaking countries, indicates many potential benefits in health, wellbeing and work productivity can be obtained from developing a more comprehensive understanding of potential EMF bio-effects. They also indicate ways in which present communications systems, and the electromagnetic nature of the microenvironments individuals occupy, can be improved to benefit all. It is suggested that the potential cost benefits of adopting improved EMF-hygiene protocols and developing new generations of technology that can actually improve biological functioning and human performance is immense, makes tremendous commercial sense and present enormous commercial opportunities.

As can be seen in the following table, both beneficial and detrimental biological effects are indicated at exposure levels far lower than those required for 'thermal effects', the traditional marker used to set many guidelines on presently 'acceptable' power density levels.

The Precautionary Principle/Approach?

'... [the] actions taken under the precautionary principle should be commensurate with anticipated risks of health detriment.'

Section 6.14
The Stewart Report, 2000

The need for additional impartial scientific research appears warranted to address such concerns for everyone's benefit and that of the planet...

Power Density – International Regulations and Possible Biological Effects		
Power Density	Reported Biological Effects / Comments	References
0.0000000000000001 $\mu\text{W}/\text{cm}^2$	Cosmic background at 1800 MHz approx. average	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0000000001 $\mu\text{W}/\text{cm}^2$	Natural background level for all RF frequencies	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0000000001 $\mu\text{W}/\text{cm}^2$	Threshold of human sensitivity	N.N. Kositsky, A.I. Nizhelska and G.V. Ponezha (2001), Influence of high-frequency electromagnetic radiation at non-thermal intensities on the human body (a review of work by Russian and Ukrainian researchers) <i>Translation by Patricia Ormsby, No Place To Hide</i> , 3(1) Supplement. www.emfacts.com/ussr_review.pdf
0.0000000001 – 0.00000001 $\mu\text{W}/\text{cm}^2$	Normalising effect on cell growth of isolated cells damaged by ionising radiation exposed for 7 minutes	L.S. Bundyuk, A.P. Kuz'menko, N.N. Ryabchenko and G.S. Litvinov (1994), Corrective action of millimeter waves on systems of various levels of hierarchy. <i>Physics of the Alive</i> , 2(1):12-25, cited by Kositsky et al 2001.
0.0000000002 $\mu\text{W}/\text{cm}^2$	Mobile phone handsets can work down to about this level	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.000000001 $\mu\text{W}/\text{cm}^2$	Altered EEG in humans – a relaxation frequency of protein-bound water thought to occur between 100 - 1,000 MHz. Absorption and quantum effects may be the mechanistic basis for EEG changes noted in most subjects from 0.00000001 $\mu\text{W}/\text{cm}^2$ CW RF energy of 130-960 MHz.	W. Bise (1978), Low power radio-frequency and microwave effects on human electroencephalogram and behavior. <i>Physiological Chemistry and Physics</i> , 10(5):387-398. www.ncbi.nlm.nih.gov (abstract)
0.0000000027 $\mu\text{W}/\text{cm}^2$	Growth stimulation in <i>Vicia fabus</i>	Brauer (1950), Experimental studies on the effect of meter waves of various field intensities on the growth of plants by division. <i>Chromosoma</i> 3:483-509.
0.00000001 $\mu\text{W}/\text{cm}^2$	Effects on immune system of mice exposed for 5 minutes per day for 5 days to 54-76 GHz at this level	L.S. Bundyuk, A.P. Kuz'menko, N.N. Ryabchenko and G.S. Litvinov (1994), Corrective action of millimeter waves on systems of various levels of hierarchy. <i>Physics of the Alive</i> , 2(1):12-25, cited by Kositsky et al 2001.
0.00000002 $\mu\text{W}/\text{cm}^2$	Stimulation of ovulation in chickens	P.A. Kondra, W.K. Smith, G.C. Hodgson, D.B. Bragg, J. Gavora, M.A.K. Hamid and R.J. Boulanger (1970), Growth and reproduction of chickens subjected to microwave radiation. <i>Canadian Journal of Animal Science</i> 50:639-644, cited by A. Firstenberg 2001.
<0.000001 $\mu\text{W}/\text{cm}^2$	Altered EEG in humans – temporary changes in brain waves and behaviour.	W. Bise (1978), Low power radio-frequency and microwave effects on human electroencephalogram and behavior. <i>Physiological Chemistry and Physics</i> , 10(5):387-398. www.ncbi.nlm.nih.gov (abstract)
0.000001 $\mu\text{W}/\text{cm}^2$	Burgerforum BRD proposal, sleeping areas (1999)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.000005 $\mu\text{W}/\text{cm}^2$	Effect on cell growth rate in yeast <i>S. cerevisiae</i>	W. Grundler and F. Kaiser (1992), Experimental evidence for coherent excitations correlated with cell growth. <i>Nanobiology</i> 1:163-176
0.00001 $\mu\text{W}/\text{cm}^2$	Conditioned 'avoidance' reflex in rats	N.N. Kositsky, A.I. Nizhelska and G.V. Ponezha (2001), Influence of high-frequency electromagnetic radiation at non-thermal intensities on the human body (a review of work by Russian and Ukrainian researchers) <i>Translation by Patricia Ormsby, No Place To Hide</i> , 3(1) Supplement. www.emfacts.com/ussr_review.pdf
0.000027 $\mu\text{W}/\text{cm}^2$	Premature aging of pine needles	Selga, T. & Selga, M. (1996), Response of <i>Pinus sylvestris</i> L. needles to electromagnetic fields. Cytological and ultrastructural aspects. <i>The Science of the Total Environment</i> 180:65-73, Elsevier Science BV.
0.0001 $\mu\text{W}/\text{cm}^2$	Burgerforum BRD proposal, waking areas (1999)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0001 $\mu\text{W}/\text{cm}^2$	Salzburg GSM/3G inside houses (2002)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp

