Measurements of Exposures Around Vodafone New Zealand Limited Cellsites from March 2011 to May 2012

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Technical Report

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This is an electronic copy of an original report signed by Adam Yeabsley on 6 June 2012.

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An Appendix is not included in the online PDF version (www.esr.cri.nz) of this report.

Summary

This report outlines the results from measurements of radiofrequency (RF) fields around base stations (cellsites) for the Vodafone New Zealand Limited yearly monitoring project that took place from March 2011 to May 2012.

At the time of measurement, RF exposures in the areas around the 10 cellsites ranged from less than 0.1 to 2.0 $\mu W/cm^2$. In general, all of the readings were less than 1.0% of the (900 MHz) public limit prescribed by the New Zealand Standard 2772.1:1999 *Radiofrequency Fields: Part 1 - Maximum Exposure Levels - 3 kHz to 300 GHz* (the Standard).

Based on the areas monitored, all of the Vodafone telecommunications cellsites measured in this project comply with the Standard.

On this basis, no adverse health effects are anticipated from exposure to RF fields in the areas tested.

1. Introduction

The National Radiation Laboratory (NRL) is a specialist unit of the Institute of Environmental Science & Research Limited (ESR). ESR, a New Zealand Government-owned Crown Research Institute, is a principal science advisor to the Ministry of Health, providing science advice and services in the field of radiofrequency (RF) magnetic and electric fields and their health effects.

The RF monitoring project was conducted at the request of Vodafone New Zealand Limited. The purpose of the project was for NRL to select 10 telecommunication base stations (cellsites) and determine whether exposures to RF fields in the areas around the cellsites accessible by the public comply with the exposure limits in the New Zealand Standard 2772.1:1999 *Radiofrequency Fields: Part 1 - Maximum Exposure Levels - 3 kHz to 300 GHz* (the Standard).

The main report describes the procedures for measuring RF fields around the cellsites and it summarises the findings from the cellsites visited from March 2011 to May 2012. The Appendix provides more detailed descriptions of the cellsites and explains and/or shows where the RF exposures (power flux density in microwatts per centimetre squared ($\mu W/cm^2$)) were recorded.

1.1. Nature of RF fields

Radio waves and microwaves are forms of electromagnetic energy collectively described by the term radiofrequency or RF. Some common terms used when discussing RF emissions are "radiation", "fields" and "energy."

"Electromagnetic radiation" can best be described as waves of electric and magnetic energy moving together (ie, radiating) through space. For example, the alternating movement of charge in an antenna at a cellular base station generates electromagnetic waves that radiate away from the transmitting antenna.

The term "RF field" is used to indicate the presence of electromagnetic energy at a given location. The RF field can be described in terms of the electric and/or magnetic field strength at that location.

"Electromagnetic energy" can be characterised by a wavelength and a frequency. The frequency is the number of electromagnetic waves passing a given point in one second and is usually expressed in terms of a unit called the hertz (Hz). For example, a typical radio wave transmitted by an FM radio station has a wavelength of about three meters and a frequency of about 100 million cycles (waves) per second or 100 MHz.

2. Measuring Equipment and Procedures

The instrument used to measure the RF fields was a Wandel and Goltermann EMR-300 broadband isotropic radiation meter with a type 8.2 field probe. Full specifications are presented in Table 1.

Table 1 Details of field monitor and electric probe

Manufacturer:	Wandel and Goltermann
Model:	EMR-300, Isotropic Broadband Field Strength Meter, serial number P-0021
Probe:	E-field probe type 8.2, high sensitivity electric field strength, serial number M-0086
Ranges:	0.6–800 V/m
Spectrum:	100 kHz to 100 MHz ± 1 dB, 100 MHz to 3 GHz ± 2.4 dB
Isotropicity:	±1 dB, f > 1 MHz
Calibration:	By manufacturer, September 2009 and March 2012 Uncertainty ± 0.5 dB Recommended interval: 2 years

Electric field strength is expressed in units of volts per metre (V/m). For ease of comparison with the limits prescribed in the Standard, measurement results are presented in terms of the equivalent power flux density of a plane wave, in units of $\mu W/cm^2$.

The estimated detection threshold of the meter is 0.6 V/m, equivalent to a power flux density of about 0.1 $\mu W/cm^2$.