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0.001 $\mu\text{W}/\text{cm}^2$	100 Yards from a Cellular Phone	A. Firstenberg (2001), Radio Wave Packet, www.goodhealthinfo.net/radiation/radio_wave_packet.pdf .
0.001 $\mu\text{W}/\text{cm}^2$	Exposure Limit in New South Wales, Australia as at 2001	A. Firstenberg (2001)
0.001 $\mu\text{W}/\text{cm}^2$	Salzburg GSM/3G outside houses (2002)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.002 $\mu\text{W}/\text{cm}^2$	Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problems, fewer schoolchildren promoted – controlled study near a shortwave transmitter	Altpeter <i>et al.</i> (1995, 1997), Study on health effects of the shortwave transmitter station of Schwarzenburg, Berne, Switzerland, Study No. 55, Swiss Federal Office of Energy), cited by A. Firstenberg 2001.
0.0027 $\mu\text{W}/\text{cm}^2$	Growth inhibition in <i>Vicius fabus</i>	I. Brauer (1950), Experimental studies on the effect of meter waves of various field intensities on the growth of plants by division. <i>Chromosoma</i> 3:483-509, cited by A. Firstenberg 2001.
0.0027 to 0.065 $\mu\text{W}/\text{cm}^2$	Smaller tree growth rings	Balodis, V., <i>et al</i> (1996), Does the Skrunnda Radio Location Station diminish the radial growth of pine trees? <i>The Science of the Total Environment</i> 180:57-64.
0.0048 $\mu\text{W}/\text{cm}^2$	Median level, 15 US cities 1977 (mainly VHF & TV)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.007 $\mu\text{W}/\text{cm}^2$	50 Feet from a Cordless Phone	A. Firstenberg (2001).
0.01 $\mu\text{W}/\text{cm}^2$	Human sensation	Kolbun and Sit'ko (1987), Sensory indications by the human body of EHF-range electromagnetic radiation. <i>Mechanisms of Biological Action of Electromagnetic Radiation: Proceedings of the Pushchino Symposium</i> , 27-31 Oct. 1987, cited by A. Firstenberg 2001.
0.01 $\mu\text{W}/\text{cm}^2$	EU-Parl, GD Wissenschaft, STOA GSM (2001), Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.016 $\mu\text{W}/\text{cm}^2$	1 Mile from a Cellular Tower	A. Firstenberg (2001)
0.04 – 0.2 $\mu\text{W}/\text{cm}^2$	SAR-value of 80-400 $\mu\text{W}/\text{kg}$, 0.002 V/m at 947.5 MHz	O. Johansson (1995), 'E'överkänslighet samt överkänslighet mot mobiltelefoner: Resultat från en dubbel-blind provokationsstudie av metodstudiekaraktär' (=Electrohypersensitivity and sensitivity to mobile telephones: Results from a double-blind provocation study of pilot character', in Swedish), Enheten för Experimentell Dermatologi, Karolinska Institutet, Stockholm, Rapport nr. 2, 1995, ISSN 1400-6111
0.06 $\mu\text{W}/\text{cm}^2$	Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, structural changes in liver, spleen, testes, and brain – in white rats and rabbits	Dumanskij & Shandala (1974), The biologic action and hygienic significance of electromagnetic fields of super-high and ultrahigh frequencies in densely populated areas. <i>Biologic Effects and Health Hazards of Microwave Radiation, Proceedings of an International Symposium, Warsaw</i> , 15-18 Oct. 1973, P. Czernski <i>et al.</i> , eds., cited by A. Firstenberg 2001.
0.05 $\mu\text{W}/\text{cm}^2$	10 Feet from a Wireless Computer	A. Firstenberg (2001).
0.06 $\mu\text{W}/\text{cm}^2$	Slowing of the heart, change in EEG in rabbits	Serkyuk, reported in McRee 1980, cited by A. Firstenberg 2001.
0.1 $\mu\text{W}/\text{cm}^2$	Italy (single frequency), Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.1 $\mu\text{W}/\text{cm}^2$	Salzburg 1998 (sum GSM), Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.1 $\mu\text{W}/\text{cm}^2$ (0.001 W/Kg SAR)	EEG brain waves altered under exposure to cell phone signal	L. Von Klitzing (1995), 'Low-Frequency pulsed electromagnetic fields influence EEG of man.' <i>Physica Medica</i> , Vol. 11, No. 2, pps 77-80, April-June 1995, cited by C. Sage 2004.

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0.1 $\mu\text{W}/\text{cm}^2$	Increased in melatonin in cows on 1 st night of re-exposure after 3-30 MHz transmitter inoperational for 3 days – difference in salivary melatonin concentration statistically significant, indicating a 2-7-fold increase of melatonin concentration.	K.D.C. stark , T. Krebs, E. Altpeter, B. Manz, C. Griot and T. Abelin (1997), Absence of chronic effect of exposure to short-wave radio broadcast signal on salivary melatonin concentrations in dairy cattle. <i>Journal of Pineal Research</i> 22(4):171-176.
0.1 to 1.8 $\mu\text{W}/\text{cm}^2$	Decreased life span, impaired reproduction, structural and developmental abnormalities in duckweed plants	Magone, I. (1996), The effect of electromagnetic radiation from the Skrunda Radio Location Station on <i>Spirodela polyrhiza</i> (L.) Schleiden cultures. <i>The Science of the Total Environment</i> 180:75-80.
0.13 $\mu\text{W}/\text{cm}^2$	Decreased cell growth (human epithelial amnion cells)	Kwee & Raskmark (1997), Radiofrequency electromagnetic fields and cell proliferation. In <i>Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine</i> , June 8-12, 1997, Bologna, Italy, F. Bersani, ed.
0.16 $\mu\text{W}/\text{cm}^2$	Attention, memory and motor function of school children significantly affected in comparison to control groups. Reaction times slower and neuromuscular apparatus endurance also reduced.	A.A. Kolodynski and V.V. Kolodynska (1996), Motor and psychological functions of school children living in the area of the Skrunda radio location station in Latvia. <i>The Science of the Total Environment</i> , 180 (1):87-93.
0.168 $\mu\text{W}/\text{cm}^2$	Progressive decrease in number of newborns and irreversible infertility in mice after 5 generations exposure to radiation from 'antenna park'.	I.N. Magras and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, <i>Bioelectromagnetics</i> , 18(6), pp. 455-461.
0.2 – 8 $\mu\text{W}/\text{cm}^2$	Two-fold increase in childhood leukaemia from AM-FM exposure from TV towers compared to areas with levels of 0.02 $\mu\text{W}/\text{cm}^2$	B. Hocking, I.R. Gordon and H.L. Grain (1996), Cancer incidence and mortality and proximity to TV towers. <i>Medical Journal of Australia</i> 165(11-12):599-600, cited by Sage 2004.
0.3 $\mu\text{W}/\text{cm}^2$	Impaired motor function, reaction time, memory and attention of schoolchildren, and altered sex ratio of children (fewer boys)	A.A. Kolodynski and V.V. Kolodynska (1996), Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia. <i>The Science of the Total Environment</i> 180:87-93.
0.6 $\mu\text{W}/\text{cm}^2$	Change in calcium ion efflux from brain tissue	S. K. Dutta et al, (1986). Microwave radiation-induced calcium ion flux from human neuroblastoma cells: dependence on depth of amplitude modulation and exposure time. <i>Biological Effects of Electropollution</i> , S. Dutta and R. Millis, eds., pp. 63-69. Philadelphia, PA: Information Ventures, cited by A. Firstenberg 2001.
0.6 $\mu\text{W}/\text{cm}^2$	Cardiac arrhythmias and sometimes cardiac arrest (frogs)	Frey, 1986. Evolution and results of biological research with low-intensity nonionizing radiation. <i>Modern Bioelectricity</i> , A.A. Marino, ed., pp. 785-837. New York, NY: Dekker.
0 – 4 $\mu\text{W}/\text{cm}^2$	Altered white blood cell activity in schoolchildren	H. Chiang et al., 1989. Health effects of environmental electromagnetic fields. <i>Journal of Bioelectricity</i> 8(1):127-131, cited by A. Firstenberg 2001
1.0 $\mu\text{W}/\text{cm}^2$	Headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion (humans—occupational exposure)	V. B. Simonenko et al., 1998. Influence of electromagnetic radiation in the radiofrequency range on the health condition of an organized collective. <i>Voenno-meditsinskiy zhurnal CCCXIX(5):64-68</i> , cited by A. Firstenberg (2001)
1.0 $\mu\text{W}/\text{cm}^2$	Stimulation of white cells in guinea pigs	M.G. Shandala and G.I. Vinogradov, 1978. Immunological effects of microwave action. <i>Gigiyena i Sanitariya</i> , no. 10:34-38, JPRS 72956, pp. 16-21, cited by A. Firstenberg (2001)
1 $\mu\text{W}/\text{cm}^2$	Change in immunological functions in NMRI mice after exposure to whole body microwave sinusoidal irradiation of 8.15-18 GHz (1 Hz within).	E.E. Fesenko, V.R. Makar, E.G. Novoselova and V.B. Sadovnikov (1999), Microwaves and cellular immunity. I. Effect of whole body microwave irradiation on tumor necrosis factor production in mouse cells. <i>Bioelectrochemistry and Bioenergetics</i> , 49(1):29-35.

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1 $\mu\text{W}/\text{cm}^2$	In vivo irradiation at 8.15-18 GHz (1 Hz within) increased cytotoxic activity of natural killer cells in rat spleen. For mice exposed 24-72 hours, activity of natural killer cells increased 130-150%. This level persisting within 24 hours after end of treatment. In vivo irradiation for 3.5 and 5 hours, and short exposure of splenic cells in vitro did not affect activities of natural killer cells.	E.E. Fesenko, E.G. Novoselova, N.V. Semiletova, T.A. Agafonova and V.B. Sadovnikov (1999), [Stimulation of murine natural killer cells by weak electromagnetic waves in the centimeter range]. <i>Biofizika</i> 44(4), pp.737-741, (Article in Russian), cited by A. Marino, Recent studies (1995-2000) on the biological effects of radiofrequency and cell phone radiation, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html
1 $\mu\text{W}/\text{cm}^2$	Immune system response affected by a single 5-hour whole-body exposure to 8.15-18 GHz microwave radiation (with 1 Hz impulse frequency) that stimulated the immune potential of macrophages and T cells. Antioxidant treatment (through diet) was found to further enhance this effect.	E.G. Novoselova, E.E. Fesenko, V.R. Makar and V.B. Sadovnikov (1999), Microwaves and cellular immunity. II. Immunostimulating effects of microwaves and naturally occurring antioxidant nutrients. <i>Bioelectrochemistry and Bioenergetics</i> , 49(1):37-41.
1 $\mu\text{W}/\text{cm}^2$	Standards in the former USSR for permissible exposure levels to 30-300 MHz for 8-hour workday.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. <i>Gigiena i sanitariya</i> 5:72-74, cited by Kositsky et al 2001.
1 $\mu\text{W}/\text{cm}^2$	Wien (sum GSM)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1 $\mu\text{W}/\text{cm}^2$	Typical reading 100 metres from base station (0.2 to 6 V/m)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1.053 $\mu\text{W}/\text{cm}^2$	Irreversible infertility in mice after 3 generations exposure to radiation.	I.N. Magras and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, <i>Bioelectromagnetics</i> , 18(6), pp. 455-461.
1.3 – 5.7 $\mu\text{W}/\text{cm}^2$	Exposure to AM RF caused two-fold increase in leukaemia in adults	H. Dolk, G. Shaddick, P. Walls, C. Grundy, B. Thakrar, I. Kleinschmidt and P. Elliott (1997), cited by Sage 2004. Cancer incidence near radio and television transmitters in Great Britain. <i>Am J Epidemiology</i> 145(1) P 1-9 Jan 1997.
2–10 $\mu\text{W}/\text{cm}^2$ Exposure Limit in Bulgaria, Hungary, Russia and Switzerland as at 2001, cited by A. Firstenberg 2001.		
2.0 $\mu\text{W}/\text{cm}^2$ (lower threshold not known)	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	A.H. Frey (1963), Human response to very-low-frequency electromagnetic energy. <i>Nav. Res. Rev.</i> 1968:1-4. A.H. Frey (1971), Biological function as influenced by low power modulated RF energy. <i>IEEE Transactions on Microwave Theory and Techniques</i> , MTT-19(2):153-164. A.H. Frey and R. Messenger (1973), Human perception of illumination with pulsed ultrahigh-frequency electromagnetic energy. <i>Science</i> 181:356-358, cited by A. Firstenberg 2001.
2.0 $\mu\text{W}/\text{cm}^2$	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	D.R. Justeson (1979), Behavioral and psychological effects of microwave radiation. <i>Bulletin of the New York Academy of Medicine</i> 55(11):1058-1078, cited by A. Firstenberg 2001.
2.0 $\mu\text{W}/\text{cm}^2$	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	R.G. Olsen (1980), Evidence for microwave-induced acoustic resonances in biological material. <i>Bioelectromagnetics</i> 1:219, cited by A. Firstenberg 2001.
2.0 $\mu\text{W}/\text{cm}^2$	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	C.W. Wieske (1963), 'Human Sensitivity to Electric Fields.' Proceedings of the First National Biomedical Sciences Instrumentation Symposium. (Vol. 1). Ed. Dr. Fred Alt. New York: Plenum Press, 1963, cited by A. Firstenberg 2001.
2.0 $\mu\text{W}/\text{cm}^2$	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	J.C. Lin (1978), <i>Microwave Auditory Effects and Applications</i> . Springfield, IL: Charles C. Thomas, Publisher, Springfield, IL 1978, 221 pp, cited by A. Firstenberg 2001.
2.4 $\mu\text{W}/\text{cm}^2$	Belgium (Wallonia)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
2.4 $\mu\text{W}/\text{cm}^2$	Interference caused to medical devices at least up to 1000 MHz (from digital mobile phones).	K.J. Clifford, K.H. Joyner, D.B. Stroud, M. Wood, B. Ward and C.H. Fernandez (1996), Mobile telephones interfere with medical electrical equipment. <i>Australas Phys Eng Sci Med</i> 1994 Mar. 17(1). P 23-7, cited by C. Sage 2004

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2.5 $\mu\text{W}/\text{cm}^2$	Breakdown of blood-brain barrier (digital cellular phone used to provide the radiation)	Salford <i>et al.</i> , (1997), Blood brain barrier permeability in rats exposed to electromagnetic fields from a GSM wireless communication transmitter. In: <i>Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine</i> , June 8-12, 1997, Bologna, Italy, F. Bersani, ed., cited by A. Firstenberg 2001.
2 – 4 $\mu\text{W}/\text{cm}^2$	Low power microwaves directly effect the operation of cellular ACh-related ion-channels that have vital roles in behavioural and physiological functions.	G. D'Inzeo, P. Bernardi, F. Eusebi, F. Grassi, C. Tamburello and B.M. Zani (1988), Microwave effects on acetylcholine-induced channels in cultured chick myotubes. <i>Bioelectromagnetics</i> 9(4):363-372.
4 $\mu\text{W}/\text{cm}^2$	Standards in the former USSR for permissible exposure levels to 3-30 MHz for 8-hour workday.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. <i>Gigiena I sanitariya</i> 5:72-74, cited by Kositsky et al 2001.
4 – 10 $\mu\text{W}/\text{cm}^2$	Lower memory function/visual reaction time in children slowed in tests	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. <i>Journal of Bioelectricity</i> , 8: 127-131, cited by Sage 2004.
5 $\mu\text{W}/\text{cm}^2$	Standards in the former USSR for permissible exposure levels to 0.3-300 GHz for 8-hour workday.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. <i>Gigiena I sanitariya</i> 5:72-74, cited by Kositsky et al 2001.
5.0 $\mu\text{W}/\text{cm}^2$	Study investigated immune systems of women exposed to 500 KHz-3 GHz fields from radio/television transmitters in their residential area for ≥ 2 years. Exposure levels of 4.3 ± 1.4 V/m (mean +/- S.D.) measured on the balconies of the women's homes. Control group exposed to < 1.8 V/m fields. Higher field exposure found to reduce cytotoxic activity in the women's peripheral blood without a dose-response effect.	P. Boscol, M.B. Di Sciascio, S. D'Ostilio, A. Del Signore, M. Reale, P. Conti, P. Bavazzano, R. Paganelli & M. Di Gioacchino (2001), Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. <i>Sci Total Environ</i> 273(1-3):1-10.
5.0 $\mu\text{W}/\text{cm}^2$	Leukaemia, skin melanoma and bladder cancer near TV and FM transmitter	H. Dolk, G. Shaddick, P. Walls, C. Grundy, B. Thakrar, I. Kleinschmidt and P. Elliott (1997), cited by Sage 2004. Cancer incidence near radio and television transmitters in Great Britain. <i>Am J Epidemiology</i> 145(1) P 1-9 Jan 1997.
5.0 $\mu\text{W}/\text{cm}^2$	Biochemical and histological changes in liver, heart, kidney, and brain tissue	V.S. Belokrinitskiy (1982), 'Hygienic evaluation of biological effects of nonionizing microwaves', <i>Gigiyena i Sanitariya</i> 6:32-34, JPRS 81865, pp. 1-5, cited by A. Firstenberg 2001.
5 – 10 $\mu\text{W}/\text{cm}^2$	Nervous system activity impaired	Dumanski and Shandala (1974), The Biological Action and Hygienic Significance of Electromagnetic Fields of Superhigh and Ultrahigh frequencies in Densely Populated Areas,' from <i>Biological Effects and Health Hazards of Microwave Radiation</i> . Proceedings of an International Symposium, Warsaw 15-18 October, 1973, Polish Medical Publishers, Warsaw, 1974, cited by Sage 2004.
7–10 $\mu\text{W}/\text{cm}^2$	Exposure Limit in People's Republic of China as at 2001,	Cited by A. Firstenberg 2001.
8 $\mu\text{W}/\text{cm}^2$	Association between increased incidences of childhood leukaemia and mortality through RF fields from TV transmitters in comparison to areas with lower power densities. Overall rate ratio of incidence was 1.58 (95% CI, 1.07-2.34). For mortality it was 2.32 (95% CI, 1.35-4.01). For childhood lymphatic leukaemia the rate ratio for incidence was 1.55 (95% CI, 1.00-2.41) and 2.74 (95% CI, 1.42-5.27) for mortality.	B. Hocking, I.R. Gordon, H.L. Grain and G.E. Hatfield (1996), Cancer incidence and mortality and proximity to TV towers. <i>Med J Aust</i> 165(11-12), pp. 601-605, 1996. (Published erratum appears in <i>Med J Aust</i> 166(2):80, 1997), cited by A. Marino, Recent studies (1995-2000) on the biological effects of radiofrequency and cell phone radiation, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html