The instrument measures total exposure RF fields across a wide range of frequencies, including those from cellsites, mobile radios, and TV and radio transmitters. The advantage of this approach is that the exposure recorded is from all sources in an area, not just the site being measured. Hence, for example, if a cellsite from the Telecom network is located close to a Vodafone site, the instrument measures the total exposure from both sites. However, the contribution from individual sources cannot be identified.

At each cellsite tested, the person carrying out the survey walked around the area in the vicinity of the Vodafone transmitters, concentrating on areas where maximum exposures might be expected and recording the signal strength on the meter. The maximum power flux density between a height of 2 m above the ground and 30 cm above the ground was recorded.

In most cases, the measurements were made in areas which are reasonably accessible to the public. If it appeared likely that exposures on private land may be greater than those on publicly accessible land, then efforts were made to access that land. The intention was to measure the greatest exposure at the time the survey was carried out, and also to gain an idea of "typical" exposures in the area around the cellsite.

2.1. Site selection criteria

Vodafone had no say in the choice of cellsites to be tested or when they would be tested. Selection of cellsites and testing times were entirely at NRL's discretion. In general, cellsites were selected to ensure:

- a good geographic spread of cellsites
- a range of cellsite types (central city/urban/rural)
- coverage of cellsites known to be of community interest.

A greater weighting was given to monitoring cellsites in residential areas, as results from monitoring this type of cellsite are more likely to be of interest to the public. Some weighting was also given to cellsites which NRL staff knew to have been of particular community interest.

3. Recommended Exposure Limits

The New Zealand Standard

In April 1999, New Zealand adopted NZS 2772.Part1:1999 *Radiofrequency Fields Part 1: Maximum Exposure Levels – 3 kHz to 300 GHz* (the Standard). The limits in this Standard are based on international guidelines[1], and are similar to those in many other international and national standards[2]. The validity of the international guidelines was reaffirmed in 2009. The Standard sets out limits for exposure to the RF emissions produced by all types of radio transmitters, for people exposed occupationally and for the general public. The limits are based on a careful review of the research into the health effects of exposure to RF radiation, and include wide safety margins. Reference levels for the general public are stricter than for occupational exposures, and are set at levels more than 50-times lower than the recognised threshold for established effects.

The Standard sets *basic restrictions* on the amount of RF power absorbed by the body (the *specific absorption rate*). As RF power absorption is difficult to measure, the Standard also prescribes *reference levels* in terms of the more easily measured electric and magnetic field strengths, and power flux density. Compliance with the reference levels ensures compliance with the basic restrictions, and in most applications the reference levels can be effectively regarded as "exposure limits" (although this term is not used as such in the Standard).

The amount of power absorbed by the body depends on the frequency of the radio signal, so the reference levels vary as a function of frequency to take this into account. At frequencies of around 900 MHz, 1800 MHz and 2100 MHz, as used by the Vodafone equipment, the reference levels allowed for members of the general public are approximately 450 μW/cm², 900 μW/cm² and 1000 μW/cm², respectively.

The most restrictive limit of 450 $\mu W/cm^2$ has been used in Table 2 and Figure 2 to determine the maximum measured exposure as a percentage of the Standard. This ensures a conservative evaluation, and means that the exposure level as a percentage of the Standard will be overestimated should the cellsite actually have transmitters operating at 1800 or 2100 MHz.

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1 International Commission on Non-Ionizing Radiation Protection. 1998. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Physics* 74 (4), 494–522. www.icnirp.org

2 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Radiation Protection Series No. 3. Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz (2002). http://www.arpansa.gov.au/Publications/codes/rps3.cfm

4. Site Descriptions

Cellsite locations and descriptions are shown in the Appendix.

The exposure measurements are a snapshot of the RF fields at the time the survey was carried out. Exposures vary over the day as more or less calls pass through the cellsite. All Vodafone cellsites transmit a fixed minimum standby power, even if no calls are passing through it. The maximum output power depends on the configuration of the cellsite.

According to the information provided by Vodafone, both 2G and 3G services can operate at a cellsite. The 2G system (GSM) operates at frequencies of 900 MHz and 1800 MHz. It transmits on up to two channels, one of which always operates at constant power. The other channel only operates intermittently, as required, to handle cell phone traffic. If it is assumed that only one 2G transmitter was operating at the time of the measurements, the maximum 2G exposure that occurs when the cellsite is operating at full power can be determined by multiplying the measured exposures by two. If two transmitters are installed, the measured exposures would be multiplied by four.