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8 $\mu\text{W}/\text{cm}^2$	Association between increased incidences of childhood leukaemia and mortality through RF fields from TV transmitters in comparison to areas with lower power densities. Overall rate ratio of incidence was 1.58 (95% CI, 1.07-2.34). For mortality it was 2.32 (95% CI, 1.35-4.01). For childhood lymphatic leukaemia the rate ratio for incidence was 1.55 (95% CI, 1.00-2.41) and 2.74 (95% CI, 1.42-5.27) for mortality.	B. Hocking, I.R. Gordon, H.L. Grain and G.E. Hatfield (1996), Cancer incidence and mortality and proximity to TV towers. <i>Med J Aust</i> 165(11-12), pp. 601-605, 1996. (Published erratum appears in <i>Med J Aust</i> 166(2):80, 1997), cited by A. Marino, Recent studies (1995-2000) on the biological effects of radiofrequency and cell phone radiation, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html
9.5 $\mu\text{W}/\text{cm}^2$	Switzerland, Lichtenstein, Luxembourg	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 $\mu\text{W}/\text{cm}^2$	Russian Federation, People's Republic of China, Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 $\mu\text{W}/\text{cm}^2$	Italy (sum of frequencies)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 $\mu\text{W}/\text{cm}^2$	Maximum permitted exposure levels for base stations inside and outside of living, public and industrial areas for 300-2400 MHz frequencies (Russian Federation, since 1 June 2003)	Hygienic requirements for siting and exploitation of land mobile telecommunication systems, SanPiN 2.1.8/2.2.4.1190-03 (2003), Ministry of Health of Russian Federation / Russian Ministry of Health Protection, SanPiN (Sanitary and Epidemiological Norms). (Standard for siting and using 27-2400 MHz land mobile phone systems in the Russian Federation).
10 $\mu\text{W}/\text{cm}^2$	Impaired / reduced short-term memory function and significant differences in visual reaction time (1170 test subjects).	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. <i>J. Bioelectricity</i> 8(1):127-131.
10.0 $\mu\text{W}/\text{cm}^2$	Decreased size of litter, increased number of stillborns in mice	Il'Chevich (reported in McRee 1980), cited by A. Firstenberg 2001.
$\leq 10 \mu\text{W}/\text{cm}^2$ (max. mean exposure)	Sperm counts of Danish military personnel operating mobile ground-to-air missile units, which used several RFR emitting radar systems, were significantly lower than controls.	N.H. Hjollund, J.P. Bonde, J. Skotte (1997), Semen analysis of personnel operating military radar equipment. <i>Reprod Toxicol</i> 11(6):897, cited by www.energyfields.org/science/CWTI.RFR_studies_2.02.doc
10.0 $\mu\text{W}/\text{cm}^2$	Redistribution of metals in the blood, bones, brain, heart, liver, lungs, kidney, muscles, spleen and skin	O.I. Shutenko, I.P. Kozyarin and I.I. Shvayko (1981), Effects of superhigh frequency electromagnetic fields on animals of different ages. <i>Gigiyena i Sanitariya, no. 10:35-38, JPRS 84221</i> , pp. 85-90, cited by A. Firstenberg 2001.
10 $\mu\text{W}/\text{cm}^2$	Damaged mitochondria, nucleus of cells in hippocampus of brain	V.S. Belokrinskiy (1982), Destructive and reparative processes in hippocampus with long-term exposure to nonionizing microwave radiation. <i>Bulletin of Experimental Biology and Medicine</i> 93(3):89-92, cited by A. Firstenberg 2001.
10 $\mu\text{W}/\text{cm}^2$	Altered brain permeability	W.R. Adey (1982).
10 – 25 $\mu\text{W}/\text{cm}^2$	Changes registered in hippocampus of the brain	Belokrinskiy, 1982, cited by Sage 2004 'Destructive and reparative processes in hippocampus with long-term exposure to nonionizing radiation.' In U.S.S.R. Report, Effects of Nonionizing Microwave Radiation, No. 7, JPRS 81865, pp. 15-20.
10 – 100 $\mu\text{W}/\text{cm}^2$	RFR at low intensities (0.0027- 0.027 W/kg) induced behavioural and endocrine changes in rats. Decreases in blood concentrations of insulin and testosterone reported, though CW microwaves had no influence on insulin secretion. Inhibition of behaviour by microwaves may depend on strength, exposure time and inhibitory effects on nervous system. Activation correlated with decreases in serum concentrations of insulin and testosterone.	M.A. Navakatikian, L.A. Tomashevskaya (1994), Phasic behavioral and endocrine effects of microwaves of nonthermal intensity. In 'Biological Effects of Electric and Magnetic Fields, Volume 1,' D.O. Carpenter (ed) Academic Press, San Diego, CA, pp.333-342, cited by www.energyfields.org/science/CWTI.RFR_studies_2.02.doc

Power Density	Reported Biological Effects / Comments	References
20 $\mu\text{W}/\text{cm}^2$	Changes in brain wave patterns caused by microwave or radio frequency radiation	C.H. Dodge and Z.R. Glaser, 1977. 'Trends in non-ionizing electromagnetic radiation bio-effects research and related occupational health aspects', <i>Journal of Microwave Power</i> , 12, 4 (1977), cited by P. Bentham (1991), VDU Terminal Sickness: Computer health risks and how to protect yourself, Green Print, London, ISBN 1 85425 043 4.
20 $\mu\text{W}/\text{cm}^2$	Pulsed RF radiation (900 MHz with 217 Hz pulse) slightly elevated cortisol serum level (cortisol is a hormone involved in stress reactions). The increase was transient, suggesting adaptation to the stimulus by the subject. No significant effects found for growth hormone, luteinizing hormone or melatonin under field exposure compared to control condition. The EEG sleep-data revealed no significant variations on exposure, although there was a trend for suppressed REM.	K. Mann, P. Wagner, G. Brunn, F.Hassan, C. Hiemke and J. Roschke (1998), Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system. <i>Neuroendocrinology</i> 67(2):139-144.
25 $\mu\text{W}/\text{cm}^2$ at 300 MHz-300 GHz.	Workers' exposure standard in Russia for 8-hour day (occupational standard introduced in 1986) The standard is based on the total amount of energy absorbed and permits exposures for shorter time periods, e.g. 100 $\mu\text{W}/\text{cm}^2$ for 2 hours, cited by C.W. Smith & S. Best (1989).	
27 $\mu\text{W}/\text{cm}^2$	Standards in the former USSR for permissible exposure levels to 0.3-3 MHz for 8-hour Workday.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. <i>Gigiena i sanitariya</i> 5:72-74, cited by Kositsky et al 2001.
30 $\mu\text{W}/\text{cm}^2$ (0.015 W/Kg SAR)	Elevation of PFC count (antibody producing cells) in immune system	B. Veyret, C. Bouthet, P. Deschaux, R. de Seze, M. Geffard, J. Joussot-Dubien, M. le Diraison, J.-M. Moreau and A. Caristan (1991), Antibody responses of mice exposed to low-power microwaves under combined, pulse and amplitude modulation,' <i>Bioelectromagnetics</i> 12: P 47-56), cited by Sage 2004.
30 $\mu\text{W}/\text{cm}^2$	Increased brain-amine levels	W.R. Adey (1982).
32.5 $\mu\text{W}/\text{cm}^2$	102 nd Floor, Empire State Building in New York	R. Tell & N. H. Hankin (1978), 'Measurements of Radio Frequency Field Intensity in Buildings with Close Proximity to Broadcast Systems', ORP/EAD 78-3, U.S. Environmental Protection Agency, Las Vegas.
50 $\mu\text{W}/\text{cm}^2$	Exposure Limit in Auckland, New Zealand as at 2001	A. Firstenberg (2001).
50 $\mu\text{W}/\text{cm}^2$	18% reduction in REM sleep, which is important to learning and memory functions	Mann <i>et al.</i> , 1996, cited by Sage 2004. Effects of pulsed high-frequency electromagnetic fields on human sleep. <i>Neuropsychobiology</i> 1996;33:41-7.
50 $\mu\text{W}/\text{cm}^2$	Decreased sperm counts	W.R. Adey (1982).
50 $\mu\text{W}/\text{cm}^2$	2.375 GHz exposure for 30 days resulted in decreased T-cell responses with suppressed phagocytosis noted in rats and guinea pigs.	M.G. Shandala, M.I. Rudnex, G.K. Vinogradov, N.G. Belonozhko and N.M. Gonchar (1977), Immunological and haematological effects of microwave radiation at low power densities. In: Proceedings of the International Union Radio Science Symposium on Biological Effects of Electromagnetic Waves, Airlie, V.A., p. 84, cited by Adey, 1982.
50 $\mu\text{W}/\text{cm}^2$	No differences noted in the awake EEG of healthy subjects exposed nearly 3.5 minutes to the 900 MHz radiation pulsed at 217 Hz with a pulse width of 580 microseconds when compared to effects of inactive GSM system.	J. Roschke and K. Mann (1997), No short-term effects of digital mobile radio telephone on the awake human electroencephalogram. <i>Bioelectromagnetics</i> 18(2), pp.172-176.
60 $\mu\text{W}/\text{cm}^2$	Disturbance of female cycles of test animals, reduced fertility, dystrophic changes in reproductive organs. Reduced weight and number of offspring; postnatal deaths of rat pups increased by factor of 2.5.	H.G. Nikitina and L.G. Andrienko (1989), Condition of reproductive functions in experimental animals under the influence of electromagnetic radiation of mm waves. <i>Fundamental and Applied aspects of Use of mm Electromagnetic Radiation in Medicine, Proceedings of the 1st All-Union Symposium with International Participation</i> (10-13 May 1989, Kiev: VNK 'Otklik,' pp. 288-289, 1989, cited by Kositsky et al 2001.

Power Density	Reported Biological Effects / Comments	References
60 $\mu\text{W}/\text{cm}^2$	Brain wave activation observed in human subjects exposed to 902.4 MHz mobile-phone radiation. Significant correlation on EEG recordings noted, particularly when the subjects eyes were closed. This was suggested to be a manifestation of cortex activation under mobile-phone EMF exposure.	N.N. Lebedeva, A.V. Sulimov, O.P. Sulimova, T.I. Kotrovskaya and T. Gailus (2000), Cellular phone electromagnetic field effects on bioelectric activity of human brain. <i>Crit Rev Biomed Eng</i> 28(1-2):323-337. Cited by www.energyfields.org/science/CWT1.RFR_studies_2.02.doc
65.9 $\mu\text{W}/\text{cm}^2$	50 th Floor, Sears Building in Chicago	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985), <i>The Body Electric</i> , Quill, ISBN 0-688-06971-1.
67.4 $\mu\text{W}/\text{cm}^2$	47 th Floor, 1100 Milam Building in Houston	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985).
1 - 97 $\mu\text{W}/\text{cm}^2$	Location specific values found inside tall U.S. buildings that housed or were near broadcast antennas.	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS).
98.6 $\mu\text{W}/\text{cm}^2$	38 th Floor, One Biscayne Tower in Miami	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985).
100 $\mu\text{W}/\text{cm}^2$ at 300 MHz-300 GHz for max. 2 hours.	Workers' exposure standard in Russia for 8-hour day (occupational standard introduced in 1986) Standard based on total amount of energy absorbed, cited by C.W. Smith & S. Best 1989.	
100 $\mu\text{W}/\text{cm}^2$	Maximum permitted exposure levels for MPEL for mobile stations (including cellular phones) for 300-2400 MHz frequencies (Russian Federation, since 1 June 2003)	Hygienic requirements for siting and exploitation of land mobile telecommunication systems, SanPiN 2.1.8/2.2.4.1190-03 (2003), Ministry of Health of Russian Federation / Russian Ministry of Health Protection, SanPiN (Sanitary and Epidemiological Norms). (Standard for siting and using 27-2400 MHz land mobile phone systems in the Russian Federation).
<100 $\mu\text{W}/\text{cm}^2$	54-900 MHz exposure of 95% U.S. urban population in 1979. In urban areas median exposure was 0.005 $\mu\text{W}/\text{cm}^2$.	EPA (Environmental Protection Agency) (1978), Population Exposure to VHF and UHF Broadcast Radiation in the United States, R.A. Tell and E.D. Mantiply, EPA Technical Report ORP/EAD 78-5. Cited in "An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy", Board on Radiation Effects Research (2005), http://books.nap.edu/openbook.php?record_id=11205&page=48
100 $\mu\text{W}/\text{cm}^2$	Changes registered in immune system function of male mice	Elekes et al., 1996. Effect on the immune system of mice exposed chronically to 50 Hz amplitude-modulated 2.45 GHz microwaves. <i>Bioelectromagnetics</i> Vol 17, Issue 3, pp.246-8, cited at www.cellphonesar.com/research/rf_radiation
100 $\mu\text{W}/\text{cm}^2$	26% drop in insulin registered	Navakatikian & Tomashevskaya, 1994. 'Phasic Behavioral and Endocrine Effects of Microwaves of Nonthermal Intensity,' by Carpenter DO and Ayrapetyan S, editors. <i>Biological Effects of Electric and Magnetic Fields</i> . Volume 1, published by Academic Press, cited at www.cellphonesar.com/research/rf_radiation
111.5 $\mu\text{W}/\text{cm}^2$	Belgium (ex Wallonia) Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp

Power Density	Reported Biological Effects / Comments	References
120 $\mu\text{W}/\text{cm}^2$	Pathological change noted in the blood brain barrier at 915 MHz	Salford, L.G., Brun, A., Perrson, B.R.R., and Eberhardt, J., 1993. 'Experimental studies of brain tumor development during exposure to continuous and pulsed 915 MHz radio frequency radiation,' in <i>Bioelectrochemistry and Bioenergetics</i> , Vol. 30: pp. 313-318.
180.3 $\mu\text{W}/\text{cm}^2$	Roof, Home Tower in San Diego	R. Tell & N. H. Hankin (1978), cited by R.O. Becker & G. Selden (1985).
200 $\mu\text{W}/\text{cm}^2$ Public exposure (average)	ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m. ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes. Reference level category 100 – 400 MHz, cited by A. Phillips (2002)	
200 $\mu\text{W}/\text{cm}^2$	Exposure Limit in Australia as at 2001, cited by A. Firstenberg 2001.	
200 – 1000 $\mu\text{W}/\text{cm}^2$	Exposure Limit in Canada, Germany, Japan, New Zealand and US as at 2001, cited by A. Firstenberg 2001.	
250-500 $\mu\text{W}/\text{cm}^2$	Decreased reproductive capacity and litter size , also premature cessation of reproductive function in mice exposed to microwaves for 4 hours a day for 48 weeks – details on carrier frequencies not given.	Z.V. Gordon, A.V. Rosein and M.S. Byskov (1974), 'Main directions and results of research conducted in USSR on the biologic effects of microwaves,' <i>Biologic Effects and Health Hazards of Microwave Radiation</i> , P. Czerski, ed., Polish Medical Publications, Warsaw, p. 22-35, cited by W.R. Adey, 1982.
≤ 230 $\mu\text{W}/\text{cm}^2$	Location specific values measured outside tall buildings in close proximity to broadcast antennas.	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," <i>Environmental Protection Agency Technical Note, ORP/EAD 78-3</i> , Aug. 1978 (NTIS Order No. PB 290 944/AS).
0.2-360 $\mu\text{W}/\text{cm}^2$	Mortality rate of exposed chickens almost twice that of control colony.	C. Romero-Sierra and J.A. Tanner (1970), <i>Microwave Radiation and Egg Production in Chickens</i> . Proceedings of IMPI 5th Annual Microwave Symposium, Scheveningen, Holland. October 1970.
10-10,000 $\mu\text{W}/\text{cm}^2$	Deterioration noted in radiation sensitive Mimosa plant.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), <i>Interaction of Electromagnetic fields And Living Systems With Special Reference To Birds</i> , Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
400 $\mu\text{W}/\text{cm}^2$	Standards in the former USSR for permissible exposure levels to 30-300 kHz for 8-hour workday.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), <i>Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. Gigiena i sanitariya 5:72-74</i> , cited by Kositsky et al 2001.
>500 $\mu\text{W}/\text{cm}^2$	Autoimmune disease evoked , along with production of anti-liver and anti-brain antibodies.	M.G. Shandala, M.I. Rudnex, G.K. Vinogradov, N.G. Belonozhko and N.M. Gonchar (1977), <i>Immunological and haematological effects of microwave radiation at low power densities</i> . In: <i>Proceedings of the International Union Radio Science Symposium on Biological Effects of Electromagnetic Waves</i> , Airlie, V.A., p. 84, cited by Adey, 1982.
500 $\mu\text{W}/\text{cm}^2$	High Blood Pressure due to imbalances of Potassium and Sodium levels in the body , also significant shifts in carbon dioxide – rats exposed to 2,450 MHz for 7 hours a day for 3 months.	R.H. Lovely, A.W. Guy, R.B. Johnson, and M. Mathews (1978), <i>Alteration of behavioural and biochemical parameters during and consequent to 500 $\mu\text{W}/\text{cm}^2$ chronic 2450 MHz microwave exposure</i> , <i>Proceedings of the International Symposium on Electromagnetic Waves and Biology</i> , Ottawa, p. 34, cited by W.R. Adey (1982).
500 $\mu\text{W}/\text{cm}^2$	Peak level at residential locations near the Radio Location Station at Skrunda in Latvia which had 2 pulsed-radar systems operating at 152 to 162 MHz, at 1250 kW, with pulse duration of 0.8 msec, interpulse interval of 41 msec and pulse repetition rate of 24.5 Hz. The <u>average</u> intensity at these areas was <10 $\mu\text{W}/\text{cm}^2$.	A. Romancuks (1996), <i>Measurement of the intensity of the electromagnetic radiation from the Skrunda Radio Location Station. The Science of the total environment</i> , 180 (1):51-56. Cited in "An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy", Board on Radiation Effects Research (2005), http://books.nap.edu/openbook.php?record_id=11205&page=135