The 3G service (UMTS) operates at frequencies of 900 MHz and 2100 MHz. The 3G system operates on one 900 MHz and one 2100 MHz carrier, each transmitting up to 40 watts of total power, as needed. Each carrier has a pilot power output constantly operating at a minimum of 2 watts of total power. The difference between 2 and 40 watts of total power is used, as required, to handle cell phone traffic. If it is assumed that the 3G transmitters were operating at the minimum 2 watts of power at the time of the measurements, the maximum 3G exposure that occurs when the cellsite is operating at full power can be determined by multiplying the measured exposures by 20.

Thus, depending on the configuration of the cellsite, a factor of two, four (eg, two GSM transmitters), 10 (eg, 20 watts total UMTS power) or 20 may apply. For possible future use, Vodafone's 3G system has the capability to transmit up to 80 watts of total power (two channels operating at 40 watts each).

One of the sites visited had mobile radio antennas co-located on the same roof top.

5. Measurement Results

The meter and probe used in this survey measure the total exposure from all transmitters in the frequency range 100 kHz to 3 GHz, so the measurements include all transmitters likely to make a significant contribution to the overall exposure, including other cellsites nearby and any other radio and telecommunication transmitters.

The exact power output of each cellsite at the time of measurement was not known, but was seen to vary on the meter. The output from transmitters varies according to the amount of traffic being handled.

It is assumed that each survey was conducted during a normal traffic period and hence the 2G and 3G transmitters were operating at a typical power level. The maximum power flux density recorded is shown in Table 2 and the Appendix.

Table 2 Summary of cellsite descriptions and measurement results

City, (region) and name of the cellsite	Date measured	Type of cellsite	Maximum power flux density measured during survey ($\mu W/cm^2$)*	Typical exposure around the cellsite ($\mu W/cm^2$)	Additional comments
Auckland, Argyle Street	29/06/2011	Residential, lamp post	0.53 (0.12)	<0.2	
Auckland – Waiheke Island, Surfdale	02/07/2011	Residential, roof top	2.0 (0.44)	<0.4	
Pukekohe, Pukekohe	13/07/2011	Rural, monopole	0.19 (0.04)	<0.1	
Orewa, Orewa	10/08/2011	Residential, roof top	0.7 (0.16)	<0.4	
Blenheim, Blenheim Central	31/08/2011	Commercial, roof top	0.6 (0.13)	<0.4	Mobile radio antennas are co-located on the same roof top
Auckland – Waiheke Island, Surfdale Beach	01/10/2011	Residential, roof top	0.62 (0.14)	<0.2	
Taupo, Rifle Range Road	16/10/2011	Residential, monopole	0.43 (0.10)	<0.2	
Christchurch, Tower Junction	26/01/2012	Industrial, lamp post	0.34 (0.08)	<0.2	
Thames, Thames	11/05/2012	Urban, roof top	0.15 (0.03)	<0.1	
Matamata, Matamata Hub	13/05/2012	Rural, monopole	0.32 (0.07)	<0.1	

* Numbers in brackets represent the exposure as a percentage of the exposure limit at 900 MHz in the Standard.

Figure 1 and Figure 2 present the maximum exposures at the 10 cellsites, expressed as the power flux density in microwatts per square centimetre ($\mu W/cm^2$) (Figure 1), and as a percentage of the 900 MHz public limit prescribed in the Standard (Figure 2).