Power Density	Reported Biological Effects / Comments	References
900 $\mu\text{W}/\text{cm}^2$	ICNIRP (1998), WHO, Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1,000 $\mu\text{W}/\text{cm}^2$	FCC (USA) OET-65, Public Exposure Guidelines at 1800 MHz	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
<1,000 – 4,500 $\mu\text{W}/\text{cm}^2$ (0–45 mW/cm^2)	Beneficial effects noted in transient, reversible and dose-dependent alterations in rates of blastic transformation of unstimulated lymphocytes of hamsters after 15 minutes of irradiation of 2.45 GHz CW field for 5 day period.	A.T. Huang, M.E. Engle, J.A. Elder, J.B. Kinn and T.R. Ward (1997), The effect of microwave radiation (2450 MHz) on the morphology and chromosomes of lymphocytes, Radio Science, 12, Supplement 6, pp. 173-177, cited by W.R. Adey, 1982.
<1,000 $\mu\text{W}/\text{cm}^2$	Change in bioelectric activity of human muscles during deep stages of hypnosis after 10-20 second exposure at 57-78 GHz	S.I. Gerashchenko, O.I. Pisanko and Yu.N. (1991) Mus'kin., Some physiological reactions of organisms under the influence of EHF radiation. <i>Apparatniy kompleks 'Elektronika-KVCh' I yevo primenenie v meditsine.</i> , L.G. Gassanova, ed. Moscow, 156 pp. NPO 'Saturn, Kiev, pp. 65-71, cited by Kositsky et al 2001.
600 $\mu\text{W}/\text{cm}^2$ at 900 MHz – FCC Exposure Limit in USA (FCC OET65:1997-01 based on NCRP report No.86)		
1000 $\mu\text{W}/\text{cm}^2$ at 1800 MHz – FCC Exposure Limit in uncontrolled environment in USA (FCC OET65:1997-01 based on NCRP report No.86)		
1,000 $\mu\text{W}/\text{cm}^2$	ODC activity increased up to 50% in human melanoma cells (450-500 MHz at 16 Hz).	W.R. Adey et al., Studies on ornithine decarboxylase (ODC), an enzyme essential for cell growth through DNA synthesis, cited by B.B. Levitt (1995), <i>Electromagnetic Fields: A Consumer's Guide to the Issues and How to Protect Ourselves</i> .
1000 $\mu\text{W}/\text{cm}^2$ Occupational exposure (average)	ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m. ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes.	Alasdair Phillips, Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects. 24th July 2002
1000 $\mu\text{W}/\text{cm}^2$	At 2,450 MHz, maximum specific absorption rate (SAR) for energy of 2.0 W/kg occurs in outer 1.0cm of phantom head (dummy head used for testing).	H.N. Kritikos and H.P. Schwan (1972), Hot spots generated in conducting spheres by electromagnetic waves and biological implications. IEEE Transactions on Biomedical Engineering, 19 (1), 53-58. Cited by W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' Physiological Reviews, 61(2), 435-51.
1000 $\mu\text{W}/\text{cm}^2$	At 918 MHz, energy absorption at centre of head is 0.45 W/kg.	W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' Physiological Reviews, 61(2), 435-51.
2000 $\mu\text{W}/\text{cm}^2$	Australian Standard public exposure level – Australian Standard AS2772.1. (1990) Radiofrequency Radiation Part 1: Maximum Exposure Levels -- 100 kHz to 300 GHz. Sydney: Standards Australia.	
700-2,800 $\mu\text{W}/\text{cm}^2$	EEG changes resembling those induced by hallucinogenic drugs noted in rabbits exposed to 9.3 GHz radiation for 5 minutes. Change noted 10 minutes after exposure with decreased total integrated EEG lasting \leq 15 minutes.	L. Goldstein and Z. Sisko (1974), A quantitative electroencephalographic study of the acute effects of X-band microwaves in rabbits. In: <i>Biological effects and health hazards of microwave radiation</i> (P. Czerski, Ed.), p. 128-133. Warsaw: Polish Medical Publishers. Cited by R.O. Becker and A.A. Marino (1982), <i>Electromagnetism & Life</i> , State University of New York Press, pp. 211, ISBN: 0873955609, www.ortho.lsuhs.edu/Faculty/Marino/EL/ELTOC.html
1,000-5,000 $\mu\text{W}/\text{cm}^2$ above 300MHz	The American National Standard Institution's voluntarily required limit for worker and public exposures as at 1989, cited by C.W. Smith and S. Best (1989).	
2,600 $\mu\text{W}/\text{cm}^2$	Maximum exposure in school with base station on roof. Maximum power density of 0.01 $\mu\text{W}/\text{cm}^2$ measured at two schools without nearby base stations.	A. Thansandote, G.B. Gajda and D.W. Lecuyer (1999), Radiofrequency radiation in five Vancouver schools: exposure standards not exceeded. Canadian Medical Association Journal, 161(10), pp. 1311-1312.
5,000 $\mu\text{W}/\text{cm}^2$	Increased bone marrow cellularity in mice exposed to a 2.88 GHz field (SAR 2.3 W/kg) for 80-400 hours – effect not noted at 10,000 $\mu\text{W}/\text{cm}^2$ indicating possible window effect.	H.A. Ragan and R.D. Phillips (1978), Hematologic effects of mice exposed to pulsed and CW microwaves. In: Proc. Int. Union Radio Sci., Symp. On Biologic Effects of Electromagnetic Waves, Helsinki, p. 48, cited by W.R. Adey, 1982.

Power Density	Reported Biological Effects / Comments	References
5,500 $\mu\text{W}/\text{cm}^2$	Exposing developing chick embryos to 428 MHz radiation for >20 days caused lethal and/or teratogenic effects and delayed hatching.	K. Saito and K. Suzuki (1991), Lethal and teratogenic effects of long-term low-intensity radio frequency radiation at 428 MHz on developing chick embryo. <i>Teratology</i> , 43, pp. 609-614.
6400 $\mu\text{W}/\text{cm}^2$ Public exposure (peak)	ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m. ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes, cited by A. Philips 2002.	
2,640 $\mu\text{W}/\text{cm}^2$ at 400 MHz – General Public Exposure Limit in UK (NRPB, 1993) (TETRA operates at 400 MHz)		
3,300 $\mu\text{W}/\text{cm}^2$ at 900 MHz – old UK General Public Exposure Limit to June 2000). Now ICNIRP is used for 900 MHz		
31,000 \pm 5,000 $\mu\text{W}/\text{cm}^2$ (Peak values)	Exposure of BALB/c mice to 42.2 GHz fields (with peak specific absorption rate (SAR) at skin of 622 ± 100 W/kg) for 30 minutes daily for 3 days found to ameliorate the immunosuppressive effects of cyclophosphamide (CPA) – a regularly used anticancer drug – by augmenting proliferation of splenocytes and altering activation and effector functions of CD4 ⁺ T cells.	V. Makar, M. Logani, I. Szabo, and M. Ziskin (2003), Effect of Millimeter Waves on Cyclophosphamide Induced Suppression of T Cell Functions, <i>Bioelectromagnetics</i> 24:356–365.
4,000 $\mu\text{W}/\text{cm}^2$	Threshold for neuroendocrine effects	W.R. Adey (1982).
5,000 $\mu\text{W}/\text{cm}^2$	FCC threshold in controlled environment.	Luxorion, Electromagnetic radiations and your health, www.astrosurf.com/luxorion/qs1-em-radiation
6400 $\mu\text{W}/\text{cm}^2$ Public exposure (peak)	ICNIRP (& UK) public guidance levels at 400 MHz (TETRA) and 28 V/m. based on power levels averaged over 6 minutes.	A. Philips (2002), Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects.
<10,000 $\mu\text{W}/\text{cm}^2$	EHF EMR capable of changing functional condition of living organisms	O.I. Pisanko, V.I. Pyasetskiy and Yu.N. Mus'kin (1991), Questions of hygienic standardization of EHF radiation. <i>Apparatniy kompleks 'Elektronika-KVCh' i yevoye primeneniye v meditsine</i> . L.G. Gassanova, ed. Moscow, 156 pp. NPO 'Saturn,' Kiev, pp. 18-24, cited by Kositsky et al., 2001.
10,000 $\mu\text{W}/\text{cm}^2$ at 1800 MHz	Old UK General Public Exposure Limit to June 2000). Now ICNIRP is used for 1800 MHz, cited by A. Firstenberg 2001.	
10,000 $\mu\text{W}/\text{cm}^2$	Exposure level recommended as safe by the NRPB for the frequency range 30 to 30,000 MHz (as at 1991) was 10 mW/cm ² or, 1 mW hour/cm ² , during any 1 hour period. The NRPB did not include considerations relevant to small children.	
10,000 $\mu\text{W}/\text{cm}^2$	Molecular and genetic effects (thermal)	W.R. Adey (1982).
10,000 $\mu\text{W}/\text{cm}^2$	Exposure to 2450 MHz radiation for 90 minutes produced activation of the hypothalamic-pituitary-adrenal axis and increased oestradiol in both virgin and pregnant rats, suggesting microwaves may greatly stress pregnant organisms.	H. Nakamura, T. Seto, H. Nagase, M. Yoshida, S. Dan and K. Ogino (1997), Effects of exposure to microwaves on cellular immunity and placental steroids in pregnant rats. <i>Occup Environ Med</i> 54(9), pp. 676-80, cited by A. Marino, www.niehs.nih.gov/emfrapid/extmurabs/marino.html
10,000-30,000 $\mu\text{W}/\text{cm}^2$	Chickens exposed at pulse repetition rate of 8,000 pulses per sec and frequency of 16,000 Mc/s. Birds all exhibited a startled reaction at radiation onset, sustained extensor activity of wings and legs also noted. Similar findings obtained with pigeons and seagulls. <u>Note: ICNIRP levels are 200 $\mu\text{W}/\text{cm}^2$ at 400 MHz rising to 1000 $\mu\text{W}/\text{cm}^2$ at \geq 2 GHz</u>	J.A. Tanner (1966), Effect of Microwave Radiation on Birds, <i>Nature</i> , pp. 636.
10,000 $\mu\text{W}/\text{cm}^2$	No detectable ocular damage to the eyes of rabbits and non-human primates after either single 8-hour exposure to 60 GHz CW radiation or five separate 4-hour exposures on consecutive days.	H.A. Kues, S.A. D'Anna, R. Osiander, W.R. Green and J.C. Monahan JC (1999), Absence of ocular effects after either single or repeated exposure to 10 mW/cm ² from a 60 GHz CW source. <i>Bioelectromagnetics</i> 20(8), pp.463-473.
1000 –10,000 $\mu\text{W}/\text{cm}^2$	Exposure limit in UK as at 2001.	A. Firstenberg (2001).

Power Density	Reported Biological Effects / Comments	References
10,000 $\mu\text{W}/\text{cm}^2$	US Occupational Safety and Health Administration's standard as at 1989	C.W. Smith & S. Best (1989), <i>Electromagnetic Man: Health & Hazard in the Electrical Environment</i> , J.M. Dent & Sons Ltd., London, ISBN 0-460-86044-5.
13,300 $\mu\text{W}/\text{cm}^2$ (Average Power Density)	Millimeter wave treatment (MMWT) is widely used in Eastern Europe. Among reported beneficial effects is suppression of melanoma growth. Tests on mice injected with B16 melanoma cells used 15-minute exposures (at 61.22 GHz). 5 daily exposures found to suppress subcutaneous tumour growth if started 5 days after inoculation; though if course started on day 1 or day 10 following inoculations they were ineffective.	A.A. Radzievsky, O.V. Gordiienko, I. Szabo, S.I. Alekseev, and M.C. Ziskin (2004), Millimeter Wave-Induced Suppression of B16 F10 Melanoma Growth in Mice: Involvement of Endogenous Opioids, <i>Bioelectromagnetics</i> 25:466–473.
20,000-50,000 $\mu\text{W}/\text{cm}^2$	Exposed chickens respond with escape or avoidance reactions within seconds of radiation onset.	J. A. Tanner, C. Romero-Sierra and S. J. Davie (1967), Non-thermal Effects of Microwave Radiation on Birds, <i>Nature</i> 216, pp. 1139.
25,000 $\mu\text{W}/\text{cm}^2$	Young chicks became weak on entering pulsed 16 GHz fields. Some collapsed to cage floor (where field intensity shown was registered) until radiation switched off. Collapse time (5-20 seconds) varied with chicks' orientation in field. Induced panting continued briefly after field removed. Drowsiness also noted.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagnetic fields And Living Systems With Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
28,000 $\mu\text{W}/\text{cm}^2$	Teratogenic and tumour causing effects	W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' <i>Physiological Reviews</i> , 61(2), 435-51.
32,000 $\mu\text{W}/\text{cm}^2$ Occupational exposure (peak)	ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m. ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes.	Alasdair Phillips, Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects. 24 th July 2002.
40,000-165,000 $\mu\text{W}/\text{cm}^2$	Dogs avoid exposure to 2800 MHz radiation at these intensities	S. Michaelson et al., (1958). The biological effects of microwave irradiation in the dog, Proc. Second Tri-Serv. Conf. on Biological Effects of Microwave Energy, Rome, New York, p.175, cited by A.S. Presman (1970), <i>Electromagnetic fields and life</i> , (Translated from Russian by F.L. Sinclair). Plenum Press, New York, ISBN 0-306-30395-7, 356pp.
45,000 $\mu\text{W}/\text{cm}^2$	Dorsally stimulated adult birds exhibited behaviour ranging from immobility to initiation of both flight and collapse. Contributory factors were found to be behaviour prior to exposure, area of bird radiated and bird's location.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagnetic fields And Living Systems With Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
46,000 $\mu\text{W}/\text{cm}^2$ (average field intensity 0.152m above floor)	Birds exposed to 9.3 GHz radiation pulsed at 416 pps with 2.3 μsec pulse-width. Collapse of wing and legs noted at start of irradiation. Birds align themselves to outside of field, with their outer side becoming paralysed. Some exhibit hyperactivity. Escape behaviour also noted.	J.A. Tanner, C. Romero-Sierra and S.J. Davie (1967), <i>Non-thermal Effects of Microwave Radiation on Birds</i> , <i>Nature</i> , 216, (5120), pp. 1139.
50,000 $\mu\text{W}/\text{cm}^2$	Almost total paralysis observed in chickens. After 10-20 seconds irradiation pigeons and seagulls showed increased signs of distress noted through defecation, vocalisation and initiation to flight.	J.A. Tanner and C. Remero-Sierra (1974), Beneficial and harmful accelerated growth induced by the action of nonionizing radiation, <i>Annals of New York Academy of Sciences</i> 238, pp. 171-175.
60,000 $\mu\text{W}/\text{cm}^2$	Significant differences noted in EEG patterns of birds when exposed to microwave field modulated sinusoidally at 4 Hz in comparison to non-irradiated situations.	F. Villa, C. Romero-Sierra and J.A. Tanner (1972), Changes in EEG Patterns of Birds under Microwave Radiation. NRC, DME Control Systems Laboratory Technical Report, LTR-CS-56, January 1972.

Power Density	Reported Biological Effects / Comments	References
60,000 $\mu\text{W}/\text{cm}^2$	Increased diffusion rate of aqueous solutions of electrolytes through membranes noted under 10 GHz, CW microwave radiation, being most pronounced when electric field vector oriented perpendicular to plane of the membrane.	J. Bigu del Blanco, C. Romero-Sierra, J.A. Tanner and M.L. Bigu (1973), Progress Report on the Investigation of the Effects of Microwave Radiation on the Diffusion Rate of Electrolytes through Membranes II. NRC, DME Control Systems LTR-CS-73.
80,000 $\mu\text{W}/\text{cm}^2$	Repeated 1 hour exposures (20-24 times) to 2.45 GHz fields caused lens opacities in the eyes of 1 of 11 rabbits tested – other studies do not find evidence of cumulative effects.	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
100,000 $\mu\text{W}/\text{cm}^2$	Repeated exposures caused lens opacities in the eyes of 4 of 10 rabbits tested – other studies do not find evidence of cumulative effects. (Lens opacities of rabbits used as model for human cataract induction)	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
120,000 $\mu\text{W}/\text{cm}^2$	Approximately two minutes exposure caused sudden wilting reaction in a Mimosa plant that died without reopening.	J. A. Tanner and C. Romero-Sierra (1974), Beneficial and harmful accelerated growth induced by the action of nonionizing radiation, Annals of New York Academy of Sciences 238, pp. 171-175.
120,000 $\mu\text{W}/\text{cm}^2$	Repeated exposures caused lens opacities in the eyes of 8 of 10 rabbits tested – other studies do not find evidence of cumulative effects.	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
140,000-190,000 $\mu\text{W}/\text{cm}^2$	5-10 minutes exposures at 140,000-190,000 $\mu\text{W}/\text{cm}^2$ caused plants' primary leaves to wilt. 10-30 minute exposures of most plants to 190,000 $\mu\text{W}/\text{cm}^2$ irradiation caused permanent wilting.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagnetic fields And Living Systems with Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.

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