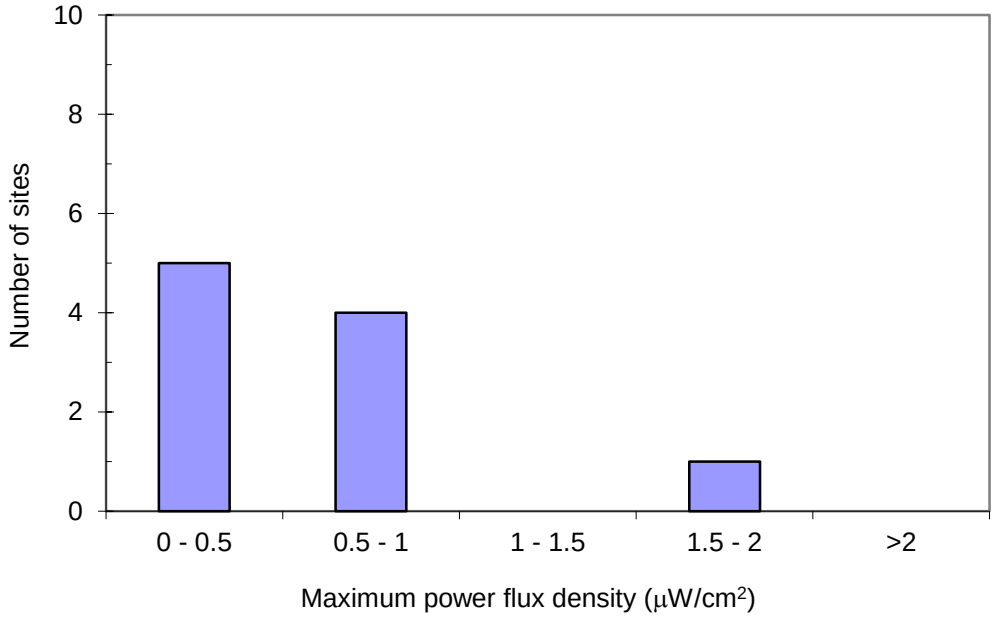

Figure 1 Maximum power flux density around the Vodafone cellsites (*N* = 10)

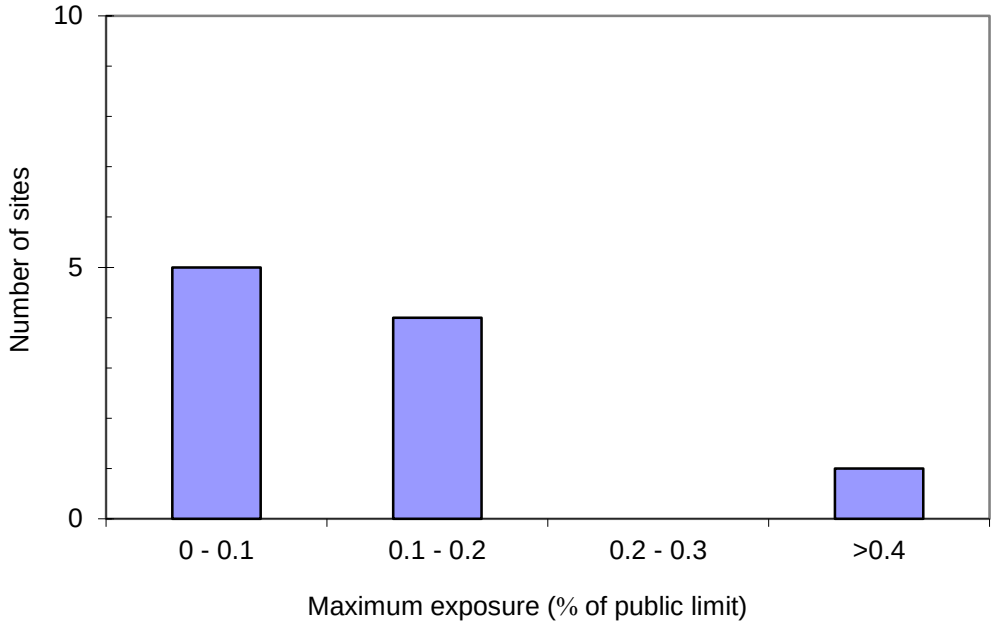

Figure 2 Maximum public exposure limits around the Vodafone cellsites (*N* = 10), expressed as a percentage of the 900 MHz public limit prescribed in the Standard

6. Comparison with Recommended Exposure Limits

Assuming that all exposures were attributable to the Vodafone equipment, the maximum exposure was less than 0.44% (2.0 $\mu W/cm^2$) of the limit recommended for the public in the Standard. In general, the maximum RF exposures in public areas were all less than 1% of the public limit.

It is assumed that the cellsites were operating at their normal power when the measurements were taken. As described in Section 4, a worst-case estimate of the maximum exposure level that may occur when the cellsite is configured to the maximum extent and is operating at maximum power can be derived by scaling the measured exposure values in Table 2 by 20. RF exposures will continue to comply with the (900 MHz) general public reference level of 450 $\mu W/cm^2$ recommended in the Standard, even if the cellsites transmit to the maximum power in their current configuration.

7. Conclusions

The RF field levels measured in this project were all less than the general public reference level recommended by the Standard. On this basis, no adverse health effects are anticipated for people who live, work or pass by close to the cellsites.

Additional information on the Vodafone monitoring project is available at the ESR website: http://www.esr.cri.nz/competencies/nrl/faq/Pages/ELFandRFsurveys.aspx